



BOOK OF  
PROCEEDINGS

THE 2nd ITB  
GRADUATE SCHOOL  
CONFERENCE (IGSC) 2022

*“Strengthening Multidisciplinary  
Research to Enhance its Impact on Society”*

## **PREFACE**



It is a great privilege for us to present the proceedings of the 2<sup>nd</sup> ITB Graduate School Conference to the authors and delegates of the event. The postgraduate education in ITB is a locomotive for achieving academic excellence through research, innovation, and scientific publications. The ITB's Graduate School Conference (i-GSC) is held by ITB's Graduate School and Institute for Research and Community Service (LPPM) as a platform for scientific publications of ITB postgraduate students whose basis is the results of their thesis and dissertation research. The conference is also open to academia and researchers from outside the university.

The responses to the call-for-papers had been overwhelming both from ITB and from other universities. This conference invited 3 keynote speakers from Kyoto University (Assoc. Prof. Osamu Kozan), Osaka University (Asst. Prof. Dr. Sastia P. Putri), and ITB (Prof. Dr. Delik Hudalah). The organizing committee of the 2<sup>nd</sup> IGSC also collaborated with eight (8) ITB reputable Scientific Journals with various scopes of research. The submitted manuscripts were peer-reviewed and parts of them were accepted for publication in the journal. We are truly appreciating all the participants.

In the end, we would like to express our gratitude and appreciation for all the reviewers who helped us maintain the high quality of the manuscripts. We would also like to extend our thanks to the organising team members for their hard work. Last but not least, we thank all participants and wish to see you on the next occasion.

We do hope that this conference activity can continue and support the advancement of science, art, and technology in Indonesia.

Conference Chair

Dr. Kiki Adi Kurnia  
On behalf of the 2<sup>nd</sup> IGSC Committees  
21<sup>st</sup> July 2022  
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## Comparison of Mooc Application User Experience in Indonesia (Case Studies: Ruang Guru and Zenius)

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**Abstract.** The development of science and technology affects various learning media, one of which is distance learning such as the Massive Open Online Course (MOOC). The characteristics of the MOOC Platform are the system is open for public, users can choose a specific topic, the entire learning process is carried out online and the video-based learning materials. Some well-known MOOC's are the Coursera and Udemy apps. The MOOC applications that have developed in Indonesia are Ruang Guru and Zenius, but it is not yet known how the user experience (UX) in MOOC applications in Indonesia. This study aims to find out how the user experience (UX) response in the Ruang Guru and Zenius applications. This research method uses a moderated remote usability test with seven aspects of Honeycomb UX. The stages of the method carried out consist of facilitator (researcher), task, and participant (user). The research subjects consisted of five student participants from several Universities in Indonesia. The result obtained is that users feel more comfortable using the Zenius application. This is because the Zenius application design system is more integrated, the navigation is easier to understand, and the buttons and the text have good readability.

**Keywords:** *application; massive open online learning (MOOC); user experience; usability testing.*

### 1 Introduction

The current development of learning has developed very rapidly. Learning is not only carried out face-to-face, but also remotely using additional devices. Learning using additional devices as a link for the delivery of learning materials began in the 19<sup>th</sup> century, which was delivered by Pomerol et al., in [1]. One of learning model that uses other tools to deliver material is Massive Open Online Courses (MOOC's). Millennials aged 25-39 years in Indonesia have the motivation to use MOOC's to increase their skills, and than to achieve their career or educational goals based by Nurhudatiana in [2]. Stephen Downes and George Siemens in [3] posit that the MOOC is based on a distributed learning model or 'connectivist'.

MOOC-based learning is online learning that arises and is disruptive from traditional education. The basic characteristics of the Massive Open Online Courses (MOOC) platform on learning are in the number of users, systems and channels on the learning process. Pomerol et al in [1] their book entitled *MOOC: Design, Use and Business Models*, explain the characteristics of Massive Open Online Courses (MOOCs) as follows.

Massive; has the characteristic of "Large", which means there are no specific prerequisites regarding the number of learners joining or using the MOOC platform. Although it is attended by tens or hundreds of thousands of people, it does not apply to all the learning offered. Open; refers to the fact that enrollment is unlimited, open to all audiences, and is not conditioned by enrollment in any particular university. However, "open" in MOOC's does not mean Open Source or Open Access, in other words software and content are not necessarily open. Online; means that all courses and exercises are organized within the Internet network, both on the placement of online class content and on the distribution of content. Course; meaning that teaching on MOOC,s is available not only to a half users and limited portion, but to students around the world. On the other hand, the teaching does not only focus on the relationship between teacher and student but more than that students can interact with each other.

The obstacle that arises from the characteristics of MOOCs that have been described above is that many students who use a MOOC application do not complete their learning in MOOC's. Some MOOC platforms are aware that there are factors that cause low study completion or not to reach the end. One such the factor is, the user's discomfort with the appearance of an incomprehensible interface or training program, based by Gamage et al., in [4]. Florjan and Gamage conducted research on user subjects or students outside Indonesia. Florjan in [5] states that MOOC's have a bad reputation because only 10% of users are able to complete learning. Meanwhile, Gamage et.al in [4] stated that poor interface design is one of the causes of users not completing their learning in MOOC applications.

Nurhudatiana & Caesarion in [2] conducted research on the user experience of using the Coursera and Udemy applications in Indonesia. The results of the research obtained are, according to users, Coursera is a credible MOOC platform and has a simple and clean user interface design. The user's opinion about Udemy is that Udemy is identified as a less formal platform with a colorful user interface design. Users tend to prefer a simple interface design, based by Korableva et al., in [6]. Research conducted by Sethi in [7] on the problem of learning dropouts on healthcare through MOOC's with improved interface design, shows that changing the appearance of the interface through iterations can improve users.

The existence of a MOOC application is inseparable from the word of user. User experience is the totality of effects felt by users before, during, and after interaction with a product or system, based on by Rex Hartson, in [8]. User and system interaction in a feature can be recognized and known for its success through usability tests. The identification of usability can be seen from several user situations such as: the user expresses frustration, impatience, uncertainty, interest and needs when completing his tasks, Hertzum, in [9]. User Experience honeycomb written by Peter Morville in [10] offers seven aspects to identify a good user experience.

Seven aspects of Honeycomb's user experience are based on by Morville, in [10] are usefulness, usability, desirability, findability, accessibility, credibility, and value. Usefulness means that the feature or product can be well received by the user. Usability means, the interface design displayed must have usability and provide convenience to the user. Desirability is the knowledge of what the user attracts, thus motivating them to continue using the product. Findability, pay attention to whether the user can navigate, access and find the location of the feature properly. Accessibility indicates whether users with sensory impairments can access the application properly. Credibility, which is the user's trust that needs to be explored for the interface design presented. Value, indicates whether the product used provides an impact and benefit to the user or related agency. According to Mansson et al., in [11] honeycomb's UX model works well to organize participant input to understand the existing value of the smartphone application.

Ruang Guru and Zenius applications are MOOC-based applications that are developing in Indonesia, but research on user experience (UX) on the MOOC platform has not been studied in detail. Based on the description above, the formulation of the problem that can be drawn from this study is. 1) How user needs and user pain points in the Ruang Guru and Zenius applications. 2) Are there any differences in user experience towards the interface design of the Ruang Guru and Zenius applications. The findings in this study can be useful for MOOC providers, as knowledge in the field of educational technology, and can be used by professional designers application as a consideration when designing MOOC-based applications in Indonesia.

## **2 Method**

The method used in this study is the Remote Usability Test. The method is one of remote testing (synchronous). It means that the user and evaluator are in different physical locations and conduct testing sessions via video link, based on by Hertzum, in [9]. Researchers as evaluators can assign tasks to users, observe users while working on assignments, and listen the feedback given during or after

working on a given task. Users will be given the task of trying out the application and providing feedback. This research approach was used to consider pandemic conditions in Indonesia. The purpose of using the Remote Usability Test is to find out user behavior, user needs, and user pain points. Some studies have concluded that remote usability testing is effective, leading to user behavior and usability findings similar to other standardized tests, based on by Mcfadden et al., in [12], Sauer & Sonderegger, in [13].

The respondents of this study were five (5) students who came from different universities in Indonesia in the pharmaceutical field and were between the ages of 21 to 25 years old. Data collection was carried out on February 20, 2022. The characteristics of these respondents were selected to find out how the user experience in the segmentation was. All respondents as users are given the following tasks. 1) Users are confirmed to have installed the Ruang Guru and Zenius applications and are using a personal smartphone. 2) Users are given the first task to open the main page and try the "Learning Strategies" feature on the Ruang Guru application. 3) Users are given the task to trying out the "English" feature on the Zenius app. 4) Users are requested to try different things they like on the main page of both Apps. This testing process is carried out with the help of the Zoom application and users share a smartphone interface display so that researchers can observe what the user is doing. Data collection is carried out by recording the feedback submitted by users and observations to users when carrying out the assigned tasks. The data obtained were then analyzed with criteria as in Table 1.

**Table 1** The Ux Honeycomb Dimensions.

<b>Variabel</b>	<b>Deskripsi</b>
<i>Usefulness</i>	Users feel easy or well-received to the subject matter.
<i>Usability</i>	Users can use the buttons smoothly, Users can adjust the video display well.
<i>Desirability</i>	Users feel comfortable and interested in using the MOOC platform.
<i>Findability</i>	Users know the various features of the application, for example, knowing the material page or knowing how to answer the questions presented in the feature.
<i>Acessibility</i>	Users can listen and read from the learning video display well.
<i>Credibility</i>	Users feel that the materials, instructors, and teaching materials contained in the features are already credible.
<i>Value</i>	Users can receive the costs incurred in the MOOC learning package according to what is obtained or used.

(source: Morville, 2004)

### **3 Result and Discussion**

Based on the method and process of taking data from the research conducted, the following results were obtained.

#### **3.1 Usefulness**

Users on the MOOC platform, Ruang Guru and Zenius applications have the same feel. Users feel that both applications make them easier to learn and they can improve their skills through learning videos and materials followed by question and discussion features. Both applications based on their usefulness, have successfully assisted the users in understanding the material.

#### **3.2 Usability**

The usability element in the MOOC platform of the Ruang Guru and Zenius applications tends to be different. Users feel more comfortable and quicker to understand the buttons presented on the interface design of the Zenius application compared to the Ruang Guru application. The existence of advertising content on the MOOC platform is very much a consideration for users. Users tend to be more comfortable using interface designs with ad layouts that tend to be one place compared to appearing in several places. In addition, the repetitive feature page sharing structure is less preferred by users.

#### **3.3 Desirability**

Users tend to have almost the same interest in presenting the material on MOOC Platform for the Ruang Guru and Zenius applications, but there are differences in the interface design, especially the layout. Users more like the systematic and structured sharing. This makes most users feel interested and facilitated in accessing the application. Users also feel challenged by the existence of features that get rewards. For example: if they completed a task well, then they will get a good score. In the interface design or user interface (UI), the user is more helped by a cleaner appearance with a simple shape. Overall, users feel that the interface on the Zenius application has the same color and is simpler when compared to the Ruang Guru application which is more colourful and has buttons with different styles.

#### **3.4 Findability**

Users confused when looking for one of the features presented in the assignment the MOOC platform on the Ruang Guru application. Users feel that the Ruang Guru application has too many ads, so that it covers the part of the features that

will be searched for. The arrangement of content on the features on the homepage or main page is an important point (start point) for users in accessing the application. If the user is confused at the initial stage, it will affect the next result. Content placement that is a priority for user needs is taken into consideration, for example, advertisements and key features. Users feel that the features in the Ruang Guru application appear simultaneously, while in the Zenius application on the homepage it is less and more focused.

### **3.5 Aaccessibility**

In terms of aaccessibility, users of the Ruang Guru and Zenius applications feel that the readability of the application is clear, and the sound produced can be heard well. Users can adjust the appearance of the application, either portraits or landscapes. All users report, when accessing learning materials there are no obstacles about the internet network, but some users feel confused when learning videos have usage restrictions because some users are users in the free package. Some users also give appreciation to both applications for providing a learning summary feature that is presented in a structured manner and writes down important points. Users have also suggested that explanations using pointers can make it easier to understand the material rather than seeing the tutor's posture directly.

### **3.6 Credibility**

All users agree that Ruang Guru and Zenius have credible materials and professional teachers. Both applications are also the most downloaded online learning applications in Indonesia. This makes users feel safe in installing and accessing both applications.

### **3.7 Value**

Users feel enthusiastic, interested and some want more information about Ruang Guru and Zenius applications. Just one of the seven users who were respondents in this study used paid services from the Zenius application. Price or paid content in Indonesia is still one of the considerations and it's sensitive. This opinion is in line with the research conducted by Nurhudatiana & Caesarion, in [2] about MOOC's in Indonesia, that most users still want a certain discount from the features offered. Pricing considerations on online learning are still not the main users need. On the other hand, Meng in [14] there was an increase in the field of electronic needs in Indonesia. This is an indication that in the future there will be an increase in the need for online-based learning.

## 4 Conclusion

Based on the research that has been done, it can be concluded that the usefulness aspects of the Ruang Guru and Zenius applications based on the MOOC platform are successfully used well by users. However, in terms of the usability aspect, users are more comfortable using the Zenius application because the buttons and icons used are easier to understand, this is in line with similar research conducted by Kusuma et al., in [15] on Ruang Guru application, that the desirability aspect has the lowest value caused the community in Ruang Guru has not been fully formed, so the users not many understand the features presented. In terms of accessibility, credibility, and value, the two applications tend to have similarities. Users of the MOOC platform in the application tend to be more comfortable using features with structured materials, there are learning challenges, easy recognize buttons with clean layouts and simple shapes, and there are not too many colors.

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## New BPS Vortices in Maxwell-Chern-Simons-Higgs Model with Neutral Scalar Field

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**Abstract.** Vortices are topological defects that exist in the planar dimension. In this paper, we present first-order formalism to Maxwell-Chern-Simons-Higgs model with general coupling functions using the BPS Lagrangian method. We obtain finite energy solution with the potential that depends on the generalized functions  $w(|\phi|, N)$  and  $h(|\phi|, N)$ . We introduce some particular generalized functions and present the numerical solution to the obtained BPS equations. We find that the vortex solution of our model does not have electric field and the energy density forms a ring-like structure. Using the conserved local  $U(1)$  current, we obtain that the charge density of this model is localized and the charge itself is proportional to the magnetic flux.

**Keywords:** *BPS equations; BPS Lagrangian; Maxwell-Chern-Simons-Higgs; topological defects; vortex.*

### 1 Introduction

Topological defects have become an interesting topic of discussion in recent years. This type of solutions which arise from a nonlinear model can be interpreted as a type of particles that is different from the usual elementary particles in the Standard Model. They have distinct topological property from their vacuum such that there are no physical processes with finite amount of energy which can deform these solutions into their vacuum. One particular kind of topological defects in planar space is known as vortices, Manton *et al.* and Weinberg [1, 2]. There exist two kind of vortices, namely global and gauged vortices, each corresponds to the global and local  $U(1)$  transformation respectively. The generalization of global vortices in 3+1 dimensional spacetime have their application in cosmology. Kibble mechanism explains how the formation of cosmic strings may occurs in the early universe during the course of symmetry-breaking cosmological phase transitions, Weinberg and Kibble [2, 3].

Gauged vortices also have their own interesting application in condensed matter physics, mainly in the superconductor of the second group that has been studied by Abrikosov in [4].

The standard kinetic term of the gauge field in gauged vortices is the Maxwell Lagrangian. However, in the odd-dimensional spacetime, there exist another possible kinetic term for the gauge field that is Lorentz invariant, local, and remain gauge invariant up to its boundary term, that is the Chern-Simons term, Dunne [5]. In planar dimension, coupling between Chern-Simons term and matter field give rise into a new kind of particles which have distinct statistics from the ordinary bosons and fermions. It was studied by Wilczek in [6] and is called anyons.

Mathematically, it is possible to consider a model in which the kinetic terms of the gauge field are described both by the Maxwell and Chern-Simons term. In one of the earliest studies, Lee *et al.* [7] shows that coupling between Maxwell-Chern-Simons term and the Higgs field (MCSH) give rise into electrically charged vortices. The first differential formulation in this study leads into a conclusion that the self-dual solution is static and there is an identification between the scalar gauge field and the neutral scalar field, removing the gauge invariant problem. This study is generalized by Bazeia *et al.* in [7] by adding generalized coupling functions. In this generalization, coupling functions between Maxwell and the kinetic term of neutral scalar field remain identical, which makes the scalar gauge and neutral scalar field remain identical. Different approach was done by Torres in Ref. [8] by introducing anomalous magnetic moment to the coupling between gauge and Higgs field. This addition makes the second order dynamical equation for the gauge field to be satisfied by first order differential equation. This enables the temporal gauge field to be written in terms of the Higgs field, thus removing the gauge invariant problem. Generalization of this model was done in a quite similar manner as in the previous model<sup>1</sup> was done by Andreade *et al.* [9]. Recent study by Andreade *et al.* [10] shows that vortex solution may exist in the generalized MCSH model even with no neutral scalar field and minimal coupling between gauge and the Higgs field. Approach to this model was done by considering the stressless condition. In this study, first-order differential equation is introduced in the analysis such that is satisfy stressless condition and the equation of motion. The consequence of this is that the equation which relates scalar gauge field to the Higgs field is obtained.

We learn that in the previous studies, the identification between temporal gauge field and a scalar field is need to be done to avoid violating gauge invariant condition. In this paper, we attempt to obtain vortex solution with all the involved

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<sup>1</sup> The one with neutral scalar field.

fields independent to one another. The method that we will use to obtain the first-order formalism is the BPS Lagrangian method introduced by Ardian in [11]. This paper consists of four sections. In Sec. II, we introduce the model and apply the radially symmetric ansatz into it. In Sec. III, we implement the BPS Lagrangian method into the model and analyze the obtained equations numerically. Finally, we conclude this study in Sec. IV where we give our final comment and discuss the possibility for further research.

## 2 Generalized Maxwell-Chern-Simons-Higgs Model

In this paper, we consider the most general version of the model with the Lagrangian density

$$\begin{aligned} \mathcal{L} = & -\frac{h(|\phi|, N)}{4} F_{\mu\nu} F^{\mu\nu} - \frac{\kappa}{4} \delta^{\mu\nu\rho} A_\mu F_{\nu\rho} + w(|\phi|, N) |D_\mu \phi|^2 \\ & + \frac{G(|\phi|, N)}{2} \partial_\mu N \partial^\mu N - V(|\phi|, N), \end{aligned} \quad (1)$$

where  $h(|\phi|, N)$ ,  $w(|\phi|, N)$ , and  $G(|\phi|, N)$  are the generalized coupling functions that satisfy positive-definite and dimensionless condition,  $V(|\phi|, N)$  is a general potential with non-negative value,  $F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$  is the abelian gauge curvature tensor, and  $D_\mu \phi = \partial_\mu \phi + ieA_\mu \phi$  describes the minimal coupling between Higgs and the gauge field.

The equation of motions for the fields in this model are given by the Euler-Lagrange equations. For the gauge field, we have

$$\partial_\mu (hF^{\mu\nu}) + J^\nu = \kappa F^\nu, \quad (2)$$

where

$$J^\nu = iew \left( \phi \overline{D^\nu \phi} - \overline{\phi} D^\nu \phi \right), \quad (3)$$

is the  $U(1)$  conserved current and

$$F^\nu = (1/2) \delta^{\nu\rho\sigma} F_{\rho\sigma}, \quad (4)$$

is the dual of gauge curvature tensor. From eq. (2), one can observe that the temporal gauge,  $A_0 = 0$ , cannot be used since it will lead to the trivial solution.

The remaining equation of motions to Lagrangian (1) can be written as

$$D_\mu (wD^\mu \phi) + \frac{1}{2} \partial_{\bar{\phi}} h (F_\mu F^\mu - \partial_\mu N \partial^\mu N) - \partial_{\bar{\phi}} w |D_\mu \phi|^2 + \partial_{\bar{\phi}} V = 0, \quad (5)$$

$$\partial_\mu (G \partial^\mu N) + \frac{1}{2} (\partial_N h F_\mu F^\mu - \partial_N G \partial_\mu N \partial^\mu N + 2 \partial_N w |D_\mu \phi|^2) + \partial_N V = 0, \quad (6)$$

We may also calculate the energy-momentum tensor for the latter calculational purpose.

$$T^{\mu\nu} = h(|\phi|, N) \left( F^{\mu\rho} F_\rho^\nu + \frac{1}{4} \eta^{\mu\nu} F_{\rho\sigma} F^{\rho\sigma} \right) + \eta^{\mu\nu} V(|\phi|, N) + G(|\phi|, N) \left( \partial^\mu N \partial^\nu N - \frac{1}{2} \eta^{\mu\nu} \partial_\rho N \partial^\rho N \right), \quad (7)$$

We are interested to the radially-symmetric static solution of the form

$$\phi(r, \theta) = v g(r) e^{in\theta}; \quad N \equiv N(r); \quad A_0 \equiv A_0(r), \quad (8a)$$

$$\vec{A}(r, \theta) = -\frac{\hat{\theta}}{er} (a(r) - n), \quad (8b)$$

with  $v$  being the vacuum expectation value of Higgs field and  $n = \pm 1, \pm 2, \dots$  is the winding number. Substituting ansatz (8) into the Lagrangian density (1), we obtain

$$\begin{aligned} \mathcal{L}_{eff} = & \frac{h}{2} A_0'(r)^2 - \frac{h}{2} \left( \frac{a'(r)}{er} \right)^2 - v^2 w \left( g'(r)^2 + \frac{a^2 g^2}{r^2} \right) \\ & - \frac{G}{2} N'(r)^2 + \frac{\kappa}{2er} (A_0'(r)(a-n) - A_0(r)) \\ & + e^2 v^2 A_0^2 g^2 w - V. \end{aligned} \quad (9)$$

We may also take the 00-component of the energy-momentum tensor and write it in terms of the defined ansatz so that the energy density of this model is

$$\rho = \frac{h}{2} \left( A_0'(r)^2 + \frac{a^2}{e^2 r^2} \right) + v^2 w \left( g'(r)^2 + \frac{a^2 g^2}{r^2} + e^2 A_0^2 g^2 \right) + \frac{G}{2} N'(r)^2 + V, \quad (10)$$

where we have  $w \equiv w(g, N)$ ,  $h \equiv h(g, N)$ ,  $V \equiv V(g, N)$ , and the primed function denotes its derivative with respect to  $r$ .

### 3 BPS Equations Formalism

#### 3.1 BPS Lagrangian Method

It has been shown in [11] that the BPS Lagrangian method is sufficient to derive the BPS equations for vortices in the standard and generalized Maxwell-Higgs and Born-Infeld-Higgs models. Furthermore, the method has been used for the case of Skyrme model [12]. In the BPS Lagrangian method, we basically trying to rewrite the original Lagrangian density into quadratic terms that consist of all first-derivative of the fields by subtracting it with a BPS Lagrangian density,  $L_{BPS}$ . The Bogomolnyi's equations are obtained when all these quadratic terms are equal to zero,  $L - L_{BPS} = 0$ . The cost for introducing this BPS Lagrangian density is additional constraint equations, which are the Euler-Lagrange equations of the BPS Lagrangian density, that must be considered in solving the Bogomolnyi's equations. As an example, a Lagrangian density of a model with  $k$ -scalar fields can be written down as,

$$L - L_{BPS} = \sum_{i=1}^k \left( \partial_\mu \phi^i - f^i(\phi^1, \dots, \phi^N; \partial_\nu \phi^j; \vec{x}) \right), \quad (11)$$

with  $j = 1, \dots, i-1, i+1, \dots, k$ . Setting  $L - L_{BPS} = 0$ , the Bogomolnyi's equations are given by

$$\partial_\mu \phi^i = f^i(\phi^1, \dots, \phi^N; \partial_\nu \phi^j; \vec{x}). \quad (12)$$

For the most of well-known cases, the BPS Lagrangian density consists of only boundary terms, or in another word its Euler-Lagrange equations are trivial [11]. In general, the BPS Lagrangian density can also contain non-boundary terms such as shown in [13] which results in BPS vortices with non-zero stress tensor in the

generalized Maxwell-Higgs and Born-Infeld-Higgs models. In this article, we consider a BPS Lagrangian density only with non-boundary terms of the form<sup>2</sup>,

$$\mathcal{L}_{BPS} = -X_0 - \frac{X_1}{r} g'(r) - \frac{X_2}{r} a'(r) - \frac{X_3}{r} A'_0(r), \quad (13)$$

where  $X_i \equiv X_i(g, a, A_0, N)$  with  $i = 0, 1, 2, 3$ . This BPS Lagrangian is not the most BPS Lagrangian but it is sufficient for our purpose in this article, as it will be clear in the next sections.

### 3.2 BPS Equations for All Effective Fields

In the BPS limit, we calculate  $\mathcal{L} - \mathcal{L}_{BPS} = 0$  and solve the equation for each field one by one. We obtain,

$$g'(r) = \frac{X_1}{2rv^2w}, \quad (14a)$$

$$a'(r) = \frac{er}{2h}(2eX_2 - \kappa A_0), \quad (14b)$$

$$A'_0(r) = \frac{\kappa(n-a) - 2eX_3}{2erh}, \quad (14c)$$

$$N'(r) = \frac{X_4}{rG}, \quad (14d)$$

and a constraint equation. This constraint function can be written in the form of a polynomial in  $r$ . Since the coefficients of this polynomial do not contain  $r$  explicitly, this constraint equation will be satisfied if each of the coefficient is zero,

$$X_0 = -\frac{(A_0\kappa - 2eX_2)^2}{8h} - A_0^2 e^2 v^2 g^2 w + V, \quad (15a)$$

$$8v^2 a^2 g^2 w = -\frac{(2eX_3 + (a-n)\kappa)^2}{e^2 h} + \frac{4X_4^2}{G} + \frac{2X_1^2}{v^2 w}. \quad (15b)$$

Besides the above constraint equation, there are other conditions that must be satisfied by the BPS Lagrangian. From the Euler-Lagrange equations of the BPS

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<sup>2</sup> We follow suggestions in [13] to determine explicit radial coordinate dependent for each term in the BPS Lagrangian density.

Lagrangian, we may substitute the BPS equations (14) into these equations. We then write the equations in polynomial of  $r$  and setting all the coefficients to zero. From the coefficient of  $r^0$ -term, we find

$$X_2 \equiv X_2(g, A_0, N), \quad (16a)$$

$$X_l = aY_l(g, A_0, N) + Z(g, A_0, N), \quad (l = 1, 3, 4). \quad (16b)$$

Substituting the above results into the coefficient for  $r^1$ -term, we write the obtained result as a polynomial in  $a(r)$ . From  $a^0 r^1$ -term, we obtain

$$Y_1 = \frac{1}{4eh(2eX_2 - A_0\kappa)} \left( 8h^2 \frac{\partial(V - A_0^2 e^2 v^2 g^2 w)}{\partial g} + \frac{\partial h}{\partial g} (A_0\kappa - 2eX_2)^2 \right), \quad (17a)$$

$$Y_3 = \frac{4ev^2 g^2 A_0 h w}{A_0\kappa - 2eX_2} + \frac{\kappa}{2e}, \quad (17b)$$

$$Y_4 = \frac{1}{4eh(2eX_2 - A_0\kappa)} \left( 8h^2 \frac{\partial(V - A_0^2 e^2 v^2 g^2 w)}{\partial N} + \frac{\partial h}{\partial N} (A_0\kappa - 2eX_2)^2 \right). \quad (18)$$

We consider a simple case where  $X_0 = 0$  such that

$$X_2 = \frac{A_0\kappa}{2e} + \frac{sx_2}{e^2} \sqrt{2e^2 h(V - A_0^2 e^2 v^2 g^2 w)}, \quad (19)$$

where  $sx_2 = \pm 1$  denotes the choice of signature in the solutions of  $X_2$ .

If we hold the dependency of  $A_0$  with respect to  $r$ , then the coefficient for  $a^2 r^1$ -term requires  $\kappa = 0$ . Therefore, we must consider  $A_0(r) \equiv A_0$ , where  $A_0$  is a constant. This condition and the the Bogomolnyi's equation (14c) imply

$$Z_3 = \frac{n\kappa}{2e}, \quad (20)$$

$$V = \frac{A_0^2 e^2 v^2 g^2 w}{\kappa^2} (2e^2 v^2 g^2 w h + \kappa^2), \quad (21)$$

with a condition  $\text{sgn}(e) \times \text{sgn}(A_0) \times \text{sgn}(sx_2) \times \text{sgn}(\kappa) = +1$ . Substituting those functions into all the constrain equations and the equation (15b), we find the coefficient of  $a^2$  gives

$$\frac{A_0^2 e^2}{\kappa^2} \left( \frac{2v^2 g^2}{G} \left( \frac{\partial(hw)}{\partial N} \right)^2 + \frac{1}{g^2 w} \left( \frac{\partial(g^2 hw)}{\partial g} \right)^2 \right) = w. \quad (22)$$

We find that the only possible solution is  $Z_1 = Z_4 = 0$  and the solution to (22) is

$$G = \frac{2v^2 w \left( \frac{\partial(A_0 e g^2 hw)}{\partial N} \right)^2}{\kappa^2 g^2 w^2 - \left( \frac{\partial(A_0 e g^2 hw)}{\partial g} \right)^2}, \quad (23)$$

where  $\kappa^2 g^2 w^2 > \left( \frac{\partial(A_0 e g^2 hw)}{\partial g} \right)^2$ . The corresponding Bogomolnyi's equations are

$$\frac{a'(r)}{r} = s x_2 2e^2 v^2 \sqrt{\frac{A_0^2 e^2}{\kappa^2}} g^2 w, \quad (24a)$$

$$g'(r) = s x_2 \sqrt{\frac{A_0^2 e^2}{\kappa^2}} \frac{a}{r w} \frac{\partial(g^2 hw)}{\partial g}, \quad (24b)$$

$$N'(r) = s x_2 \sqrt{\frac{\kappa^2}{A_0^2 e^2}} \frac{a}{r w} \frac{\kappa^2 g^2 w^2 - \left( \frac{\partial(A_0 e g^2 hw)}{\partial g} \right)^2}{\kappa^2 \frac{\partial(g^2 hw)}{\partial N}}. \quad (24c)$$

In this BPS limit, one may show that the energy density (10) becomes

$$\rho_{BPS} = -s x_2 A_0^2 e \sqrt{\frac{\kappa^2}{A_0^2 e^2}} B + \frac{s x_2 2v^2}{r} \sqrt{\frac{A_0^2 e^2}{\kappa^2}} \frac{d(ag^2 wh)}{dr}, \quad (25)$$

With  $B$  being the two-dimensional magnetic field that is defined as

$$B(r) = -\frac{1}{er} \frac{da}{dr}. \quad (26)$$

To this model, we apply the standard boundary condition for topological vortices

$$g(0) = 0, \quad a(0) = n, \quad N(0) = N_0, \quad (27a)$$

$$g(\infty) = 1, \quad a(\infty) = 0, \quad N(\infty) = N_\infty. \quad (27b)$$

Integrating the BPS energy density (25) with respect to the boundary condition (27) throughout all space, we obtain

$$E_{BPS} = 2\pi \int \rho_{BPS} r \, dr = -sx_2 2\pi n \sqrt{\frac{A_0^2 \kappa^2}{e^2}}. \quad (28)$$

The negative sign indicates that positive  $sx_2$  is related to negative winding number, and vice versa.

### 3.3 Numerical Calculation

For the following calculation, we do the rescaling

$$r \rightarrow \frac{r}{\kappa}, \quad N \rightarrow \frac{\kappa}{e} N, \quad A_0 \rightarrow \frac{\kappa}{e} A_0, \quad v \rightarrow \frac{\kappa}{e} v. \quad (29)$$

In this model, there are three generalized coupling functions and a potential that are free to choose. Nevertheless, equation (21) and the positive definite condition of (23) reduce the number of free parameters to two. From this, we define the constraint functions to be

$$w(g, N) = \frac{\sqrt{3}(1-g^2)^2}{\sqrt{3N^2 + 3 + 3g^2 - 3g^4 + g^6}}, \quad (30a)$$

$$h(g, N) = \frac{1}{6v^2} \frac{\sqrt{3N^2 + 3 + 3g^2 - 3g^4 + g^6}}{g^2(1-g^2)^2} \times \left( \sqrt{3N^2 + 3 + 3g^2 - 3g^4 + g^6} - \sqrt{3} \right), \quad (30b)$$

$$G(g, N) = \frac{3}{2v^2} \frac{N}{g^2(1-g^2)^2 \sqrt{3N^2 + 3 + 3g^2 - 3g^4 + g^6}}. \quad (30c)$$

One may check that the above definition satisfy the positive-definite condition. With this coupling functions, the potential becomes

$$V(g) = \frac{\kappa^4}{e^2} A_0^2 v^2 g^2 (1-g^2)^2, \quad (31)$$

and the BPS equations,

$$g' = \frac{sx_2}{2} \sqrt{\frac{A_0^2}{v^4}} \frac{ag}{r}, \quad (32a)$$

$$N' = \frac{2sx_2}{\sqrt{A_0^2}} \left(1 - \frac{A_0^2}{4v^4}\right) \frac{ag^2(1-g^2)^2}{rN}, \quad (32b)$$

$$\frac{a'}{r} = sx_2 2v^2 \sqrt{3A_0^2} \frac{g^2(1-g^2)^2}{\sqrt{3N^2 + 3 + 3g^2 - 3g^4 + g^6}}. \quad (32c)$$

From eq. (25), the energy density of this model can be written as below.

$$\rho_{BPS} = \frac{\kappa^4}{e^2} 2v^2 A_0^2 g^2 (1-g^2)^2 \left(1 + \frac{\sqrt{3}}{4v^4} \frac{a}{r^2 \sqrt{3N^2 + 3 + 3g^2 - 3g^4 + g^6}}\right). \quad (33)$$

The behavior of the fields near origin may give better understanding to the boundary condition for numerical analysis. By writing the solution to equations (32) as power series, we obtain

$$g(r \approx 0) = g_0 r^{m\eta_1}, \quad (34a)$$

$$N(r \approx 0) = N_0 - \frac{g_0^2 \eta_2}{2N_0 \eta_1} r^{2m\eta_1}, \quad (34b)$$

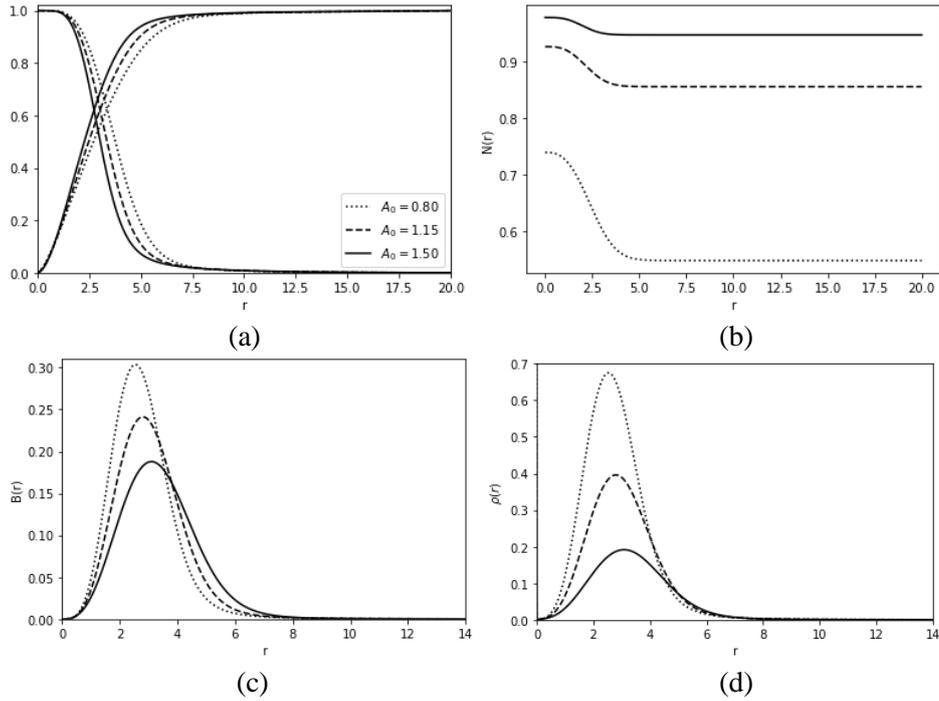
$$a(r \approx 0) = n - \frac{g_0^2 \eta_3}{n \sqrt{3(N_0^2 + 1)} \eta_1} r^{2+2m\eta_1}. \quad (34c)$$

From the above result, we may implement the boundary condition for neutral scalar field near its origin as  $N'(0) = 0$ .

For the numerical analysis, we present the solution for several values of the constant temporal gauge field, namely  $A_0 = 0.80$  (dotted),  $A_0 = 1.15$  (dash-dotted), and  $A_0 = 1.50$  (solid). In Fig. 1.a., we present solution for the modulus of the Higgs field,  $g(r)$ , and the vector gauge,  $a(r)$ . In this calculation, we set  $sx_2 = -1$  and  $e = \kappa = n = v = 1$ . These solutions obey the standard boundary condition for topological vortices. As we increase the value of  $A_0$ , we get a steeper plot. This is due to the fact that the derivative of those functions is proportional to  $A_0$ . Numerical solution to the neutral scalar field is presented in

Fig.1.b. As we can see, it approaches constant value as we have  $A_0 \rightarrow 2$ . This result can be traced back to eq. (32b), that if  $A_0^2 / v^4 \rightarrow 4$  then  $N'(r) \rightarrow 0$ . However, we cannot present the numerical solution for constant neutral scalar field due to the limitation of the numerical method that we use.

We also vary the vacuum expectation value of the Higgs field, namely  $v = 0.80$  (dotted),  $v = 1.00$  (dash-dotted), and  $v = 1.20$  (solid), with  $sx_2 = -1$  and  $e = \kappa = n = A_0 = 1$ . As we can see from Fig.2, the numerical results are pretty much similar to the results that we have obtained for several value of  $A_0$ . However, the solution for neutral scalar field shows the opposite trend as we increase the value of  $v$ . For the greater value of  $v$ , this solution deviates further from the constant solution. This is due to the same reason as the one that we have seen in the previous calculation. As the value of  $v^4 \rightarrow 0.25$ , while the other constants are unity, the solution for neutral scalar field will approach a constant solution.



**Figure 1** (a) Numerical solution for several values of  $A_0$  to the Higgs  $g(r)$  (increasing), vector gauge field  $a(r)$  (decreasing), and (b) the neutral scalar field

$N(r)$  from the BPS equations (32). In (c) the corresponding magnetic field is obtained from (26), and in (d) the energy density is presented.

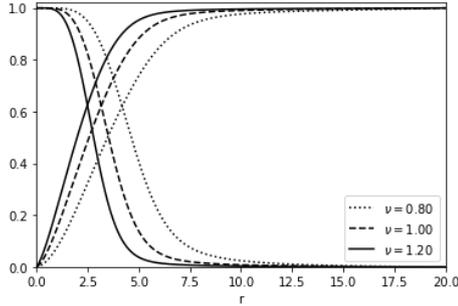
From the solution of eq. (32), we may obtain two observables namely the magnetic field and energy density. There is no particular difference for the numerical solution of the magnetic field and energy density, whether we vary the constant value of  $A_0$  or  $\nu$ . However, the energy density in this solution is quite different from the one obtained before by Bazeia *et al.* [7] and Andreade *et al.* [9], that in near origin its value approaches zero. This ring-like vortices is also obtained before by Andreade *et al.* in [10]. Nevertheless, the solution that we have obtained here is still different, it has no electric field. Even so, these vortices still have magnetic charge. From (3), we may calculate the zeroth component to obtain

$$\sigma \equiv J^0 = \frac{\kappa^3}{e} 2\nu^2 A_0 g^2 w. \quad (35)$$

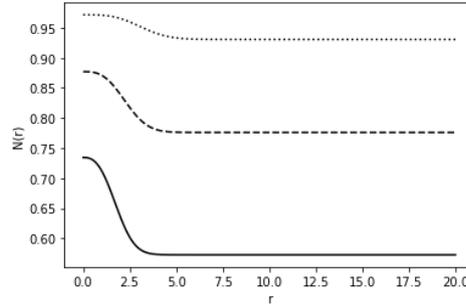
Using eq. (24a), we may integrate the charge density (35) for all space to obtain

$$Q = 2\pi \int \sigma r dr = -sx_2 \frac{\kappa^3}{e} 2\pi n \frac{A_0}{\sqrt{A_0^2}}. \quad (36)$$

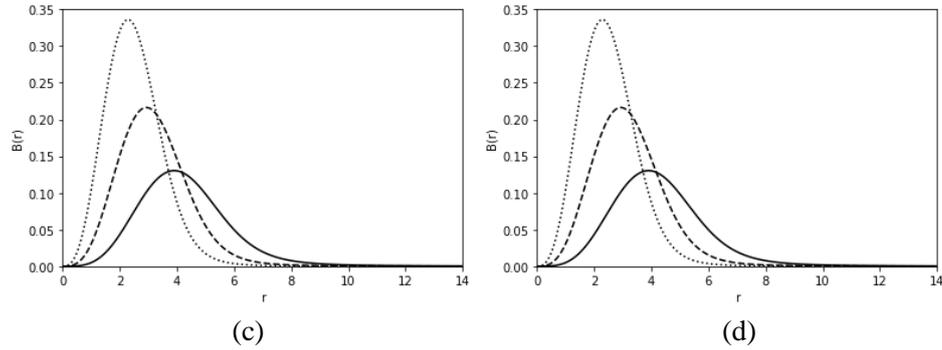
The above result can be interpreted as the magnetic charge of this MCSH vortices.



(a)



(b)



**Figure 2** (a) Numerical solution for several values of  $\nu$  to the Higgs  $g(r)$  (increasing), vector gauge field  $a(r)$  (decreasing), and (b) the neutral scalar field  $N(r)$  from the BPS equations (32). In (c) the corresponding magnetic field is obtained from (26), and in (d) the energy density is presented.

#### 4 Conclusion

We have presented that topological vortex solution to the MCSH model described with Lagrangian density (1) exist. In our derivation, we hold the condition that all the involved fields are independent to one another. This leads to a conclusion that the value of the scalar gauge field is constant, thus the vortex solution that we have derived does not have electric field. However, the magnetic field for this model can be calculated using (26). From the local  $U(1)$  conserved current, we may calculate the magnetic charge and we obtain that its value is proportional to the magnetic flux.

We also find that the potential depends to the generalized coupling functions  $w(|\phi|, N)$  and  $h(|\phi|, N)$ . For numerical analysis, we introduce the explicit form for the generalized coupling functions such that they satisfy the positive definite condition. The numerical solution for  $g(r)$  and  $a(r)$  shows the usual behavior for the topological vortices. We do the numerical calculation for several values of  $A_0$  and  $\nu$ , with the other non-varying constants are set to be unity. We obtain that the solution for neutral scalar field approaches constant solution as  $A_0^2 / \nu^4 \rightarrow 4$ . In this paper, we do not consider the solution for constant neutral scalar field since the numerical method that we use becomes ineffective.

The energy density for this model is rather different from the previous studies done by Bazeia *et al.* [7] and Andreade *et al.* in Ref. [9], that the energy density of this solution approaches zero near the origin. This ring-like solution was also

obtained before by Andreade *et al.* in [10]. However, the vortex solution that they have obtained is different from our solution in a sense that their approach involves the identification between scalar gauge field and the Higgs field.

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## Operational Analysis of BRT Trans Jateng

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**Abstract.** The existence of BRT Trans Jateng corridor I Semarang Area gets 98% interest and supportive response for the development of public transport based on BRT by Priyatno in [16]. The Society's response who support and interest in the development of BRT indicated that the application of BRT Trans Jateng Especially corridor I Semarang Area quite successful. Based on that information, an Analysis operation of BRT Trans Jateng was conducted to know about the parameter which influences the operation of BRT Trans Jateng. Two methods are being used, they are Data Envelopment Analysis and Analysis of Association. The result of the Data Envelopment Analysis shows that Covid 19 influences the operation of BRT Trans Jateng. There is a decreasing efficiency of BRT Trans Jateng around 51.3% from the two routes that are being tested. Further, the analysis association of operational of BRT Trans Jateng gives a result that the parameter which influences the total passenger of BRT Trans Jateng is a population that has a positive correlation. Every 1% increase in population will influence a 0.491% increase in the number of total passengers. The other parameter such as mileage, fleet, bus stop, number of employees, and traveling time has a positive correlation to the number of passengers although it is not significant while ritation have a negative correlation.

**Keywords:** *BRT trans jateng; data envelopment analysis; analysis association; operational.*

### 1 Introduction

Central Java Province is one of Indonesia's provinces that applied a Bus Rapid Transit (BRT) as one of their policy to provide intercity public transport. Bus Rapid Transit (BRT) of Central Java Province which is known as BRT Trans Jateng applied BRT Agglomeration which connected one region to other regions at affordable rates. Bus Rapid Transit is one alternate choice of public transport which promising, sustainable and could provide good accessibility and affordable rates from one region to another region compared to rail-based transit such as light rapid transit (LRT) and commuter train (United States Government Accountability by Nelson, etc, in [13]). Bus Rapid Transit (BRT) plays a role in a development region, especially for the road that is passed and also gives an

agglomeration effect for the surrounding area and could promote a city reconciliation of design, increasing the value of land and environmental improvement by Cui, etc, in [6]. Hossain in [12] also said that BRT is a choice for public transport which have the potential to be applied in developing cities that have limited funds.

In 2017, Balai Transportation of Central Jawa towards UPT from the Department of Transportation announced an official BRT Trans Jateng Corridor I with a route from Tawang Station (Semarang) to Terminal Bawen (Bawen) with the expectation it could help the public, especially student and labor to get access to public transport which safe, comfortable and affordable. The existence of BRT Trans Jateng corridor I Semarang Area gets 98% interest and supportive response for the development of public transport based on BRT (Priyatno (2018)). The Society's response who support and interest in the development of BRT indicated that the application of BRT Trans Jateng Especially corridor I Semarang Area quite successful. That public response also gets some evidence from the load factor of BRT Trans Jateng Corridor I Tawang Station-Terminal Bawen which reach 97% in 2019. That two conditions are an indication that the application of BRT Trans Jateng has been a success and got a positive response, especially from the public in Central Java Province. Based on that, this research does an analysis of the operational application of BRT Trans Jateng to analyze a factor that could support an application of BRT Trans Jateng.

## **2 Literature Review**

### **2.1 Efficiency and Effectiveness**

The definition of efficiency and effectivity based on Potocan in [15] was based on previous research and it differs in two groups. A first group is a group that uses an approach and a meaning to separate efficiency and effectivity. The separation is based on a difference in criteria among them such as an approach to investigating an aspect and the scope of the study. Based on this group, efficiency is a concept of organization which is focusing on the internal organization. Further, efficiency is a relation of quantity from the input used (need) to get an output. Meanwhile, the effectivity is a comprehensive study about an operational organization that is based on an understanding of the definition and goals of an organization and also a strategy of the organization in the operational process. Effectivity is an action of a process to achieve goals in the research area. For these cases, the research focuses on the operational (habit) of an organization (in whole or a part) in a way to achieve a goal or hope from the organization by Potocan in [15].

For the second group, Potocan in [15] said that efficiency and effectivity are understood as synergic research in the whole or part of the organization. Efficiency and effectiveness are analysed as a process of investigation of an organization which differs by an aspect that being research. Efficiency and effectivity joined in content with connected based on synergy and the dependency from an operational and behavior of the organization. The fundamental things that are based on this theory are efficiency and effectivity is a unity method that is being used in the research.

Farel in [8] in his research about “The Measurement of Productive Efficiency” also mentions about efficiency on the part of a firm is a successful process to produce a maximal product with a given input. Efficiency is the process to produce a product in constant return to scale conditions. Further, Farel in [8] explains that to calculate an efficiency we need to define the assumption that would be used to determine the production function of efficiency. In other words, there is a comparison between the performance of a firm toward an ideal standard from an efficiency which is considered the best one. Depending on that, the process to define a production function of efficiency need to be done before calculating a significance of the measuring an efficiency.

A Discussion of efficiency in public transport according to Daraio, etc., [7] is more focused on the result of efficiencies such as a direct impact of the implementation of public transport (the increasing efficiency and quality that is offered by public transport) and external impact such the decreasing of pollutant and congestion also increase the need of a worker in the city center. Further, Daraio, etc., [7] declare that efficiency analysis in the implementation of public transport not only focuses on the number of the passenger but also on the impact on intervention from the transportation system which influences an environmental footprints, land cover use, accessibility, and also the objective of the region. This analysis would be a deliberation for implementing a new policy as an impact from efficiency analysis which occurs such as developing new infrastructure.

## **2.2 Data Envelopment Analysis**

Data Envelopment Analysis is a mathematical approach that is being used to evaluate performance from a group of an entity known as Decision Making Unit (DMUs) by converting a multiple-input to be a multiple outputs Cooper, etc, in [5]. Data Envelopment Analysis is introduced by Charnes, Cooper, and Rhodes in 1978 as a mathematical model which provides new ways to estimate an empiric relation from a production function that is part of the modern economy. The analysis process to determine an efficiency from DMU using a Data Envelopment Analysis does not need any assumption for formulation and variation for a model

such as being needed in linear regression or nonlinear regression. It would be helpful to analyze the process without depending on any formulation. An Efficiency result from every analysis in Data Envelopment Analysis is an Efficiency which based on two things i.e (a) a DMU defined as maximally efficient (100 %) if only there is no input or output which could be added without decrease or increase in input and/or output, (b) a DMU defined as maximally efficient (100%) if only performance from another DMU didn't show any increasing value without any decreasing an input or output (Cooper, etc., in [5].

Georgios, etc., in [10] used Data Envelopment Analysis (DEA) to evaluate the performance of a route bus in the public transport system in Thessaloniki. In that research, DEA used to provide tools used to find the most efficient route and the not efficient one and also a relation in the condition that the goals of performance do not meet the standard value which needs some improvement. Further, Georgios, etc., in [10] discuss an initial definition of relative efficiency from DMUs which is determined from a basic calculation of Data Envelopment Analysis which forms an equation for a linear combination that connected a group number of observations from a group of a sample. An explanation for relative efficiency, Georgios, etc., in [10] give a sample if we have  $j = 1, 2, \dots, n$  which DMUs with  $m$  input ( $X1j, X2j, \dots, Xmj$ ) and  $s$  output ( $Y1j, Y2j, \dots, Xsj$ ) then the value of efficiency from each DMUK ( $K$  is a value from  $1, 2, \dots, n$ ) could be calculated with this equation.

$$Max\theta = \frac{\sum_{r=1}^s U_r Y_{rk}}{\sum_{i=1}^m v_i Y_{ik}} = 1 \quad (1)$$

$$subject\ to\ \frac{\sum_{r=1}^s U_r Y_{rk}}{\sum_{i=1}^m v_i Y_{ik}} \leq 1 (j=1, \dots, n) \quad (2)$$

$$u_1, u_2, \dots, u_s \geq 0 \quad (3)$$

$$v_1, v_2, \dots, v_m \geq 0 \quad (4)$$

Based on the equation above, DMU which has a maximal efficiency is a DMU with  $\theta$  value is near 1.

Another Research is done by Hirschhausen in [11] using an approach CRS and VRS from Data Envelopment Analysis to analyze the efficiency of public transport in Germany. In that research, the analysis done with input is a vehicle and worker while the output is a passenger/km. At the end of that research, there is a further analysis that uses a bootstrapping mechanism as a process to test the result of the Data Envelopment Analysis.

Data Envelopment Analysis is also being used by Pina in [14] for research in comparing the efficiency of the public and private sectors to provide public transport in Spain. In his research, Pina in [14] uses Data Envelopment Analysis which collaborates with logit regression and cluster analysis. Logit regression and cluster analysis are used to could give a justification for the compatibility of a result, data, and process. Depending on the research done by Pina in [14], know that km/vehicle, price/pesangger, and fuel/100km are a parameter that influence Efficiency.

In this research, the model which is used to be a reference for analysis is the model Data Envelopment Analysis from Fitzova, etc., in [9] in her research about “Determinants of urban public transport efficiency: a case study of Czech Republic” which use a Data Envelopment Analysis for identified a factor which influences an efficiency from a public transport system in Republic Czech. The method used for analysis in Fitzova, etc., in [9] research is a Data Envelopment Analysis and Tobit Regression. Data Envelopment Analysis in the early step is used to identify an efficiency value from DMU while Tobit Regression is used to find a relation between an efficiency value and every parameter. There is 4 step that is done in Fitzova, etc., in [9] research which is (a) determine a DMU, determine an input and output variable, (c) determine a model and calculate a DEA Score, and (d) descriptive analysis for the result of efficiency.

### **3. Method**

The analysis method that is being used in this research is Data Envelopment Analysis and Association Analysis. In the first stage of analysis, there is Data Envelopment Analysis to find an efficiency value from each DMU. In the second stage, there is Association Analysis to find a relation between a variable independent and variable dependent in each DMU. Detailed discussion about Data Envelopment Analysis and Association Analysis is contained in the following discussion.

#### **3.1 Data Envelopment Analysis Method**

In Data Envelopment Analysis, there is a process of comparing every Decision-Making Unit (DMU) to a determined benchmark by Santos [17]. Data Envelopment Analysis has 2 (two) kinds of approaches to analyze the DMU to reach maximal efficiency. The two kinds of approaches are to increase the output until reaches MO (maximization of output) and decrease the input until reaches MI (minimization of input) which is known as variable return to scale (VRS) and constant return to scale (CRS). Data Envelopment Analysis is an analysis model which is used to find a parameter that directly affects the efficiency from implementing BRT Trans Jateng.

Data Envelopment Analysis was introduced by Charnes in [3] in their research about “Measuring the efficiency of decision-making units”. The goal of the research by Charnes in [3] is to develop a method that can be used to measure efficiency from every choice based on the special reference which can be used to evaluate a “public program”. Further, the “public program” in the research which done based on decision-making units (DMUs) which have input and output values known by Charnes in [3] as Data Envelopment Analysis (DNA) Constanta return to scale (CRS). Efficiency in Data Envelopment Analysis is a total value of output / total value of the input. The mathematical equation form of the CRS Data Envelopment Analysis Model which was developot by Charnes in [3] with input-oriented is,

$$\min \theta - \varepsilon (\sum_{i=1}^m S_i^- + \sum_{r=1}^s S_r^+) \quad (5)$$

$$\sum_{j=1}^n X_j \lambda_j + S_i^- = \theta X_{i0} \quad (6)$$

$$\sum_{j=1}^n Y_j \lambda_j - S_r^+ = Y_{r0} \quad (7)$$

With value  $\lambda_j \geq 0$ ,  $S^- \geq 0$ ,  $S^+ \geq 0$ ;  $\theta \geq 0$ ,  $\varepsilon \geq 0$ ;  $i = 1, 2, \dots, m$ ;  $r = 1, 2, \dots, s$ ;  $j = 1, 2, \dots, n$ . When  $\theta$  is efficiency,  $S^-$  is a slack variable based on input;  $S^+$  is a residual variable based on output;  $\lambda_j$  is a coefficient index from input and output. While equation form of the CRS Data Envelopment Analysis Model with output-oriented is,

$$\max \phi + \varepsilon (\sum_{i=1}^m S_i^- + \sum_{r=1}^s S_r^+) \quad (8)$$

$$\sum_{j=1}^n X_j \lambda_j + S_i^- = X_{i0} \quad (9)$$

$$\sum_{j=1}^n Y_j \lambda_j - S_r^+ = \phi Y_{r0} \quad (10)$$

With value  $\lambda_j \geq 0$ ,  $S^- \geq 0$ ,  $S^+ \geq 0$ ;  $\theta \geq 0$ ,  $\varepsilon \geq 0$ ;  $i = 1, 2, \dots, m$ ;  $r = 1, 2, \dots, s$ ;  $j = 1, 2, \dots, n$ . When  $\theta$  is efficiency,  $S^-$  is a slack variable based on input;  $S^+$  is a residual variable based on output;  $\lambda_j$  is an coefficient index from input and output.

In 1984, Banker, Charnes, & Cooper do further research about a modification from the method of DEA CCR. In that research, Banker, etc., in [2] use a segregation variable that could be identified as an operational process that could produce an increase, keep or decrease in multiple input and multiple output situations. The result from the calculation is not only a single output, but also a modern version of economics. Further, Banker, etc., in [2] provides a model to estimate technically and scale efficiency from decision-making units (DMUs) based on reference from an efficiency value of production frontier. The

fundamental difference between DEA CCR model and DEA BCC model is a constraint in BBC model which always get a 1 value or in mathematically  $\sum Y_j \lambda_j = 1$ .

The Data Envelopment Analysis model which would be used in this research to analyze the efficiency of BRT Trans Jateng is DEA model developed by Charnes, Cooper, and Rhodes (CCR) with constant return to scale. This model was used by Fitzova etc, in their research in 2018 that has been discussed in theory.

### **3.2 Association Analysis Method**

Association Analysis which would be used in this research is an association analysis with multiple linear regression techniques. This technique is being used to compose a relation equation of a variable using interval data or ratio data which have more than one predictor (variable independent) by Angelia in [1]. The process of association analysis in this research with multiple linear regression technique was using Predictive Analytics Software (PASW) from IBM SPSS.

## **4. Discussion**

### **4.1 Result of Data Envelopment Analysis**

The Data Envelopment Analysis process in this research is done by comparing the performance of existing operators (bus consortium companies) from the various route in BRT Trans Jateng. That various route in BRT Trans Jateng is a Data Measurement Units (DMUs) of the research. In this stage, applied an assumption was used to find an implementation of BRT Trans Jateng which was based on the influence of external factors such as a Covid 19 and a year of implementation BRT Trans Jateng.

In the first process of Data Envelopment Analysis of implementation of BRT Trans Jateng, a few assumption and limitation is being used. This assumption and limitation were caused by a limitation in data from Central Java Transportation Service. Based on that, the assumption and limitation that are being used in this analysis is,

- a) Parameter which being tested in this research is a result of the parameter from a deduction process from previous research. Further, the parameter is being conducted by an adjustment with data from Central Java Transportation Service.
- b) Data measurement unit (DMUs) being used in this process is a route of BRT Trans Jateng. Each route of BRT Trans Jateng has a different

operator which is customized based on a consortium of existing operators.

- c) There is a variation in the process analysis, in the first variation, there's an assumption that covid 19 does not affect the number of total passengers who use BRT Trans Jateng. Depending on that assumption, the analysis process is done with current year data.
- d) In the second variation, there is an assumption that covid 19 affects the number of total passengers who use BRT Trans Jateng. Depending on that assumption, the analysis process is divided into two cases which use data from DMUs before Covid 19 and also data from DMUs after Covid 19.
- e) In the third variation, there is an assumption that the year of implementation of BRT Trans Jateng affects the number of total passengers. Depending on that assumption, the analysis process is divided into two cases which use data from DMUs in the first year of implementation and data from DMUs in the second year of implementation.
- f) The whole process of Data Envelopment Analysis in this research uses a method of DEA CRS (Constanta return to scale) model developed by Charnes, Cooper, and Rhodes (1978).

variable output for the parameter used in this research. The parameter of a variable input is bus stop, mileage, ritation, traveling time, number of employees, vehicle operating process, and population. While the parameter of variable output is load factor and number of passengers. A detail of the parameter used in this research could be found in the attachment.

In the first variation, the analysis process uses an assumption that covid 19 does not affect the number of total passengers who uses BRT Trans Jateng. Depending on that assumption, the value of a parameter in the analysis process that is used is a value from the current year which is 2020 for 5 (five) existing routes BRT Trans Jateng. That 5 existing router of BRT Trans Jateng is route of Semarang-Bawen, route of Purwokerto-Purbalingga, route of Semarang-Kendal, route of Purworejo-Magelang, and route of Surakarta-Sragen. The result of the analysis process from the first assumption shows that route of Surakarta-Sragen has an efficiency value that is lower than 4 other routes with a value of efficiency is 53,28 %. That lower value of efficiency from route Surakarta-Sragen could be because that route was recently operated in 2020 when Covid 10 occurs. But in this analysis process couldn't be concluded if the covid 19 affect the implementation of BRT Trans Jateng or not.

In the second variation, the analysis process uses an assumption that covid 19 affects the number of total passengers who use BRT Trans Jateng. Depending on that assumption, the data that is used in this analysis process is data from a route that has been operated before covid 19 occurs such as Semarang-Bawen route and Purwokerto-Purbalingga route. DMUs for this analysis process are Semarang-Bawen route Pracovid-19, Purwokerto-Purbalingga route Pracovid-19, Semarang-Bawen route Postcovid-19, and Semarang Bawen route Postcovid-19. The result of the analysis process shows that the route from Postcovid-19 has a lower efficiency than a route from Precovid-19. Depending on that, could be concluded that Covid 19 affects the implementation of BRT Trans Jateng. The decrease in efficiency of BRT Trans Jateng route which occurs in Semarang-Bawen route is 51,12% which is a decrease from 100% to 49.88%. While the decrease of efficiency of BRT Trans Jateng which occurs in Purworejo-Purbalingga route is 46.78% which is a decrease from 100% to 53.22%.

In third variation analysis process use an assumption that the year of implementation of BRT Trans Jateng affects the number of total passengers. Depending on that assumption, the route that is used in this analysis is the route that has been operated for a minimum of two years such as Semarang-Bawen route and Purwokerto-Purbalingga route. DMUs for this analysis process are Semarang-Bawen route in the first year of implementation, Purwokerto-Purbalingga route in the first year of implementation, Semarang-Bawen route in the second year of implementation, and Purwokerto-Purbalingga route in the second year of implementation. The result from the analysis shows that an efficiency value for Semarang-Bawen route for both years of implementation has the same efficiency which is 100%. This result also occurs for Purwokerto-Purbalingga route for both years of implementation that has the same efficiency which is 100%. The result of efficiency value that didn't show the difference for both years for Semarang-Bawen route and also Purwokerto-Purbalingga route indicates that the year of implementation for BRT Trans Jateng did not affect the implementation of BRT Trans Jateng.

## **4.2 Result of Associate Analysis**

The process of associate analysis in this research is used to compare the relationship between an independent variable and a dependent variable which affect the implementation of BRT Trans Jateng. The Parameter which becomes a dependent variable in this process of associate analysis is the number of total passengers. While the parameter which becomes an independent variable in this process of associate analysis is mileage, traveling time, rotation, bus stop, fleet, number of employees, and population. The initial hypothesis from this analysis

process is several passengers as a dependent variable are affected positively by mileage, traveling time, ritation, bus stop, fleet, several employees, and population as an independent variable. The result of this associate analysis is to test a relation between variable dependent toward variable independent.

The process of Variables Entered/Removed(a) shows that the chosen parameter that affected the number of passengers is a population. In the next step, there is the process to formulate an equation of variable independent (population) toward variable dependent (number of a passenger). The formulation process in this analysis depends on the B value from a table of coefficients. The equation that has been formulate by that value is,

$$Y = a + b X_1 + b X_2 + \dots + e$$

$$Y = -457253.870 + 0.491 X$$

with X being the population while Y is the number of passengers. From that equation, the population affects the number of a passenger with a positive trend. The increasing of the population would affect an increasing number of passengers i.e if there is an increasing number with 1 % amount of population, it would affect an increasing number of passenger with 0.491%.

In the final process of association analysis, there is a recalculation of parameters which not chosen in the process of variables entered/removed(a). Recalculation is a process to calculate an independent variable that has the most possibility to relate to a dependent variable. The process of determining a relationship between the parameter of the independent variable toward the dependent variable based in this research is based on t value from the table excluded variables. The result from that table is that the parameter mileage, traveling time, fleet, number of employees, and bus stop have a positive impact on the number of passengers. While a ritation have a negative impact to the number of passenger.

## 5. Conclusion

An identification process that affects the implementation of BRT Trans Jateng in this research could be divided into two parts of identification. The first one is an identification process for a parameter that comes from an external system BRT Trans Jateng. The second one is an identification process for a parameter that comes from an internal system of BRT Trans Jateng. The conclusion that could be reached from the discussion is,

- The results of Data Envelopment Analysis in this research show that Covid 19 affects the implementation of BRT Trans Jateng. This is based on the average decrease of the efficiency value of the two routes that are being tested with the average decrease is about 51.3%.
- The results of the Associate Analysis in this research show that the parameter which mostly affects the implementation of BRT Trans Jateng is the population. The effect of the population on the number of passengers is in positive relation with results that every increasing 1% in population would affect an increase in the number of passengers by 0.491%. Besides population, other parameters have a positive relationship with the number of passengers, they are mileage, traveling time, fleet, the number of employees, and bus stop. While a variation have a negative impact to the number of passengers. The positive relation shows that every an increasing of a parameter value in the independent variable would affect the number of passengers although it is not significant.

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## **Influence of Character's Visual Style on Reader's Empathy on Sad Emotional Story (Case Study: Webtoon "Bingkai Titik")**

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**Abstract.** Empathy plays an important role in story – reading experience, where it could help the reader to connect and understand the characters better. Today, storytelling could be found across media; webtoon is one of them. The increasing demand for using visual style to convey stories triggers the curiosity of, whether the variation of visual style affects empathic response in a sad emotional story. A between-participant experiment that involves 63 Indonesian webtoon/comics readers between the age of 16 – 29 was conducted. The stimuli are webtoons that have different visual styles (simplified, combination, and realistic) with the same story, background, color, and layout. The participants read the stimulus (given randomly) while being recorded in an online meeting, then fill out a questionnaire to measure the empathic and visual familiarity response. The results show that visual familiarity does predict empathy but showed that there's no significant difference in the empathic response between visual styles, although the combination style got the highest empathic response among the others. On the contrary, realistic style significantly produces higher visual familiarity. These findings confirm the hypothesis that using combination style in a sad emotional story is expected to produce a higher empathic response.

**Keywords:** *visual style; emotional story; empathy; webtoon; illustration.*

### **1 Introduction**

The decision-making process on a certain character's visual style to use in a media, plays a role in how the message or story is conveyed to the audience. Variations of visual style have different advantages and disadvantages [1]. Simplified styles tend to let the reader identifies with the character, for its lack of detail would make it easier for the reader to picture themselves as the character. This also explains the way we express ourselves in the form of smilies when texting or conversing on the internet [2] because we could fit the basic human characteristic into our own (two dots as eyes, and a mouth that resembles basic human characteristic). On the contrary, McCloud theorizes that a realistic style would give a clear distinction between characters and the reader. For realistic

style is more focused on the detail of the characters, how the character could be perceived as real, and how close it is to the human proportion. Between them, there is a combination style that combines the two characteristics of simplified and realistic. The combination style focuses on making the character looks believable (could exist in their own world), while also reducing the details of the characters, leaving space for the reader to identify themselves with the characters. Besides, combinations could also adopt the abstract–stylized aspect of the simplified style, so there would be a certain uniqueness that could make the style easier to distinguish from the others. Such as exaggeration of facial features (eyes, mouth, ears, etc), a certain type of line characteristic (using flowy or boxy lines), style of shading, etcetera.

McCloud's visual style theory explains that variations of style could be found across the triangle range of visual styles. Figure 1 explains that there are 3 points that make the visual style range. The bottom left corner is closer to reality such as realism portrait (there's photography, human, and reality outside the triangle), whereas the bottom right corner is closer to perceived – language (there are words, sentences, and language outside the triangle), and finally the picture plane on top of the range (abstractions). Character visual style in comics tends to use abstraction across the realism – simplified to make the illustration distinctive, such as drawing the nose with squiggly lines. That is why abstraction could be found whether it's simplified, combination, or realistic; the only difference is how much abstraction stylization it contains. These characteristics of the visual style raise the question, of whether they affect empathic response or not? Does visual familiarity affect empathic response too?

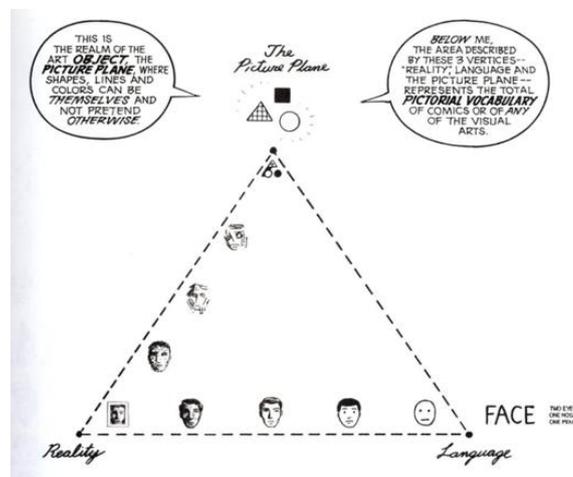


Figure 1 Scott McCloud's visual style range [1].

Empathy has been a part of human's daily lives; including our habits of consuming stories too. By definition, empathy is a series of constructions that explains how an individual responds to another person's experience [3], and that response could happen to a fictional character too. Though there are differences in empathy response to a character than it is to a human, the psychological process is similar [4]. Empathy in literature is needed for the reader so they can understand the character's perspective, reflect based on the situation the character is on, and build emotional involvement [5], [6]. That is why this research goal is to know how to utilize and optimize empathic response in story-based work using visual style.

Empathy could occur in diverse situations, whether positive or negative. But, empathy that emerges from a negative situation (problem, difficulties, etc) is argued to trigger higher involvement, fulfilled the criteria for empathy to occur, and could happen whether the reader has a similar experience or not [7]–[9]. Emotional stories could be found across genres too; it could be in drama, romance, action, or even horror. That is why this research focuses on sad emotional story as its control variable.

To get more specific, this research uses a case study of a webtoon called “Bingkai Titik”. Webtoon is a digital comic format that has the characteristic of using up to down reading direction (long horizontal layout). Webtoons are usually read using a smartphone. A company called NAVER Webtoon is one of the leading ones in the industry, where there are approximately 72 million active users monthly [10]. There are around 38.2% Indonesian respondents that show interest in this platform and is the 4<sup>th</sup> highest country in the world that tends to pay to read in the platform [11]–[13]. The platform's webtoon is dominated by combination visual style across the genres. While realistic styles tend to be found in horror and action, and simplified styles in the slice-of-life genre.

“Bingkai Titik” is a comic in drama genre by Gabriel PT Dedi, that focuses on a family-themed sad emotional story. This comic is chosen to be the main stimuli because the story fits the theory of emotional story, which has situations that trigger emotion sensitivity, expressions that signal emotions, response and reaction to a certain situation, and the reaction of how the emotions felt like [14]. The reader's response in the comment section shows how they cried while reading the story because they have a similar experience. Also, this comic has been nominated as “Story of the year” in the POPCON Awards 2018. The comic uses combination visual style, that fits the need of this research. The full first arc of the story consists of 24 episodes, but this research only uses 3 episodes (18-20) because of limited time and budget to make the other stimuli. The 3 episodes tell the summary of the story and focus on the sad emotional story about death.

## 2 Research Methodology

This research aims to understand how much visual familiarity in simplified, combination, and realistic visual style affects empathy; also, to see the differences of each variable (familiarity and empathy) across the stimuli. Based on the goal of this study, three hypotheses are formed:

1. There is linear regression between visual familiarity and empathic response. Visual familiarity is predicted to affect empathic response in webtoon emotional story using simplified, combination, and realistic visual style.
2. Combination visual style produces a higher empathic response in webtoon emotional story, compares to simplified and realistic style.
3. Realistic visual style produces higher visual familiarity response in webtoon emotional story, compares to simplified and combination style.

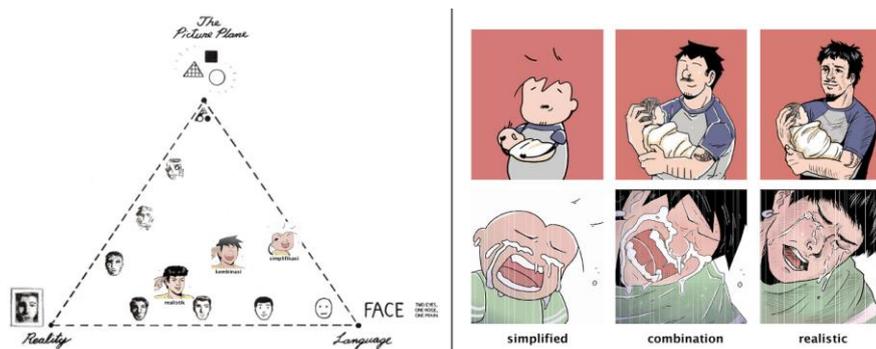
This research limits the scope of visual style to character visual style only, while keeping the background, color, layout, gesture, and other elements the same. The primary theory used for visual style is Scott McCloud's visual theory. Visual styles used as stimuli are Simplified, combination, and realistic, as representations of each range.

### 2.1 Procedure

The experiment's procedure started by asking the participant candidates to fill out a pre-measurement questionnaire, in order to map the criteria such as age, webtoon / comic reading habits, and empathy score. Participants who fit the criteria then proceed to participate in the main experiment. The main experiment was conducted with 2 choices of method, synchronous and asynchronous. A synchronous experiment involves the participant reading a given stimulus, while being recorded in an online meeting (to capture the expression), then filling out the main questionnaire anonymously to measure the empathic and visual familiarity response. The asynchronous experiment was done by giving instructions to the participants, such as the links needed to read the webtoon and fill out the questionnaire, and ensuring the environment is suitable to conduct the experiment (alone, and in a silent condition without music or noises). The stimuli are randomly assigned to each participant, except for those who previously have read "Bingkai Titik", they're given the original visual style which is combination.

## 2.2 Stimuli

Based on the original work of Bingkai Titik (combination style), stimuli are designed to fit the simplified and realistic visual style range, while maintaining the gesture, background, and layout. Each style is designed based on the other references that fit McCloud's theory on visual style. All the visual style results could be seen in Figure 2. Simplified style is focused on simplifying the details of the characters, using simple form based on geometrical shapes (circles, squares, ovals, etc), while maintaining the characteristic and uniqueness of each character using abstract stylization and expression exaggeration. The realistic style focuses on enhancing the details of the original combination style, making it closer to human proportion to make a clear distinction between the characters. The original style of the webtoon, which is combination, got the simplified human characteristics, abstract stylization, and facial exaggeration; which fits the combination style characteristic. The original work does not include eyes when drawing the face. To keep it consistent, the simplified style does not use eyes too, but the realistic does because the point of realistic style is to bring it closer to human proportion and characteristics.



**Figure 2** Stimuli comparison and range placement.

## 2.3 Participants

The participants of this experiment are webtoon readers from West Java and DKI Jakarta ( $n = 63$ ; 25 male and 37 female; age ranges from 16 – 29). The criteria of the participants are based on the majority demographic of NAVER Webtoon readers in Indonesia. Having experience or habit of reading webtoons or comics would help the participants to understand the panel reading flow. A moderate-high empathy score would help optimize the empathic response to the webtoon. Participants' average experience in reading comic/manga / webtoon is 1 – 20 years, while also having a moderate-high empathy score.

## 2.4 Variables

The variables used in this research consist of 3 independent variables and 2 dependent variables. The three independent variables are variations of visual style, which are simplified, combination, and realistic. As for the control variable, it consists of an emotional story, layout, color, gesture, visual narrative, etc.

The two dependent variables are empathy and visual familiarity. 6 dimensions formed the empathy variable, such as Fantasy (EF), Perspective Taking (EP), Empathic Concern (EE), Character Identification (EC), Narrative Situation (EN), and Emotional Contagion (EEC). As for visual familiarity, there's only one dimension that measures that variable (V).

## 2.5 Instrument & Realibility

This research uses a quantitative questionnaire as the instrument to measure empathy and visual familiarity. The instrument was designed based on several existing questionnaires and theories, such as Interpersonal Reactivity Index [15], Emotional Contagion Scale [16], Uncanny Valley Scale [17], and narrative empathy theory [9]. There is a total of 36 items on the questionnaire (25 items for the empathy variable, 11 items for the visual familiarity variable), using the 0 (strongly disagree) – 4 (strongly agree) Likert scale as the measurement.

A reliability test using Cronbach Alpha was conducted for both variables. The data used for the test was retrieved from a pilot test that consist of 30 participants in total that fits the criteria (10 participants for each stimulus). The result shows that empathy variable's Cronbach alpha is considered high across the stimuli (simplified  $\alpha = .910$ , combination  $\alpha = .955$ , and realistic  $\alpha = .833$ ). Several items could be removed to increase the reliability score, though since the overall score is considered high enough, and those items are considered important to measure the empathy score, then the items in question are only revised but not omitted from the questionnaire.

On the contrary, visual familiarity variable's alpha Cronbach value are considered low (simplified  $\alpha = .594$ , combination  $\alpha = .853$ , and realistic = .670). Upon further analysis, several items needed to be excluded to increase the alpha value across the stimuli, they're items number 26, 28, and 29 that has negative alpha scores. After removal, there's total 8 items in the visual familiarity variable, with simplified  $\alpha = .746$ , combination  $\alpha = .878$ , and realistic = .737. Other items that have relatively low alpha values are revised to increase the clarity of the statements.

**Table 1** Summary of Cronbach Alpha's reliability test

Variable	$\alpha$	Total Items	Description
Empathy (Simplified)	.910	25	Reliable
Empathy (Combination)	.955	25	Reliable
Empathy (Realistic)	.833	25	Reliable
Visual Familiarity (Simplified)	.594 (*.746)	11 (*8)	Reliable
Visual Familiarity (Combination)	.853 (*.878)	11 (*8)	Reliable
Visual Familiarity (Realistic)	.670 (*.737)	11 (*8)	Reliable

\* Score and total item after the unreliable items are omitted from the questionnaire.

### 3 Result and Discussion

#### 3.1.1 Visual Familiarity and Empathic Response Correlation Test

The data retrieved from the experiment are processed using IBM SPSS Statistics 26 to answer the hypotheses. A Pearson Correlation test and Linear Regression test was conducted to see how much visual familiarity predicted empathic response. The result on correlation test shows that there is correlation between visual familiarity and empathic response across the stimuli. Simplified style shows moderate correlation ( $r = .582$ ,  $n=21$ ,  $p < .05$ , 2 tailed), combination shows moderately high correlation ( $r = .726$ ,  $n=21$ ,  $p < .05$ , 2 tailed), and realistic shows moderate correlation ( $r = .643$ ,  $n=21$ ,  $p < .05$ , 2 tailed). After it's confirmed that there's correlation across the stimuli, then a regression analysis was conducted to see how much visual familiarity predicts empathic response. Regression analysis showed that 33.9% visual familiarity predicted empathic response in simplification style ( $R^2 = .339$ ,  $F(1,19) = 9.745$ ,  $p < 0.05$ ), while there's 52.8% in combination style ( $R^2 = .726$ ,  $F(1,19) = 21.23$ ,  $p = .000$ ), and 41.3% on realistic ( $R^2 = .413$ ,  $F(1,19) = 13.372$ ,  $p = 0.002$ ).

**Table 2** Summary of correlation and regression test.

Visual Style	R	R <sup>2</sup>	Adjusted R <sup>2</sup>	F
Simplified	.582	.339 (33.9%)	.304	9.745
Combination	.726	.528 (52.8%)	.503	21.226
Realistic	.643	.413 (41.3%)	.382	13.372
Total	.534	.285 (28.5%)	.273	24.282

### 3.1.2 Visual Familiarity and Empathic Response Correlation Result Discussion

The results indicate that there is a relatively moderate-high correlation between visual familiarity and empathy across the stimuli, thus the first hypothesis is supported. Correlation between the two variables is suspected to happen because of the cognitive aspect of empathy. The previous study found that race familiarity would affect how the brain processes empathy; when a person is used to communicate, interacting, or see with a diversity of race, they would produce a higher empathic response to other races [18]. This phenomenon is suspected to occur in visual style and empathy too, where the more reader exposed to a certain visual style, the more familiar they are, thus resulting in a higher empathy response. The result shows that familiarity with the combination style is expected to predict the highest empathic response than the other two styles; followed by realistic style, then simplified. Presumably, because combination style could be found in many media, for its characteristic allows it to use a lot of exaggeration and stylization in the design process.

### 3.1.3 Empathy and Visual Familiarity MANOVA Test

A MANOVA test was conducted to answer the second and third hypotheses. MANOVA was chosen for its advantages of avoiding type 1 error and presenting the comparison directly. The assumptions before conducting MANOVA are met, where the multivariate normality ( $p < .05$ ) and Box's equality of variance ( $p > .05$ ) are fulfilled. Also, Lavene's of equality of error variances test results both show p-value below 0.05 (empathy = .168, visual familiarity = .816). Thus, we'll be using the Bonferroni test when reading the MANOVA table. Wilk's lambda shows that there's a significant difference between the three IV groups ( $F(4,118) = 14.63, p = .000, \text{Wilk's } \lambda = .447$ ).

**Table 3** Summary of MANOVA between – subjects' effects.

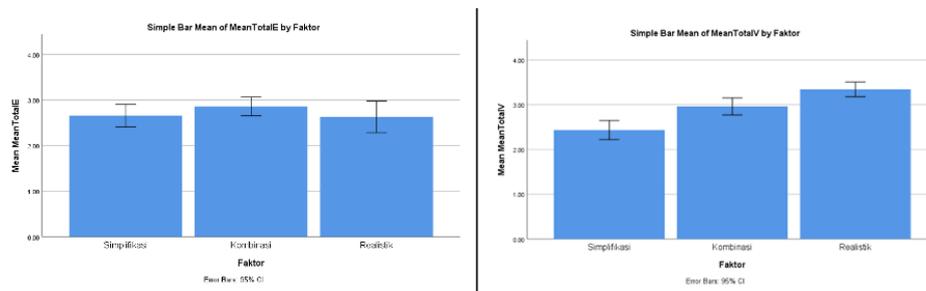
Source	Dependent Variable	df	Mean Square	F	Sig.	$\eta_p^2$
Factor	MeanTotalE	2	.328	.915	.406	.30
	MeanTotalV	2	4.377	25.123	.000	.456

The between – subjects' effects shows that there's no difference across stimuli for empathy variable  $F(2,60)=.915, p > .05, \eta_p^2 = .30$ . On the contrary, there is significant different in visual familiarity variable ( $F(2,60)=25.12, p < .05, \eta_p^2 = .456$ ). This shows that between the three stimuli, there's not too much difference in the empathy variable, and that result might show because of other variables, not the experiment. This topic will be discussed in detail later.

**Table 4** Summary of post – hoc test (Bonferroni)

DV	(I) Factor	(J) Factor	Mean Difference (I-J)	Sig.	95% Confidence Interval	
					Lower	Upper
Empathy	Simplified	Combination	-.2019	.837	-.6570	.2532
		Realistic	.0267	1.000	-.4284	.4818
Visual Familiarity	Combination	Realistic	.2286	.663	-.2265	.6837
		Simplified	-.5281*	.000	-.8454	-.2109
	Combination	Realistic	-.9091*	.000	-1.2263	-.5918
		Realistic	-.3810*	.013	-.6982	-.0637

Benferroni's post – hoc test result shows a detailed comparison between variables and stimuli. Since there are 2 variables, we use the  $\alpha$  at .025. In line with the MANOVA test, the empathy variable does not have a significant difference across variables, where the p values  $> .025$  with positive upper values on confidence interval (CI). Whereas visual familiarity's p-value  $< .025$  with negative lower and upper values indicates a significant difference across the stimuli combination.



**Figure 3** Mean difference between stimuli (empathy on the left, visual familiarity on the right)

### 3.1.4 Empathy and Visual Familiarity Result Discussion

Although the result shows that there is no significant difference in empathy, combination's mean score is higher than the other visual style. This means, the second hypothesis which says that combination produces a higher empathy response is supported, though not significantly. The causes of non – significant results presumably come from another variable that wasn't considered in the experiment. Those variables such as similar past experience, uneven story context to each participant, experience of reading story that includes metaphors,

inconsistency of using eyes across stimuli, and experience of reading silent comics.

Similar past experience are proven to affect the effort of perspective-taking, which is a part of measuring empathy [19]. From a narrative empathy perspective, having a similar emotion response or experience would result in higher empathy [9]. That is why, the dissimilarity between the participants is suspected to be one of the reasons of non – significant results in empathy variable. Besides that, some of the combination style stimuli were given to the participants that have read Bingkai Titik previously. This variable is also suspected to affect the results, because those who've read the full story (24 episodes) would get more context, and know the character better, than those who read only the stimuli, which is 3 episodes only. This assumption is supported by the participant's comments such as "it would be better if I could get to know the characters first before reading the sad part" or "I'm confused about the playing with dirt (metaphor)", where those points are told in the full 24 episodes.

Inconsistency of eyes usage across the stimuli is also assumed to be one of the reasons too. The realistic style is the only one that uses eyes on the characters. Eyes are considered to be one of the facial features that could express thoughts or emotions [20], while in painting they could also simulate the effect of gaze or looking in the mirror [21], [22]. That is why the inconsistency is suspected to result in non – significant results too. Lastly, another variable that is considered to affect the result is the experience of reading a silent comic. Silent comics are comics that do not use text to tell a story, it focuses on visual narrative to optimize the storytelling. Some participants expressed that they were surprised that they could somehow understand the story without text, while still confused at some parts of the story.

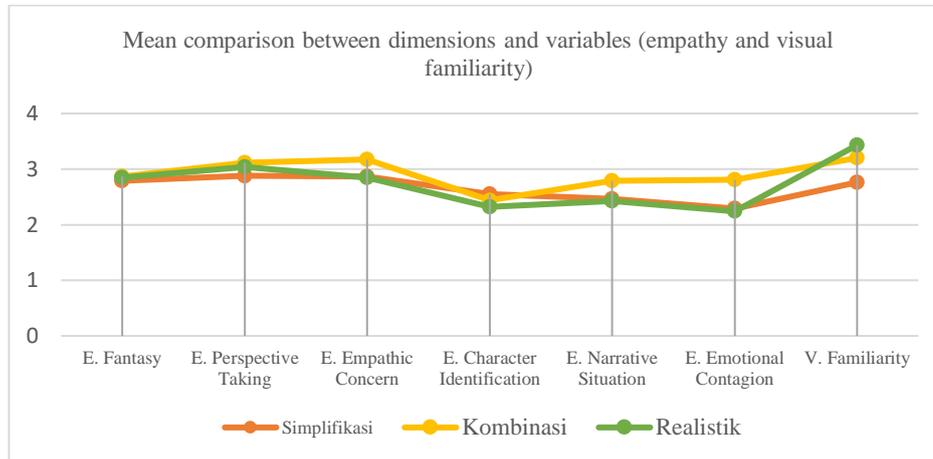
The fantasy dimension which is used to see how the reader could transport themselves to the story as the character (similar to immersive experience), shows that combination ( $r = 2.87$ ), realistic ( $r = 2.85$ ), and simplified ( $r = 2.79$ ) does not affect fantasy dimension too much since the mean score is not that different. Though combination got the highest score presumably because of its similar visual style to the background (since it's the original) and simplified facial features to make it easier for the reader to look at the character as themselves. Perspective-taking dimension shows the reader's ability to understand the character by looking from their perspective. The mean difference shows that simplified ( $r = 2.88$ ) have lower score than combination ( $r = 3.11$ ), and realistic ( $r = 3.04$ ). It is assumed that the characteristic of combination and realistic (a similar proportion to the human body) and visual familiarity affects positively to the score. As simplified style reduces a lot of detail from human proportion by using simple geometrical shapes. The empathic concern dimension shows the

reader's empathic response to the character who's going through a difficult situation. Result shows that combination ( $r = 3.17$ ) got higher mean score than simplified ( $r = 2.87$ ) and realistic ( $r = 2.85$ ). Familiarity and exaggeration of expression are assumed to influence the result. Combination style got the familiarity from a lot of exposure of style usage around the media and the similarity to human proportion, while still being able to add characteristics to the stylization and exaggerating the emotions so that readers would feel how's the character feeling. Those are the dimensions based on Davis' empathy scale (IRI). The total mean from those 3 dimensions shows that combination ( $r = 3.06$ ) got the highest score, while realistic ( $r = 2.90$ ) and simplified ( $r = 2.85$ ) are lower than combination. The results aligned with the MANOVA result where combination scores were higher in total – empathy scores.

For character identification dimension there is no significant difference between simplified ( $r = 2.49$ ), combination ( $r = 2.4$ ), and realistic ( $r = 2.22$ ). Though, simplified got the highest score is expected based on McCloud's theory, where the advantage of simplified style is being able to leave room for the readers to project themselves to the characters. The narrative situation dimension aims to measure the familiarity of the reader with the location, narration structure, behavior, etc. result shows that combination ( $r = 2.98$ ) got the highest mean score than simplified ( $r = 2.56$ ) and realistic ( $r = 2.67$ ). It is assumed that combination character style fits with the background style resulting in the combination style score highest than both styles. Familiarity with the narration type and personal experience is expected to affect the score too. Lastly, on the empathy variable, emotional contagion aims to measure how much emotions the character is feeling is being transferred to the reader. Result shows that combination ( $r = 2.80$ ) score higher than realistic ( $r = 2.24$ ) and simplified ( $r = 2.29$ ). It is suspected that exaggeration plays a role in emotional contagion. That's the reason why combination scored higher than the rest since there's a lot of exaggeration in that style. It was mentioned that participants are being recorded while reading the webtoon. The recording shows that there isn't much of a facial movement in some respondents, only subtle eyebrows movement. Though, for the more expressive person, there is verbal and huge movement in the expression while the characters are crying or when something shocking happened. This shows that emotional contagion does occur moderately based on the recording.

Visual familiarity shows a significant difference between stimuli. Realistic ( $r = 3.43$ ) score highest than the rest, followed by combination ( $r = 3.20$ ), then simplified ( $r = 2.76$ ). This result proves McCloud's point around how the closer it is to picture / realism, the easier it gets for the information to be received. On the other hand, the closer it is to language or text (simplified), the more effort is needed to perceive the information. That is why realistic visual style scores highest in familiarity since it is easier to receive the detailed image of the

character. Whereas simplified style requires the reader to perceive and fill between the gaps of simplified proportion. Since combination style includes both realistic and simplified characteristics, this also explains why it produces higher mean scores than simplified.



**Figure 4** Mean comparison between dimensions and variables (empathy and visual familiarity).

#### 4 Conclusions and Limitations

This research aims to understand human’s empathic response towards the variation of visual style in sad emotional story webtoon. It is found that there is a correlation between visual familiarity and empathic response across the stimuli. The cognitive part of empathy is one of the suspected reasons that explain the correlation between both variables since prior study shows that familiarity with a certain race would affect empathy. Combination shows the highest power in how familiarity predicted empathy than the other style. It’s suspected that the usage of combination style across media affects familiarity since combination’s abstract stylization and exaggeration characteristic makes it flexible to use.

There is no significant difference in empathy variables across stimuli. It’s suspected that other variables affect this result, such as similar past experience, uneven story context to each participant, experience of reading story that includes metaphors, inconsistency of using eyes across stimuli, and experience of reading silent comics. Even though there is no significant difference, the combination style score is higher than simplified and realistic. Using combination style in a sad emotional story is expected to increase empathy response.

Across stimuli, there is a significant difference for visual familiarity, where realistic scores are the highest, followed by combination, then simplified. This finding explains McCloud's theory even further, where realistic images would be easier to process because it's a received information. Where languages or text (the extreme point for simplified style) would require more effort to process because it's a perceived information.

Based on those findings, a combination visual style is argued to be the most suitable for sad emotional story webtoon to induce an empathic response, for its characteristic is a collaboration between the advantages of simplified and realistic. Simplified characteristics such as leaving room for the reader to identify themselves with the character/image by simplifying human proportion, expression or proportion exaggeration, also abstraction stylization. Combined with realistic characteristic that increases familiarity from its closeness to human proportion and likeness.

For further research about visual illustration and empathic response, it's recommended to look more into variables that could affect the result of the experiment, then put even more specific criteria for experiment participants. In designing the stimuli, it is recommended to use even more extreme comparison, so that the result would differ significantly.

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## **Analysis of Control Management to the Public Transport Drivers Using Global Positioning System (GPS)**

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**Abstract.** This study aims to analyze the behavior of Public transport drivers from the perspective of driving data using a vehicle tracker connected to Global Positioning System (GPS). Prior to the installation of a GPS device, it was found in the field that there were often misuse of public transport by drivers. This study used a qualitative or naturalistic approach, with purposive sampling as the technique to gather sample, the drivers of Tabalong Regency City Transportation Service, Indonesia. Observation to the drivers behavior thru GPS and in depth interview with the officers were used as data collection techniques. With the installation of this GPS application, there is a decreasing trend in the number of misconducting perpetrators of public transport in the period 2018 to 2020, namely before and after the installation of GPS control devices on the public transport units. This decrease in number proves that there is a positive effect on improved performance of public transport drivers after the installation of GPS. Analysis of public transportation management control through the use of GPS is expected to provide maximum city transportation services to meet the needs of land transportation in the city for the community by preparing quality resources, both from reliable human resources and modern technology resources.

**Keywords** *control management system; GPS; transportation.*

### **1 Introduction**

Quality is an essential aspect of public transport. In the case of regular public passenger transport by road, punctuality and regularity are criteria used to assess quality of service by Padron *et al.* in [1]. Since transportation is a complex system, there are many factors involved in transportation activities, there are (1) passenger factors, (2) driver factors, (3) economic factors, (4) safety factors, and (5) environmental factors by Gui and Wu in [2]. Grengs *et al.* in [3] stated that conventional travel surveys have several serious limitations for travel behavior research. First, the self-reporting of data is known to be unreliable. People typically underreport short trips, and underestimate trip durations and misrepresent the time that a trip starts and ends. Trip destination locations are reported inconsistently, such as listing the nearest main intersection when a street

address is unknown. A second disadvantage is that self-reported surveys are collected over very short time periods, typically over two days. Third, these self-reported surveys fail to capture important spatial information about trips because they collect data on individual trips by aggregating them to traffic analysis zones (TAZs) for analysis and modeling. Furthermore, this method of limiting data collection to trip end locations leaves no information about travel behavior between origin and destination, so that the actual route traveled between TAZs is unknown. Transportation planners must resort to such methods as route choice modeling or shortest path networks to ascertain the route between TAZs.

GPS-based data are becoming a cornerstone for real-time transportation applications by Zhao *et al.* in [4]. Data collecting through GPS tracking is considered to overcome the shortcomings of conventional travel surveys. Because GPS data do not rely on the memory, estimations, and diligence of a person's self-reporting, they also provide precise locations and times. Two main types of GPS receivers used in urban transport vehicles measurements can be distinguished; (1) stationary receivers, built-in vehicle receivers, working without the need for an observer to interfere, being a part of vehicle equipment – useful for current, permanent registration of urban public transport system, particularly for schedule optimization; and (2) manual receivers, manned by measurers who additionally take measurements of vehicle occupancy; particularly important in corridor research and for individual lines, mostly useful in case of searching the reasons of disturbances on the public transport lines or corridors by Bauer in [5].

Tanjung is the capital of Tabalong Regency, South Kalimantan, Indonesia, which has a high traffic and community, which resulted in dense vehicle traffic. This condition is also coupled with the existence of bus transportation facilities for coal company employees which operates daily, so the implementation of Public transport, which are currently managed by the Tabalong Regency Transportation Service, can help reduce traffic density in Tabalong Regency. This is in line with Primatama's research in [6] that public transport should be integrated into one authority board to minimize conflict and creating an effective and efficient network of transport. Changes in transportation modes and their arrangements must be supported by public transportation conditions that can match the comfort of private vehicles by Minea & Dumitescu in [7].

Structuring the transportation system and urban transportation services is an integrated manner and an inseparable unit. Optimal service is the key in everything. Good service and driver's attitude are outputs that are an important part of this service, with expectations to provide transportation services based on the demand. Demand management is another way to better serve customers. Traditionally, travel demand management (TDM) has focused on road congestion; however, with more public transport agencies facing crowding problems, there is an increasing need to develop more structured conceptual and

methodological approaches for public transport TDM by Halvorsen *et al.* in [8]. However, before good service is realized as the output, resources that have a competitive advantage are needed to develop and implement a Management Control System from the Tabalong Regency Transportation Service to regulate performance, so that it is more optimal than the drivers whose main task is as the driver of this City Transport Car.

In order to actualize this output, the Tabalong Regency Transportation Service has equipped a software device in the form of a Vehicle Tracker tool that is connected to the Global Positioning System (GPS) as part of the existing resources in the Management Control System to supervise the performance of drivers. A mobile app that provides information on public transport in a city could be extremely useful too for people who live in that city and for those who live outside the city by Lupasc [9].

The Indonesian government, through the Ministry of Transportation since 2019 has required public transportation of people with motorized vehicles to install an electronic vehicle movement monitoring device or Global Positioning System (GPS). Technical instructions regarding the obligation to install GPS have been regulated in the Regulation of the Director General of Land Transportation Number: KP.2081/2019, containing some information in the GPS such as real-time vehicle monitoring via google map, speed information (odo meter) address location, and google view street, information on the origin and destination of the vehicle, the route of each vehicle, the duration of the trip for each vehicle, able to provide speed limit warnings, data asset management and drivers, record travel data for at least 7 working days and so on by Yuniartha & Laoli in [10]. The enforcement of this regulation is given for one year, after which, public motorized vehicles that do not have GPS will be penalized or their licenses will not be extended. The policy of installing electronic vehicle monitoring devices is aimed at making supervision of public transportation easier to carry out.

The efficiency of a transport system depends on several elements, such as available technology, governmental policies, the planning process, and control strategies by Ibarra-Rojas *et al.* [11]. Indeed, the interaction between these elements is quite complex, leading to intractable decision making problems. Suadi in [12] argues that Control Management are efforts to ensure that company resources are used effectively and efficiently to achieve company goals. Control Management System is a system consisting of several related subsidiary systems, namely: programming, budgeting, accounting, reporting and accountability to help management influence other people in a company to achieve company goals through certain strategies effectively and efficiently. The same thing is also expressed by Anthony in [13], in which he stated that Control Management System is a process to ensure that resources are obtained and used efficiently and

effectively to achieve organizational goals. On the other hand, the current perspectives of Control Management System attempt to address the behavioral issues within and outside organizational operations by Hared *et al.* in [14].

In its relevance to this study, it is concluded that the Control Management System is a system (activities, actions, programs, regulations, SOPs) that is carried out to use the available resources (GPS and City Transport Cars) to regulate other resources (Car Drivers and City Transportation) so that the company's goals (optimal driver performance for City Transportation Car services) can be achieved. Vehicle movement trajectory recorded by GPS maps the vehicle's lane position in time sequence, therefore theoretically can be used to assess driving behavior by Sun *et al.* in [15]. Although stable in the short term, individual travel behavior generally tends to change over the long term by Lou & Cheng in [16]. To provide sufficient parameters for driving behavior assessments, Sun *et al.* in [17] depicts the requirement of GPS data for each category, there are Lane Maintenance, Traffic Sign Compliance, Speed Regulation, Driving Maneuvers, Navigation and Wayfinding. For example, when turning, it is important to make the turn as accurate as possible, wide turns or cutting a turn too sharply are considered to be inappropriate behaviors. Thus, an accurate vehicle trajectory with precise curvature is required in order to evaluate the quality of turning behavior. GPS derived vehicle movement trajectory provides possibilities to quantitatively assess such on-road driving behavior.

One of the resources available at the Tabalong Regency Transportation Service are Drivers. Currently, the number of drivers who work as city transport car drivers are 38 people. However, prior to the installation of a GPS device, it was found in the field that there was often misuse of public transport by drivers. Whereas in the Standards of Ethics and Work Procedure (SETK) there are several regulations that emphasize warnings and prohibitions that must be obeyed by City Transport Car Drivers, including regulations regarding maximum speed, parking duration and the suitability of the route traversed. And all these regulations can be supported by monitoring the GPS-based Vehicle Tracker.

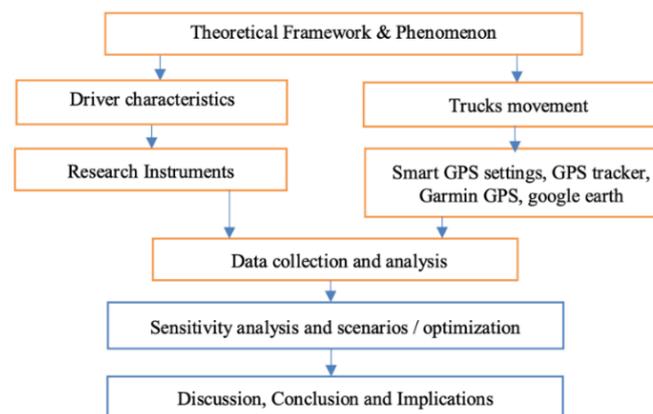
Problems arise when the waiting period was felt too long for the passengers. It could be the result of cars passing through the wrong route lane, or the possibility that the car is parked and stuck in one place for too long. In fact, the quality of public transportation services is judged by the short waiting time for passengers by Liu *et al.* in [18]. Thus, the Tabalong Regency Transportation Service considers this as a problem, and if left it will have an impact on the performance and productivity of the City Transport Car service itself.

These misconducts are the root of the problem which leads to the low performance of the City Transport Car Driver. The misconducts are visible

through the lengthy duration of driving (20 minutes), route breach and exceed maximum speed limit (over 60 km/hour). The Supervisory Officers were not able to monitor all of the city transportation car's activities due to the unavailable system that records the misuse of the city transportation car. Therefore, the Tabalong Regency Transportation Service installed a GPS-based vehicle tracker, which is also another resource added as a tool in the Management Control System to regulate the performance of drivers for the use of the City Transport Car. However, in general, the literature review shows that only very few examples can be found of using real-time information about drivers and passengers in disturbance management, which indicates that this application area is underutilized by Jevinger & Persson in [19]. For this reason, this paper describes the use of GPS for public transportation in the city of Tanjung by paying attention to the behavior of the drivers.

## 2 Methodology

Yuniar *et al.* in [20] stated in her study that a GPS-based vehicle tracker tool installed on a truck car unit aims to avoid truck loss and travel time waste to achieve a reduced fuel waste. GPS installation on trucks also assist operators and field supervisors to track trucks, provide warnings to drivers, monitor truck locations, provide information, and mark the speed of each truck. Field supervisors can immediately warn drivers who made an extended stop and helps them to point out the exact location where damages occur to trucks in order to deal with it efficiently. This study uses the same theoretical framework in analyzing public transport driver's behavior, as shown in the Figure 1.



**Figure 1** Theoretical Framework in Analysing Truck Driver's Behaviour (Yuniar *et al.* 2020).

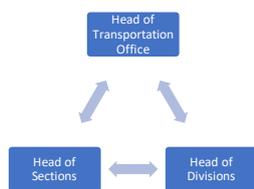
This study used a qualitative or naturalistic approach. A qualitative approach is defined as a research approach in describing phenomena based on the viewpoints of informants, finding various realities and developing a holistic understanding of a phenomenon in a particular context by Hilal and Alabri in [21]. In line with this opinion, Almalki in [22] calls the qualitative method a method that is usually used in describing inductively, with assumptions based on the construction of social reality, variables that are difficult to measure, complex and interrelated, and the data collected contains the angle in-depth interview of the informant.

Research subjects are determined through purposive sampling technique. In accordance with the objectives of this study, research subject are focused on informants as source persons who work at the Tabalong Regency Transportation Service as shown in the following Table 1.

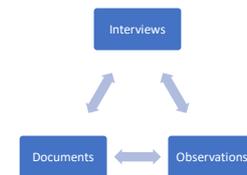
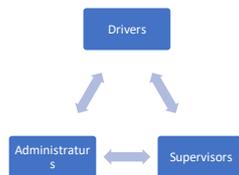
**Table 1** Table 1: Resource persons at the Tabalong Regency Transportation Service.

No	Source Persons	Number of Source Persons
1.	Head of Department	1 person
2.	Head of Transportation and Multimoda	1 person
3.	Section Head of Insider Transport Route	1 person
4.	Driver	11 persons (out of 38 persons)
5.	Supervisor	4 persons (out of 10 persons)
6.	Admin	2 persons (out of 4 persons)

Data collection technique in this study was done through triangulation (combined) technique, in which the data analysis was inductive, and the results of qualitative research emphasized meaning rather than generalization. As shown in the Figure 2 and 3.



**Figure 2** Data Source Triangulation



**Figure 3** Triangulation of Data Collection Techniques

### **3 Results and Discussion**

#### **3.1 The Management Control System in the Transportation and Multimode Sector of the Tabalong Regency Transportation Service**

The Tabalong Regency Transportation Service is a government agency under the Tabalong Regency Government, South Kalimantan Province. In accordance with the main tasks of its function, the Tabalong Regency Transportation Service is responsible for regulating public transportation in its area. In the Transportation and Multimode Sector, the Tabalong Regency Transportation Service, which directly supervises the Insider Transportation Section of the Route and the SOTK (Organizational Structure and Work Procedures) under it, of course has a separate management control system that regulates the operations of transporting people on the route, in this case the car.

City Transportation, where there are a number of human resources in it who are directly involved in this research such as Drivers, Supervisors and Admin staff, as well as technological resources which support the competitive advantage of the Tabalong Regency Transportation Service, namely the Vehicle Tracker tool that is connected to the Global Positioning System (GPS). GPS which is applied to twenty-five units of City Transport Car facilities as part of the existing resources in the management control system to monitor the performance of the driver for the use of the city transportation car so that services can be created. It is good for the community who use the City Transportation Car facility in Tabalong. As stated by Lupasc in [23] that a mobile app that provides information on public transport in a city could be extremely useful for people who live in that city and for those who live outside the city

The Head of the Tabalong Regency Transportation Service explained in the interview that to produce good driver performance, a management control system arrangement that specifically regulates the operation of City Transportation Car facilities is needed. From the legal aspect, starting from the recruitment process for human resources, which is regulated in the Tabalong Regent Regulation (*Perbup*) No. 25 of 2014 concerning Guidelines for Procurement of Contract Labor at the Tabalong Regency Transportation Service, and is stipulated by a decree from the Head of the Tabalong Regency Transportation Service every year. As for the operation of the City Transport Car itself, it is regulated in the Tabalong Regulation No. 24 of 2014 concerning the City Transport Route Network in Tabalong Regency, and Tabalong District Regulation No. 23 of 2014 concerning Minimum Service Standards for City Transportation in Tabalong Regency. By putting the arrangements of City Transport Cars to the Tabalong Regency Transportation Service is in line with Primatama's research in [24] that

stated, "Public transport should be integrated into one authority board to minimize conflict and creating an effective and efficient network of transport".

The same thing was also stated and added by the Head of the Transportation and Multimoda Division of the Tabalong Regency Transportation Service that to emphasize the implementation of human resource operational activities within the SOTK (Organizational Structure and Work Procedures) in their respective fields, a Standard Operating Procedure (SOP) was drawn up which was approved by the Ministry of Education and Culture. The Head of the Tabalong Regency Transportation Service in the SOP Endorsement Sheet for the Implementation of City Transportation in Tabalong Regency No. B.590/2014 which consists of SOPs: City/Route Transportation; Maintenance, Monitoring and Repair of City Transportation Fleet; Handling of Crime and Emergencies in City Transportation; Handling of Crime and Emergency Situations in the Office Environment; Payment of Honorarium/Salary of Contract Workers; Receipt and Deposit; and Disciplinary Sentences.

In a separate interview, the Head of the Insider Transportation Section added that to be able to regulate the work procedures of human resources in the SOTK ranks below it, a Standard of Ethics and Work Procedure (SETK) was prepared which was also ratified by the Head of the Tabalong Regency Transportation Service in the Sheet. Ratification of the Special Contract Labor SETK for the Implementation of City Transportation No. B.591/2014 consisting of SETK: City Transport Drivers; City Transportation Supervisor; City Transport Technician; Security officer; and Administrative/Finance Officer; and a Transportation Evaluation and Development Team was also formed.

From the several regulations disclosed above, it shows the seriousness of the local government of Tabalong Regency in implementing a control management system to regulate the smooth operation of public transportation in this area. All aspects have been regulated, particularly related to human resource management, in addition to travel route arrangements, passenger safety and comfort, and vehicle maintenance. This comprehensive arrangement that has been implemented is in line with the control management practice framework starting from cultural control, administrative control, and process control by Giraud *et al.* in [25]. Cultural control is the explicit set of organizational definitions that senior managers communicate formally and reinforce systematically to provide basic values, purposes and direction for the organization. These cultural control elements are considered the key factors that shape the design and implementation of an organization operation generally, given in three activity levels; employees' selection and recruitment, socialization process and the alignment of employees' behavior to the organization's objectives. Administrative control tasks refer to the organizational structure and governance system. Whereas process control is

an integrated group of activities that are employed to accomplish specific organizational goals, such as physical, people and material elements.

The existence of these regulations makes a strong legal basis in the supervision and control of public transportation operations. This is also a sign in determining the behavior of drivers and supervisors. This is in line with the thought of Anthony in [26], in which he stated that Control Management System is a process to ensure that resources are obtained and used efficiently and effectively to achieve organizational goals. On the other hand, the current perspectives of Control Management System attempt to address the behavioral issues within and outside organizational operations by Hared *et al.* in [27].

### **3.2 The Effect of Management Control on the Performance of City Transport Car Drivers**

The current perspectives of Control Management System attempt to address the behavioral issues within and outside organizational operations by Hared *et al.* in [28]. In the City Transport Driver work procedure (SETK) No. SETK.PAK.001/2014 can be taken several points that are related to management control of driver performance, it regulates as follows; First, the city transport driver duties including transporting passengers according to the provisions that have been set, also pick up and drop off passengers at places on the route that has been determined. Secondly, the city transport driver functions are driving the city transport fleet properly and correctly, also protects and gives a secured feeling to the passengers. Third, the attitudes and behavior of city transport drivers must show discipline, polite, friendly, honest, fair, and wise. They must comply with state regulations and respect applicable norms in the work environment/area. Fourth, the city transport driver administrative work procedure must comply the arriving time at the workplace at least 15 (fifteen) minutes before the set working hours, as well as carry out internal coordination in harmony. Fifth, the city transport driver functional work procedure must serve the track according to the route permit given, also raise and lower passengers at predetermined places with a maximum time of 60 (sixty) seconds. And sixth there are Warnings and Don'ts procedures to the drivers that prohibit them to (i) carrying and consuming narcotics and liquor, carrying firearms and sharp weapons or other dangerous objects, (ii) conduct sexual harassment/violence, personal harassment, race, ethnicity, and religion, (iii) committing criminal acts in the form of extortion, fraud, gambling, and other evil acts that cause harm to oneself, others, and the environment, (iv) exceeding the highest speed limit for public transport, (v) exit from the route and lane that has been determined, and (vi) terminating the vehicle for reasons that cannot be justified. The contents of this regulation are in line with the context of research conducted by Sun *et al.* in [29], which includes categories of lane maintenance, traffic sign compliance, speed regulation, driving

maneuvers, as well as navigation and wayfinding. Each category is governed by three things, that is driving events, driving behaviors assessment variables, and GPS derived vehicle trajectory.

The SETK Driver above is supported by the work procedure (SETK) of City Transportation Supervisor/Timer No. SETK.PAK.002/2014 which also has several points related to management control of driver performance, that related to city transport supervisor/timer duties, they are recording the arrival time of city transportation at the control post according to the schedule, also recording the number of passengers. Related to the city transport supervisor/timer function, they must ensure that city transportation vehicles pass on the route specified according to the schedule and record the time and number of passengers. The Administrative Procedure regulates them to carry out internal coordination in harmony, and reporting incidents/events that occur while carrying out tasks. As an addition, the Functional Work Procedure regulate them to stand by at the designated transport trajectory control post, record the arrival time of transportation at the designated control post in the same route, and recapitulate records of time and number of passengers. Regulations regarding supervision of driver behavior are part of the administrative and process control proposed by Hared *et al.* in [30]. Administrative control tasks refer to the organizational structure and governance system. It is the control tasks that involve the administrative matters such as the design of organizational structure, setting responsibilities and defining governance mechanisms, while process control is an integrated group of activities that are employed to accomplish specific organizational goals, such as physical, people and material elements.

Referring to the two interrelated work procedures above, the Head of the Tabalong Regency Transportation Service stated that these two work procedures have become the standard of work ethics for City Transport Car Drivers in carrying out their duties. Control of the driver's attitude affects the quality of service, and the regulation of supervision of the driver can also affect the accuracy in carrying out tasks, in the case of regular public passenger transport by road, safety, punctuality, comfort and regularity are criteria used to assess quality of service by Padron *et al.* in [31]. So, with these regulations, it can be said that the performance of City Transport Car Drivers has met expectations even though it needs to be improved and quickly adapt (with the applicable work procedures) so that it is able to adjust to the wishes in serving the community.

The same thing was also conveyed by the Head of the Transportation and Multimode Division of the Tabalong Regency Transportation Service that currently the performance of City Transport Car Drivers is quite good and of course in the Transportation and Multimode Sector itself, they are doing the continuous improvement to provide services even better for the community.

Unlike conventional travel diaries that provide no information between origins and destinations, GPS data offer insights into the traveler's choices and decisions while en route by Grengs *et al.* in [32]. This opinion is also said by the Head of the Insider Transportation Section for the Tabalong Regency Transportation Service Route, "At first the implementation of management control was only manual, namely using supervisors as timers in the field. This is considered less effective and efficient." The most important advantage of GPS data is that they allow us to address the dynamic properties of travel behavior by capturing detailed spatial, temporal, and attribute conditions throughout the full length of the traveling experience by Grengs *et al.* in [33]. From this explanation, it can be understood that before the GPS-based Vehicle Tracker was installed on the City Transport Car unit, the supervision was carried out manually by supervisory officers by going to the field. However, this method is considered less effective and less efficient and adds to the burden of office costs. It is impossible for unit monitoring to be carried out comprehensively, cannot be validated and not real time due to the limitations of officers and supervisory equipment.

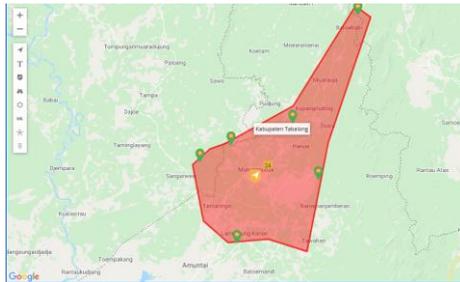
Furthermore, it was conveyed by the Head of the Insider Route Transportation Section that with the SOP and SETK and supported by existing applications, the Tabalong Regency Transportation Service could minimize driver inconsistencies. Thus, the Tabalong Regency Transportation Service believes that the implementation of SOP and SETK as a formal basis for the implementation of a management control system and supported by the GPS application as part of the management control system, city transportation cars and can improve the performance of City Transportation Car Drivers.

### **3.3 The GPS Supervising the Performance of City Transport Car Drivers**

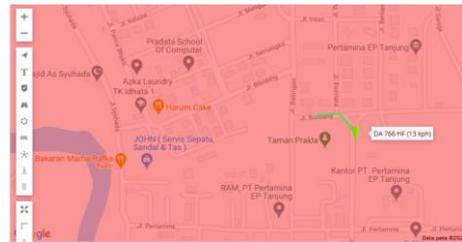
The Vehicle Tracker GPS tool, which was later named the GPS-Based Unit Monitoring Application (*in Bahasa they abbreviate it as PUBG*), is not only able to track the position of the unit's presence but can also detect several activities carried out by the driver City Transport Car service organizations, and of course on the performance of the driver himself, such as the maximum speed, duration of parking and the suitability of the route traversed.

This PUBG application is installed on a PC device under the supervision of the Head of the Insider Transportation Section for the Tabalong Regency Transportation Service, which is managed by City Transport Admin officers with a protection system in the form of an Admin User ID and Password. This application can be monitored, both for each car unit or just randomly or as needed.

The Map menu in Figure 4 displays an image of a map of the area that is monitored for the operation of the City Transport Car, in this case the Tabalong Regency area. Map images can be seen by sighting Google Streets, Google Satellite, or Google Hybrid. The Objects menu in Figure 5 displays all twenty-five units of cars that have been installed with Vehicle Tracker GPS, both those that are actively operating and those that are just standing by.



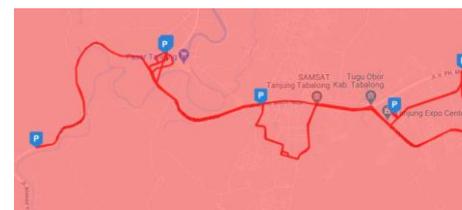
**Figure 4** An Image of the Area that is Monitored



**Figure 5** The Position of the Object that are Monitored

The unit object can be selected according to the needs of the Supervisor when carrying out supervision. The picture on the figure 6 above shows the monitoring of the position of the object of the DA 766 HF car unit which is operating on April 7, 2021, at 17:43 (GMT +8) (monitoring in real time). The Supervisor or Admin can monitor the existence/position of the desired unit in real time. On the screen also showed the coordinates of the unit and the car speed.

This Object menu is usually used when, for example, to track a unit that is experiencing technical problems such as a breakdown, tire leak, or delay in returning to the terminal, so that action or policy can be taken immediately.



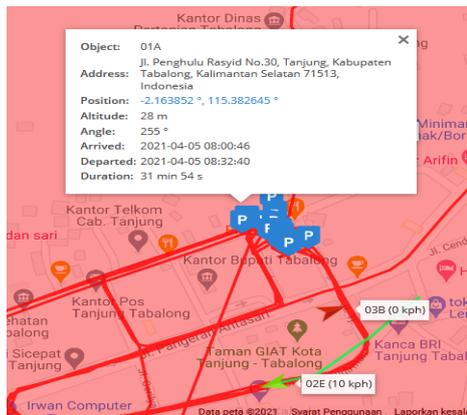
**Figure 6** Speed Monitoring**Figure 7** The Stop and Overspeed Signs

Events menu which displays which units overspeed, above the specified speed, which is sixty kph. In the Figure 6, were the events of unit 01A (unit identity withheld) which over speeded, namely speeds above 60 kph (kilometers per hour) on April 5, 2021. According to the Head of the Section for Insider Transportation, this overspeed incident is not always considered as an abuse of the unit, although the Insider Route Transportation Section still considers it a violation of the Driver's SETK. However, every overspeed incident like this is usually investigated first before the driver is sentenced to commit an abuse, especially until he is subject to warning letter sanctions and so on. If the reasons and the situation are understandable, then this kind of incident may be considered normal. Moreover, the overspeed incident on that day only occurred 1 (one) time, namely at 07:25 am (GMT +8). If the incident is investigated, it could be only because of the situation and conditional, not because of the behavior of the driver.

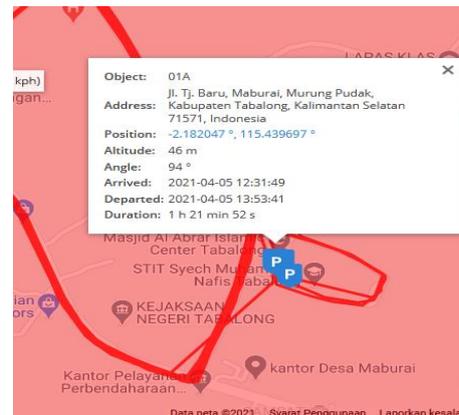
Another menu is History which displays the history of unit activity over a certain time, for example former day, this week, last week, even within this month or last month. Unit objects can be selected as desired and can view overspeed events and unit stop duration for 5 minutes, 10 minutes, 20 minutes, 30 minutes, 1 hour, 2 hours and 5 hours.

In the Figure 7 above, several dots marked with the letter "P" which means parking or stopping, and "E" which means event or overspeed incident. Supervisory officers or Admin can check what causes driver 01A to stop and overspeed. As explained above, it is not always the case that these incidents are considered as misuse of the unit. In the Driver's SETK, as mentioned in the previous point, activities such as: Exceeding the highest speed limit for public transportation; Exit from the designated route and lane; and terminating for reasons that cannot be accounted for is prohibited.

The Head of the Section for Insider Transportation for the Route confirmed that the maximum speed limit is sixty kph, and the long stop time limit is 20 minutes. But they still give tolerance the limit that can be considered reasonable according to the conditions in the field. The following is an example of an activity that should be included in the violation/abuse of the unit (terminating more than 20 minutes) but can still be tolerated because the situation and conditions are still acceptable to the Tabalong Regency Transportation Office, as shown on figure 8.



**Figure 8** The Activity Sample of the 01A Car at 08.00 (GMT +8)



**Figure 9** The Activity Sample of the 01A Car at 12.30 (GMT +8)

The appearance of the activity of the 01A car unit above occurred in the morning where the unit stopped for about 32 minutes. The location point is the Barunak Terminal (when the map is zoomed in, it can be seen that several units have gathered in the Barunak Terminal). It is believed that the driver is reporting to the supervisory team regarding the data on the number of passengers in the first batch departing from Mabuun Terminal to Barunak Terminal. Furthermore, unit 01A is still waiting for the next passenger to go to Pamarangan.

While waiting for the second batch of passengers, the driver could also take a breakfast break, because previously the unit had to be operating at 07.00 WITA departing from Mabuun Terminal, and the driver had to be present 15 minutes before the unit operated to check and prepare the car unit. So, the driver is believed to have enough time to do breakfast. Also, at Barunak Terminal, the driver can be available for breakfast. The habit of thinking about eating in the middle of work also occurred in research about taxi driver behavior in Haikou City, Japan by Gui & Wu in [34]. The transportation management in Haikou still adhered to the traditional system. The transportation utility values calculated by traditional utility methods are not comprehensive because traditional utility methods have been established within western economics, and their perspectives are limited to customers only by Gui & Wu in [35]. For instance, a passenger might arrive at their destination on time, but the taxi driver might not be able to eat dinner with his family. As a result, the passenger would benefit significantly from the trip, while the taxi driver would not. According to Gui & Wu in [36] to improve the utility of taxi drivers, we can analyze the willingness of taxi drivers by their real-time locations and compromise strictly with his work schedule, GPS surveillance becomes significant.

In the case of the driver having breakfast, he is still tolerated, if it is not done continuously or becomes a habit because it is done during service hours, so that it affects the performance of the driver himself, let alone affects the performance of other drivers. If it is done continuously and becomes a habit, it will receive warnings in stages starting from the Supervisory Team, Section Head to Head of Service in the form of Verbal Warning, 1<sup>st</sup> Warning Letter (SP), 2<sup>nd</sup> SP, to 3<sup>rd</sup> SP/Termination of Contract (firing).

The appearance of the activity of the 01A car unit in Figure 9 above occurred during the day where the unit stopped for about 1 hour 22 minutes. The location point is the Tabalong Al Abrar Islamic Center Mosque (when the map is zoomed in, it looks like several units are parked at the Mosque). It is believed that the driver was taking a break, praying, and having lunch. This condition may still be tolerated even though the provision is that the break is only 1 hour. If it is more than 1 hour, then it should gain a warning or sanction.

However, just like the previous conditions, this type of violation is still tolerated, of course, if it is not carried out continuously or becomes a habit, so that it can affect the performance of the driver himself, especially if it affects the performance of other drivers. Where between one driver and another, jealousy can occur if the Tabalong Regency Transportation Service does not take firm action and instead allows negligence or misuse of public transport to occur among the drivers.

By using GPS monitoring, supervisor can isolate: time of waiting for the possibility of taking a position at the stop, dwell time (also called as: alighting and boarding time), time of waiting for the possibility to departure, and travel time of a section between two following stops, It such an approach entitles to draw binding conclusions on operation of a line and enables to identify the causes of potential disorders by Bauer in [37].

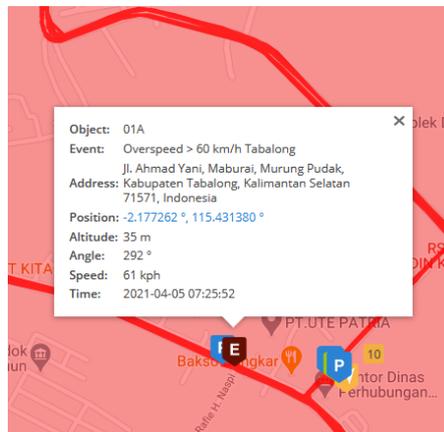
Next is the event where unit 01A performs overspeed activity with a speed exceeding sixty kph. Just like parking activities (stopping), overspeed exceeding sixty kph is also not necessarily an abuse as long as there are reasons that can be justified and certainly not carried out continuously.

When confirmation is made to the Supervisory Team what causes the Driver to exceed the maximum speed, Supervisor 1 explains the possibility that the Driver exceeds the maximum speed simply because he wants to overtake other road users. But that does not mean the driver can do this all the time. Especially if it occurs on the main road route of the unit. All forms of violation still have consequences. *"If it is a minor mistake, it is enough to be personally reprimanded,*

*but if it is a serious mistake, immediately report it to your superiors. Like repeating mistakes or fighting back when reprimanded.”*

Supervisor 2 also confirmed this that every form of abuse committed by the Driver must still have consequences, the Supervisor is obliged to give sanctions even though it is only in the form of a verbal warning and make notes as a report. The report is submitted to the admin for data verification. Then the Admin can ask why the abuse happened so that further action can be taken.

The following figure 10 is a picture of the appearance of the activity of unit 01A doing Overspeed during the period (History) from 05 to 09 April 2021.



**Figure 10** The Activity Sample of the 01A Car that Showed Overspeed

The appearance of the activity of the 01A car unit above occurred in the morning where the unit over speeded sixty-one kph. The location point is on Jalan Mabuun Raya (when the map is zoomed in, the unit can be seen traveling at a speed of sixty-one kph). It stated that the driver only wants to overtake other road users, this data can be seen during the period (05 to 09 April 2021) the driver only overspeed once. And for the Tabalong Regency Transportation Service, this condition cannot be explicitly stated as an abuse.

### **3.4 The Development of GPS Applications to Improve City Transport Car Services**

The Head of the Section for Insider Transportation Route said that the PUBG application has undergone development in collaboration with the Tabalong Regency Communication and Information Office and the Tabalong Regency Statistics Agency. *"We are also developing the application within collaboration with Communication, Information and Statistics Office at Tabalong Regency*

*under the name **Langsat Manis** which is not only useful for us as operators in watching the vehicles but can also be used by users to make it easier to get vehicle services. And the development of this application is included in the nomination for the Smart City project.”*

This application, which can be downloaded via the Play Store on an Android Smart Phone, is not only useful for the team of the Insider Transportation Section of the Tabalong Regency Transportation Service which acts as an operator in the supervision of City Transport Cars, but can also be used by users, namely passengers and the general public to make it easier to get information and city transportation services. Prospective passengers can make their choice, location of the pick-up point and estimated time to wait for the pick-up. A mobile app that provides information on public transport in a city could be extremely useful too for people who live in that city and for those who live outside the city by Lupasc in [38]. Furthermore, Lupasc in [39] states that the design and implementation of such an information system generates a number of advantages and benefits, the most important being: (1) fast access to information on public transport (stations and route map, route timetable) on any mobile device that has this application installed, without the need for an Internet connection; (2) the possibility of searching for the means of transport running between two stations or between two streets that the user inserts into the search module; and (3) the opportunity to run the app on both Android and iOS smartphone mobile devices.

The development of this application included in the nomination for the Tabalong project towards Smart City. This app uses the same principles as other online transportation apps. Through this application, prospective passengers can monitor where the position of the car unit is and how long the estimated time it will take to wait for the arrival of the car unit, and at the same time can make direct orders so that City Transport Car Drivers can find out that there will be prospective passengers on the route they will pass.

In the initial development of this application, there are six routes that can be accessed by prospective passengers to serve 3 (three) sub-districts in the central region, namely Murung Pudak, Tanjung and Tanta. And for the next there will be additions in the northern and southern regions.

The Head of the Transportation and Multimode Division explained that the existence of this application does not mean that the car unit only operates according to passenger orders, the unit continues to operate and continues to provide services as usual, it is just that prospective passengers cannot know for sure when the unit passes.

### **3.5 The Effect of GPS Control Devices on the Performance of City Transport Car Drivers**

This GPS-based control device known as the PUBG Application has helped a lot in improving the driver's performance in providing services to the Tabalong community. This application has become a separate tool in management control for the Tabalong Regency Transportation Service. Drivers become more disciplined, honest, and motivated at work.

Both supervisors in the field and admins in the office have made it easier to supervise and record the activities of public transport, which total thirty-three units, even though only 25 GPS devices are installed. This application has also been able to cut the workload more easily, practically, and efficiently.

Supported by the expression of the Head of the Tabalong Regency Transportation Service that with the installation of this GPS control device, the performance of the drivers will be better, more efficient and can minimize the misuse of City Transport Cars, "Their performance will be better because with this application they can help a lot in handling transportation operations, are much more efficient, minimize violations and are right on target."

This is in line with research conducted by Zhao and Carling in [40] which observes the use of GPS through two aspects: geographic position of the vehicle and speed by tracking vehicles in a complex road network with varying transportation modes, environmental conditions and collection settings in real settings. The results of the research show that (1) the GPS tracking data identified the actual positions of the vehicles successfully, and (2) the tracked instantaneous speeds are quite accurate with a tendency of underestimation.

Regarding violations and abuse of Public transport, the Head of the Section for Insider Transportation added that every form of SETK violation is still called a violation even though the scale and impact are small or rarely carried out. The sanctions imposed can be in the form of a verbal warning, first warning letter (SP), 2<sup>nd</sup> SP, up to 3<sup>rd</sup> SP/Termination of Contract (firing). The following table 2 is a recapitulation of Admin data regarding the sanctions issued by the Tabalong Regency Transportation Service against drivers who violate and abuse Public transport in the period 2018 to 2020.

**Table 2** Recapitulation of the Drivers' Sanction in the Period 2018-2020.

Warning Letter (WL)	Caused	2018 (Person(s))	2019 (Person(s))	2020 (Person(s))
WL 1	Absence without evidence	2	3	1
	Indiscipline (speed, out of line)	5	4	2
WL 2	Transit too long	2	2	1
	Absence without evidence	1	1	1
	Indiscipline (speed, out of line)	1	2	1
	Take passenger in fast lane	1	-	-
	Leaving at working hours	-	1	1
WL 3/ Fired	Absence without evidence	2	-	-
	Indiscipline (speed, out of line)	2	-	-

Note: 2018-2019 are the number of perpetrators before GPS installation. 2020 is the number of perpetrators after GPS installation.

From the recapitulation data at Table 2, it shows that there is a decreasing trend in the number of perpetrators of abusing Public transport in the period 2018 to 2020, namely before and after the installation of GPS control devices on the City Transportation Car unit. This decrease in the number of abusers at least proves the positive influence towards improving the performance of City Transport Car Drivers after GPS installation.

#### 4 Conclusion

In line with the research conducted by Yuniar *et al* in [41]. which was written in the Journal of Truck Driver Behavior and Travel Time Effectiveness Using Smart GPS, that by installing a GPS device on a truck, apart from improving driver performance, driver safety, reducing ineffective time, saving fuel, saving operational costs, increasing vehicle usability, increasing driver productivity and customer service, it can also assist field supervisors in tracking the presence of trucks, provide warnings, monitor locations, provide information, and mark the speed of each truck. Even field supervisors will call drivers who have stopped for too long somewhere and can find out the location if there is damage to the truck so that it can be handled quickly.

Based on The Resource-Based View (RBV) theory used in this study describes that the basis of competitive advantage lies in a set of tangible or intangible assets (physical and non-physical resources) in an organization, company, or government agency, in this case the Tabalong Regency Transportation Service. The main assets owned by the Tabalong Regency Transportation Service (Drivers, Public transport equipped with GPS) are tools that can be used to carry out management control, which in turn will be able to regulate and supervise the activities of City Transport Car Drivers so that they have performance according to the SOP and SETK that has been enforced. So that in the end it will be able to

produce optimal service output for the community using City Transport Cars in the Tabalong Regency area, and on the other hand the strength of the main resources with competitive advantages owned by the Tabalong Regency Transportation Service will be able to support the preparation of achieving the Tabalong Regency target towards Tabalong Smart City.

The installation of this GPS application at least has an impact on decreasing the trend of imposing sanctions on drivers who commit violations in 2018 to 2020, although there are also other sanctions that are not related to indiscipline monitored by GPS, such as not coming to work without explanation and leaving work on time, work for no apparent reason. However, with the decrease in the number of perpetrators of this abuse, at least it proves the positive effect of increasing the performance of City Transport Car Drivers after GPS installation.

However, the implementation of investigations and the application of sanctions by supervisors still needs to be firmer. It can be seen from the observation that supervisors are still too tolerant of several reasons put forward by the driver. Regulations must be the basis for enforcing discipline. For example, if the break time is 1 hour, then the implementation must be appropriate, there are no exceptions, especially for trivial reasons, such as the use of time to eat too long. Also, in the case of speed violations for reasons of chasing passengers. This cannot be a tolerable excuse because passengers must be educated to be disciplined in waiting for the arrival and departure of vehicles.

The Tabalong Regency Government must also consider that the transportation applications that have been developed can be linked to existing and popular applications in the community. This is to maximize the use of the application, and to avoid people's excuses because the phone's memory is already full, so they are not interested in downloading the application. Do not let this application become useless in the future.

In the pandemic covid-19 era of 2020, the City Transport Car service activity will still be carried out even though not all car units operate at the same time. The unit operates on a shift system by setting a schedule for which unit will operate. Thus, the drivers and supervisors will also continue to work according to their shifts. And this condition will still be carried out in 2021 due to the Covid-19 pandemic which has not yet ended.

In line with the aspirations of the Tabalong Regency Government to go to Tabalong Smart City, the Tabalong Regency Transportation Service will continue to strive to provide maximum city transportation car services to meet the needs of land transportation within the city for the people of Tabalong Regency by

preparing quality resources, both in terms of resources, reliable human resources and modern technological resources, in accordance with the mission of the Tabalong Regency Government point 3, namely "Realizing independence by building and developing potential resources".

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## Wind Flows and Pressure on the Joglo Roof, One of Indonesia's Traditional Houses: A Simulation and Numerical Study

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**Abstract.** Joglo is one of the traditional houses in Indonesia. Joglo roof has a different angle. Angle of the Joglo roof is very important to note. In this study, simulated wind with a speed of 10 m/s hitting the Joglo's roof, with roof angles 0°, 35°, 45°, and 55°. The simulation is completed through the Standard k-Epsilon turbulence model with several functions in OpenFOAM and ParaView. First the wind is set in the direction of the x axis and the second is set in all directions towards the horizontal x and y direction, and towards the vertical z direction. The overall flow pattern shows that the velocity gradient towards zero is at the rear of the joglo roof. In unidirectional winds, the highest pressure occurs when the wind bends at a distance of  $\pm 45$  m. While the lower pressure is on the back of the roof. For wind from all directions, the highest wind speed is at a distance of 7m to 13m. The greater the angle of the Joglo roof, the greater the initial pressure received, and the greater the decrease in pressure value due to the wind being deflected to the vertical z direction.

**Keywords:** *joglo's roof; openFOAM; paraview; wind.*

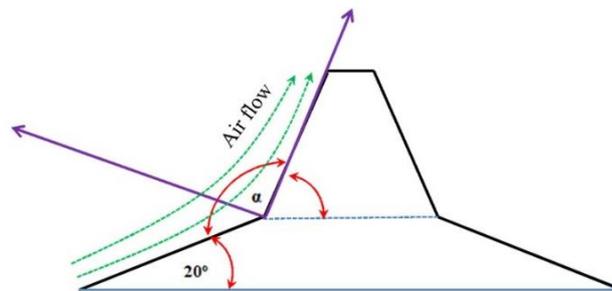
### 1 Introduction

Indonesia has more than 34 traditional houses with their own characteristics. These characteristics can be located on the stage floor, stairs, walls, and roof. The uniqueness of the traditional house makes the house comfortable to live in, warm, safe from wild animals, and sturdy when strong winds come. One of the traditional houses in Indonesia is the Joglo house, a Javanese traditional house made of teak wood with a pyramid-shaped Joglo roof that refers to the shape of a mountain. In each area, the Joglo house has a roof with a different angle of inclination. The characteristic of the Joglo roof can be seen from the shape of the roof which is a combination of two triangular roof planes with two trapezoidal roof planes, each of which has a different slope angle and is not the same size. The roof of the Joglo is always located in the middle and is always higher and flanked by the roof of the porch. The roof of the Joglo house has a variation of the angle of inclination between 30° to 60°. The angle of the roof slope is an

important thing to consider when building or renovating a Joglo roof. The roof will not function well as a house protector from heat or rain if the angle of inclination is wrong. If it is too sloping, the roof will sag easily and if it is too sloping, the rainwater will not flow smoothly. In addition, the slope of the Joglo roof is predicted to affect wind deflection so that it can withstand the speed and pressure caused by strong winds. Studies on the analysis of the effect of the Joglo roof angle on changes in wind speed and pressure have not been previously reported.

In the last few decades, there have been many studies on simulation and numerical modeling of wind flow on roofs and building shapes. Simulations and modeling use openFOAM to model airflow induced loads on various structures (Isaev et al., 2019; Rajput et al., 2021). Open FOAM has several advantages, such as free access, easy to use, accurate results, and can be used for various purposes related to Computational Fluid Dynamics (CFD). Research that has been carried out includes dynamic simulation of two-phase fluid flow and mass transfer in a forward flow reactor (Nieves-Remacha et al., 2015), simulation of non-premixed turbulent combustion (integration and validation) (Gaikwad & Sreedhara, 2019), flow turbulent buoyant atmosphere over complex geometries (Flores et al., 2013), numerical simulation of viscoelastic two-phase flow (Habla et al., 2011), simulation of airflow inside a horticultural high tunnel greenhouse (Lubitz, 2018), and others.

This paper is structured to determine the effect of the slope angle of the Joglo roof on changes in wind speed and pressure in certain directions. The slope of the angle that is varied is the magnitude of the value of  $\alpha$  as shown in figure 1.



**Figure 1.** Schematic of the Joglo roof with the value of being a varied angle

Wind flow is simulated using openFOAM software and paraView to display the simulation results. This study is expected to be able to provide information in determining variations in the angle of the roof of the Joglo house so that the house can withstand strong winds or tornadoes.

## 2 Building Equations and Methods

### 2.1 Building Equations

Pay attention to the airflow hitting the front side of the roof. For convenience, the coordinate axes are selected as shown in Figure 1. The potential flow around the two walls forms an angle  $\alpha$ : (Bird et al., 2002).

$$w(z) = -\beta z^\alpha \quad (1)$$

where  $\beta$  is the parameter that determines the wind strength,  $z = x + iy$  is a complex variable and  $i = \sqrt{-1}$ . The complex velocity is derived from the flow potential equation as follows

$$-v_x + iv_y = \frac{dw}{dz} = -\beta \alpha z^{\alpha-1} = -\beta \alpha r^{\alpha-1} e^{i(\alpha-1)\theta}$$

Where  $r = \sqrt{x^2 + y^2}$  and  $\theta = (y/x)$ . From equation (2), it can be determined the velocity component along the x and y coordinates as follows

$$v_x = \beta \alpha r^{\alpha-1} \cos(\alpha-1)\theta$$

and

$$v_y = -\beta \alpha r^{\alpha-1} \sin(\alpha-1)\theta$$

The velocity in the radial direction satisfies the equation:

$$v_r = v_x \cos \theta + v_y \sin \theta$$

$$v_r = \beta \alpha r^{\alpha-1} \cos \theta \cos(\alpha-1)\theta - \beta \alpha r^{\alpha-1} \sin \theta \sin(\alpha-1)\theta$$

$$v_r = \beta \alpha r^{\alpha-1} \cos \alpha \theta$$

The magnitude of the total momentum of the left changing direction is the same, because of that,

$$dp = \sqrt{p_r^2 + p_l^2 - 2p_r p_l \cos(\pi - \pi/\alpha)}$$

$$= \sqrt{p_r^2 + p_l^2 + 2p_r p_l \cos(\pi/\alpha)}$$

$$= \rho L_R \beta^2 \alpha^2 a^{2\alpha-1} dt \varphi(\alpha)$$

$$\sqrt{1 + (b/a)^{4\alpha-2} + 2(b/a)^{2\alpha-1} \cos(\pi/\alpha)}$$

If  $a \approx b$ :

$$p = \rho L_R \beta^2 \alpha^2 a^{2\alpha-1} dt \varphi(\alpha) \sqrt{2} \sqrt{1 + \cos(\pi/\alpha)} \quad (2)$$

The force experienced by the Joglo roof can be defined by the equation:

$$F_d = \frac{dp}{dt} \quad (3)$$

If  $a$  and  $b$  are large enough then we can assume that  $p_l \approx p_r$  so that the direction of the Bernoulli force and the force due to bending of air is exactly opposite. Thus, the net upward force received by the roof becomes:

$$F_{nett} = F_B - F_d \quad (4)$$

## 2.2 Method

OpenFOAM is a free and open source software for Computational Fluid Dynamics (CFD). The workflow in this study is divided into 3 parts, namely: Pre-Processing, Processing, and Post-Processing as shown in figure 2.

**Pre-Processing:** The Joglo roof geometry was created with the Salome software. Then imported in OpenFOAM. Mesh is created using the tools "blockMesh" and "snappyHexMesh" tools. To complete pre-processing, first define initial conditions and boundary conditions.

**Processing:** The numerical parameters for the simulation are set according to the Joglo roof problem. Although a problem can be solved through several solving methods, it is very important to choose the appropriate parameters in order to solve the problem efficiently.

**Post-Processing:** carried out after completing the simulation to interpret the results using the ParaView software. Flow fields can be analyzed by extracting data, plotting, and applying filters such as flowlines and coloring.

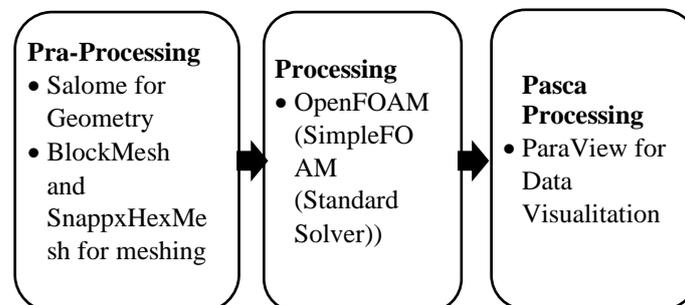
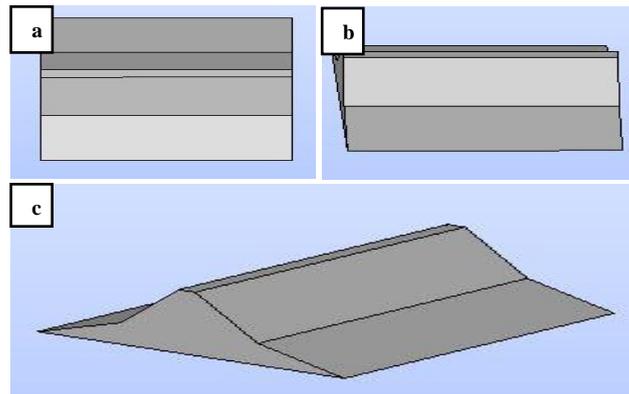


Figure 2. Workflow of simulation.

## 2.3 Pre-Processing: Creating Geometry and Meshing

The base mesh was created using "blockMesh", then added the Joglo roof mesh using "snappyHexMesh". The Joglo roof geometry used by snappyHexMesh was created in the SALOME-9.7.0 software as shown in Figure 3.



**Figure 3.** Geometry of the Joglo roof, top view, side and diagonal

## 2.4 Processing: Solution Using HELYX-OS and OpenFOAM

### 2.4.1 Boundary Conditions

The general boundary conditions are defined as in the case of a similar CFD (Dwyer 2014) and can be seen in Table 1. In general, the speed on the ground and on the roof of the Joglo is defined with a fixed value of “0”, while the other parameters are set to the appropriate Wall-Functions.

The speed at the inlet is set according to the desired inlet wind. In this case, the inlet speed of 10 m/s is used. Meanwhile, the turbulence parameters  $k$ , Epsilon ( $\epsilon$ ) and Omega ( $\omega$ ) are calculated based on the derivation according to the respective turbulence models used. All other values are defined as zero gradient, except for the pressure at the outlet, where a fixed value of "0" is defined to allow free flow of air out.

**Table 1** Conditions for the modeling of the joglo roof.

Boundary Condition	Type	U	P	k	( $\epsilon$ )	nut
<b>Inlet</b>	Patch	Fixed value	zeroGradient	Fixed Value (calculated)	Fixed Value (calculated)	Fixed Value (calculated)
<b>Outlet</b>	Patch	pressure <i>InletOutletVelocity</i>	totalPressure	<i>InletOutlet</i>	<i>InletOutlet</i>	Fixed Value (calculated)
<b>Ground</b>	Wall	Zero Gradient	Zero Gradient	kqRWall Function	epsilon WallFunction	nutkWall Function
<b>Front</b>	symmetry	Zero Gradient	Zero Gradient	Zero Gradient	Zero Gradient	Zero Gradient

<b>Back</b>	symmetry	Zero Gradient	Zero Gradient	Zero Gradient	Zero Gradient	Zero Gradient
<b>Geometri Atap Joglo</b>	Wall	Fixed Value	Zero Gradient	kqRWall Function	Epsilon - WallFunction	nutkWall Function

## 2.5 Turbulence and Coefficient Model

Based on the literature review, the Standard k-Epsilon turbulence model (Norton et al. 2007) can be applied to this case. The Standard k-Epsilon model is one of the turbulence models based on the resolution of two additional transport equations for turbulent kinetic energy ( $k$ ) and dissipation rate (Epsilon) (Launder and Spalding, 1974). The following settings are used for the model, following the default OpenFOAM values as used in the case of other CFDs

**Table 2** Standard parameter values for k-Epsilon.

Parameter	Standard k-Epsilon
$\sigma_k$	Calculated
$\sigma_\epsilon$	Calculated
$k$	Calculated
Epsilon ( $\epsilon$ )	Calculated
$C_1$	1.44
$C_2$	1.92
$C_\gamma$	0.09

The constants  $C_1$ ,  $C_2$ , and  $C_\gamma$  were experimentally determined by (Shih et al. 1994) as  $C_1 = 1.44$ ,  $C_2 = 1.92$ ,  $C_\gamma = 0.09$  which is the default setting in OpenFOAM. Turbulence coefficient of turbulent kinetic energy ( $k$ ), turbulence dissipation ( $\epsilon$ ) and specific turbulence dissipation ( $\omega$ ) were calculated from turbulence intensity ( $Tu$ ), turbulence length scale ( $TuL$ ), constant  $C_\gamma$  and freestream velocity ( $U_\infty$ ). The Standard k-Epsilon turbulence model is applied to the four variations of the roof angles of the joglo house

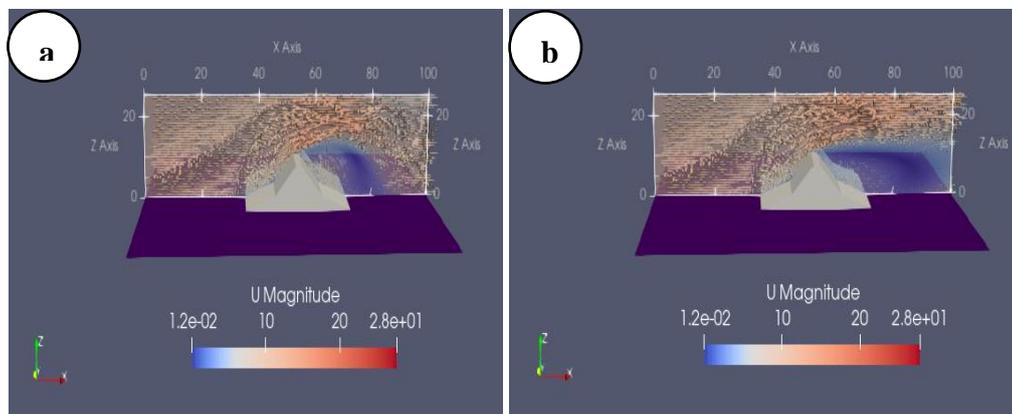
**Table 3** Convergence criteria for simulation.

Parameter	Toleran Value
Pressure (p)	$1 e^{-6}$
Velocity (U)	$1 e^{-6}$
Turbulent Kinetic Energi (k)	$1 e^{-6}$
Turbulent Kinetic Energy Dissipation (epsilon)	$1 e^{-6}$
nuTilda (nut)	$1 e^{-6}$

ParaView is used to view simulation results and sample data. ParaView provides a GUI and is included with OpenFOAM via the "paraFoam" command. ParaView can display data objects in the form of images or videos. In ParaView, the function object "probe" is used to extract data from a certain point, for example from a certain point the airflow along the roof of a Joglo house is measured using the "volFieldValue" function.

### 3 Results and Discussion

The overall flow pattern shows that a velocity gradient towards zero is present at the back of the Joglo roof as shown in figure 4. The wind speed is set uniformly at 10 m/s towards the horizontal direction (x axis). At a time of 100 seconds, an increase in speed occurs at a distance of  $\pm 50$  m after undergoing a turn at a distance of  $\pm 45$  m as shown in

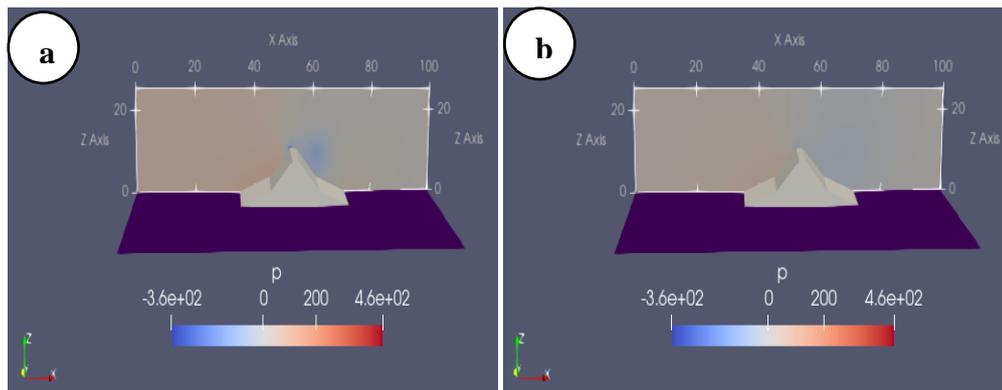


**Figure 4:** Showing the velocity magnitude of the convergent simulation (k-epsilon turbulence model, Inlet Velocity 10 m/s). 2D View with ParaView uses the "slice" function in the normal Y direction. Roof angle  $45^\circ$  (a) time 50 seconds, and (b) time 300 seconds.

Figure 4a. The increase in speed occurs up to  $\pm 80$  m and then starts to stabilize again at a distance of  $\pm 85$  m. The highest speed value is above the top of the Joglo roof, which is 16.61 m/s at a distance of  $\pm 58$  m. In this section there is wind that experiences a deflection towards the vertical direction (z axis). Meanwhile, at a time of 300 seconds, an increase in speed occurs at a distance of  $\pm 50$  m to  $\pm 100$  m (the very end). The deflection distance of the wind is further than the time of 100 seconds as shown in Figure 4b.

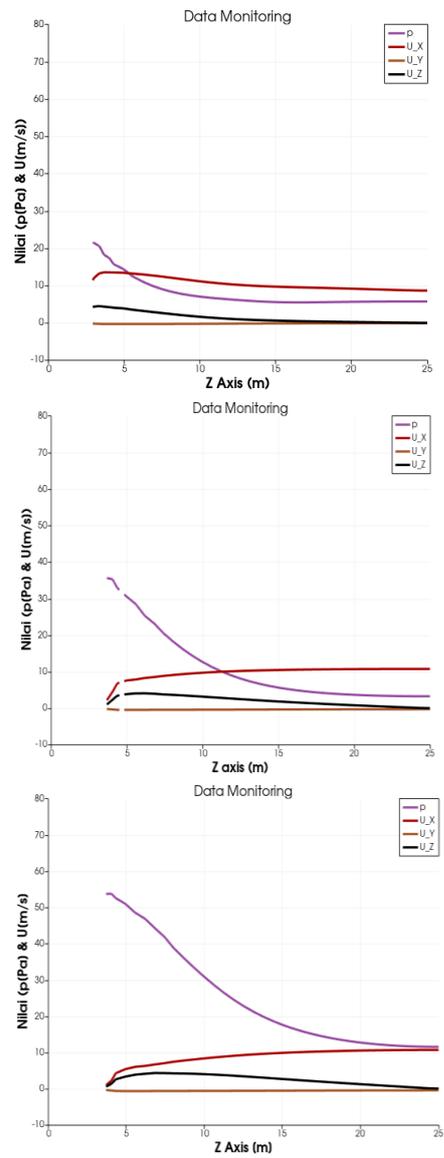
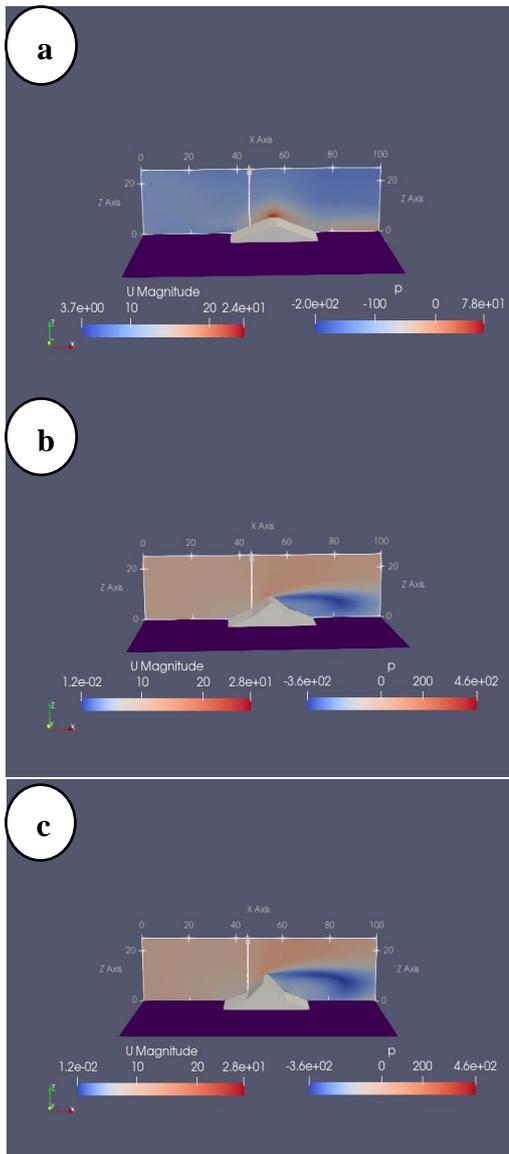
The pressure distribution is shown in figure 5. At a time of 50 seconds an increase in pressure occurs at a distance of  $\pm 45$  m when the wind bends as shown in figure 5a. This is indicated by the color gradation that is redder than the other parts.

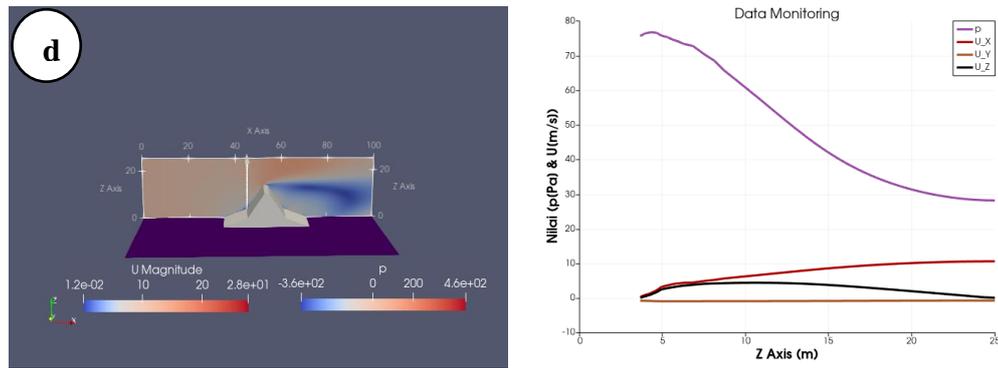
Similarly, at the time of 300 seconds shown in Figure 5b, the highest pressure occurs when the wind bends. While the lower pressure is on the back of the roof. This is because the wind is deflected towards the vertical (z) direction. The pressure distribution does not change significantly at 100 seconds to 400 seconds. This shows that the longer the pressure will be more stable at a certain amount because the wind speed stabilizes after that time.



**Figure 5:** Showing the convergence simulation pressure (k-epsilon turbulence model, entry speed 10 m/s). A 2D View with ParaView uses the "slice" function in the second row in the normal Y direction. Roof angle 45°. (a) Time 50 seconds and (b) time 300

Significant changes occur at the beginning of the wind towards the roof of the Joglo, which is between time 0 to 50 seconds. In addition to the velocity and pressure in the horizontal direction (x axis), there is also velocity and pressure in the vertical direction (z axis) from the bottom of the Joglo roof to the top. This can cause the roof to lift if the velocity and pressure are very large, or in other words the lifting force is very large. Therefore, in this section, a vertical line is taken to show changes in the value of velocity and pressure at each point as shown by the arrow in Figure 4. This vertical line data is then depicted on a graph as monitoring data. The angles of the Joglo roof are varied to see their effect on changes in velocity and pressure. In this case the angles that are varied are 0°, 35°, 45° and 55°. Completion of the model is completed through the standard k-Epsilon turbulence model until it reaches certain convergence criteria.





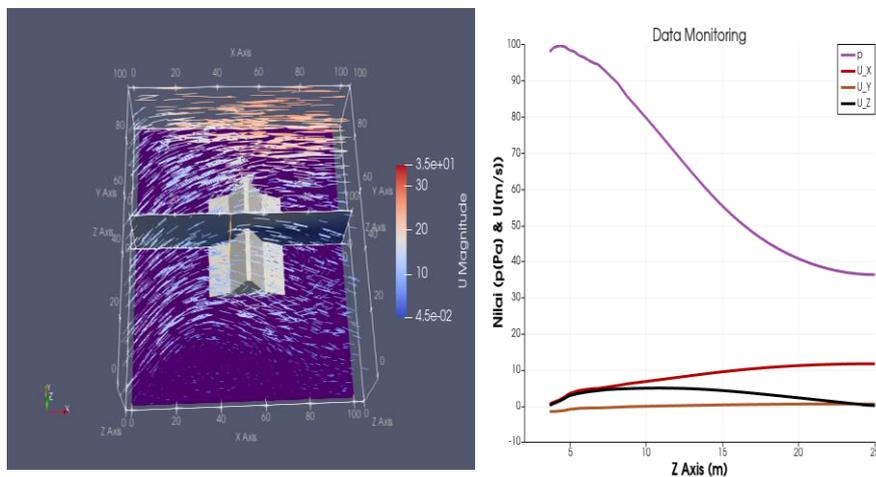
**Figure 6.** Simulation model and graph of changes in pressure and velocity values in the z direction (z axis) of the Joglo roof where (a) 0°, (b) 35°, (c) 45°, dan (d) 55°

Probes and other simulation data were obtained using pre-configured functions in /system/controlDict as well as some functions in ParaView. The figure shows that there is a difference in the value of the initial pressure received by the roof. The initial pressure received is 21.31 Pa for an angle of 0°, 35.65 Pa for an angle of 35°, 53.77 Pa for an angle of 45°, and 75.77 Pa for an angle of 55°. This shows that the greater the angle of inclination of the Joglo roof, the greater the pressure received. While the final pressure on the boundary conditions section, namely at x: 45, y: 0, and z: 25, is at a value of 5.74 Pa for a 0° slope angle, 3.31 Pa for a 35° slope angle, 11.6 Pa for a 45° angle, and 28.24 for a 55°. The wind speed in the horizontal direction x (U\_x) tends to be stable at 10 m/s for an angle of 0°. This is because the incoming wind speed is set to the horizontal x direction and there is no large enough wind deflection. Meanwhile, angles of 35°, 45° and 55° have small wind speeds, namely 2.24 Pa, 1.05 Pa, and 3.86 Pa. This is because the wind is blocked by the roof which is then deflected upwards. There is no velocity in the horizontal y direction. However, in the vertical z direction (U\_z) there is a wind speed value due to the deflection of the wind from the x direction to the z direction on the Joglo roof, so that the wind goes vertically upwards. The greatest speed value is at the bottom at the beginning of the deflection of the wind, which is 4.25 Pa.

**Table 4** Changes in pressure and velocity values in the vertical direction (z axis) at each corner of the Joglo roof

No	Atap Joglo	Parameter											
		p			U_X			U_Y			U_Z		
		Awal	Akhir	Diff	Awal	Akhir	Diff	Awal	Akhir	Diff	Awal	Akhir	Diff
1	Nol derajat	21.31	5.74	-15.57	11.44	8.65	-2.79	0	0	0	4.25	0	-4.25
2	35 Derajat	35.65	3.31	-32.34	2.24	10.8	8.56	0	0	0	1.08	0.06	-1.02
3	45 Derajat	53.77	11.6	-42.17	1.05	10.76	9.71	0	0	0	0.63	0.12	-.51
4	55 Derajat	75.66	28.24	-47.43	3.86	10.65	6.79	0	0	0	0.11	0.18	.07

Changes in the value of pressure and wind speed from each angle variation are shown in table 4. The greater the angle of the Joglo roof, the greater the decrease in the pressure value in the vertical direction (from bottom to top) as shown in the table in green. This is indicated by the difference between the final pressure and the initial pressure. The large angle of the Joglo roof can reduce the pressure value significantly. The greater the angle of the Joglo roof, the wind speed in the x direction (x axis) will increase up to a  $45^\circ$  angle as shown in blue in table 3 column U\_X. Meanwhile, for the  $55^\circ$  angle, the wind speed has decreased. In the vertical direction (z axis), the greater the angle of the Joglo roof, the higher the wind speed as shown in blue in table 1 column U\_Z. This indicates that the wind coming from the x direction will soon be deflected towards the z direction so that the wind speed increases. Joglo roof studies through Computational Fluid Dynamic (CFD) can be implemented in OpenFOAM using the Darcy-Forchheimer Equation. Comparison with similar cases from the literature confirms the results (F. D. Molina-Aiz et al. 2012) and (Muñoz, Montero, and Antón 2001). However, it must be said that the results are based on airflow coming mostly from a uniform direction. If you take into account winds that come diagonally, as happens in nature, the results will change (López et al. 2016). No significant change in airflow pattern could be found for the different speeds. Comparison of four models with different Joglo roof angles shows similar flow patterns. The same is true for variations of different angles. If the incoming wind is set from all directions with the same speed value, which is 10 m/s until there is a rotation resembling a tornado, the simulation model is obtained as follows.



**Figure 7.** Tornado wind model simulation and graph of changes in pressure and velocity values in the vertical direction (z axis) of the Joglo roof with the k-epsilon turbulence model, the incoming speed is 10 m/s. A 2D View with ParaView uses the "slice" function in the second row in the normal Y direction. Roof angle 55

In this simulation, the wind is set from all directions, namely from the horizontal direction (x axis and y axis) and the vertical direction (z axis) so that the wind rotates as shown in figure 6. Winds that experience rotation are most likely to lift the roof if the speed is high, and the pressure is great. In this section, one line is taken on the slice to see changes in pressure and wind speed in the vertical direction (z axis). The line is indicated by a yellow arrow in figure 4, precisely at points x: 45 m and y: 45 m. Changes in wind speed in the horizontal direction (x axis), the higher the roof will be because there is a driving force from the vertical (z axis) and horizontal (y axis) direction. Meanwhile, for changes in speed in the vertical direction (z axis), the highest wind speed is found in the distance between 7 m to 13 m, precisely on the roof after the wind bends. The initial pressure at the bottom of the Joglo roof is 98.00 Pa and the final pressure at the top of the Joglo roof is 36.37 Pa, so that it has a difference or pressure drop of 61.63 Pa.

The difference value obtained is greater than the change in pressure in a uniform wind direction (see Figure 5 and table). This is due to the large angle of the roof so that it can turn the wind direction quickly and reduce the pressure significantly. Thus, a larger roof angle will be more resistant and stronger against wind pressure than a smaller angle if there are strong winds or tornadoes.

#### **4 Conclusion**

The completion of the Joglo roof simulation was completed through the Standard k-Epsilon turbulence model with several functions in OpenFOAM and ParaView. The overall flow pattern shows that the velocity gradient towards zero is at the back of the Joglo roof, with the highest velocity value of 16.61 m/s at a distance of  $\pm 58$  m. At the wind speed which is set in the direction of x, the highest pressure occurs when the wind bends at a distance of  $\pm 45$  m. While the lower pressure is on the back of the roof. For wind speeds that are set from all directions, namely the horizontal direction (x axis and y axis) and vertical direction (z axis), the highest wind speed is at a distance of 7 m to 13 m. The initial pressure at the bottom of the Joglo roof is 98.00 Pa and the final pressure at the top of the Joglo roof is 36.37 Pa, with a large difference of 61.63 Pa. The value of the difference is quite large due to the large angle of the roof of the Joglo so that it can turn the wind direction quickly and reduce the pressure significantly. The greater the angle of the Joglo roof, the greater the initial pressure received because the wind is restrained by the vertical roof walls. The presence of wind that is deflected in a vertical direction will reduce the initial pressure value received significantly, so that the greater the angle of the Joglo roof, the lower the pressure value will be even greater. Conversely, the smaller the angle of the Joglo roof, the smaller the initial pressure received will be. The very small corner of the Joglo roof shows the shape of a straight roof in the direction of the wind. This results in no

significant vertical deflection of the wind so that the initial pressure received is small and the pressure drop is also small.

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## **The Effect of Big Five Personality Traits on Anticipatory Socialization with Professional Skepticism as A Mediating Variable**

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**Abstract.** This study aims to determine the effect of the big five personality traits on anticipatory socialization with professional skepticism as a mediation variable. this study uses purposive sampling and data analysis techniques using Structural Equation Modeling-Partial Last Square (SEM-PLS). This study used data collection techniques using questionnaires distributed to accounting students at the Raden Mas Said State Islamic University and the Muhammadiyah University of Surakarta with a total sample of 125 students. This study uses cognitive dissonance theory which discusses uncomfortable behavior so that the person must change behavior for his discomfort. This theory also discusses the relationship between student personality, professional skepticism, and anticipatory socialization. The results of this study prove that the big five personality traits consisting of agreeableness and conscientiousness have a positive and significant influence on professional skepticism. Extraversion, openness, and neuroticism have no effect on professional skepticism. Extraversion, agreeableness, conscientiousness, openness, and professional skepticism have a positive and significant influence on anticipatory socialization. neuroticism has a negative and significant effect on anticipatory socialization.

**Keywords:** *big five personality traits; professional skepticism; anticipatory socialization.*

### **1 Introduction**

The number of cases of audit errors in detecting fraud has occurred internationally and nationally. This is evidenced by 45 cases related to financial statement fraud, 24 cases or 60% occurred due to a low level of professional skepticism, therefore a lack of professional skepticism can lead to failure to find fraud in financial statements Winantyadi & Waluyo, (2014). Cases of audit errors that occur internationally are proven by the existence of cases of accounting fraud in the United States Sarbanes Oxley Act (SOX) rules that require more accounting considerations. Apart from that, other case examples such as Xerox Corp in 2001, XeroxCorp has made improper financial records and violated Generally Accepted Accounting Principles (GAAP). Auditors certify compliance with GAAP

standards on financial statements made. However, the fact is that fraud still occurs (Stephanus, 2021). Enron (2001), World Com (2001), Tyco (2002), in this case, Arthur Andersen KAP dragged both of whom were proven to have manipulated the results of financial statements Serikat (Yeremia, 2020). Cases in Indonesia also occur in Slaughterhouses and Slaughterhouses Cultivating Penggaron in Semarang City, PT. Kimia Farma and bank, BDO International Limited at PT. Garuda Indonesia and the big KAP Ernest Young at Indosat Ooredoo, where the auditors could not provide supporting evidence (Nasional.Kontan.News, n.d.).

The number of cases of auditor fraud due to the lack of professional skepticism above, it is necessary to take preventive action by using anticipatory socialization which is the anticipation stage during years of college education. In this stage, individuals will learn and internalize the nature of professionalism in the profession they are interested in. Anticipatory socialization to students needs to be emphasized, because the failure to transfer professional values will have a negative impact on the students themselves as well as their profession (Farg & Elias, 2016). Anticipatory socialization can also be said to be a person's adjustment to his new environment which at this stage of anticipatory socialization will have an influence on the formation of one's character and mind set (Ahmad et al., 2012). For example, failure to believe in the profession, there are still students who are unsure of the major they have chosen when completing the anticipatory socialization stage in college. So that the doubts in these students will affect the choice of the next career.

In the research of Farag & Elias, (2016) revealed the results of big five personality traits have a positive influence on anticipatory socialization. These results are reinforced by research by Li et al., (2014) that there is a positive relationship between five personality types and anticipatory socialization. The results of this study indicate that anticipatory socialization is broadly beneficial for one's characteristics. In addition, research by Lamsa et al., (2008) also shows a positive influence on economics students with an understanding of anticipatory socialization, where students who have a high understanding of anticipatory socialization will work better than employees who have low anticipatory socialization. However, the results of this study are different from the results of research that has been carried out by Santoso, (2018) which shows the results that openness personality has no effect on anticipatory socialization. An imaginative person is easier to understand abstract and interesting ideas. Santoso, (2018) also shows that the nature of neuroticism has a positive influence on anticipatory socialization, where someone who often experiences mood swings and does not believe in himself has a part of the time that keeps them busy and has a high anticipatory socialization attitude.

Furthermore, professional skepticism, being an auditor of course must have high professional skepticism, according to Aminudin & Suryandari, (2016), personality type and auditor experience have an influence on auditor professional skepticism. According to the results of research by Farag & Elias, (2016) who identified that personality characteristics are positively related to professional skepticism. These results are reinforced by the research of Winantyadi & Waluyo, (2014) that there is a positive relationship between ethics and professional skepticism of auditors. Idawati, (2019) also shows a positive relationship between Professional Skepticism in detecting fraud. Research by Rustiarini, (2013) and Dewi et al., (2015) also strengthens the results that of the five traits, extraversion, agreeableness, conscientiousness, and openness have a positive effect on auditor performance. However, the results of this study are different from the research of Aminudin & Suryandari, (2016) which shows that personality type has a negative effect on the auditor's ability to detect fraud through professional skepticism, which is used by auditors to be skeptical in carrying out their duties. The research of Khan & Harding, (2020) also shows the results of 10 basic human values that have a negative effect on the traits of scepticism. Suryandari & Yuesti, (2017) also shows that workload and personality type have no effect on professional skepticism and the ability to detect fraud.

In addition to the relationship with big five personality traits, professional skepticism according to Farag & Elias, (2016) has a relationship with anticipatory socialization where differences in the level of knowledge about something can affect each individual's attitude towards it, and this attitude will affect the person's intention in pursuing his profession, including when accounting students become auditors who must uphold professional skepticism in order to avoid fraud. This anticipatory socialization variable is related to the importance of professional skepticism to properly review financial statements. Farag & Elias, (2016) show the results of research that professional skepticism has a positive relationship with anticipatory socialization. These results are supported by research by Elias, (2006) who found a strong positive relationship between anticipatory socialization accounting students and their ethical perceptions of earnings management practices. Ahmad et al., (2012) in his research also showed the results that the level of anticipatory socialization of accounting students had a positive relationship with professional commitment.

The purpose of this study was to determine the effect of big five personality traits on anticipatory socialization mediated by professional skepticism. The contribution of this research for Islamic accounting and accounting students, to describe the extent to which the nature of professional skepticism among accounting students and to recognize certain personality characteristics to be introduced into auditing training in addition to showing that accounting students with high levels of skepticism will have a high level of anticipatory socialization

experience. tall one. Also, this research is expected to broaden the horizons for final semester accounting students who want to be involved in the world of auditing and to develop their professional skepticism since college so that they can prepare themselves to become good auditors and of course maintain their professionalism as auditors.

## 2 Literatur Review

This study uses cognitive dissonance theory. Cognitive dissonance theory is a social psychological theory about individual feelings that are uncomfortable because of inversely related behaviors, attitudes and thoughts, and how this motivates individuals to make changes because of their discomfort (Aminudin & Suryandari, 2016). This theory will explain the relationship between a person's personality with professional skepticism and anticipatory socialization. The personality of accounting students will determine the level of professional skepticism of auditors later, therefore this anticipatory socialization is used by students to prepare themselves before becoming auditors in order to apply professional skepticism in the auditing process. The concept of cognitive dissonance is used because being an auditor has risks in their work, such as problems during auditing. For example, the auditor trusts the client too much, while the auditor's professionalism requires skepticism in the assessment of audit evidence. So, students who later work in the auditing profession must try to change this dissonance. By changing their attitudes and behavior, harmony will be achieved. In the big five personality traits, one of which is neuroticism, where this trait prefers to avoid problems and risks. So this trait will tend to run away from stressful problems. If students have these characteristics when they become auditors, it will cause dissonance. Therefore, students who are auditors must reduce such traits and attitudes so that harmony can be achieved (Li et al., 2014).

Anticipatory socialization is a person's actions regarding all the learning they receive during their education which is used in taking action before entering the agency or profession. According to research conducted by Farag & Elias, (2016), anticipatory socialization uses indicators based on research by Clikeman & Henning, (2000) entitled *The Socialization of Undergraduate Accounting Students with 4 indicators Misstate, Disclosure, Cost Benefit, and Responsibility*, consisting of 11 question items. Big five personality traits are groupings of thousands of human traits and characteristics into five big personalities called personality dimensions, which consist of extraversion (an individual attitude is related to the attitude of an individual who is friendly, adaptable, active, enthusiastic, and has a positive mood), agreeableness (individual attitudes related to altruism where individuals will tend to have a trusting, warm, cooperative, polite, sympathetic, and helpful attitude), conscientiousness (the attitude of individuals who are generally cautious before acting), neuroticism (negative

attitudes of individuals because they tend to be emotionally unstable, nervous, moody, and jealous and cause individuals to be easily anxious and easily angry), and openness (will tend to have an imaginative mind, creative, subtle, moderate and like new things). To measure the big five personality traits, the researchers used indicators from the research Farag & Elias, (2016) which is based on research conducted by Donnellan et al., (2006) research entitled *The Mini-IPIP Scales: Tiny-Yet-Effective Measures of The Big Five Factors of Personality* using 20 items in a questionnaire called the mini-IPIP scale (International Personality Item Pool).

Professional skepticism is the ability to think critically in questioning and digging up audit hills to be able to provide an assessment of financial statements. So that professional skepticism is one of the things that can affect the auditor's ability to question or think critically about any indications of fraud caused intentionally or unintentionally in the financial statements that affect the assessment of the financial statements. Professional skepticism is measured by being measured based on research by Hurtt, (2010) entitled *Development of a Scale to Measure Professional Skepticism*, with indicators using a 30-item questionnaire containing 6 indicators Questioning Mind, Suspension of Judgment, Search for Knowledge, Interpersonal Understanding, Autonomy, and Self-Esteem.

## **2.1 Hypothesis Development**

### **2.2 Big Five Personality Traits on Anticipatory Socialization**

Farag & Elias, (2016) argue that students who have positive personality characteristics and high skepticism will tend to be successful auditors in their profession. Extraversion is a human trait associated with a friendly and adaptable individual attitude, so people with an extroverted personality will tend to look for problems and be skeptical when faced with the profession they are doing. This opinion is supported by Rustiarini, (2013), Santoso, (2018) and Dewi et al., (2015) which state that extraversion has a positive effect on professional skepticism. So the hypothesis in this study: H1a. Extraversion has a positive effect on professional skepticism. Agreeableness is a human trait associated with trusting, warm, cooperative, polite, and sympathetic attitudes. This personality will tend to uphold honesty towards users of financial statements, because dishonesty will have a negative impact on users of financial statements. Therefore, high skepticism is carried out as best as possible in the audit process. This opinion is supported by research by Rustiarini, (2013), Santoso, (2018) and Farag & Elias, (2016) which state that agreeableness has a positive effect on professional skepticism, so the hypothesis of this study: H1b. Agreeableness has a positive effect on professional skepticism. Conscientiousness relates to being careful before acting. Research conducted by Farag & Elias, (2016), Rustiarini,

(2013), Santoso, (2018), and Dewi et al., (2015) stated that there was a positive influence of conscientiousness with professional skepticism. Where people with this personality will tend to be highly skeptical in the audit process because they uphold the precautionary principle to do the best in their work. So the hypothesis of this research: H1c: Conscientiousness has a positive effect on professional skepticism.

Openness is a personality that is associated with a critical mind and thinks about all the findings they get, so they will have a very big skepticism. Larimbi et al., (2017) also stated that auditors who have more experience have high professional skepticism. This opinion is supported by Rustiarini, (2013) and Dewi et al., (2015) which state that of the five traits, extraversion, agreeableness, conscientiousness, and openness have a positive influence on auditor performance, so the hypothesis in this study is H1d: Openness has a positive effect on professional skepticism. Neuroticism is a trait related to emotional stability, in which this personality trait is prone to negative emotions. Khan & Harding, (2020) neuroticism has a negative influence because auditors who have low emotional control tend to be able to cope with it while maintaining their profession, so that it will not affect their performance. This opinion is also supported by research by Farag & Elias, (2016), Rustiarini, (2013), and Santoso, (2018). So the hypothesis in this study are H1e: Neuroticism has a negative effect on professional skepticism.

### **2.3 Big Five Personality Traits on Anticipatory Socialization**

People with an extraversion personality tend to have a friendly and adaptive attitude towards their new environment. Where this personality becomes the main determinant in work when it comes to interpersonal and adaptive to the work environment for the success of the team in their work (Li et al., 2014). The greater the extraversion of a person, the higher the anticipatory socialization, so the hypothesis in this study is H2a: Extraversion has a positive effect on anticipatory socialization. Agreeableness is owned by people with honest and trustworthy personalities. People with this personality will tend to sympathize with others. Someone with this personality will have a better understanding of science than other employees who have a low level of anticipatory socialization. Because the high anticipatory socialization will have a lot of information that can be used to identify other people's personality types and interact in their professional environment. This opinion is supported Li et al., (2014) and Lamsa et al., (2008) so that the hypotheses in this study are: H2b: Agreeableness has a positive effect on anticipatory socialization. Conscientiousness has a prudence of all things. In the research of Farag & Elias, (2016) stated that people with this personality will be careful in preparing financial reports by applying anticipatory socialization that has been obtained during the development period in college. Research Li et

al., (2014) also shows that there is a positive relationship between anticipatory socialization and conscientiousness personality types, especially on employee performance. Employees who have high prudence tend to carry out high anticipatory socialization as well. These results indicate that anticipatory socialization is broadly beneficial for a person's characteristics, so the hypothesis of this study I H2c: Conscientiousness has a positive effect on anticipatory socialization.

Openness is the personality of someone who is creative and likes something new. Where positive characteristics can explain curiosity about something very large, so that personality will have a positive relationship with anticipatory socialization. This is also supported by research by Farag & Elias, (2016) and Li et al., (2014) which state that there is a positive relationship between openness and anticipatory socialization, so the hypotheses in this study are: H2d: Openness has a positive effect on anticipatory socialization. The nature of neuroticism shows a negative influence on anticipatory socialization, because this personality has unstable emotions such as anxiety, anger, and depression so that this character is predicted to have a negative relationship with anticipatory socialization. This opinion is supported by Farag & Elias, (2016) and Li et al., (2014) so the hypotheses in this study are H2e: Neuroticism has a negative effect on anticipatory socialization.

#### **2.4 Professional Skepticism on Anticipatory Socialization**

Research conducted by Farag & Elias, (2016) states that professional skepticism has a positive effect on anticipatory socialization. This is also supported by research by Ahmad et al., (2012) that the level of anticipatory socialization among accounting students produces a positive relationship with professional commitment. Elias, (2006) found a strong positive relationship between anticipatory socialization accounting students and their ethical perceptions of earnings management practices. When anticipatory socialization is high, professional skepticism will also increase. So that cognitive dissonance theory can occur when students do not increase their anticipatory socialization. So the hypothesis in this study are H3: Professional skepticism has a positive effect on anticipatory socialization.

### **3 Research Method**

This study used a sample of 125 accounting students class 2018 and 2019 at Raden Mas Said State Islamic University Surakarta and Muhammadiyah University Surakarta who had taken auditing courses and passed the courses. Data collection using questionnaires and sampling techniques using purposive sampling, the formula used to determine the sample based on the theory of data

analysis using theory Ferdinand, (2014). Data analysis using structural equation modeling-partial last square (SEM-PLS).

#### 4 Results and Analysis

The measurement model or outer model aims to test the validity and reliability of a processed data. The important stages are Convergent validity, discriminant validity, composite reliability, and Cronbach alpha. This study has met the validity and reliability test where the rule of thumb value is greater than 0.7. In addition, this study uses a 5% significance with the Rule of thumb used, namely t-statistics > 1.96 and p-values < 0.05. The results of hypothesis testing are as follows:

**Table 1** Hypothesis Test Results.

	<b>Sampel Asli (O)</b>	<b>Standar Deviasi (STDEV)</b>	<b>T Statistik</b>	<b>P Values</b>
E -> SP	0,025	0,081	0,304	0,761
E -> SA	0.355	0.060	5.962	0.000
A -> SP	0.203	0.099	2.060	0.040
A -> SA	0.250	0.076	3.280	0.001
C -> SP	0.418	0.117	3.564	0.000
C-> SA	0.162	0.077	2.110	0.035
N -> SP	-0.099	0.073	1.356	0.176
N ->SA	-0.132	0.062	2.110	0.035
O -> SP	0.078	0.131	0.590	0.556
O ->SA	-0.162	0.068	2.379	0.018
SP -> SA	0.318	0.077	4.112	0.000

The extraversion variable has a t-statistic value of 0.304 and p-values of 0.761 so that extraversion has no effect on the professional skepticism of accounting students at UIN Surakarta and UMS. This is the same as the research conducted by Suryandari & Yuesti, (2017). This is because accounting students believe that they can apply professional skepticism when becoming an auditor without having to consider the personality of an auditor. The extraversion variable has a t-statistic value of 5.962 > 1.96 and p-values 0.000 < 0.05 and the path coefficient value indicates a positive direction of 0.355 which indicates a positive influence on anticipatory socialization. This is in line with research conducted by Farag &

Elias, (2016), Li et al., (2014), and Santoso, (2018). Students with extraversion personality tend to have an adaptive attitude and this makes it easier for them to work later when dealing with interpersonal and work environments. Accounting students at UIN Surakarta and UMS have high extraversion for when they later become auditors, they are easy to adapt to their team and work environment. Individuals who are easy to socialize and adaptive to their work environment will tend to be more aware of various conditions and interpersonal problems.

Agreeableness has t-statistics and p-values of 2.060 and 0.040, respectively. The path coefficient on the agreeableness variable also shows a positive direction of 0.203. The results of this study support the results of research conducted by Farag & Elias, (2016), Rustiarini, (2013), Dewi et al., (2015), and Santoso, (2018) which stated that there was a positive influence of agreeableness personality on professional skepticism. Students with agreeableness personalities tend to uphold honesty in their future work. For example, being honest in the use of financial statements, because they are aware and feel that dishonesty will have an impact on users of financial statements. So that skepticism will be carried out as well as possible in the auditing process. Agreeableness variable has a path coefficient value of 0.250 which indicates a positive direction. In addition, the t-statistics and p-values on the agreeableness variable were 3.280 and 0.001. In cognitive dissonance theory, individuals who have empathy tend to be able to understand and find out why other people behave in certain ways. In his work when he later becomes an auditor, it is very necessary to dig up information as audit evidence and can be accounted for. Accounting students at UIN Surakarta and UMS will tend to identify audit evidence before making decisions and when they become auditors they will produce accurate financial reports.

The conscientiousness variable has a t-statistic value of 3.564 and p-values of 0.000 with a path coefficient value of 0.418 which indicates a positive direction. The results of this study support the results of research conducted by Farag & Elias, (2016), Rustiarini, (2013), Dewi et al., (2015), and Santoso, (2018) which state that the conscientiousness variable has a positive influence on professional skepticism. Accounting students at UIN Surakarta and UMS have high conscientiousness personalities, complete assignments quickly, have memories of what I will do, and do it in a structured manner. This personality will tend to quickly complete the given task in a fast, structured, and detailed manner. In the auditor profession, this personality will have a lot of information obtained to be used as audit evidence, where the more audit evidence obtained, the individual must have a high sense of skepticism. Conscientiousnes who have t-statistics and p-values of 2.110 and 0.035. The path coefficient value of 0.162 indicates a positive direction. Where this personality will tend to be careful in preparing financial statements later when working. In addition, students with this personality will tend to be careful in doing their assignments which can minimize

the risk of errors in the audit process. So it can be concluded that individuals who have high caution can increase high anticipatory socialization as well.

Openness has a path coefficient value of 0.078 which indicates a positive direction. The t-statistic value is 1.356 and the p-value is 0.176. There are conditions that are not met where t-statistics  $< 1.96$  and p-values  $> 0.05$ , The results of this study indicate that there is no effect of openness on the professional skepticism of accounting students at UIN Surakarta and UMS. The results of this study support the results of research conducted by Suryandari & Yuesti, (2017) which states that openness has no effect on professional skepticism and the ability to detect fraud. This means that accounting students at UIN Surakarta and UMS agree that openness does not affect professional skepticism. Where skepticism can still be applied during the auditing process without having to look at the openness of an auditor's personality. The openness variable has a path coefficient value of -0.162 which indicates a negative direction. The t-statistics and p-values are 2.389 and 0.018. This value indicates a negative and significant effect of openness on anticipatory socialization. Accounting students at UIN Surakarta and UMS do not understand abstract ideas, but are still able to apply anticipatory socialization in their new environment to maximize their performance.

The last big five personality is neuroticism. Neuroticism personality has a path coefficient value of -0.099 which indicates a negative direction. The t-statistics and p-values are 1.356 and 0.176 this shows that there is no influence between neuroticism on professional skepticism. On average, accounting students at UIN Surakarta and UMS experience rapid emotional changes and have no influence with professional skepticism. Accounting students will control their emotions even later in the world of work and when it is associated with the professional skepticism of an auditor, the individual will still be able to control his emotions in the existing situation and still maintain his professional skepticism as an auditor. The path coefficient value for neuroticism is -0.132 which indicates a negative direction. The t-statistics and p-values were 2.110 and 0.035 which resulted in the neuroticism variable having a negative and significant effect on anticipatory socialization of accounting students at Raden Mas Said State Islamic University Surakarta and Muhammadiyah University of Surakarta. The results of this study support the results of research conducted by Farag & Elias, (2016), and Li et al., (2014) which state that neuroticism has a negative influence on anticipatory socialization. To be able to apply high anticipatory socialization, accounting students at UIN Raden Mas Said Surakarta and Muhammadiyah University Surakarta must be able to reduce this personality in order to maximize the application of anticipatory socialization in their new environment and get good performance.

Professional skepticism variable has a path coefficient of 0.318 which indicates a positive direction, with t-statistics and p-values of 4.112 and 0.000. The results of the study support the results of research conducted by Ahmad et al., (2012) and Farag & Elias, (2016) which stated that there was a positive relationship between professional skepticism and anticipatory socialization. The higher the application and understanding of anticipatory socialization of accounting students at the two universities in the world of auditing will increase the nature of auditors' professional skepticism. By applying the understanding of the auditor's code of ethics received during the college period, it will be useful to provide an assessment of financial statements and can minimize misstatements in financial statements. In addition, the auditor can also dig up accurate audit evidence with the ability to ask questions, the ability to think, and like to seek knowledge.

this study also conducted additional testing and stated the following results:

**Table 2** Mediation Test Results.

	<b>Sampel Asli (O)</b>	<b>Standar Deviasi (STDEV)</b>	<b>T Statistik</b>	<b>P Values</b>
E -> SP -> AS	0.008	0.026	0.304	0.761
A -> SP -> AS	0.064	0.033	1.955	0.051
C -> SP -> AS	0.133	0.045	2.960	0.003
O -> SP -> AS	0.025	0.044	0.563	0.573
N -> SP -> AS	-0.031	0.024	1.307	0.192

The indirect effect of extraversion on anticipatory socialization through the mediating variable of professional skepticism is 0.008. From the value in the first stage of 5.962 and the second stage of 0.304, which means it has decreased and is not significant. So it can be concluded that full mediation professional skepticism influences extraversion on anticipatory socialization. The indirect effect of agreeableness on anticipatory socialization through the mediating variable of professional skepticism is 0.064. From the value in the first stage of 3.280 and in the second stage of 1.955, which means it has decreased and is not significant. So it can be concluded that professional skepticism is a full mediation of the effect of agreeableness on anticipatory socialization. The effect of conscientiousness on anticipatory socialization through the mediating variable of professional skepticism is 0.133. From the value in the first stage of 2.110 and in the second stage of 2.960, which means that it has increased and is significant. So it can be concluded that professional skepticism does not mediate the effect of conscientiousness on anticipatory socialization. The effect of openness on anticipatory socialization through the mediating variable of professional skepticism is 0.025. From the value in the first stage of 2.379 and in the second stage of 0.563, which means it has decreased and is not significant. So it can be concluded that full mediation professional skepticism influences openness on anticipatory socialization. The effect of neuroticism on anticipatory socialization

through the mediating variable of professional skepticism is -0.031. From the value in the first stage of 2.110 and in the second stage of 1.307, which means that it has decreased and is not significant. So it can be concluded that full mediation professional skepticism influences neuroticism on anticipatory socialization.

## 5 Conclusion

The results of this study prove that the big five personality traits consisting of agreeableness and conscientiousness have a positive and significant influence on professional skepticism. Extraversion, openness, and neuroticism have no effect on professional skepticism. Extraversion, agreeableness, conscientiousness, openness, and professional skepticism have a positive and significant influence on anticipatory socialization. neuroticism has a negative and significant effect on anticipatory socialization.

The scope of this research is only limited to students of the accounting study program at UIN Raden Mas Said Surakarta and Muhammadiyah University Surakarta, so it is necessary to conduct extensive research. suggestions for further researchers are advised to use broader research objects or data outside of this research so that it can be stated broadly and thoroughly, such as using respondents from more than two universities and It is hoped that further researchers can explore other mediating variables in order to explain the role of anticipatory socialization.

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## Flexible Work Arrangement Factors to Determine Startup Office Workspace Models in New Normal Situation

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**Abstract.** Flexible Work Arrangement (FWA) is a common trend used by companies during the COVID-19 pandemic. Technological developments make startup companies appear. FWA is the choice of startup companies to carry out work activities, besides those economic conditions are the main reason for the implementation of FWA. Employees will continue to depend on the work area to carry out various work activities such as focus, face-to-face interaction, and collaborative work. It is necessary to determine a new workspace model to support employee work activities. This is the main strategy in designing a new work environment for startup companies to face business competition in the new normal situation in order to reduce the cost of renting a work area in the midst of high rental prices for office land in the business center district. This study focuses on identifying FWA factors and office workspace attributes to determine the new workspace model for startup companies. Using a qualitative approach research method, the data was generated through a Focus Group Discussion (FGD). The results of the study are 12 FWA factors that affect the attributes of the workspace model in the new normal situation.

**Keywords:** *flexible work arrangement; new normal startup; workspace.*

### 1 Introduction

Work practices such as flexy time, work locations, and use of technology have increased by 140% since 2005 due to global technology progressing very well [1]. This provides support for employees working outside the office and bringing work home. In addition, flexible work arrangements (FWA) also make it easier for organizations to recruit, retain employees, reduce employee absenteeism [2] and technological developments have an impact on economic growth. Various new companies have sprung up, especially in the technology sector. Startup companies are the topic of conversation in the business sector [3]. The use of technology and digitalization is changing the paradigm of conventional business

models. It is known that startup company employees are dominated by generations Y and Z, this generation has a different view from other generations towards the work environment [4] such as non-formal working and flexible work.

Flexibility is the keyword to define a startup company. FWA is an option applied by startup companies to carry out employee work activities. In addition, economic conditions are the main reason for the implementation of FWA. Employees can choose their work location, this is an advantage for startup companies to reduce the cost of office facilities and infrastructure, in line with the government's efforts to change conventional business patterns to hybrid ones is the government's first step to protect employees in breaking the chain of transmission of the COVID-19 virus, written in the Decree of the Minister of Health of the Republic of Indonesia number HK.01.07/menkes/328/2020 and government regulation number 21 of 2020. This change also has an impact on the way employees communicate and work patterns, such as Work from Home (WFH), where this work pattern is a form of implementing FWA.

The pandemic has triggered major changes in global work patterns. New behaviors, new technologies, and adjustments to new ways of working are aspects that need to be understood more deeply about the fundamental role of the office [5]. Mass vaccination in Indonesia is a government effort to restore daily activities, one of which is work activities. It is impossible for the world of work to carry out restrictions forever because the country's economy must continue to run. Optimizing workplace readiness is a further effort that can be done at this time, so that employees can adapt to changing lifestyles in new normal situations.

The general chairman of the Indonesian Technology Startup Association, Handito [6] stated that Indonesia has 2,229 startup companies and occupies the fifth largest position in Asia until April 2021. 10 to 15 percent of startup companies are out of business in Indonesia. The strategy of startup business activists needs to be considered in order to complete the needs and readiness for competition in the new normal situation. Designing a workspace is certainly one of the opportunities and strategies that startup companies need to consider. Such as designing a new work environment, more digital office areas, layout, and consideration of the use of furniture. In addition, an assessment of employee activities during the pandemic needs to be carried out because it has an impact on space management in the new normal situation [7] [8].

In recent years, the office has become a social destination for designers to focus on office design with an emphasis on activity-based working. FWA is a familiar thing when there is a radical change in work activities caused by the covid-19 pandemic. According to the Georgetown University Law Center, FWA is a concept of flexible work arrangements by changing work patterns that allow

employees to be able to make their choices. These arrangements include flexibility in working hours (flexy time), flexibility in the number of working hours (shifting and job sharing), flexibility in the workplace (work from anywhere). This is an advantage for employees in working time arrangements [9], FWA also affects the shift in the meaning of the office, meaning that when humans can do work anywhere and when they go to the office only for social interaction with other employees or colleagues, the meaning of the office turns into a social destination [10] [11].

In the development of the workspace model, work activities are always related to the employees who work in it. Employee development is due to the ever-evolving structure and function of the office workspace. The design of the workspace model adapts the form and produces employee satisfaction, comfort, and efficiency. According to previous research, the physical attributes of the workspace that need to be considered before designing a new workspace model include:

**Table 1** Workspace Physical Attribute.

<b>Variable</b>	<b>Researcher</b>
Workspace layout	De Paoli dkk (2017), Haynes (2009), Kallio dkk (2015), Zeiny (2012)
Density and Distance	Charles dan Veitch (2002), May dkk (2005), Nag (2019), Nag (2019), Sugiyama dkk (2021)
Workstation	Nag (2019), Muchtar (2021)
Partition	Goin dkk (2010), Lee (2010), Nag (2019)
Accessibility	Nag (2019)

Startup companies are synonymous with startup companies that involve the use of information technology in business products [12]. Startup company work culture is different from corporate culture because of the need for a clear company vision, setting short-term goals and employees having the same mindset [13]. Most startup companies have flexible organizational forms with centralized specific business strategies. Generally, this company has a collaborative work pattern.

This research needs to be carried out aiming to contribute to complementing the FWA factors that have not existed in previous studies, providing an

understanding of the process of the relationship between human activities and work facilities in new normal situations. In addition, the results obtained can also be used as a basis for evaluation for designers and company management in understanding the activities of company employees so that the design of a new workspace model for startup companies becomes appropriate and ideal in new normal situations.

## **2 Research Methodology**

This study used a qualitative approach with a descriptive method. Qualitative research method was used to examine natural objects where the researcher acts as a key instrument, data collection techniques are carried out in a combined manner, data analysis is inductive and qualitative research results emphasize meaning rather than generalization [14]. The focus of qualitative research was used to emphasis on a wider and deeper angle to reveal a phenomenon object of research [14]. The purpose of this descriptive research is to reveal events or facts, circumstances, and phenomena being investigated.

### **2.1 Collecting Data Method**

Data was distributed online Focus Group Discussion (FGD) method, via web-conferencing systems, Zoom. Data was conducted in March 2022 from 5 participants, according to Koentjoro [16] too many participants in one discussion group will reduce the opportunities from each participant to provide deep thoughts and aspirations so that the FGD implementation were divided into two groups with a duration of 90 minutes each group. This research used purposive sampling technique to determine research participants. The decision to use this technique is in accordance with the criteria and research needs [14]. The selected participants are employees who work in startup companies in Jakarta with the minimum position criteria of manager from different types of startup industry with cockroach and ponies level startup. By selecting those categories, we hope we can provide an understanding of the diversity of industries and startup levels in dealing with work situations during the pandemic and related to FWA factors.

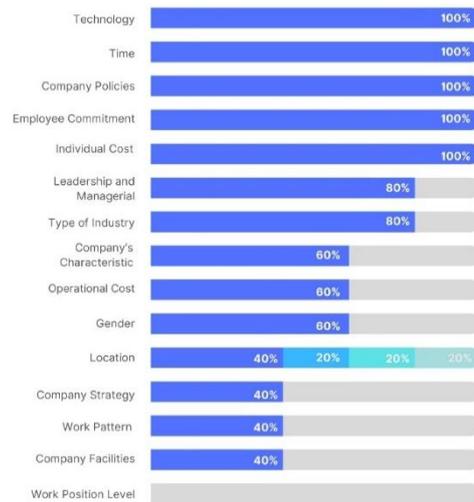
### **2.2 Data Analysis Method**

The data collected was then analyzed using open coding techniques to identify keywords based on the answers of research participants to the FWA factors, then these factors are correlated with literature studies regarding the physical attributes of the workspace and analyzed were used descriptive analysis.

### 3 Result and Discussion

#### 3.1 FWA Factors

Based on graph 1, there are 15 factors that affect the FWA of startup employees during the pandemic and 1 factor that does not affect the application of the FWA concept, namely the position factor.



**Figure 1** Startup Employees FWA Factors.

Technology, time, company policies, employee commitment and personal budget are FWA factors that greatly affect participants in flexible work. 100% of the participants agreed that technology is the main factor in completing work online. Internet speed is a crucial thing that companies need to pay attention to, according to participants, internet connection speed affects employee work performance when implementing FWA.

The time-saving factor affects FWA, participants feel they benefit when implementing FWA, because there is no time wasted on traveling to the office location.

The company's policy factors have an influence on the implementation of FWA, giving freedom to employees to determine their choice of work (WFH or WFO)

The employee commitment factor is needed to build trust in the company and all participants feel that implementing FWA saves their personal expenses, such as saving on transportation money, in addition 40% participants also say that they

save money on food, 60% of participants do not feel that way because they keep buying food through the online food delivery.

Leadership and managerial factors, the participants stated that these factors affect the ease of work flexibility such as the division of work tasks for each employee.

The type of industry factor also affects the implementation of employee FWA, as many as 20% of participants stated that they changed their type of industry during the covid-19 virus pandemic, this type of industry is the outsourcing industry. In essence, it can be concluded that not all types of industries can apply FWA.

The company's characteristic factors also affect the implementation of FWA, 60% of participants stated that they had implemented work from anywhere before the covid-19 pandemic.

The operational cost factor, 60% of the participants agreed that the implementation of FWA can reduce the company's operational costs because of the savings in electricity costs and employee mobility. 40% of participants stated that their startup companies moved their work locations due to the high cost of renting office land in high rise buildings and the lack of profits during the pandemic.

Gender factors are considered in the application of FWA, as many as 60% of participants stated that employees who choose to apply FWA or work from home are female employees, while male employees tend to choose to work in the office.

The work location factor, based on the results of the study, 40% of participants stopped renting office land in Mega Kuningan and renting houses and renting coworking space. 20% of participants plan to rent office land in SCBD Jakarta with a smaller land area, 20% of participants rent shop houses in the mall area, 20% of participants rent office land in south Jakarta with a smaller area and only used for meetings and correspondence processes.

For company strategy factors, work patterns, and company facilities factors, 40% of participants stated that it was necessary to implement a strategy from the management towards work arrangements in new normal situations with the aim of reducing operational costs. For the work pattern factor, participants stated that if the pattern applied in the long term was to work from home (WFH), it would have an impact on employees stress and work did not achieve maximum results during the collaborative work process and exchange of ideas. All participants agreed that it is necessary to provide facilities from the company, especially internet allowance benefit to support employees when implementing FWA.

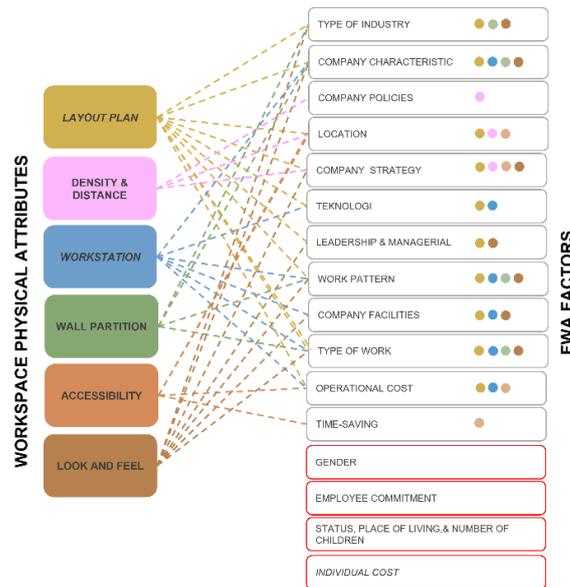
Work position level factors, 100% of participants did not agree that the career position factor affects the implementation of FWA in startup companies, this is contrary to ASN research, according to participants all employees with various types of positions can work flexibly without problems using technology-based applications.

Of the 16 factors in graph 1. There are 2 other factors that are considered by all participants. The first factor is the type of work. The participant stated that the type of work related to finance and sales was prioritized for working in the office during the pandemic and the new normal situation because it was related to physical documents and face-to-face interaction. Types of work such as web developers and programmers are given the freedom by the company to choose a work location and are not required to work in an office. The second factor is status, place of living, and number of children. These factors are closely related. participants stated that the lowest level of disturbance was found in participants who were married, had their own house, and did not have children, this had an impact on working from home activities and the least number of work disturbances experienced when WFH. While the highest level of disturbance is found in participants who are married, have their own house and have children. This is crucial because the noise level at home is very high and not effective to the application of WFH.

Of the 18 factors that have been described, 17 factors affect FWA and 1 does not. The researcher selected these factors to determine the new workspace model for the startup office when facing a new normal situation by referring to Hameed and Amjad's statement [17] before designing a new workspace model, it is necessary to have an analysis process and a process of identifying the factors that affect work activities, this is intended so that the design of the workspace model is appropriate for a company.

### **3.2 FWA Factors Affecting Workspace Physical Attributes**

According to Nag [18], before designing a workspace model, it is necessary to consider the use of the physical attributes of the workspace. The physical attributes of the workspace include workspace layout, density, distance, workstations, partitions, accessibility, and work area aesthetics (look and feel).



**Figure 2** FWA factors that affect the physical attributes of the workspace.

**a. Layout**

Layout plan are influenced by the type of industry, organizational characteristics, work location, company strategy, technology, leadership and managerial, work patterns, company facilities, type of work and operational cost budget. According to Haryadi [19], Space in relation to humans is designed to fulfill a function or use of that space. In line with Wohlers & Hertel [20] studies which results in the type of industry, characteristics, work patterns, and social interaction between employees need to be considered when designing a workspace layout, in line with Candido [21]. Workspace layout must support work patterns and a variety of work activities, such as enhance an employee focus, collaborative work, face-to-face interaction Company strategies such as work schedule setting at the office (WFO) and working from home (WFH), leadership and managerial are also FWA factors that support the determination of workspace attributes because it can be a win-win solution for employees and the company [22]. Leadership and managerial have an influential role in the process of work coordination, company goals, and work patterns while working online [23]. Technology is an FWA factor that needs to be considered for determining the workspace layout in a new normal situation, technological changes have gone hand in hand with company strategy factors, work patterns, and work culture characteristics [24]. This statement is also in line with Ajzen & Taskin [25] statement, workspace layout design needs to be focused on employee FWA which has an impact on technology. In addition,

companies also need to ensure the availability of appropriate communication and technology facilities for every employee who implements FWA [26] in line with research by Choi [27] regarding technology facilities is an important factor for the implementation of employee FWA.

#### **b. Density and Distance**

Density and distance are influenced by company policy, work location, and company strategy. The COVID-19 pandemic has changed the perception of all employees to maintain a distance between individuals. This research is in line with the statement by Puckett & Hammer [28] that there are company policies and strategies to regulate the ratio of employees working in the office. This is in line with research of Omondi [29] regarding FWA can benefit the company owner and employees if there is a policy that has been set by the company owner. Employees do not return to the office at the same time, but the arrangement of different work schedules between employees is one strategy to limit distance. Aburas [30] also stated that the number of employees in one permanent office would be reduced by a hybrid work pattern strategy.

#### **b. Workstation**

Workstations are influenced by organizational characteristics, technology, work patterns, company facilities, type of work, operational cost budget. Referring to research by Ávila [31], workstations must meet the needs of work activities, where work activities are closely related to considerations of organizational characteristics, types of work, and work patterns. Kawecka-Endler & Mrugalska [32] also stated that the characteristics of the company and work patterns are the basic criteria in choosing the type of workstation. The characteristics of startup companies are identical to collaborative work patterns, namely the union of several individuals or organizations with objective goals [18] and requires high interaction between employees. This is in line with research by Ávila [31] that communication and the role of technology are factors that influence the determination of the type of workstation. In addition, the facilities and operational cost budget provided by startup companies also affect the choice of workstation type.

#### **c. Partition**

Partition is influenced by the type of industry, organizational characteristics, work patterns, types of work. This is in line with the statement of Aburas [30] regarding the configuration of the workspace model during the pandemic, employees have the view that partitions are not their size, they will avoid the spread of viruses, especially high partitions and four walls. Aburas' research [30] results that some employees have the view that low partition is safe enough to carry out work patterns when employees return to the office.

#### **d. Look and Feel**

Workspace look and feel are influenced by the type of industry, organizational characteristics, company strategy, leadership and managerial, work patterns, company facilities and type of work. Many studies have been conducted on the look and feel of the workspace on the creativity and work performance of employees [33]. Schein [34] states that individual reactions to look and feel are influenced by organizational characteristics, work patterns, and types of work so that they form the work environment and culture of the company itself. Look and feel is an attribute of the workspace model in designing a workspace model in a new normal situation because it affects creativity, employee work performance, and employee perceptions of the new workspace model when returning to work in the office.

#### **4. Conclusion**

The design of the workspace model is the arrangement of the workspace so that work can be done efficiently. The design of the work area by taking into account the physical attributes of the workspace. The design of the work area is an important factor for the formation of employee job satisfaction and affects the way employees work. Analysis and identification of factors for the application of work patterns need to be applied before designing a workspace model, this is intended so that the design of a workspace model is appropriate for a company. Designing a new workspace model is a fundamental thing that becomes a priority to achieve the company's business targets with objective considerations during the design process.

In this study, 12 FWA factors were found that affect the physical attributes of the workspace for designing a new workspace model for a startup office in a new normal situation. These factors are: type of industry, organizational characteristics, company policies, work location, company strategy, technology, leadership and managerial, work patterns, company facilities, type of work and operational cost budget.

The results of the research analysis found that there are FWA factors that greatly affect the physical attributes of the workspace model such as organizational characteristics, company strategy, work patterns, and types of work. Further researchers can examine the FWA factors that affect the attributes of the workspace model in a larger number of samples, and different types of industries so that the results obtained can be better and more accurate.

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## Comparison of Original and Modified Buton Weaving in Kulisusu Buton Utara

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**Abstract.** North Buton Regency is the furthest area from Buton Sultanate's cultural center which was recently formed in 2007. It has the lowest quantity in weaving production. However, the use of original Buton Weaving at traditional events at the *Kulisusu* Palace North Buton is still sacred but new conditions are emerging more mass and industrial. This study investigates the relationship between aspects of meaning, production, and utility in Buton Weaving in North Buton and comparison between original and modern Buton Weaving. The ethnographic method is carried out by interview on figures who are influential in the preservation and development of Buton Weaving and observation of traditional rituals at the *Kulisusu* Palace North Buton. The results of the analysis show a new insight that important aspects related to Buton Weaving are production process, utility, and meaning. The three aspects are interconnected and produce two contradictive conditions of Buton Weaving which is loaded with customary rules, sacred and the other hand freer, mass-produced conditions. Further research needs to be done to document the customary rules that are currently passed down through hereditary customs for North Buton to have a valid source to be referenced.

**Keywords:** *buton weaving; kulisusu, modern; northern buton; original; tradition.*

### 1 Introductions

Buton weaving is a heritage tradition of the Buton Sultanate, one of the great Islamic-style kingdoms located in Southeast Sulawesi. In the 14th century, during the leadership of Sultan Dayanu Ikhsanudin (1597 – 1631), the Sultanate of Buton used *kampua* (woven products) as a medium of trade. Weaving is also a social measuring tool. The types of motifs and patterns on Buton Woven fabrics can show a person's structural status, nobility title to marital status in women[1]. Until now, the people in the Buton region still preserve and adhere to traditional ordinances in the use of Buton Weaving as a sacred symbol [2].

One of the areas that inherited the tradition was Kulisusu, northern Buton. During the sultanate era, the Territory of the Buton Sultanate included the island of buton,

the island of muna, wakatobi, kabaena and parts of Sulawesi. The Sultanate of Buton has 4 main Barata in the form of small kingdoms and serves as a stronghold, namely Kaledupa, Muna, Tiworo and Kulisusu Palace Fort. This Barata region later became a residential area. and changed following the Indonesian system of government and forming districts [3].

North Buton Regency is the farthest territory of the former Buton sultanate and was recently formed in 2007 [4]. The establishment of North Buton was passed based on Law Number 14 of 2007. Although North Buton Regency is the farthest area and has only been formed for 13 years, the traditional traditions of the Kulisusu Palace, which was once part of the Buton Sultanate, are still very well preserved and sacred, the community uses the original Buton Weaving in palace rituals according to customary rules. (masri, 2011)

However, the tradition of using Buton Weaving, which is still maintained, is not comparable to the low number of Weaving industries in North Buton. Based on 2019 BPS data, buton weaving production in North Buton is the lowest among other regencies on Buton island (table 1), which is 5.95% of the total weaving industry on Buton Island [5]

**Table 1** The number of villages/kelurahan according to the existence of the fabric and weaving industry (source BPS 2019)

No.	Districts/Cities	Industrial of Fabrics / Weaving
1	Buton	7
2	North Buton	5
3	Middle buton	24
4	South Buton	28
5	Baubau City	20
<b>Total</b>	<b>Buton Island</b>	<b>84</b>

In fact, the North Buton Regency Government made a Strategic Plan to increase the contribution of massive cultural tourism both in traditional events and cultural festivals, including in the use of Buton Weaving. [6] With this strategic plan, demands for the use of Buton Weaving have arisen massively, the market demand for Buton weaving has increased so that the phenomenon of Industrial Weaving and modifications have emerged to meet market needs at mass events. Even the diversification of Buton Weaving is not only in the aspects of production but also the quality, type of product, use and price [7] strengthened by the presentation of the Ministry of Manpower which regulates the standardization of the weaving industry by the Ministry of Manpower in 2015. This regulation was made because there was a shift in the production of Buton Weaving from time to time. [8]

There is no research that examines the emergence of the phenomenon of modified Buton Weaving in the midst of the traditional traditions of the Kulisusu Palace in North Buton which is still sacred, making a study entitled "Comparison of Traditional and Modern Buton Weaving in the Culture of the North Kulisusu Buton Community" needs to be carried out to examine aspects of production, use and meaning related to Buton Weaving in North Buton Regency and comparing between the condition of the Original Weaving which is still maintained customary rules with the freer modified Buton Weaving / modern.

## 2 Methodology

This research uses a **qualitative approach using ethnographic methods** for the people of Kulisusu, North Buton Regency in southeast Sulawesi province. This research consists of 3 stages consisting of the stages of observation involved, interviews and data processing,

1. The first stage is *the participatory observation* stage that will be carried out on Buton weaving and community behavior related to the preservation of buton weaving traditions. Observations were made to find out what elements are important related to Buton weaving and the preservation of Buton weaving in everyday life.
2. The second stage is an interview with the source. This stage aims to obtain information about the culture and thoughts of the community related to Buton weaving. The Fieldwork is shown below:

**Table 2** Interview and observation fieldwork

Interview					
No	Time	Sources	As	Interview topics	Place
1	Week I April 2022	Irnowati, S.Sos	-Buton Weaving Users -practitioners of traditional dance lenses	<b>Utilities:</b> The culture of the use of buton weaving in the community includes its completeness, procedures for use and changes	Eelahaji North Buton
2	Week II April 2022	Mr. Agus salim, S.Kep	-Head of the Arts Division of the Department of Culture and Tourism. - Fashion Designer	<b>Meaning and Regulation:</b> The tradition of buton weaving in official academic manuscripts that become government documents and regulations related to buton weaving	Office Department of Culture and Tourism
3	Sunday II April 2022	Ahmad Isal, S.Pd	Art Division Staff of the Department of Culture and Tourism		

4	Sunday III April 2022	Husniati, S.Pd. M.Si	-Owner of Boutique and Buton Weaving House Restika -Weavers -Conservationist of weaving traditions	<b>Production and diversification:</b> Buton weaving production, the development of the buton weaving industry in northern buton and the diversification of buton weaving products	Restika Boutique, Wandaka, North Buton
5	Week IV April 2022	Mrs. Haliana	Sellers and Owners of Weaving shops in the Great Market of north buton	<b>Distribution and Product diversification:</b> Buton weaving supply chain in northern Buton, product diversification and consumer preferences	North Buton Big Market
6	Sunday II of May	Laode Ahlul Musafi, S.P.	Indigenous Stakeholders currently serves as King/Sultan of Kulisusu Palace	<b>Imposition:</b> Customary procedures and norms in the use of buton weaving. History and meaning contained in buton weaving (patterns, motifs, colors)	Tangkeno Sara'ea North Buton

- The third stage is data processing. At this stage the data will be transcribed into text and coded based on the main idea of the discussion, the theme codes are analyzed with affinity diagrams to find the relationships between themes arranged, then the data is interpreted.

### 3 Results and Discussion: Comparison of Original and Modified Buton Weaving in Kulisusu Buton Utara

#### 3.1 Original Buton Weaving

Original Buton Weaving is a buton weaving produced using conventional looms (heritage looms since the time of the sultanate) or Non-Machine Looms (ATMB) and worked by humans. The use of traditional Buton Weaving is more exclusive because it is used for important occasions of the Kulisusu Palace. In addition, the production of traditional weaving is very limited because its manufacture takes a long time and great effort. With a limited production process, the price of original Buton Weaving is sold at a higher price. This weaving is produced throughout the island of buton

##### 3.1.1 Utility

Based on an interview with Husniati, the owner of restika weaving house in North Buton, there are four motifs that are characteristic of North Buton and are very popular in North Buton, namely *Doridi*, *Leja*, *Kasopa giu giu* and *Katamba Gau*. The four types of weaving are original motifs inherited from ancestors and have not undergone modification from society (table 2)

**Table 3** The most popular types of traditional buton weaving in buton (source: interview of Husniati, figures taken by author,2022)

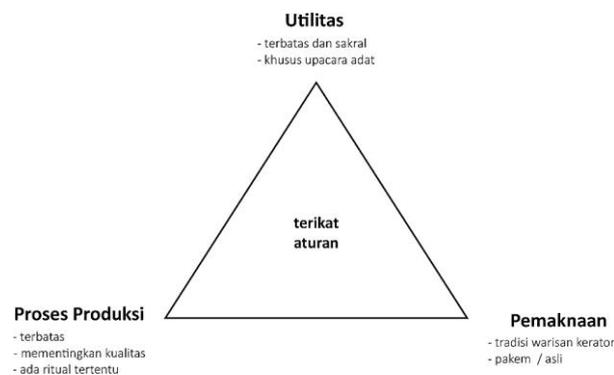
No.	Pattern	Picture	Characteristics
1	Doridi		<ul style="list-style-type: none"> <li>• Black and white in colour , can have a variety of shiny yarn or not.</li> <li>• Horizontal pattern</li> <li>• Especially worn by women</li> <li>• The type of Buton woven fabric used for sacred traditional events</li> <li>• Must be used for lense dance gloves</li> </ul>
2	Leja		<ul style="list-style-type: none"> <li>• Mixed color of yellow, green, or red.</li> <li>• The pattern line is horizontal and large</li> <li>• Used by women</li> <li>• Dominant for traditional events such as escorting proposals or weddings</li> </ul>
3	Kasopa Giu Giu		<ul style="list-style-type: none"> <li>• Colorful</li> <li>• The outline is horizontal</li> <li>• The pattern is small and tight</li> <li>• Used by Women</li> </ul>
4	Katamba Gau		<ul style="list-style-type: none"> <li>• Horizontal and vertical stripes (checkered)</li> <li>• The color can be any but, the most widely used is black and white</li> <li>• Used by men</li> </ul>

Original Buton weaving is commonly used on sacred occasions or traditional rituals at the Kulisusu Palace. The use of buton weaving in traditional events includes:

**Table 4** Traditions and rituals of *kulisusu* north buton

No	Rituals	Description
1	Eid al-Fitr and Eid al-Adha.	people of North Buton performed congregational prayers at the Kulisusu Palace Mosque. Male pilgrims used to use Buton Weaving sarongs and kampurui head accessories or Buton Weaving songkok.
2	Folk parties commemorate Eid al-Fitr and Eid al-Adha	After Eid, the traditional leaders of the Kulisusu Palace held a series of folk parties containing dances. At this event, traditional stakeholders are required to use nobility clothes sewn from Buton Woven fabric
3	Bringing a betel nut / offering for the bride-to-be.	Tandaki in North Buton is done to circumcise both boys and girls. One of the rituals is arak-arakan, the circumcised child will be dressed in traditional

	Circumcision or tandaki events.	clothes and paraded in a decorative carriage. Meanwhile, parents who organize circumcision events for their children use a pair of Buton Woven Fabrics The event of carrying a betel nut before marriage is carried out with the ritual of giving the goods of the woman's needs by her future husband. In this event, the delivery man wore a Buton Weaving sarong
5	Poongke (inviting guests)	Before the residents will hold celebrations such as weddings, circumcision, beckons, or shaving the host's hair, they will invite relatives, family and neighbors by coming to their homes using Buton Weaving scabbards
6	Dance Lenses	Especially for dance lenses, dancers are required to use a Doridi-type Buton Weaving sarong
7	Wedding Events	many processions use Buton woven cloth, including the mapaci tradition which is carried out on the night before the marriage contract, the bride-to-be is dressed up in a bludru shirt and a Buton Weaving sarong. In addition, there are parents who are called/hired to recite traditional verses typical of North Buton, the parents of readers of this verse use a Buton Weaving sarong
8	Haroa Banthea	This event is a meal together to express gratitude. Haroa is done to celebrate the harvest feast, welcome the month of Ramadan and holidays, celebrate the traditional events of the Palace in Baruga, harvest feasts etc. At this event, traditional stakeholders had to wear Buton Woven cloth and nobility clothes



**Figure 1** Scheme of the aspects relationship meaning, utility and production of original Weaving buton (source: author,2022)

Based on the presentation of aspects of meaning, utility / use and production process of original Buton Weaving, concluded that there is a relationship between the three aspects. The use of weaving is only used for sacred events and customary ceremonies that are bound by customary rules. Due to the limited intensity of use on traditional events and rituals of the Kulisusu Palace, the existence of the original Buton Weaving is only used at certain times so that the Artifacts of the Buton Weaving wastra can be changed both in terms of the quality of the weaving itself and its meaning. These limited and special needs are supported by a limited production cycle thus keeping the original buton weaving exclusive and sacred.

### 3.1.2 Meaning

Buton weaving as a tradition passed down from generation to generation since the time of the Buton Sultanate. Based on an interview with Lakino (king) of the traditional leader of the Buton Palace, Laode Ahlul Musafi, the Kulisusu Palace has a tradition passed down from the Buton Sultanate which currently exists in Baubau City

Until now, the traditions of the Sultanate of Buton and the Kulisusu Palace still survive and are passed down both in terms of their organizational structure, customary rituals, clothing and customary rules. In tables 3 and 4 shows that the use of buton woven fabric is still used from the time of the sultanate to the present day.

**Table 5** Table 1 The use of Buton Weaving by nobles and people in the Traditions of the Sultanate of buton in the past (Figure source:ghafar, 2019)

No.	The Use of Buton Weaving in History	Description
1		Photo of Sultan Buton and his ministers using Buton woven cloth as national dress. The king and the high-ranking officials of the sultanate wore white shirts in woven cloths and ka'bensi whose shape showed the position of office
2		Buton Woven Cloth is not only used by the Nobility but also used by the community as clothes, sarongs, skirts, or carrying tools. In addition, they also use head accessories (ka'bensi) For people do not wear shirts before using buton woven clothing outers

**Table 6** Table 2 The use of Buton Woven Cloth by nobles in the tradition of the Kulisusu Palace in the present (Figures source: Author,2022)

No	The Use of Buton Woven Fabric in the present day	Description
1		Lakino (king) of the Kulisusu Palace together with the king of the kingdom under kulisusu, namely the areas of Bone, Lemo, Mataoleo, Kalibu, Sampu, Kotawo, Tomoai. Wearing a white shirt with a Buton Weaving outers, buton sarongs and head accessories according to the position.

2		<p>Lakino (king) and his wife (empress of the Kulisusu Palace) were wearing traditional noble clothes. This shirt should only be used by the king and his wife. The king wears a white shirt, black outerwear, a black and orange buton woven sarong as well as several accessories on his chest and head. Meanwhile, his wife wears a traditional dress called raji cloth. It also uses a veil and buton woven purse accessories.</p>
3		<p>At the Kompania Dance event, traditional stakeholders are tasked with starting the performance, monitoring the course of the performance and providing a brief explanation of the history and meaning of kompania dance.</p>
4		<p>The use of Buton Weaving by the general public is currently only carried out on certain traditional occasions. Northern buton women used to use weaving sheaths of the type doridi, leja, or kasopa gau gau.</p>
5		<p>On more sacred formal occasions married women wear traditional lapi clothes</p>
6		<p>The rules for wearing a Buton Weaving sarong for girls are that blouse clothes are not included in the <i>sarung</i></p> <p>Meanwhile, for married women, tops are put in a <i>sarung</i></p>
7		<p>As for the general public, men usually use buton-woven sarongs to worship in the mosque, especially during Eid al-Fitr prayers. The type of weaving used is the katamba gau which has a checkerboard pattern. The colors used are diverse. Equipped with kampurui or songkok patterned buton weaving.</p>

### 3.1.3 Production

Husniati explained that the process of making original Buton Weaving in North Buton is unique because the manufacturing process begins from planting cotton trees as raw materials. The presentation was strengthened by the presentation from Laode Ahlul Musafi and Agus Salim that buton weaving produced in the North Buton area is made from cotton grown by themselves. Cotton harvested from trees goes through several soaking and drying processes. Furthermore, it is broken down into a long cotton chain and then spun into threads with a thread spinning device (figure 22). The finished thread is white, then soaked in dye.

Husniati added that the staining process can use natural materials or synthetic materials.

The next process is panguri, which is dangling the threads on the warp. To carry out this process cannot be done by one person, at least it must be done by two or three people. Then the weaving process can be done with conventional / traditional tools or non-machine looms (ATBM). These two tools are manual tools and produce original weaving. The difference lies in its speed and ease of operation. For traditional tools (figure 23) the weaver must sit on the floor, the process of making one piece of cloth takes about 4-7 days, while for ATBM (figure 24) the work can be done by standing or sitting on a chair with a work duration of one day can produce 2-3 pieces of cloth.

The production process of the original Buton Weaving also has special institutions / rituals that are believed by the Buton people. Buton Weaving is preceded by prayers that are used to intend for the work to be smooth and quickly completed. In addition, weavers must also take into account the condition of the seawater, they will start weaving at high tide so as not to be exposed to *ngare-ngare* / lazy diseases. The time (hour) of the weaving process begins is also important, the weaver must determine a good time to start, because the community believes that accuracy in choosing the time and obeying ancestral institutions can streamline the weaving process and avoid neglecting the work.

## **3.2 Modified Buton Weaving**

Mass Industrial Buton Weaving is a buton weaving produced by factories. Although Buton Weaving comes from the island of buton, the production process of this industry is carried out outside the island of buton (Java or the city of Makassar). In terms of usage, Industrial weaving is produced to meet the high demand of consumers to meet the needs of Buton Weaving at massif events such as cultural festivals or uniforms. The rules of use also tend to be free and creative.

### **3.2.1 Utility**

Apart from the traditional events of the sacred Kulisusu Palace, the people of North Buton explored the use of Buton Weaving. Along with the times, traditions began to be eroded by influences from outside the region and the process of inheritance of knowledge about indigenous traditions was not perfect so that the younger generation made creations outside the customary rules. Although many uses have shifted from the initial rules, this free creation also had a positive impact and made various achievements related to Buton Weaving.

Agus Salim, head of the art division of the North Buton Regency Culture and Tourism Office stated that the North Buton Tourism Office often sends delegates

to participate in various festivals or competitions at the regional, national or international levels. Some of the achievements recorded by the Dinas include having participated in the GCC Fashion senayan Jakarta 2019, the King's Food Order in Singapore (wearing buton weaving for accessories), JFC weaving carnival (1st place), TMII Anniversary (3 times won at the weaving carnival), Putri Negara ASEAN (North Buton clothing), Nusantara Bridal Fashion Competition, Indonesia First 2013 in Bali, Fashion show in Italy, Hong Kong and the Netherlands, Putri weaving Sultra in 2018 (1st place), and often participate in various festivals / exhibitions in the province and



**Figure 2** Carnival doridi Sultra (b) Princess Wakamondu (c) ASEAN Indigenous Peoples Palace Festival in Baubau City (source: author,2020)

The use of Industrial Buton Weaving sarongs is also often used as a school uniform and in government agencies. Haliana, the owner of a weaving shop in Pasar Raya Buton Utara, stated that government agencies often place large orders for industrial weaving. In addition, the school also often orders for the manufacture of Weaving uniforms. Haliana stated *"Sales varying can be up to > 100 pieces of weaving. Festivals also affect the frequency of sales, sometimes up to > 200- 300 pieces of weaving, mostly from government agencies. "*

### 3.2.2 Meaning

The exploration carried out by the community related to Buton Weaving outside the traditional events of the Kulisusu Palace is freer, from the motifs, patterns to their meaning. Weaving is no longer patterned with vertical and horizontal lines only but began to be created with various plant motifs and other motifs. Even to support the creativity of weavers in Southeast Sulawesi, the Provincial Government holds a creation weaving competition every year.

This statement is also supported by Agus Salim and Ahmad Isal that now Buton Weaving is widely created to participate in competitions held by the Southeast Sulawesi provincial government



**Figure 3** Weaving Creations with Rice motif by Husniati (Source: Author 2022)



**Figure 4** Modern Buton Weaving Creations by designer Ian Adrian at Jakarta Fashion Week 2013 (Source: Instagram ianadrianofficial)

The exploration of modern Buton Weaving often violates customary rules, such as horizontal line motifs that should be used by women but are now also widely used by men, horizontal motifs such as doridi and leja that should be worn in the direction of horizontal lines are now widely created line motifs in the vertical direction for aesthetic purposes.

### 3.2.3 Production

The production process of modified Buton Weaving on an Industrial scale uses weaving machines in textile factories. But the fact is that on the island of Buton there is no textile factory so the manufacture of modified Buton Weaving is carried out outside the island of Buton, namely in Java or the city of Makassar. From Haliana's narrative, "*Taken from Baubau City / Buton Regency, we only choose examples to the motifs, later people will make it in their factories, don't know where, in Makassar or Surabaya (machines). There is no factory in Baubau only in Makassar or Surabaya there. If it is in Baubau, it is only originally made by people. The weaving machine is so in the factory. If it's in pinrang, it's rich*"



**Figure 5** Weaving production with industrial machinery (source: rekotomo)

Due to the high demand for Buton Weaving for festival events and uniforms, the need was met by diversifying products both from the type of product, its price and quality. Currently, products with Buton Weaving materials are starting to appear produced by local home industry such as women's bags, masks, decorative products or accessories. This buton-woven material product is usually exhibited at the Sulawesi Tenggara Festival.



**Figure 6** Diversification of buton weaving products into bags (source: author,2022)



**Figure 7** Differences between traditionally produced (original)-left buton weaving with industrial production (machine)-right (source: author 2022)

Industrial Buton Weaving Production also produces different qualities from Original Buton Weaving. In the Original Buton Weaving, the production process starts from growing cotton, the fertile buton soil produces good cotton quality, then the process of spinning, panguri and weaving is carried out naturally

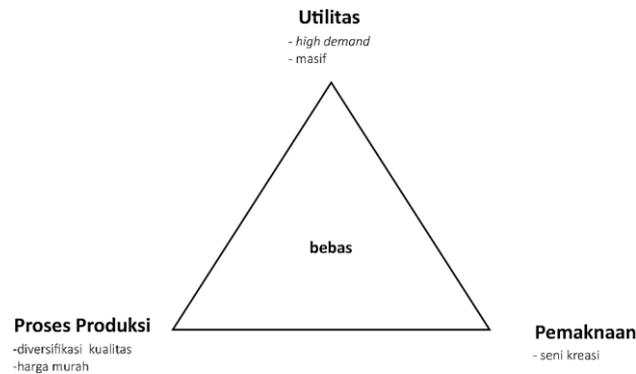
resulting in a smooth and soft weaving. While the production of industrial Buton Weaving has a rougher and stiffer texture. Haliana said, "*O the difference is really (the quality of the original weaving with the manufacturer), the fabric feels softer, then the fabric is cold (because it is made of cotton)*" This narrative was corroborated by Irnawati who showed the traditional Buton Woven fabric and the manufacturer at the interview (Figure 8). Industrially produced Buton weaving is marketed at a lower price compared to Original Weaving. For industrial production, one sheet of buton woven fabric at pasar Raya Buton Utara is sold at a price of 120,000 rupiah.

While the original Buton Weaving is sold at various prices depending on the complexity of the motif and consumer demand, one sheet can be sold at a price of 300,000-500,000 rupiah, for complex special order motifs with exclusive materials can be sold at a price above 1 million rupiah. Husniati said that the price of Factory Buton Weaving he sold at a price of 120,000 rupiah for one sheet, while for the Original Buton Weaving it was 300,000 per sheet



**Figure 8** Buton weaving production machine sold in the north buton grand market, line motif for women, checkered motif for men and headband called kampurui (source: author, 2022).

Corroborated by Husniati's statement that selling the original weaving at the Restika Weaving House "*Anyway, the more there is a motive, the motive is level, the more difficult the manufacture is the higher. If it is in my boutique, there are those who start at a price of 300-1 million to 1.5 million.*"



**Figure 9** Scheme of the relationship of aspects of meaning, utility and production in modified buton weaving (source : author, 2022)

From the presentation of aspects of utility, meaning and production process of modified Buton Weaving (industry) it can be concluded that in the development of Buton Weaving there emerged a freer condition where the use of Weaving did not consider the customary rules of the Palace, but also for daily life, formal uniforms, festivals, competitions, and fashion creations. With wider interests, market demand demands the production of buton weaving which is industrially mass. Such mass production has led to diversification of both the type of product, its quality and price so that it can be used by more people, more opportunities at low prices.

#### 4 Conclusion

Based on the research proses can be concluded that there are two interrelated conditions of Buton Weaving in northern Buton :

Cultural changes in North Buton are relatively fixed, evidenced by the production of Buton Weaving which still uses Traditional tools and produces original Buton Weaving. In addition, traditional rituals are still well maintained by applying the rules of the Kulisusu Palace which have been passed down for generations since the time of the Buton Sultanate, including the rules for wearing Weaving Buton and its meaning. So that the Original Buton Weaving was formed which was exclusive in quality and produced in a limited manner.

In contrast, Buton Weaving began to be created as an art and was used at festivals, carnivals, uniforms or mass dances. The large number of public demands gave rise to Buton Weaving industrial production of factories that were made massively with diversified prices and quality so that they could meet market

needs. In addition, the community also began to explore buton weaving in various fashion and craft competitions freely by overriding customary rules.

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## Consumers' Visual Perception of First and Second Generation Luxury Sleeper Train Passenger' Seats

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**Abstract.** The development of railways in Indonesia has experienced good innovation. An example is Sleeper Luxury Train. This train innovation aims to increase comfort and give a luxurious impression to the passengers. This innovation is realized in the form of a luxury sleeper passenger seat. Currently, the sleeper luxury train has two generations. The two generations carried differences in the design of the passenger seat. These two designs are distinctly different in appearances. Due to the differences, this research was conducted to determine consumer perceptions of trains towards the two designs and which design is preferred by consumers. This research was conducted on 102 train passengers using a 7-point semantic differential method and using 15 affective words. As a result, the design of the first-generation luxury sleeper train passenger seats is more attractive to consumers and there are differences in consumer perceptions on the variables of luxury, comfort, calm, relaxation, private and compact. Even so, the two designs of the luxury sleeper passenger seats are still in accordance with the brand made by KAI.

**Keywords:** *luxury; passenger seats; semantic differentials; trains; transportation design; visual perception*

### 1 Introduction

KAI is the sole railway company responsible for railway affairs in Indonesia. KAI is an important factor who act as the backbone of the rail-based transportation system in Indonesia [1]. Based on data from the Central Statistics Agency, train passengers in Indonesia are always increasing [2] until at its peak in 2019 KAI where they had carried 429.26 million passengers.



**Figure 1** Graph of the increase in the number of train passengers from 2015 – 2019 [2].

Aside of experiencing good development in increasing number of passengers, KAI is also actively developing its variety of modes. In 2018, KAI launched the Light Rail Transit (LRT), the Minangkabau airport train and the Sleeper luxury train. The following year, in 2019, KAI operated two new airport trains named the New Yogyakarta International Airport Train and Adi Soemarmo Airport Train, Solo and brought in 438 new trains and also launching the second generation of luxury train. KAI is still developing its mode until 2020 where KAI collaborated with the DKI Jakarta Provincial Government and PT Mass Rapid Transit Jakarta (Perseroda) to inaugurate four integrated stations named Tanah Abang, Sudirman, Pasar Senen, and Juanda stations. The development carried out by KAI aimed to connect the country and provide easy mobilization for the community as well as increasing comfort for passengers. [1][3].

From the numbers of these innovations, the luxury sleeper train is a new class in the long-distance train class which is above the executive class. This luxury sleeper train is a super luxury train created by KAI that aimed to increase the comfort of long-distance travel and provide more privacy to passengers. KAI targeted this train for market segments that usually used trains for business trips and passengers who needed more comfort when traveled. According to Mukti Jauhari, the sleeper luxury train is expected to create better image for KAI as it stands as a new brand in the premium class [4].

Luxury sleeper train has had two generations. The first generation was launched in 2018 and the second generation was launched in 2019. In general, this train has several facilities offered to increase passenger's comfort. However, there are visible differences in the design of the passenger seat of this train. The shapes, materials, and colors in these two designs are very apparent. The visual differences in the design of the sleeper train seats in these two generations might potentially affected the brand image which currently built by KAI. According to Krezbauer and Malter, design influenced the concept of a brand and one of the factors that influence it is perception [5]. Human perception usually uses all the senses it has, but 80% of human perception is done visually [6]. Therefore, regarding to the phenomenon of these two different luxury sleeper train seat designs, research to reveal consumer visual perception is needed to be done so that consumer perception can be revealed regarding to the preference of its sleeper train seat design, especially the luxury design preference. This needs to be done so the branding KAI built can become a continuation. This revelation will become KAI's evaluation regarding to branding and design development.

## **2 Research Methodology**

This research was done using an online survey by distributing questionnaires to 100 long-distance train passengers to determine the visual perception of train consumers towards the design of the first and second generation of luxury sleeper passenger seats. Stages of the questionnaire carried out in several stages. The first stage was carried out to obtain consumer perceptions about the design of the first and second generation of luxury sleeper train passenger seats. The second stage was carried out with the aim of obtaining consumer preferences for design elements in the design of the first and second generation luxury sleeper passenger seats. In the third stage, it was carried out to find out the respondents' design preferences for the design of the luxury sleeper train passenger seat which the consumer prefers.



**Figure 2** Design of the first and second generation of luxury sleeper passenger seats used in the questionnaire.

The measurement in the first stage is carried out by assessing the image of the passenger seat from the first and second generation of luxury sleeper trains using a 7-point semantic differential scale carrying 15 adjectives as the measuring instrument. The semantic differential method is used because this technique can measure people's interpretation regarding to certain concepts quite objectively, reliably, and valid [7] and the 15 adjectives are obtained by choosing adjectives from its branding, brand luxury index, and combining them with the result of the impression from some designers about the meaning of 'luxury' in train passenger seats. From the various adjectives collected, the set of adjectives will be used has been determined such as: luxurious, attractive, unique, expensive, good quality, impressive, comfortable, quiet, relaxation, spacious, ergonomic, compact, easy to use, private, and modern.

**Table 1** Luxury sleeper train passenger seat design elements.

Design elements [8]	Chair section
<b>Color</b>	Chair color
<b>Form</b>	<i>Enclosure</i> shape, sofa shape, stitch pattern, head cushion
<b>Product graphics</b>	-
<b>Material</b>	Sofa material, <i>enclosure material</i>

The method of measuring consumer preferences is carried out by revealing consumer interest in the design elements of the luxury sleeper train passenger seat. According to Jordan, what is meant by design elements are color, shape, product graphics, materials, sound and design interactions [8]. Because this research is focusing on visual design, the design elements that will be assessed are design elements that can be measured only visually. Therefore the design elements which become the measuring tools are; color, shape and material. Product graphics will not be used due to unavailability of such element in the design of the luxury sleeper train passenger seats.

The last stage, respondents will be asked to choose the design they preferred between the first and second generation luxury sleeper train passenger seat designs to find out their interest in the design of this luxury sleeper passenger seat as a whole.

The data analysis method is carried out by comparing the average between variables of the two passenger seat designs for the first and second generation of luxury sleeper trains. Therefore, statistical analysis by T-test might be performed to find the average differences between the two designs.

### **3 Results and Discussion**

#### **3.1 Demographic Data**

This survey obtained 102 respondents, consisting of 53 female respondents and 49 male respondents. The executive train class is the train class most frequently used by respondents. 52 respondents stated that they most often used executive class trains, then 25 people stated that they most often used premium economy class trains and 21 respondents stated that they most often traveled to Surabaya – Jakarta using Argo Bromo-Angrek.

#### **3.2 Semantic Differential Scale**

The collected data was then retrieved using the IBM SPSS 26 program by performing a different test to see the average difference in each variable. After analyzing the difference test (T-test), the results obtained are shown in table 2.

**Table 2** Mean Comparisons between First- and second-generation Luxury Sleeper Seat design per variable.

Variable	Chair Design	Mean	Mean Difference	Sig. (2-tailed)
<b>Luxurious</b>	Generation 1	5.54	.431	.031
	Generation 2	5.11		
<b>Interesting</b>	Generation 1	5.05	-.059	.792
	Generation 2	5.11		
<b>Unique</b>	Generation 1	4.71	-.373	.084
	Generation 2	5.08		
<b>Expensive</b>	Generation 1	5.66	.353	.061
	Generation 2	5.30		
<b>Good Quality</b>	Generation 1	5.61	.118	.481
	Generation 2	5.49		
<b>Impressive</b>	Generation 1	5.25	.049	.811
	Generation 2	5.20		
<b>Comfortable</b>	Generation 1	6.01	.686	.000
	Generation 2	5.32		
<b>Calm</b>	Generation 1	5.95	.990	.000
	Generation 2	4.96		
<b>Relax</b>	Generation 1	5.93	.676	.000
	Generation 2	5.25		
<b>Large</b>	Generation 1	5.30	.510	.011
	Generation 2	4.79		
<b>Ergonomic</b>	Generation 1	5.53	.333	.065
	Generation 2	5.20		
<b>Compact</b>	Generation 1	5.24	-.461	.007
	Generation 2	5.70		
<b>Easy to use</b>	Generation 1	5.67	-.137	.317
	Generation 2	5.80		
<b>Private</b>	Generation 1	5.68	1,696	.000
	Generation 2	3.98		
<b>Modern</b>	Generation 1	5.15	-.353	.076
	Generation 2	5.50		

### 3.2.1 Not Luxury – Luxury

In the luxury variable there is a significant difference seen from the value of Sig. (2-tailed) = 0.031 < 0.05. The first generation design is perceived as more luxurious than the second generation design as seen from the mean difference

value = 0.431 which means the average value obtained by the first generation design is greater than the second generation design.

### **3.2.2 Boring – Interesting**

In the interesting variable the value of Sig. (2-tailed) = 0.792 > 0.05 which means that there is no significant difference between the first generation design and the second generation design.

### **3.2.3 Ordinary – Unique**

In the uniqueness variable, the value of Sig. (2-tailed) = 0.084 > 0.05 which means that there is no significant difference between the first generation design and the second generation design.

### **3.2.4 Cheap – Expensive**

On the expensive variable the value of Sig. (2-tailed) = 0.061 > 0.05 which means there is no significant difference between the first generation design and the second generation design.

### **3.2.5 Poor Quality – Good Quality**

On the quality variable the value of Sig. (2-tailed) = 0.481 > 0.05 which means there is no significant difference between the first generation design and the second generation design.

### **3.2.6 Not Impressive – Impressive**

In the impression variable, the value of Sig. (2-tailed) = 0.811 > 0.05 which means there is no significant difference between the first generation design and the second generation design.

### **3.2.7 Uncomfortable – Comfortable**

In the comfort variable there is a significant difference seen from the value of Sig. (2-tailed) = 0.000 < 0.05. The first generation design is perceived as more comfortable than the second generation design, as seen from the mean difference = 0.686, which means that the average value obtained by the first generation design is greater than the second generation design.

### **3.2.8 Not Calm – Calm**

There is a significant difference in the calmness variable, which can be seen from the Sig value. (2-tailed) = 0.000 < 0.05. The first generation design is perceived as calmer than the second generation design as seen from the mean difference

value = 0.990 which means the average value obtained by the first generation design is greater than the second generation design.

### **3.2.9 Not Relaxed – Relax**

In the relaxation variable there is a significant difference seen from the value of Sig. (2-tailed) = 0.000 < 0.05. The first generation design is perceived as more relaxed than the second generation design, as seen from the mean difference = 0.676 which means the average value obtained by the first generation design is greater than the second generation design.

### **3.2.10 Narrow – Broad**

In the wide variable there is a significant difference seen from the value of Sig. (2-tailed) = 0.011 < 0.05. The first generation design is perceived as wider than the second generation design as seen from the mean difference = 0.510 which means the average value obtained by the first generation design is greater than the second generation design.

### **3.2.11 Not Ergonomic – Ergonomic**

On the ergonomic variable the value of Sig. (2-tailed) = 0.065 > 0.05 which means that there is no significant difference between the first generation design and the second generation design.

### **3.2.12 Complicated – Compact**

In the Compactness variable there is a significant difference seen from the value of Sig. (2-tailed) = 0.007 < 0.05 and the second generation design is perceived to be more Compact than the first generation design as seen from the mean difference value = -0.461 which means the value obtained by the second generation design is greater than the first generation design value.

### **3.2.13 Difficult to Use – Easy to Use**

In the convenience variable using the value of Sig. (2-tailed) = 0.317 > 0.05 which means that there is no significant difference between the first generation design and the second generation design.

### **3.2.14 Not Private – Private**

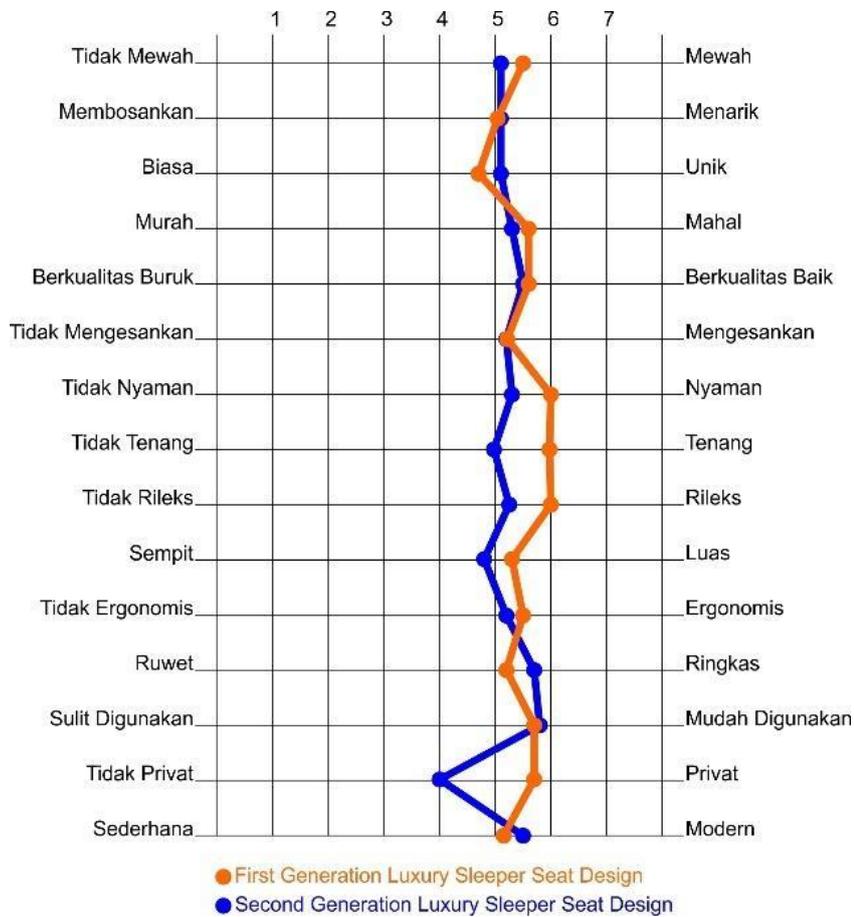
In the privacy variable there is a significant difference seen from the value of Sig. (2-tailed) = 0.000 < 0.05 and the first generation design is perceived to be more private than the second generation design as seen from the mean difference value

= 1.696 which means that the value obtained by the first generation design is greater than the value of the second generation design.

### 3.2.15 Simple – Modern

The modernity variable uses the value of Sig. (2-tailed) = 0.076 > 0.05 which means that there is no significant difference between the first generation design and the second generation design.

After determined the average value of each design per variable, the semantic differential graph can be described as in Figure 3.



**Figure 3** Semantic Differential Scale of consumer perception for First and Second Generation of Luxury Sleeper Passenger Train Seat Design

### 3.3 Consumer' Preferences

Consumer preference analysis uses the same method as the previous method by means of a different test (T-test) with the IBM SPSS 26 computer program. The results obtained are shown in table 3.

**Table 3** Mean Comparison consumer' preferences of design elements between First- and second-generation Luxury Sleeper Seat design

Variable	Chair Design	mean	Mean Difference	. Sig (2-Tailed)
Color	Design 1	4.72	.461	.079
	Design 2	4.25		
Sofa Shape	Design 1	5.15	.343	.121
	Design 2	4.80		
Enclosure Shape	Design 1	4.69	-.206	.380
	Design 2	4.89		
Sofa Material	Design 1	5.31	.480	.015
	Design 2	4.83		
Enclosure Material	Design 1	4.93	-.137	.508
	Design 2	5.07		
Stitch Pattern	Design 1	5.02	.382	.068
	Design 2	4.64		
Headrest Shape	Design 1	5.35	.529	.008
	Design 2	4.82		

The results of the analysis above shows differences in consumer preferences for sofa materials and the shape of the headrest. This is evidenced by the value of Sig (2-tailed) on the sofa material variable is  $0.015 < 0.05$  and the head cushion shape variable is  $0.008 < 0.05$  and with a positive mean difference value, 0.480 for the sofa material and 0.529 for the shape of the headrest, it can be interpreted that consumers are more interested in the material of the sofa and the shape of the headrest in the design of the first generation luxury sleeper train passenger seat. Meanwhile, the other variables did not show any significantly different results.

In the third stage of the previous questionnaire, respondents were asked to choose which design is more attractive to them and the results are 79 people (77%) expressed interest in the design of the first generation luxury sleeper train seat and 23 people (23%) expressed interest in the second generation luxury sleeper train seat.

#### 4 Conclusion

The result of the analysis shows that there is a difference in perception between the design of the passenger seat of the first and second generation of luxury sleeper trains. The design of the passenger seat of the first generation is perceived as more luxurious, comfortable, quiet, relaxing and spacious compared to the design of the passenger seat of the second generation luxury sleeper train, but it is also found that the passenger seat of the second generation of luxury sleeper train is perceived to be more compact than the design of the first generation luxury sleeper train passenger seat. In other variables, there was no significant difference in perception between the two designs.

The passenger's preferences for the design elements are revealing that the shape of the sofa/seat and the shape of the headrest in the design of the first generation luxury sleeper passenger seat are more attractive to consumers. Other variables do not show significant differences between these two designs. Overall, consumers are more interested in the design of the first generation luxury sleeper train passenger seats.

So that the statement by Krezbauer and Malter which says that design affected the concept of a brand [5] is proven because there is a difference in perception between the two designs. Even though the statement is proven to be true, the researcher considered this difference in perception to be reasonable and does not make a distinct clash with the branding which currently built by KAI.

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## **Climbing Up or Down? An Overview of the Ten Years of Citizen Participation in Malaysian Public Sector Projects**

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**Abstract:** The Government of Malaysia has been promoting citizen participation since the enactment of the country's Town and Planning Act 1976 (Act 172). The Shared Prosperity Vision 2030, which can be interpreted as the commitment of the Malaysian Government to accelerate the country's sustainable growth, reaffirmed the Government's intention to enhance citizen participation in Malaysia's public affairs. But do average citizens really have the chance to engage in public-sector projects? This work intends to discover the extent to which the Malaysian public had the opportunity to participate in public sector projects. Based on Arnstein's ladder of participation, the present work analyzes citizen participation in Malaysia for ten years. The findings signify that the general people's opportunity to engage in Malaysia's public-sector projects has eventually increased within the last ten years. Nevertheless, the levels of participation were still considerably low, suggesting tokenism as the highest level of participation that the Malaysian public can negotiate. Finally, the work highlights the importance of the Malaysian government to overcome the barriers to enable higher level of citizen participation in the country.

**Keywords:** *citizen participation; malaysia; ladder of participation; public-sector projects.*

### **1 Introduction**

Citizen participation has long been argued as one of the useful tools to enable individuals' active involvement in decision-making regarding matters that may impact their lives [1]. It is argued to be the vehicle to deliver citizens' pursuits and apprehensions related to development proposals where the proposed development may affect their livelihood [2]. The participation itself might reduce the political and administrative difficulties particularly if the involvement were properly set up and professionally advocated [3]. Likewise, it could help identify a public concern and desires and lead to the excellent management of resources [4][5]. With the nature of stimulating the information exchange among the affected stakeholders, citizen participation might assist communities to build better connections and boost consensus that would contribute positively to the proposed development plans [6].

Nevertheless, the success of the participation process is based on the extent to where citizen is permissible to participate [7]. A great participation process requires the citizen to participate in numerous planning and development phases, as Litchfield [8] recommended. Unfortunately, though, many restrictions may obstruct citizens from involving in the implementation of the participation process. Research demonstrates that participatory setting regulations and objectives in public provision projects are frequently vague [9][10]. Its effectiveness has also been questioned as some scholars believed that citizen participation is a delusional concept, even if it was conducted under collaborative working [11][12][13] and through utilization of modern information technologies [14][13]. No matter how scholars discuss it, we cannot deny that citizen participation is an essential element in community development in ensuring its sustainability. For example, Egan [15] listed 'governance' as one of the criteria for achieving a sustainable community. Under this governance criteria, he indicated citizen participation or involvement as one of the features that construct a sustainable community [15]. Thus, citizen participation is embedded as one of the elements of good governance and has been widely accepted worldwide [16].

In the present study, we focus on the implementation of citizen participation in Malaysia, a country predicted by the World Bank [17] would achieve its transition from an upper middle-income economy to a high-income one by 2024. Since 1976, the country has been advocating the importance of citizen participation in Malaysia's town and country planning. Through the Town and Country Planning Act 1976 (Act 172) [18], Malaysia introduced the possibility for the public to be involved in the town and country planning affairs [19][13]. It is suggesting Malaysia's stronger acknowledgement of the significance of citizen participation in achieving good governance and sustainable development [20][13]. The country's commitment to incorporate citizen participation in its development is reaffirmed in the Shared Prosperity Vision 2030, a national policy that aims to deliver proper essential livelihood to all citizens by 2030 [21]. This policy places citizen participation as the first objective and priority. It emphasizes the importance of 'Development for All', a statement which can be interpreted as restructuring the economy to be more escalating, knowledge-based, and superior-valued with full 'community participation' [21]. In this vision, apparently Malaysia perceived citizen participation as an entry point for achieving sustainable future and understanding the public demands better [5]. But does the strong political statement from the government guarantee the real opportunity to participate?

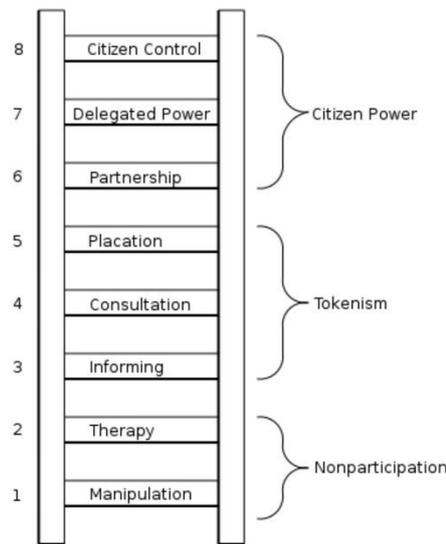
The article begins with an introduction to Arnstein's [22] ladder of participation, the basic theory that will be used as the main reference for the study. Following this, an overview of citizen participation's practice in Malaysia will be given, in particularly those related to the public sector projects conducted between 2010

and 2020. This ten-year span was chosen because in 2010, Malaysian Government announce of tenth (10th) and eleven (11th) Malaysian Plan that serve as national development guideline which emphasizing on citizen participation [23][24]. It marked the government effort in highlighting citizen participation through implementation of both plans. Secondly, Malaysia started to announce targeted 17 Sustainable Development Goals (SDGs) introduced by United Nations in 2015 where citizen participation being reemphasized again [25]. The five-year Malaysia Plan sounding getting stronger because of announcement of the SDGs. Furthermore, new Shared Prosperity Vision 2030 has been designated within those 10 years. In addition, there were some changes in political power from 2018 to 2020 that spotlight the inclusiveness of the citizen in mid-term review of the 11th Malaysia Plan. Most of these documented policies obviously accentuating on 'citizen participation' [26][21]. Using Arnstein's [22] ladder theory, this section would also explore the levels of participation that Malaysian people experienced so far. Finally, the article will be closed with a concluding discussion and recommendation for future research.

## 2 The Ladder of Citizen Participation

Citizen participation is identified as the process via stakeholder influence and shared power on priority set-up, resource distributions, policy decisions, and entrance to community services and products [17]. Skeffington Committee in the United Kingdom earlier interpreted that citizen participation is an act of sharing ideation of policies and suggestions. Public can genuinely take part in the planning process [27]. Thus, citizen participation is related with public action that seeks to influence policy decisions [28]. The importance of citizen participation in the democratic political process has been acknowledged across the globe [29]. Demand is increasing from citizens to let them play a significant role in the government process rather than passive voters [30].

One of the most often used theories to measure citizen participation is the Ladder of Participation (See **Figure 1**). This theory was introduced by Arnstein [30] in 1969, asserting that there are eight rungs that portray the distribution decision making power between the powerholders and the citizens. The lowest rungs known as non-participation interpreted as an objective of powerholder to 'educate' or 'cure' citizen with no intention to get genuine participation from them. There are two (2) types that were considered in this rung known as manipulation and therapy. Manipulation seen as placing citizen in such advisory group for the goal of 'educating' the citizen and not really concern in tapping their ideas for decision-making. While Therapy is more on 'curing' the citizen mind in an extensive engagement by the powerholder.



**Figure 1.** Arnstein’s Ladder of Participation (1969). Ladder of Participation by Dulithgow, 2004. Public Domain

The middle rung stated as degree of tokenism which allows citizen to voice out their opinion and to be heard by the powerholder. No assurance of changing any status quo or follow through done. The final decision is still hold by the powerholder. In this rung, (3) ‘information’, (4) ‘consultation’ and (5) ‘placation’ was arranged accordingly in showing the citizen influence in the matter discuss or decision-making. At the highest level in this rung, which is placation, advised been given and attentively heard but no power to obstruct the final decision by the powerholder. The upper rung known as degree of citizen power that shows great citizen influence in the process of decision-making with the powerholder. It enables them to discuss and connect in trade-offs with conventional power holder indicated as partnership. At the highest rung, citizen get majority control in decision-making or in great power on management which known as delegated power (7) and citizen control (8).

While there have been several scholars proposing different theories of citizen participation such as Wiedemann and Femers (1993), B.C.R.T and Dorsey (1994), and D.M. Connor (1994), Arnstein’s theory is still the most and continuously referred to by scholars for their research in expanding their philosophy of citizen participation [31][32][33][34][35]. Thus, the present study also used Arnstein’s ladder of participation to conduct a deeper analysis of the levels of citizen participation in Malaysia.

### 3 Materials and Methods

The study uses the works of literature relevant to the citizen participation in Malaysia that were published between 2010 and 2020. The literature was searched with three keywords as follows, (i) Citizen participation in public project Malaysia, (ii) citizen participation towards sustainable community development Malaysia, and (iii) level of citizen involvement Malaysia. These articles were later screened and only those met the following criteria (See **Table 1**) would be selected for further analysis.

**Table 1** Screening Criteria.

No	Criteria
1	Published between 2010 and 2020
2	Identified certain level of citizen participation
3	Covered the public sector projects, such as transportation, local government service, local agenda 21, tourism, deforestation, and city planning

Thematic analysis was then applied to analyse the levels of citizen participation in the introduced projects or programs. Thematic analysis focuses on recognizing, examining and interpreting patterns within qualitative data [36][37] where coding act as the main process for developing patterns or themes [38]. The recognized interested elements of analytical data or dominant theme will be categorised with coding label [38][39]. The test then is analysed to verify the presence and occurrence of a theme [40].

### 4 Results

Despite the strong political message that Malaysian government sent to the public, several studies conducted by local scholars indicated how citizen participation in public sector projects still needs to be scrutinized and improvised. Not only that the level of participation is low and restricted, but some scholars also underlined the shortage in the preparation and knowledge of public participatory planning [41][42][43][13]. In contrast with the political message at the national level, the local government appeared to have insufficient initiatives to encourage citizen participation, resulting in the lack of citizen participation in the local level. Some of examples were reported in Muhammad et al., [44] and Zolkafli et al.,[13], who identified the absence of citizen's involvement in the enhancement of local service delivery and blueprint development. This absence can be intentional as Malaysia is somehow put itself as a developing nation that gives vital importance to economic growth [45][46][47] and public opinions

against it tend to be relegated [47][48]. Thus, powerholder tend to not include mass citizen in development design and betterment of service distribution [44][13]. Apparently, excessive public participation is perceived by the local authority as posing some risks that could decelerate a project or program execution and lag overall development progress [49]. Moreover, there were some administrative costs to implement citizen participation in the public sector projects [50][51][52]. The cost of involving mass citizen is said to be expensive than singular administrator for decision-making with suitable skill and knowledge [51] and fear upon losing command of the process [53]. For Malaysia, which is currently still focusing on its economic development, taking the risk to add more cost to the development is not a favourable option. However, to reduce the social friction, apparently, Malaysian citizens were still allowed to exercise their power through the facilitated planning processes, but there is a little opportunity for them to negotiate more decision-making power [54][55][47][56].

In the following Table 2, we categorized the decision-making powers that Malaysian citizens could exercise so far based on the category defined by Arnstein's [22] Ladder of Participation. This analysis derived from eleven studies which reported the extent of citizen participation in public project or program in the areas of transportation, local government service and program, housing settlement post-disaster, tourism, GIS, general and city planning.

**Table 2** Findings on Citizen Participation in Malaysia Public Project based on Arnstein's Ladder of Citizen Participation

No	Author	Study Design	Focus of Study	Findings	Level of Citizen Participation
<i>Lowest Rung, The Non-Participation</i>					
1	Zain et al. [57]	Quantitative study (survey)	To recognize the extent of public participation and understanding in environmental impact assessment (EIA) process in Mass Rapid Transit (MRT) project.	<ul style="list-style-type: none"> <li>Indicated low level understanding of citizen participation.</li> <li>Public unaware about development procedure and their rights.</li> <li>Not met objective of citizen participation.</li> <li>Significant changes required by authority in promoting program and educating citizen continuously via mass media.</li> </ul>	Non-participation
2	Muhammad et al. [44]	Quantitative study (survey, interview)	To evaluate level of community involvement in sustainable development process to measure public service delivery.	<ul style="list-style-type: none"> <li>Progressive upgrading needed in facility services and maintenance culture.</li> <li>Minimal community participation and sharing information with the authority.</li> <li>Community unaware of participating right and skeptical thoughts on the authority in valuing their opinion.</li> <li>Community showed heavy interest in contributing ideas to improvise service delivery.</li> </ul>	Non-participation
3	Roosli [58]	Quantitative study (survey, document, and review)	To examines technological, spatial and social impact of post-disaster housing projects on disaster victims of tsunami in Kedah and Penang.	<ul style="list-style-type: none"> <li>Victims highly satisfied with the housing project but more concerned about their livelihood and community healing.</li> <li>Short-term action failed to identify main problem socio economic survival.</li> </ul>	Non-participation

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				<ul style="list-style-type: none"> <li>• Required adaptable method and include victims' participation in the decision-making process.</li> </ul>	
<b><i>Middle Rung, Degree of Tokenism-Information and Consultation</i></b>					
4	Marzukhi [47]	Qualitative study (interview, document review)	To evaluate whether idea of planning discourse-sustainability can assist in capital accumulation via transformation of governance practices.	<ul style="list-style-type: none"> <li>• Minimalist consultative tactic being applied and designed by government.</li> <li>• Citizen participation not genuinely practiced and restricted.</li> <li>• Exposed government supremacy and administrative difficulties in the planning system.</li> </ul>	Degree of tokenism
5	Kaur et al. [59]	Qualitative study (Interview, focus group, observation, document review)	To determine the effectiveness of the participatory mechanisms used in Local Agenda 21 (LA21) programs in East West Malaysia.	<ul style="list-style-type: none"> <li>• Official equipment and traditional approaches were utilized to engage with citizen-single manner of communication.</li> <li>• The council led the process and hold the final verdict.</li> <li>• Lack of citizen empowerment in decision-making. Bottom-up approach framework relating public participation need to be outlined.</li> </ul>	Degree of tokenism
6	Manaf et al. [49]	Quantitative study (survey)	To assess the level of involvement of local citizens in local government decisions in Malaysia-northern part of Malaysia.	<ul style="list-style-type: none"> <li>• Citizen wanted to be included in decision-making process and not only as recipient of the services offered.</li> <li>• Authorities appeared unpleasant with excessive citizen involvement which may increase expectations and slowing public project process.</li> <li>• Perception of citizen that their involvement does not affect final verdict but believe they have rights to contribute to the process.</li> </ul>	Degree of tokenism

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				<ul style="list-style-type: none"> <li>Urban community is more responsive, vigilant, and knowledgeable than rural community.</li> </ul>	
7	Nurudin et al. [60]	Quantitative study and case study approach (interview, survey, secondary data)	To explore the actual dimensions of public participation practice in Seremban Municipal Council (MPS).	<ul style="list-style-type: none"> <li>Most participants understand the concept of citizen participation and attended program related to cleanliness, environment, LA 21, health and security.</li> <li>Citizen participation seldomly achieved for overall program conducted due to inadequate distribution of program information and citizen ability in the activities.</li> </ul>	Degree of tokenism
8	Marzuki et al. [43]	Qualitative study (interview)	To examine the public participation approach to tourism planning in Langkawi Island Malaysia.	<ul style="list-style-type: none"> <li>Constraints in citizen participation due to of behavior of the residents, ineffective approach by authority, and insufficient information provided.</li> <li>Limited occasions were given for consultation.</li> <li>Verdict made by authority does not involve public. Indicated authority dominance in participation process.</li> </ul>	Degree of tokenism
9	Zolkafli et al. [13]	Quantitative study (survey, internet based-PGIS mapping via website by facilitated and self-administered mode)	To evaluates the capacity of general public to effectively contribute to land use planning outcomes in Malaysia using Participatory GIS (PGIS).	<ul style="list-style-type: none"> <li>Facilitated PGIS process delivered greater quality spatial data compared to self-administered PGIS.</li> <li>PGIS platform together with facilitated PGIS is needed to enhance public participation and value of spatial data produced.</li> </ul>	Degree of tokenism
<b><i>Middle Rung, Degree of Tokenism-Placation</i></b>					
10	Connolly [61]	Qualitative study (Interview,	To evaluate the potential of emergent urban governance	Initiatives of Non-Governmental Organization (NGO-Penang Forum), active	Degree of tokenism (placation)

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	storyline, observation, document review)	initiatives in Penang, Malaysia, for achieving more socially and environmentally just forms of urban development.	co-operation by the government and citizen (PHW-citizen as informer) exhibited significant interconnection, positive impact on safeguarding and cultivating multi-species flourishing to sustain metropolitan ecologies and its value of living.		
11	Abdullah et al. [62]	Qualitative/Observational cohort study (observation and self-experience)	To analyze the process of public participation during the preparation of the Kuala Lumpur City Plan (KLCP).	<ul style="list-style-type: none"> <li>• Citizen involvement and opinion was seriously shown and taken into consideration at the overall planning stage.</li> <li>• It indicated that citizen involvement has shifted higher to new paradigm than previous decade.</li> </ul>	Degree of tokenism (placation)

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#### 4.1 The Lowest Rung in the Ladder of Participation

The lowest rung known as the lowest level in citizen participation. At this rung, the objective was to get citizen support and to ‘educate’ them upon matters that appeared by the one who holds the power. Thus, their participation considered as non-participative as stated by Arnstein’s [22]. Table 3 identified three (3) studies that portrayed cases relevant to this rung; Zain et al. [57], Muhammad et al., [44] and Roosli [58]. Zain et al. [57] obviously mentioned lack of understanding on citizens participation in his case study. While Muhammad et al. [44] indicated minor involvement of community and minimal sharing of information with the authority. This happened even though the citizens had interest in contributing ideas for service delivery betterment provided by the authority. On the other hand, Roosli [58] remarks on the failure in recognizing the citizens necessities. The citizen was included only as a formality to fulfil the provision in the Town and Country Planning Act 1976 (Act 172) [18]. Therefore, these 3 studies showed that in some part of Malaysia, not all citizen was genuinely involved in decision-making process.

#### 4.2 The Middle Rung in the Ladder of Participation

##### 4.2.1 Tokenism: Informing and Consultation

The middle rung represents little citizen influence or power in participation process. No assurance of their ideas was going to be implemented. The final verdict is still hold by powerholders. Based on these description, six (6) studies showed several characteristics in the informing and consultation level. The 6

studies were represented by Marzukhi [47], Kaur et al. [59], Manaf et al. [49], Nurudin et al. [60], Marzuki et al. [43] and Zolkafli et al. [13]. For instance, minimal consultative approach being applied where the rights of citizens participation falsely practiced in the study by Marzukhi [47]. Kaur et al. [59] mentioned about lack of citizen empowerment in decision-making that evidently needed a bottom-up method. In other case by Manaf et al. [49], the authority thought that including massive citizen will slower the progress in achieving authority designated goals. Besides that, the citizen felt that their contribution would not give significant impact, even though they know their rights to participate in the process. Nurudin et al. [60] noticed that most citizen understood the idea of public participation. However, even so, they rarely engaged with the authority. This is because of insufficient dissemination of information by the authority and lacking in citizens ability to participate. Marzuki et al. [43] disclosed that citizen participation is restricted even though space been given for them to participate. This is due to dominance action by the authority in hearing session in the case study. Furthermore, Zolkafli et al. [13] revealed on utilization of ICT apparatus via facilitated and self-administered approach in his study. It was suggested that more facilitated or consultative method need to be promoted. This is to help in expanding citizen participation to deliver extraordinary quality of spatial data. Thus, these 6 cases fall under ‘information’ and ‘consultation’ level in the middle rung. It proved that in certain area in Malaysia, action conducted by the authority clearly represented their willingness to listen to citizen opinions but with no assurance that the views will be executed or embedded in the designated development. In other words, citizens were involved in participation process via certain platform just to get their voice to be heard but no serious follow through upon the ideas [22].

#### **4.2.2 Tokenism: Placation**

At this level, citizens opinion and ideas being seriously heard but final decision was still hold by authority or the powerholder. Two (2) case study were identified that were Connolly [61] and Abdullah et al. [62]. Connolly [61] indicated active citizen participation together with non-governmental organization (NGO) in safeguarding their habitants and ecosystem at Penang Hillside. Cooperation between parties was being witnessed in this case with NGO’s is highlighted as the significant component in disseminating information and knowledge to the citizen. This is regarding instilling awareness of their environment that may affected their life. It is obviously exhibited citizen influence in the program or project that was going to be executed. Therefore, urging the authority to act appropriately even though some criticisms were raised upon their decisions in allowing special approval to few developments on the hillside. Similarly in the case of Kuala Lumpur City Plan stated by Abdullah et al. [62], serious participation of citizen in planning was demonstrated. Citizen’s suggestions being

considered by the authority before the plan was published. Furthermore, 'changes of paradigm' in citizen participation occurred during the process of planning. The process showed remarkable awareness and comprehension of the citizen on their rights. Thus, in few parts in Malaysia especially in urban area, these cases interpreted "Placation" theory by Arnstein's [22] where citizen have some strong influence in the decision-making process. They were allowed to advise the powerholder even though the authority holds decisive power upon matters that need to be decided.

## 5 Discussion

The above analysis signified that Malaysian citizen have had little opportunity to exercise a higher level of citizen participation. Most cases analysed above showed the restricted opportunity for Malaysian public to negotiate their power in the decision-making process in the public sector projects. The highest level of participation that they could experience was the placation, which somehow still indicated the dominance of powerholders in the decision-making process. As pointed by Marzuki et al. [43] and Zain et al. [57], this continuous dominance might happen due to inability of citizen in understanding the true concept of citizen participation, their rights and restricted opportunity given for them to contribute their ideas even though they desire it. Kaur et al. [59] further mentioned about lack of citizen empowerment in decision-making that evidently needed a bottom-up method. In other case by Manaf et al. [49], citizen felt that their contribution would not give significant impact, even though they know their rights to participate in the process. Even so, in the study by Marzukhi [47] revealed that minimal consultative approach being applied where the rights of citizens participation vaguely practiced. Another factor might be related to is the inefficiency of the powerholders in publicizing information and communicating their intention to the citizens as identified by Nurudin et al. [60].

Moreover, great level of political interference in Malaysia is another possible factor is related to it. Powerholders have the advantages in controlling the planning process to achieve their designated growth and they may ignore the citizen appeal for the sake of delivering faster and smoother public projects as indicated by Manaf et al. [49]. However at the same time, there is also a possibility where the powerholders would ride on the trend of citizen participation to get smoother approval from the general public. Abdullah et al. [62] and Nurudin et al. [60] showcased some examples indicating that active participation from the citizen did took place in Malaysia. It occurred when the authority was thoughtful and genuine opportunity was given to the citizen in empowering them to influence decisions that may affected their life. In short, it means empowering the citizen. However, as verified in this study, these cases are still somehow uncommon. Hence, to ensure that the citizen participation'

invitation mentioned in the Shared Prosperity Vision 2030 is not going to be another government's lip-service, it is essential for the government to address the current obstacles. The government must showcase stronger genuine invitation to welcome citizen participation and acknowledge that citizen awareness is indeed a crucial component in ensuring a successful participation case.

The study of Manaf et al. [49] documented the interest of citizen in the public affairs, such as designing programs to increase the quality of the authority and service delivered. In short, this recommend that upcoming citizen participation process must deploy applicable citizen involvement where they able to convey unreservedly within context being discuss and powerholder seriously taken into consideration of their feedback that is significant so that transparency and accountability of decisional process and citizen alertness can be enhance [63]. All cases showed that authorities still persist as the major institutes to commence citizen participation process except for the case by Connolly [61] where other entities such as non-governmental organization and local citizen lined together with local authorities to initiate the participation programme in safeguarding the environment and habitants of Penang Hillside. Thus, it indicated that with the involvement of a wide-ranging individuals that understood about democratic wisdom, the image of participatory democracy has been portrayed [64][5]. The case studies also showed that significant considerations should be given to the feedback given by the citizen in their involvement, even though some cases have shown achievement of hefty and genuine citizen participation like case studies by Connolly [61] and Abdullah et al. [62].

Furthermore, creative, and innovative approaches such as utilization of ICT tools and application is seen as a booster in enhancing citizen participation. Zolkafli et al. [13] revealed on utilization of ICT tools via facilitated and self-administered approach in his study that assist in escalating citizen participation to deliver extraordinary quality of spatial data. This is similar with other study by Kingston et al. [65] where he mentioned that technology is supposedly utilized in citizen participation process due to its instant and constant development. In addition, the authority may provide them with attractive incentives or reward in return of their active participation. It will assist in improving citizen participation, increase effectiveness and resulted in better solution-making for the community and their surroundings. Eventually, the nation can experience sustainable community development and at the same time meet the country's pledged for SDGs particularly under SDGs 11, Sustainable Cities and Communities and other parallel agenda relating to citizen participation.

## **6 Conclusions**

The present study confirmed that Malaysia has allowed some degrees of citizen participation in its public-sector projects. Within the last ten years, public were more than welcomed to participate in the public sector projects, even though the levels of participation are still somehow limited. The study verified that the levels of participation were still considerably low, suggesting tokenism as the highest level of participation that the Malaysian general public can negotiate. Apparently, the political message that was given by the national government is not yet in line with the implementation at the local level. There are still barriers to citizen participation, such as the strong concern on the hidden cost of participation, which include additional administrative cost and potential risk of lagging project activities. It is essential for the national government to overcome this problem with the local government and design a better approach to enable citizen participation at the local level. Additionally, the intention of the government to welcome citizen participation must be in unison with the opportunity for the general public in Malaysia to participate in the public sector projects. It means that the room for participation should be transparently provided and the how-to process must be clearly informed. Thus, before sending another political message to the citizens, it might be much better for the government to first overcome the barriers to citizen participation by showing more willingness and providing more interactive and clearer opportunities for citizen to participate in the public sector projects. Further studies and analysis on more case studies from different parts of Malaysia and other region are also recommended to provide better array of thoughts and tactics to genuinely involve citizen into participation.

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## **Nomenclature**

Not Applicable.

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## **Post-Pandemic Resort Hotel Principles**

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**Abstract.** The hospitality industry is one of the sectors of the tourism industry that is impacted by the COVID-19 pandemic. Based on the Tourism Trends Book issued by the Ministry of Tourism and Creative Economy of the Republic of Indonesia, the pandemic that has occurred has changed the tourism landscape that has been built into a new business landscape which is then referred to as the "Megashift Industry". This major change occurred on three different scales, namely mega (change), macro (customers), and micro (competition). Several changes after the COVID-19 pandemic forced the hotel business to adapt to the current situation. This is what then realized the importance of applying post-pandemic hotel principles so that visiting guests can still feel the experience and feel comfortable when visiting the hotel. The method used in this research is a data collection method in the form of a literature study and data analysis method. Through this research, several principles regarding post-pandemic hotels can be obtained, both related to hotel management systems and principles related to hotel building design. So that after the pandemic, existing hotels can better adapt to the possibilities that occur in the future.

**Keywords:** *change; hotel industry; post-pandemic; COVID-19; adaptive.*

### **1 Research Background**

The COVID-19 pandemic has brought a huge impact on all industrial sectors in the world since early 2020. Since this virus was detected in Indonesia in early March 2020, this has forced people to enter a new life order which is then more commonly known as the new normal. Various efforts have been made by the government to prevent and suppress the spread of the COVID-19 virus by wearing masks, washing hands, and keeping a distance to avoid crowds. Several regions have also started implementing PSBB (Large-Scale Social Restrictions) and implementing work from home policies during this pandemic. The implementation of the PSBB was also followed by restrictions on air transportation, both domestic and international. This policy was applied to most industrial sectors in Indonesia and in the end, had a significant impact on economic conditions in Indonesia.

The tourism industry is one of the most affected sectors by the pandemic. Based on the Tourism Trends Book in, since February 2020, the number of foreign tourists entering Indonesia has experienced a very drastic decline and the most significant decline occurred in April 2020 with only 158,000 tourists visiting. In 2020, the number of foreign tourists visiting Indonesia was only 4.052 million people, where this number was only 25% of the number of tourists in 2019. This also resulted in a decrease in state revenue in the tourism sector by 20.7 billion. On the other hand, the decline in tourist arrivals also directly impacts various employment opportunities in the tourism sector. This pandemic caused 12.91 million people to experience a reduction in working hours in the tourism sector and 939 thousand people to be temporarily laid off from the tourism sector. On the other hand, guest criteria in choosing hotels to visit have also changed. This in the end gave a big change to the tourism industry. This change became known as the mega shift industry.

The Megashift industry that occurred was formed from several problems that arose in the field. The first problem is the regulatory factor, wherein the implementation of travel restrictions on both national and international scales which in turn forms “domestic micro tourism” as the main target of hotel visits. Awareness of the importance of health factors also requires the hotel industry to make several adjustments. According to the Gensler Hospitality Pulse Survey there have been several requests from tourists regarding the adjustment/rearrangement of bedrooms and public spaces that are in accordance with the recommended health protocols, both in terms of room layout, air circulation, and the capacity provided. The financial factor is also a problem that must be resolved by the hotel industry, especially when a crisis is happening. The drastic decline in guest visits requires the hotel to provide inclusive public facilities in the hotel area so it can be a side income when the hotel occupancy rate is low. Operational factors are the last problem, especially for hotel management to be able to manage their properties as efficiently as possible when tourist visits are low. According to Anindi in [1] the building is required to be partially operated or easy to maintain so it does not require high costs when hotel income decreases. The selection of building materials and the determination of the building mass pattern are important in solving this problem.

Indeed, the decline of the hotel industry in Bali as it is happening now is not the first time. The Bali bombings I and II in 2002 and the eruption of Agung Mount in 2017 had almost the same impact after the current pandemic. The decline in the hospitality industry indirectly gives a signal of the importance for hotels to have a sustainable and resilient concept, where later hotel operations can still run independently with all the strategies and designs that have been prepared and can return to being a hotel in general after the crisis is over. The COVID-19 pandemic that has occurred also requires architects to be more careful in selecting building

materials and determining zone and building mass patterns so the hotel buildings can operate efficiently and with low maintenance. Architects and the hotel management can also process the facilities program provided more creatively so the hotel operational costs do not only rely on profits from staying guests but from the availability of several inclusive public facilities. Hotels designed are also required to accommodate the visitor's needs for safe accommodation facilities and are in accordance with several health protocols as well as adaptation of new normal habits that have been regulated by various related institutions. So, this facility can provide confidence for tourists to visit and can slowly restore the Indonesian tourism sector which has been quite slumped due to the COVID-19 pandemic.

### **1.1 Definition of Hotel**

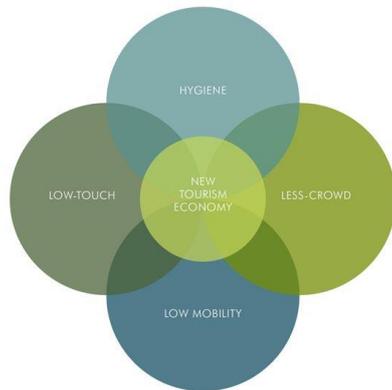
A hotel is one of the various types of tourism accommodation that can be used for tourists as a means of recreation. The following are several definitions of hotels according to several sources, including:

- a. A hotel is a building that was established commercially as a place to stay, eat and enjoy entertainment. Star hotels depend on the facilities they provide to satisfy the visitors. (Suwena, I Ketut & Widyatmaja, I Gusti Ngurah, Pengetahuan Dasar Ilmu Pariwisata, Pustaka Larasan, 2017) in [2].
- b. Hotels are included in the business of providing accommodation. While the business of providing accommodation is a business that provides lodging services that can be complemented by other tourism services. (Peraturan Menteri Pariwisata dan Ekonomi Kreatif Republik Indonesia Nomor PM.53/HM.001/MPEK/2013 tentang standar usaha hotel) in [3].

### **1.2 Impact of Covid-19 on the Tourism Industry**

The Ministry of Tourism and Creative Economy of the Republic of Indonesia issued the 2021 Tourism Trends book which contains some changes that have occurred in the tourism industry from the largest to the smallest scale due to the COVID-19 pandemic. The COVID-19 pandemic was able to change a solidly built business landscape into a completely new business landscape, this was later referred to as the "mega shift industry". These changes are divided into three different scales, including mega (changes) macro (customers), and micro (competition). Mega (changes) are major changes in the fields of technology, politics, regulation, social, economic, and environmental. Macro (customer) is a change based on consumer behavior, while micro (competition) is a change that produces a new competition map in the pandemic era.

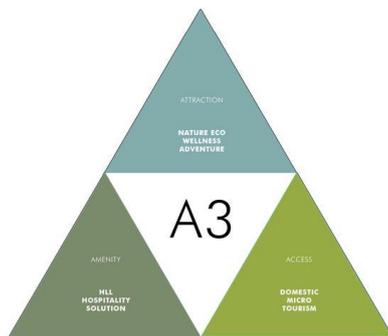
The existence of the COVID-19 pandemic has also created a new tourism economy which is characterized by four characteristics including:



- HYGIENE**
- When the threat of COVID-19 continues to lurk, **Cleanliness, Health, Safety, Environment (CHSE)** becomes the top priority and preference of consumers.
- LESS CROWD**
- In the era of a pandemic, **solitude and remoteness will become a new "luxury"**. Wellness and mindfulness will be sought in the midst of fear and anxiety due to the pandemic
- LOW TOUCH**
- The spread of COVID-19 has changed the tourism industry from **high-touch to low-touch**. Contactless solutions will be the main choice of tourists.
- LOW MOBILITY**
- The pandemic era is an era of low mobility. **Tourists will tend to take short trips**

**Figure 1** Four characteristic of the new tourism economy

In the era of the COVID-19 pandemic, the concept of A3: Attraction, Amenity, Access changed drastically as a consequence of the formation of a new tourism economy.



- NEWA**
- destinations and attractions that offer the concept of **nature, eco, wellness, adventure (NEWA)** will be **more in demand** and become the new mainstream in the tourism industry after COVID-19
- HLL HOSPITALITY SOLUTION**
- Hospitality will remain the "spirit" of service to consumers. However, in the midst of a pandemic, tourists are increasingly concerned with CHSE, so that **hospitality services must be improved with hygiene, low-touch, less-crowded (HLL)**
- DOMESTIC MICRO TOURISM**
- During the pandemic, **domestic tourists are the focus**. Tourist preferences are shifting towards "micro-tourism" where the distance and length of time to travel is getting shorter.

**Figure 2** A3 concept after the new tourism economy

### 1.3 Effect of Covid-19 on the Hospitality Industry

Based on the occurrence of the Megashift Industry in the tourism world in general, this also has an impact on some changes that must be followed by the hospitality industry in Indonesia. Many aspects are problematic and must be considered by the hotel management to adapt themselves to the current pandemic, these aspects include:

a. Regulation

One of the rules implemented by the Government of Indonesia to reduce the spread of COVID-19 is the regulation regarding transportation restrictions, both nationally and internationally. This certainly has a big impact, especially in tourist areas such as Bali, Lombok, NTT, and other tourist areas due to the decline in the number of local and foreign tourists visiting the area. Therefore, "domestic micro tourism" has become the main market targeted by a number of the hospitality industry during this pandemic.

b. Health

Health factors are the biggest concern for tourists when deciding on their vacation activities. Based on the Gensler Architect in [4], there are some tourist requests regarding the adjustment of bedrooms and public spaces in hotels, both from the capacity provided, the air circulation in it, and many other important factors. Based on data from the Ministry of Tourism and Creative Economy of the Republic of Indonesia, health factors have also led to the formation of NEWA (Nature Eco Wellness Adventure) Tourism which can be taken into consideration by hotels regarding the facilities/activities that can be offered after the COVID-19 pandemic.

c. Financial

The financial aspect is the main problem for hotels during the pandemic. Hotels that rely too much on income from staying guests as their only source of income become paralyzed when hotel occupancy rates drop dramatically. In times like this, hotels should have public facilities that are inclusive and creative so that they can be a source of side income. On the other hand, according to Khan in [5], hotels should have a sustainable concept in their operations so that they can survive the pandemic.

d. Operational

Through a pandemic that has occurred for 1.5 years, hotels are required to have an efficient building operational system. The low tourist visits have an impact on reducing the number of employees. In this quiet condition, the hotel building should be able to function partially and with minimal maintenance so that operational costs can be reduced. Based on the Archinesia webinar entitled Building Materials, Design and Pandemic in [6], materials that are easy to clean, easy to move, anti-microbial and the concept of touch-less technology are several aspects that must be considered during a pandemic to reduce the operational costs of a hotel.

## 1.4 Spread of the Covid-19 Virus

According to Fezi in [7], the COVID-19 virus can spread at three different scales, including:

### A. The scale of objects (lowest level)

At this level, the spread occurs from the surface of an object to a person (surface-to-person), where when a person touches a contaminated object surface and then touches a part of the face such as the mouth, nose, or eyes. On this scale, a person can take care of himself by maintaining personal hygiene.

### B. Architectural scale (mid-level)

The spread of the virus does not only occur from person to person, but also through air transmission (aerosol transmission). Viruses can survive in the air for hours. Protection can be done in more complex ways, such as wearing a mask or face shield.

### C. Urban scale (highest level)

On an urban scale, people can protect themselves by limiting their distance. According to an anthropologist Edward T. Hall, there are 4 zones in terms of spacing, including:

1. *Intimate distance* : close range (less than 6"/15 cm)  
long range (6-18"/15-45 cm)
2. *Personal distance*: close range (1,5-2,5 ft / 45-75 cm)  
long range (2,5-4 ft / 0.75-1.2 m)
3. *Social distance* : close range (4-7 ft / 1.2-2.1 m)  
long range (7-12 ft / 2.1-3.7 m)
4. *Public distance* : close range (12-25 ft / 3.7-7.6 m)  
long range (more than 25 ft / 7.6 m)

The spread of the covid-19 virus through droplets occurs up to 6ft/2 meters, which includes intimate, personal and social distance (close range).

## 1.5 Post Pandemic Architectural Elements

### a. Materials in building

One of the causes of the spread of the COVID-19 virus is the surface of objects that are exposed to the spread of the virus. Therefore, choosing the type of material in the room is important to minimize the possibility of viruses surviving on the surface of the material. According to Zaher in [8], materials with non-porous, germ-resistant, and smooth surfaces can be considered for use in post-pandemic buildings. A study conducted by Doremalen in [9], stated that copper material is one of the best options because the virus can only survive for 4 hours. The UV sterilization process is also being considered, according to Fezi in [7] this method was tested on the Shanghai Bus public transportation in April 2020 and has been shown to kill 99.9% of viruses in 5-7 minutes.

### b. Circulation in buildings

According to Chamass et al in [10], 4 parameters can be considered related to the arrangement of circulation in buildings to reduce the spread of the virus, including flexibility, social distancing, path configuration, and room expansion.

1. Flexibility : the ability of the room to adapt to different circumstances
2. *Sosial distancing* : the provision of distance to reduce the spread of the virus
3. Path configuration : layout related to circulation determined by space components
4. Room expansion : the ability of space to be enlarged to increase social distancing

### c. The concept of ventilation

In the current pandemic conditions, the air conditioning system in the room is an important thing to consider. Based on the ASHRAE COVID-19 guidance, the air cleaning system can reduce the spread of the virus. This cleaning system consists of HVAC systems, In-room devices: HEPA filters, mechanical air filters, electronic air filters & UV-C systems. The air cleaning system can minimize the ability of the virus to survive in the room. According to Noti et al.in [11], maintaining room humidity >40% can significantly reduce the spread of the virus.

### d. Arrangement of the building period

Based on research conducted by Gensler Architect in [12] flexibility and adaptability are the main considerations that must be considered in hotel design. Several hotels that have turned into quarantine centers show the importance of hotels in providing transformative spaces and building arrangements. On the other hand, according to Kusumadi, D in [13] after the pandemic, hotels should divide public facilities such as restaurants into separate areas, so that when occupancy rates are low, restaurant facilities can be partially operated.

## **2 Research Method**

### **2.1 Data Collection Method**

The data collection method was carried out by conducting interviews with some respondents who work in the tourism industry, especially in the hospitality sector, regarding some changes that occurred in the hospitality world after the pandemic. Data collection was also carried out by conducting literature studies through books and journals to support secondary data regarding post-pandemic hotel architecture.

### **2.2 Data Analysis Method**

The data analysis method was carried out by processing all the data collected through field interviews, literature studies that have been carried out for further analysis into post-pandemic hotel principles.

## **3 Result and Discussion**

### **3.1 Post-Pandemic Hotel Principles**

The principles regarding post-pandemic hotels are divided into two parts; Post-pandemic hotel principles related to the management system carried out and post-pandemic hotel principles related to the design of the buildings they own.

- a. Post-pandemic hotel principles related to the management system
  1. Business strategy

The pandemic that hit has blurred the boundaries between work activities and leisure activities carried out by humans. According to research conducted by Gensler Architect in [4], the concept of working from anywhere is now commonplace in society. Hotels can support the concept of “bleisure” (business plus leisure) by providing various activities and facilities that can accommodate

these needs. The pandemic that has hit is a reminder of the importance of a hotel to be able to adapt to changes that may occur.

## 2. Market trend

Based on Ministry of Tourism and Creative Economy in [14], it was stated that the trend of hotel visitors after the pandemic has led to domestic micro tourism. So the hotel must pay attention to the characteristics of the market to adjust the facilities provided in hotel services. The characteristics of post-pandemic hotel visitors also prioritize the availability of various facility services in one location to minimize mobility.

## 3. Activity

NEWA (Nature Eco Wellness Adventure) tourism is something that hotels can consider regarding activities that can be offered after the COVID-19 pandemic. Activities that can combine a relaxing experience with business support services have also become relevant to the post-pandemic hotel concept.

## 4. Facility

According to a webinar conducted by Architecture Today, facilities at hotels after the pandemic will be more personalized. This can be realized by having a multifunctional bedroom (resting, working, meeting, exercising).

## 5. Location

The availability of health facilities near the hotel location is something that must be considered in the post-pandemic hotel concept. The tendency to do outdoor activities also demands a good relationship with the surrounding environment.

## b. Post-pandemic hotel principles related to building design

### 1. Circulation

The circulation that connects each room function is mandatory to suppress the possibility of the spread of the virus. Circulation can at least accommodate the mobility of users who are engaged in activities while adhering to a distance of 6ft / 2 meters (intimate, personal & social distance). Circulation is also required to have good flexibility so that it can adapt to various possibilities.



**Figure 3** Circulation principle in post pandemic hotel

2. Building materials

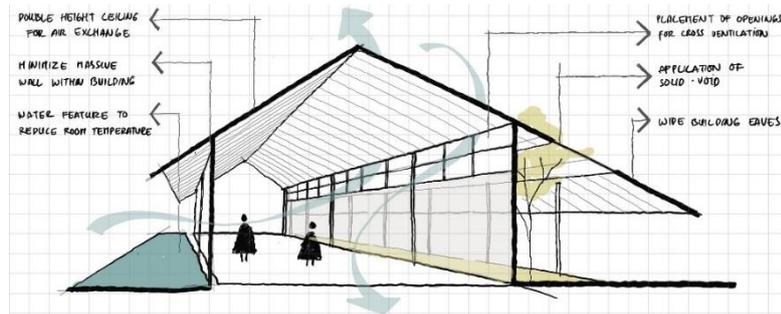
The choice of material in the building emphasizes the ease of maintenance of the material compared to the ability of the character of the material to minimize the spread of the virus. Material selection should use materials that are easy to clean. Materials such as glass, stainless steel, or laminated wood with smooth surfaces and dynamic shapes tend to be easier to clean regularly.



**Figure 4** Material principle in post pandemic hotel

3. Ventilation

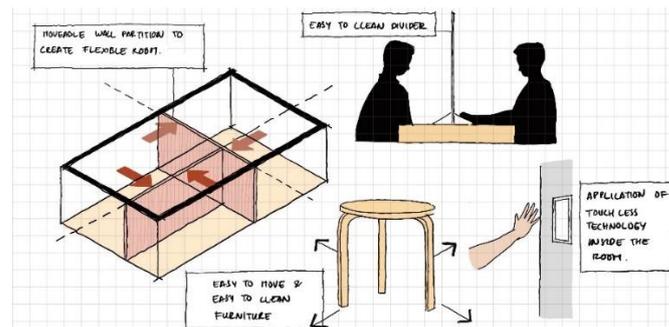
The air conditioning system in the room is focused on being able to channel fresh air in each room to maximize air exchange. On the other hand, air cleaning systems such as HVAC systems, In-room devices: HEPA filters, mechanical air filters, electronic air filters & UV-C systems can be used to minimize the ability of viruses to survive in the room.



**Figure 5** Ventilation principle in post pandemic hotel

#### 4. Inner Room

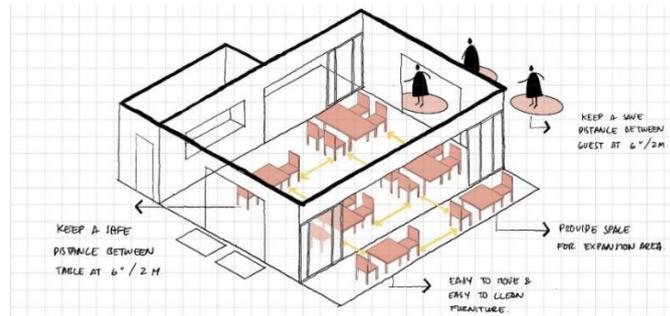
Prioritizing functional items and minimizing decorative items in the room to reduce the possibility of the spread of viruses in the room. In certain rooms, a disinfecting area can be placed as a transition area before entering the main sterile room. Space flexibility is also important so that certain spaces can be used according to their needs at certain times. The interior layout should also separate the staff and visitor areas to minimize contact between visitors and hotel staff.



**Figure 6** Inner room principle in post pandemic hotel

#### 5. Furniture

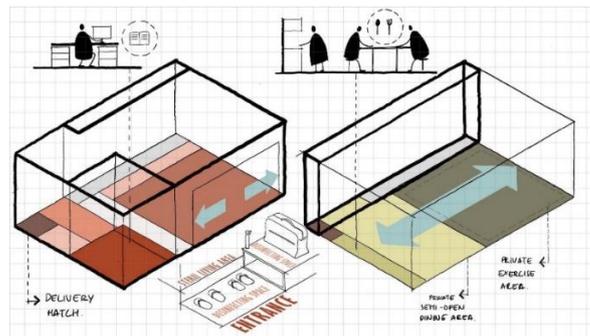
Based on the Archinesia webinar entitled building materials, design, and pandemics, the selection of furniture is prioritized to have the characteristics of being easy to clean and easy to move so it is easy to clean or adjust the arrangement when needed. Furniture with a lightweight and simple shape is highly recommended for use.



**Figure 7** Use of furniture principle in post pandemic hotel

6. Dimensions of space

In the post-pandemic hotel concept, the rooms for visitors will be more personalized. This will have an impact on reducing public spaces and increasing private spaces for visitors. One of the embodiments is a bedroom that is multifunctional to accommodate various activities carried out by its residents.



**Figure 8** Dimensions of space principle in post pandemic hotel

7. Building mass

The mass of buildings in the post-pandemic hotel concept is expected to be used separately. This is to adjust to certain conditions where only part of the building is operational and other buildings can be disabled without disrupting hotel

operations.



**Figure 9** Building mass principle in post pandemic hotel

To summarize the post-pandemic hotel principles, see the table below:

**Table 1** Post-pandemic hotel principles related to management system

NO	POST-PANDEMIC HOTEL PRINCIPLE	RELATED TO MANAGEMENT SYSTEM	SOURCE
1	Business strategy	<i>Work from anywhere movement</i>	Gensler Architect
		<i>Bleisure concept</i>	
		<i>Alternative income</i>	Kemenparekraf
		<i>Work from hotel</i>	
2	Market Trend	<i>Stay-solation</i>	Architecture today
		<i>Staycation is the new vacation</i>	
		<i>Adaptive to change</i>	Gensler Architect
		<i>Attention to hygiene</i>	
3	Activities	<i>Domestik micro tourism (small scale local tourist)</i>	Kemenparekraf
		<i>Attention to hygiene</i>	Architecture today
		<i>Various facility services in one location</i>	
4	Facilities	<i>NEWA (Nature Eco Wellness Adventure)</i>	Kemenparekraf
		<i>Combine a relaxing experience with business support services</i>	Architecture today
		<i>Workout space &amp; gym equipment in the room</i>	
5	Location	<i>Special area for disinfection of goods</i>	Gensler Architect
		<i>In-room workspace</i>	Architecture today
		<i>Multifunctional bedroom (rest, work, meeting)</i>	
		<i>Close to health facilities</i>	Gensler Architect
		<i>Good relationship with surrounding locations</i>	Architecture today

**Source :** summary of a number of recommendations from consultants and agencies

**Table 2** Post-pandemic hotel principles related to building design

No	POST-PANDEMIC HOTEL PRINCIPLE	RELATED TO BUILDING DESIGN	SOURCE
1	Circulation	Circulation with the application of social distancing, flexibility, path configuration and space expansion	Chammas et al (2021)
		Able to accommodate the provisions of the distance between users as far as 6ft / 2m	Edward T. Hall
2	Building material	Material with a non-porous, germ-resistant and smooth surface	Zaher (2020)
		Material that easy to clean	Archinesia talks– Building materials, design and the pandemic
3	Ventilation	<i>HVAC systems, In-room devices : HEPA filter, mechanical air filter, electronic air filter &amp; UV-C systems</i>	ASHRAE COVID-19 Guidance
		Room with natural ventilation system	Gensler Architect
		Maintain room humidity >40%	Noti et al. (2013)
4	Inner room	Minimizing decorative things	KEMENPAREKRAF
		Providing flexible spaces	Gensler Architect
		Minimize contact between staff and visitors	Mass Design Group
5	Furniture	Using furniture that “easy to move”	Archinesia talks– Building materials, design and the pandemic
		Using furniture that “easy to clean”	
6	Room dimension	Visitor’s activity spaces are becoming more personalized Private space becomes larger while public space becomes smaller	Archinesia talks - Design Approach Method – Dharmali Kusumadi
7	Building mass	Dividing the building mass into separate units	Archinesia talks - Design Approach Method – Dharmali Kusumadi

**Source :** summary of a number of recommendations from consultants and agencies

### 3.2 Space Expansion in a Post-Pandemic Hotel

Based on Gensler Architect in [12], several factors become the focus of guest considerations in carrying out activities in some rooms in the hotel. This in turn has an impact on the need for an expansion of the space to provide a sense of security and comfort for visiting hotel guests. Some of these factors include:

Types of activities that are accommodated (main room•• / support room•)

The intensity of visitors who come (a lot of visitors••/ few visitors•)

Room usage time (used together•• / not simultaneously/mandatory booking•)

nature of the use of the room (cannot be personalized••/ can be enchanted•)

the space character (inflexible•• / flexible•)

Assessment will be done with a point system with a value of 5-10. Points 1(•) are awarded for low risk of spread, and points 2(••) are awarded for high risk of

spread. Each reception room will be tested for its relationship with these five factors so that each room has different points based on its characteristics. The higher the points a certain space gets, the greater the risk of spreading the virus.

**Table 3** Factor of space expansion in the reception area

RUANGAN	FAKTOR PERTIMBANGAN					TOTAL
	A	B	C	D	E	
LOBBY	••	••	••	•	•	8
LOUNGE	••	•	••	•	•	7
SOUVENIR SHOP	•	•	•	••	•	6
SPA	•	•	•	•	••	6
LIBRARY	•	•	•	•	••	6
BEACH CLUB	•	••	••	•	••	8
AMPHITHEATER	•	••	••	••	••	9
PLAYGROUND	•	•	•	•	•	5
RESTAURANT	••	••	••	•	•	8
GYM	•	•	••	••	••	8

**Source :** personal analysis

Description :

- A. Types of activities that are accommodated (main room•• / support room•)
- B. The intensity of visitors who come (a lot of visitors••/ few visitors•)
- C. Room usage time (used together•• / not simultaneously/mandatory booking•)
- D. nature of the use of the room (cannot be personalized••/ can be enchanted•)
- E. the space character (inflexible•• / flexible•)

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•• (main room, a lot of visitors, used together, cannot be personalized, inflexible)

• (support room, few visitors, mandatory booking, can be enchanted, flexible)

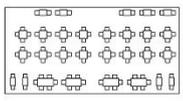
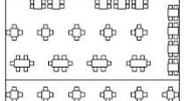
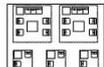
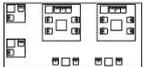
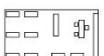
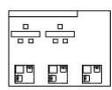
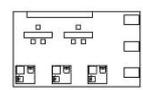
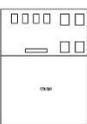
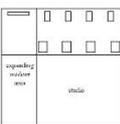
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 The risk of spreading the virus is relatively high

 The risk of spreading the virus is in medium level

Based on the space expansion points that have been made, it is known that the rooms that are included with a high level of virus spread are the lobby, restaurant, gym, beach club, and amphitheater. Meanwhile, rooms with medium-level virus spread consist of lounges, souvenir shops, spas, libraries, and playgrounds. Furthermore, research was carried out regarding the calculation of the area of the room to find out the percentage of additional space in the hotel after the COVID-19 pandemic.

**Table 4** Calculation of additional space in a number of hotel room function after the pandemic

PRE PANDEMIC	POST PANDEMIC	PRE PANDEMIC	POST PANDEMIC
<p><b>RESTAURANT</b></p>  <p>Total area = 200 m2 (TSS) Capacity = 106 person Seats distance = 53 cm Circulation distance = 90 cm Area per person = 1,8 m2</p>	<p><b>RESTAURANT</b></p>  <p>Total area = 246 m2 Capacity = 106 orang Seats distance = 180 cm Circulation distance = 180 cm Area per person = 2,3 m2 Expansion percentage = 23%</p>	<p><b>LOUNGE</b></p>  <p>Total area = 71,5 m2 (HMC) Circulation distance = 90 cm Area per room = 0,9-1,2 m2</p>	<p><b>LOUNGE</b></p>  <p>Total area = 101,5 m2 Circulation distance = 180 cm Area per room = 1,4 m2 Expansion percentage = 42%</p>
<p><b>SOUVENIR SHOP</b></p>  <p>Total area = 50 m2 (TSS) Circulation distance = 130 cm Area per person = 0,9 m2</p>	<p><b>SOUVENIR SHOP</b></p>  <p>Total area = 62 m2 Circulation distance = 180 cm Area per person = 1,16 m2 Expansion percentage = 24%</p>	<p><b>LOBBY</b></p>  <p>Total area = 85,8 m2 (HMC) Front desk area = 9,3 m2 (HRP) Area per room = 1,2 m2</p>	<p><b>LOBBY</b></p>  <p>Total area = 107 m2 Front desk area = 9,3 m2 (HRP) Self check in (3) = 1,6 m2/unit Area per room = 2 m2 Expansion percentage = 24%</p>
<p><b>GYM</b></p>  <p>Total area = 135 m2 (AD) Gym = 54 m2 Studio = 81 m2 Circulation distance = 90 cm Capacity Gym = 5-10 station Studio = 12-28 orang</p>	<p><b>GYM</b></p>  <p>Total area = 189 m2 Gym = 98 m2 Studio = 82 m2 Circulation distance = 180 cm Capacity Gym = 5-10 station Studio = 6-14 orang Persentase kenaikan = 40%</p>	<p>Description : AD = Architect Data TSS = Time Saver Standard for Building Type HMC = Hotel, Motel and Condominium HRP = Hotel &amp; Resort Planning, Design and Refurbishment</p>	

Source : personal analysis

Based on the studies that have been carried out, it can be concluded that each space function requires a different space after the pandemic. The expansion of this space is influenced by a number of factors such as the standard of the circulation distance, the standard of the distance between the furniture, the layout and the number of other design elements.

#### 4 Conclusion

The post-pandemic hotel principle is an important principle to consider to be applied to the hotel design process, especially those designed after a pandemic such as COVID-19. Changes in guest characteristics, market trends, business strategies, and other aspects are mandatory for post-pandemic hotels. Principles related to building design such as circulation, material selection, ventilation, building mass, and many other post-pandemic principles must be observed to provide comfort and a sense of security for staying guests. The post-pandemic

hotel principle is not a principle that is only applied during and sometime after the pandemic, but this principle is a long-term principle that will continue to adapt to new conditions that may occur in the future. This pandemic not only reminds the importance of health and cleanliness in hotel design, but how to create a hotel that is resilient, self-sufficient, and sustainable.

## 5 Acknowledgement

I would like to thank Mrs Woerjantai Kartidjo and Mrs Widiyani for her comments and suggestions regarding this research. I also would like to thank Mr Harry for great discussions as well as his support and encouragement. The researchers also would like to thank to Mrs Miswadita Anindi who has helped and supported in providing data and information for the purpose of this research.

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## Stock Valuation of Coal Mining Company Post Pandemic (Case Study: Adaro Energy Indonesia)

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**Abstract.** Coal is one of the commodity that is mined and consumed a lot in Indonesia and also the world. The thermal coal is needed for the electricity meanwhile metallurgical coal is needed in the steel making industry. Towards mid-2021, the coal price has escalated to all time high. It affects stock price performance of several coal mining companies in Indonesia. From having a bad downturn in 2020 due to Covid-19 and less energy demand, coal starts to gain more demand in 2021 in line with more industrial activities and economy recovery. In Indonesia, one of the coal mining company with the huge reserves and market capitalization is Adaro Energy. The purpose of this research is to analyze the intrinsic value of Adaro Energy to help investors gain insight especially after the world economy is recovering after two years in the pandemic crisis. The financial performance of Adaro Indonesia will be projected for the upcoming five years. From the calculation using Discounted Cash Flow, it is found that the intrinsic value is IDR3.263,56. Considering the market value of Adaro in the closing date of 2021 is IDR2.250, thus the expected rates of return is 45% or IDR1.014,00.

**Keywords:** *stock valuation; discounted cash flow; fair value; coal mining.*

### 1 Introduction

According to International Energy Agency (2019) <sup>[1]</sup>, Southeast Asia is going to reach the universal access to electricity by 2030. It means the demand for electricity will increase significantly over the coming decades. It is recorded that the growth of electricity demand in the Southeast Asia region alone is averaging at 6% per year. It is considered as the fastest increasing electricity demand in the world.

One of the energy source for electricity that is common and very cheap to use is coal. Thus, Southeast Asia is one of the region that relies on coal energy source a lot and even had an increase of coal demand in their power mix in 2018. In the PLN's (Indonesia's electricity power company) RUPTL 2021 – 2030, the portion of coal in the fuel mix would remain around 60% until 2030 (ADB, 2020) <sup>[2]</sup>.

Indonesia is one of the biggest producer and exporter of coal in the world. It is recorded that the country's coal exports contributes to the GDP of Indonesia for about 5%, and 12% of all export income (LPEM UI, 2022)<sup>[3]</sup>. One of the biggest coal mining company that listed on IDX30 index by Indonesian Stock Exchange is Adaro Energy Indonesia. IDX30 is an index that measures the price performance of 30 stocks that have high liquidity and large market capitalization and supported by good company fundamentals (IDX, 2022)<sup>[4]</sup>. The index is updated regularly by Indonesian Stock Exchange as the institution that manage the capital market in Indonesia. Other than Adaro Energy Indonesia, only PT Bukit Asam that is able to be listed there. Per December 2021, the market capitalization of Adaro is USD\$6.5 billion.

The 2022 and future coal market prospect is supported by the economic recovery target in most countries to catch up after the slowdown of economic activities during COVID19 pandemic. The world economy is forecasted to grow by 4.1% in 2022 according to the World Bank<sup>[5]</sup>. Energy will be the key factor to achieve the target and coal will remain as the majority in total fuel mix. McCloskey by OPIS, a Dow Jones Company predicts that global coal demand in 2022 would grow by 2%, where 3% growth would happen in the Pacific market<sup>[5]</sup>. Therefore, it is interesting and also important to analyze one of the biggest coal producer in Indonesia which is Adaro Energy Indonesia to gain recommendation for investors.

## 1.1 Business Issue



**Figure 1** Adaro 5-years Stock Performance (Yahoo Finance, 2022).

The stock price of Adaro has reached the lowest on 15th March 2020 (during this past five years period) at IDR745 due to the less mobility of people, slowdown of economy during pandemic and thus, less energy demand. The same thing

happened to the stock price of other coal mining companies in Indonesia such as Bumi Resources at IDR50, and Indika Energy at IDR480. However, the stock price of Adaro is recovering to be as high as early 2018 in the end of 2021 into 2022 faster than other coal mining companies. At the beginning of January 2022, the stock price is at IDR2.310.

One of the cause is the high energy demand from China, India and several countries in Europe following the economic recovery post pandemic. Hence, the international coal price increases reaching the highest in the period of 5 years. Tracing back to the second half of 2018, due to unexpectedly hot weather across Asia and Europe, which resulted in greater energy usage for air conditioning, the thermal coal price reached its peak, the highest since 2012. China and India are expected to continue to be the world's largest coal consumers through 2023, with total coal consumption forecast to be roughly two-thirds of worldwide consumption.



**Figure 2** 2017-2021 Coal Price Trend (Trading Economics, 2022).

Both events have caused coal mining companies to gain more revenue, positive sentiment and increase in their stock price. Adaro as the company that exports 75% of their production is of course benefitting from the situation, but also vulnerable to the commodity price drop.

In this paper, there will be an analysis of Adaro's valuation process using Discounted Cash Flow (DCF) method and Relative Valuation method to assess the fundamental and find the fair price of Adaro Energy Indonesia. We need to recalculate the fair value of Adaro after the pandemic and whether we should invest in the company to gain return or it is not recommended. Thus, feasibly this final project will help investors to get some insight and better judgement on Adaro Energy Indonesia.

## **2 Business Exploration**

### **2.1 External Analysis**

Corporate Finance Institute (2022) <sup>[6]</sup> mentioned that external analysis is exploring the industry environment of a company including macroeconomics, global, social, political and technological analysis. In conducting a business operation activities, the external factors may affect the company. It can lean towards positive or negative effects that drive profitability, growth, and profitability.

#### **Threats of New Entrants (Low)**

In entering a coal mining industry, a company needs a lot of resources, skill and fund to be established well. First, they need to do their research to find coal reserves, getting a license from the government, and also acquiring the land. Furthermore, to survive in the competitive industry and to survive the cyclical nature, a company needs to conduct a low cost production and find the buyers of coal which might already has contract with other companies. Thus, the threats of new entrants is considered low.

#### **Bargaining Power of Suppliers (Medium)**

The bargaining power of suppliers remains medium. Adaro Energy Indonesia has an integrated business model that allows them to cut cost and also be more flexible. Using their strategically integrated coal supply chain from pit to port through their subsidiaries, they manage to be cost effective during the peak and even the lowest cycle of the industry. It has enabled Adaro to achieve the cost leadership position in both thermal and metallurgical coal. Thus, the coal is sold at competitive cost and contributes to the highest operational EBITDA margin in the sector.

#### **Bargaining Power of Buyers (Medium)**

Considering the post pandemic situation in which every country is catching up to a faster economic development, they competitively demand for energy source. In addition, the conflict between Russia and Ukraine has made countries that rely on gas exports from Russia search for other energy source including coal. Furthermore, heat waves and also the colder winter season has increased the use of electricity for air conditioning and room heater. Meanwhile, domestic demand is still high as Indonesia is going for 100% national electrification program. However, the ceiling price is limited to US\$70 per ton as stated in Keputusan Menteri Energi dan Sumber Daya Mineral No.255.K/30/MEM/2020<sup>[7]</sup>. Thus, the bargaining power of buyers is considered medium.

### Threats of Substitution (Medium)

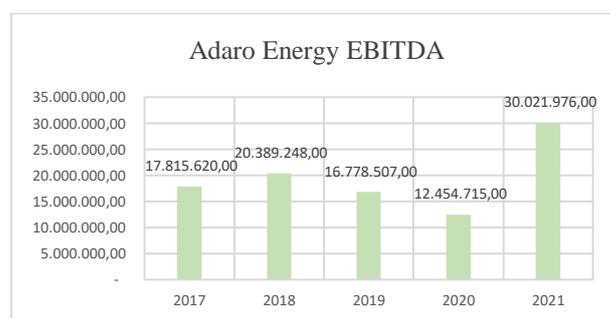
Indonesia has an abundant resource of renewal energy such as geothermal, hydropower, wind power, solar power, etc. However, the program to turn Indonesia's fuel consumption into renewable energy consumption tends to be slow. For instance, Indonesia is only using 7% of their geothermal potential (ADB, 2020) <sup>[2]</sup>. The National Energy Policy (KEN) 2014 has set the target for the primary energy mix until 2025. Although, the institution aims for 23% contribution from the renewal energy, coal is still going to be the highest contributor in the primary energy mix at 55%. Meanwhile, for export, the country relies mainly to China and India that still heavily consume coal.

### Competitive Rivalry (High)

In Indonesia itself, there are already some existing coal mining companies such as Indika Energy, Indo Tambangraya Megah, Bayan Resources, Bumi Resources, ABM Investama, Golden Energy Mines that also supply to both domestic demand and also exports to fulfil the demand from other countries. Furthermore, Indonesia is not the only country with huge number of coal reserves and exports. There are China and Australia with more amount of coal exports in the global market.

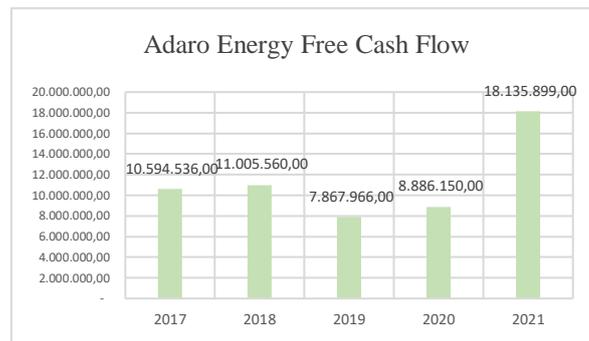
## 2.2 Internal Analysis

### 2.2.1 Adaro Financial Overview



**Figure 3** Adaro Energy Indonesia (Analysis, 2022).

In 2021, Adaro Energy Indonesia finally recovered from the declining financial position caused by the crisis during the Covid-19 pandemic. Not only they finally gain an increase in their EBITDA and free cash flow, but also outperformed their 2017 and 2018 financial performance. Operational EBITDA increases 138% y-o-y in 2021 with 30.021.976 (IDR million), and 102% increase y-o-y for the free cash flow with 18.135.899 (IDR million). With the huge amount of cash generation in 2021, Adaro closed the year in a net cash position. The company's liquidity becomes at solid position of US\$2.3 billion.

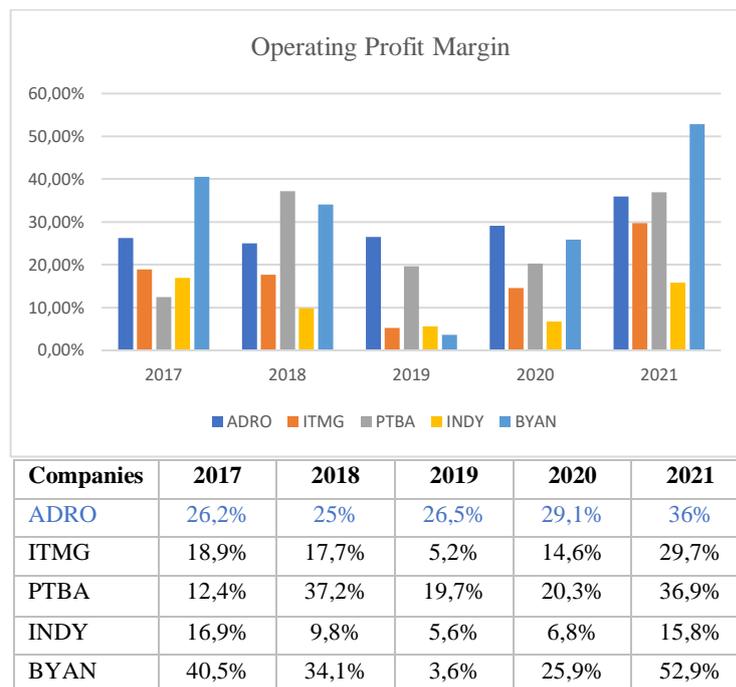


**Figure 4** Adaro Energy Indonesia Free Cash Flow (Analysis, 2022).

## 2.2.2 Financial Ratio

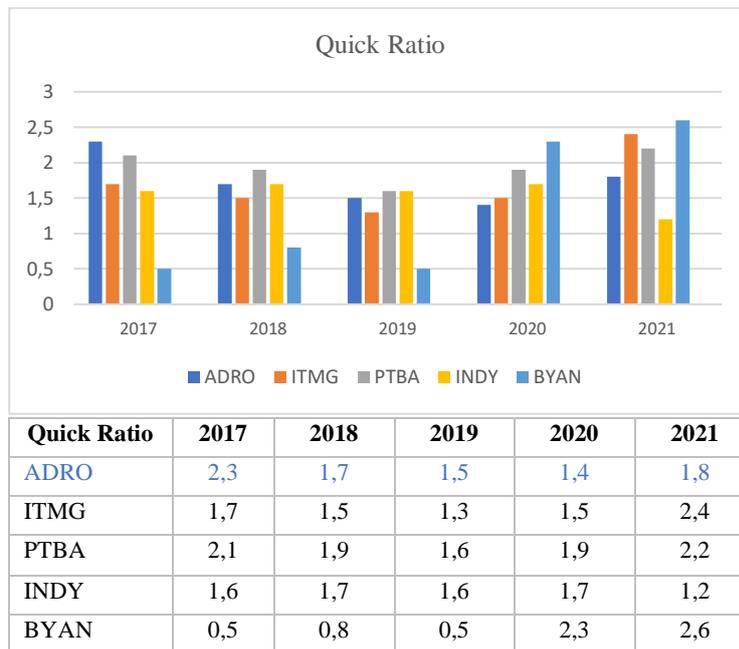
There are some financial ratio that will be used to analyze the profitability, liquidity and the market value of Adaro and other coal mining companies as the comparison. These companies has the biggest market capitalization and or coal reserves.

**Table 1** Operating Profit Margin (Analysis, 2022).

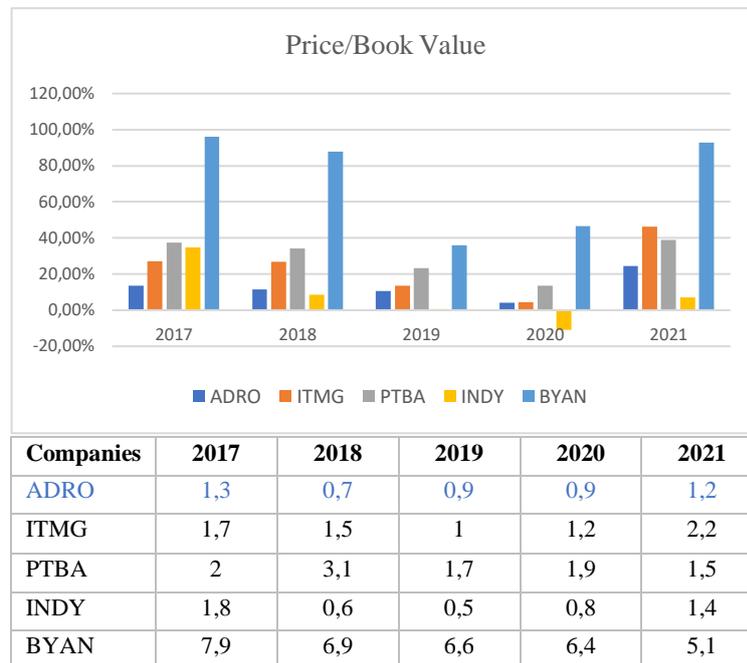


**Operating Profit Margin.** It is a measure of how a company is able to generate profit from its operating activities. The bigger percentage is generally better. From the calculation, it is found that the operating profit margin of Adaro is consistently increasing every year and reaches 36% in 2021. In addition, based on this ratio PT Bayan Resources Tbk outperforms other companies with 52,9% followed by PT Bukit Asam at 36,9%. However, during the first year of Covid-19 pandemic in 2020, Adaro Energy managed to overcome the economic challenge with the highest operating margin.

**Table 2** Quick Ratio (Analysis, 2022).



**Quick Ratio.** It is a measure of company’s short term liquidity whether the company can meet all of its current liabilities or not using near cash or quick asset. From the calculation above, it is found that Adaro quick ratio gets better to 1,8 in 2021. Any ratio above 1 is good which means the company has enough asset to be liquidated to pay for its current liabilities.

**Table 3** Price per Book Value (Analysis, 2022).

**Price per Book Value.** It is a measure of whether the company's stock is valued fairly, undervalued or overvalued. Higher ratio indicates that the stock is overvalued compared to its book value. In this calculation, Adaro has the lowest PBV in 2021 which might indicate that the price is more fairly priced compared to others.

## 2.3 Business Strategy Analysis

### 2.3.1 Diamond Strategy Framework

This strategy framework is created by Don Hambrick and Jim Fredrickson with the purpose to understand the business strategy of a big company with more complex operational aspects by visualizing it into five elements. They are arena, vehicle, differentiators, staging, and economic logic.

Arena is filled the answer about where will we be active; vehicle is about how will we get there; differentiators is about how will we win or achieve the target; staging is about what will be our speed or sequence of moves; and economic logic is about how will returns be obtained. Here is the diamond strategy framework for Adaro Energy Indonesia:

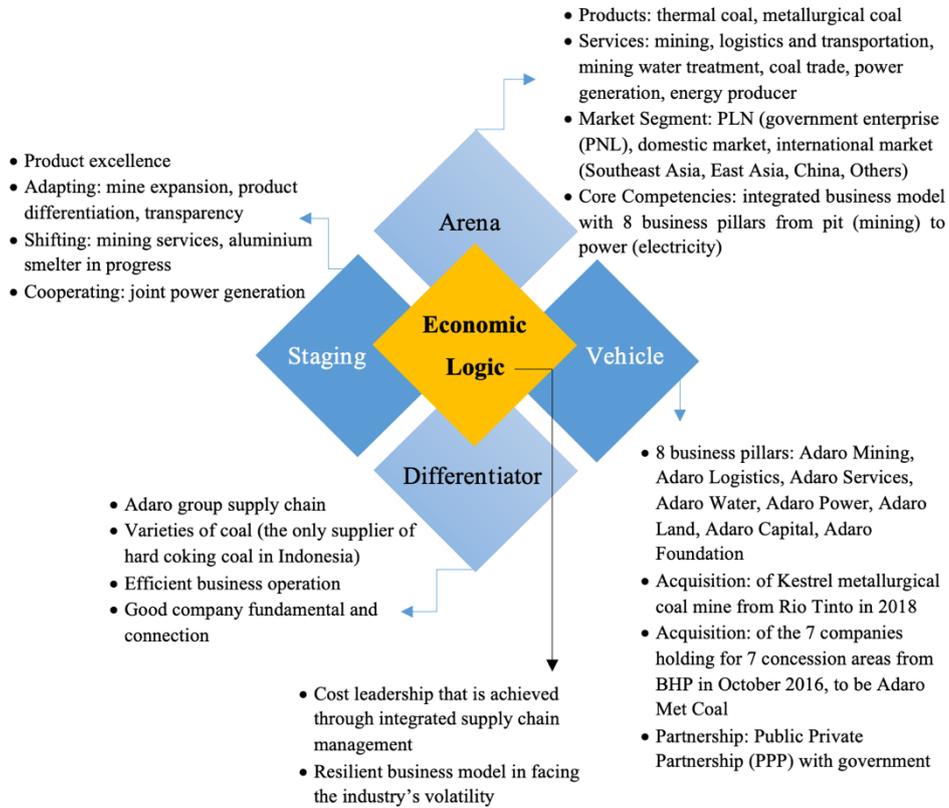
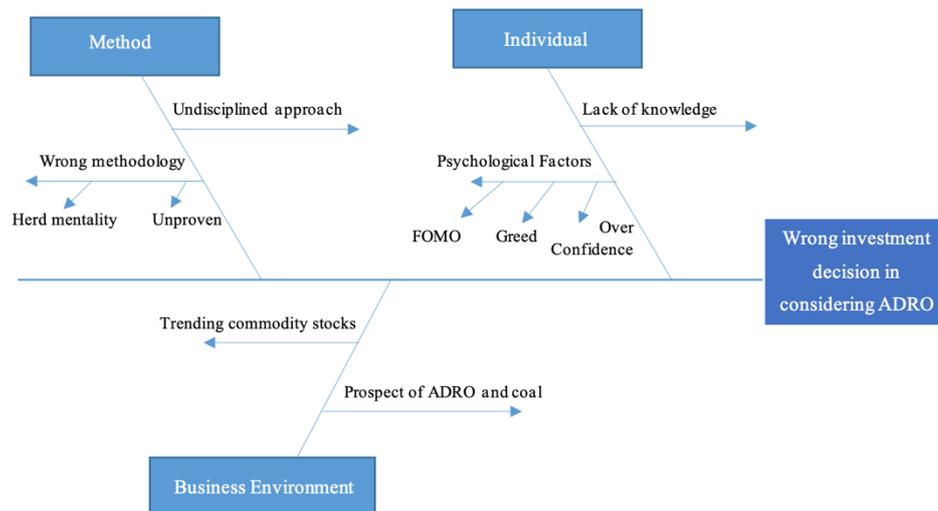


Figure 5 Diamond Strategy Framework (Analysis, 2022).

### 2.3.2 Root Cause Analysis

In analyzing a root cause of certain occurrence, fish bone diagram can be used since it is a causal diagram. It was first created by Kaoru Ishikawa to identify the possible causes of a problem. For this research regarding Adaro Energy Indonesia stock valuation, the problem that is faced by investor is making a wrong investment decision regarding ADRO stocks. Here is the visualization of possible causes:



**Figure 6** Root Cause Analysis (Analysis, 2022).

There are three main factors that affect the decision making process regarding investment in ADRO stock. First is the methodology used to analyze the stock. Investors might be using the wrong method because of using unproven method academically, or because they have a herd mentality which is when a person is making decision based on other people/majority decisions. Second is the behavior of the individual themselves. The investor might lack of knowledge regarding this type of investment or industry. Warren Buffet always recommends people to only invest in the business that we understand.

Furthermore, the investor might also have the fear of missing out (FOMO), they invest in this commodity because it is a trend since commodity prices is escalating rapidly. It also might linked to greed and overconfidence that leads to a biased investment decision. Meanwhile the third is business environment, the investor is affected by the popularity of commodity stocks and the prospect of the company or industry. Therefore, in this paper, the stock valuation and investment insight will be analyzed objectively using proven method such as absolute valuation and relative valuation.

### 3 Business Solution

#### 3.1 Absolute Valuation

In order to calculate the fair value of Adaro stock, absolute valuation model is used. The income statement and balance statement will be projected based on the historical financial statement of Adaro. The projection uses tools such as 5 years

moving average and median to generate the free cash flow for the next five years. That free cash flow will be discounted using the discount rate from weighted average cost of capital (WACC). To calculate the WACC, first we need some assumptions to find the cost of debt and cost of equity.

**Table 4** Assumption for Weighted Average Cost of Capital (Analysis, 2022).

No	Variable	Value	Remark	Source
1	Risk Free Rate	7,5%	10 years government bond yield June 2022	Bank Indonesia
2	Company Default Spread	0,63%	Adaro Interest Coverage, 2021	Damodaran
3	Country Default Spread	1,62%	Government sovereign 5 <sup>th</sup> January 2022	Moody's and Damodaran
4	Beta Stock	1,088	ADRO beta stock 3 <sup>rd</sup> March 2022	Pefindo
5	Equity Risk Premium	6,12%	Indonesia Equity Risk Premium 5 <sup>th</sup> January 2022	Damodaran
6	Country Risk Premium	1,88%	Indonesia Country Risk Premium 5 <sup>th</sup> January 2022	Damodaran
7	Tax Rate	30%	Average Tax Rate	Financial Statement

Cost of debt is an interest rates or return that is provided from the company towards their fund lender. Meanwhile, cost of equity is the rates of return that is provided for the equity investors or shareholders. The formula and calculation is as follow:

$$\begin{aligned}
 \text{Cost of Debt} &= \text{Risk Free Rate} \\
 &\quad + (\text{Company Default Spread} + \text{Country Default Spread}) \\
 &= 7,5\% + (0,63\% + 1,62\%) \\
 &= 9,75\%
 \end{aligned}$$

$$\begin{aligned}
 \text{Cost of Equity} &= \text{Risk Free Rate} + (\beta \times \text{Equity Risk Premium}) \\
 &= 7,5\% + (1,088 \times 6,12\%) \\
 &= 14,71\%
 \end{aligned}$$

After finding the cost of debt and cost of equity, here is the calculation for the weighted average cost of capital. The total debt and total equity is obtained from the 5 years financial projection.

$$\text{WACC} = (W_e \times \text{CoE}) + (W_d \times \text{CoD}) \times (1 - t)$$

**Table 5** Adaro Weighted Average Cost of Capital (Analysis, 2022).

Variable	Value
Total Firm's Debt (million IDR)	26.403.428,95
Total Firm's Equity (million IDR)	20.093.834,10
Total Firm's Debt + Equity (million IDR)	46.497.263,05
Weight of Debt	56,78%
Weight of Equity	43,22%
Estimated Cost of Debt	9,75%
Estimated Cost of Equity	14,21%
Corporate Tax Rate	30%
<b>WACC</b>	<b>10%</b>

Next, the free cash flow to the firm is calculated. This cash flow is considered to be the company's profitability after accounting for taxes, capital expenditures, and net-working capital. Thus, the formula is

$$FCFF = ((EBIT \times (1 - \text{tax rate})) + \text{Depreciation} - \text{Capital Expenditure} - \Delta \text{Net Working Capital})$$

All of the variables are obtained from the financial projection in million IDR. The fifth year's free cash flow which is IDR 191.649.177,34 million is calculated to find the terminal value.

$$\text{Terminal Value} = \frac{FCF_n \times (1 + \text{growth rates})}{WACC - \text{growth rates}}$$

The growth rates is assumed to be 4% since the World Bank predicts that the global economy will grow after the pandemic for approximately 4%. Although, PLN (the state enterprise that provides electricity) predicts that the demand for electricity will grow for 6% per year, Adaro Energy Indonesia sells 75% of their products abroad/exports.

**Table 6** Adaro Free Cash Flow to the Firm (Analysis, 2022).

Earnings Before Interest and Taxes (EBIT)	8.834.891,18	8.735.315,32	8.822.424,71	11.648.819,88
Tax of EBIT	2.720.263,00	2.689.603,59	2.716.424,57	3.586.671,64
<b>Net Operating Profit After Tax</b>	<b>6.045.711,73</b>	<b>6.106.000,14</b>	<b>8.062.148,24</b>	<b>8.062.148,24</b>
Depreciation & Amortization	4.485.338,61	4.982.922,39	5.411.075,08	5.140.773,40
<b>Operating Cash Flow</b>	<b>10.531.050,34</b>	<b>11.088.922,54</b>	<b>13.473.223,32</b>	<b>13.202.921,64</b>
Changes in NWC	1.830.233,48	1.254.190,32	1.463.005,89	(4.340.770,35)
Changes in CAPEX	3.834.390,59	3.667.093,57	4.656.831,65	6.492.180,74
<b>Free Cash Flow to the Firm</b>	<b>4.866.426,27</b>	<b>6.167.638,65</b>	<b>7.353.385,79</b>	<b>11.051.511,25</b>
<b>Terminal Value</b>				<b>191.649.177,34</b>
<b>Total Cash Flow</b>	<b>4.866.426,27</b>	<b>6.167.638,65</b>	<b>7.353.385,79</b>	<b>202.700.688,59</b>

The terminal value of Adaro then being averaged by EV/EBITDA as the future value. Then, it will be discounted to the net present value as the Enterprise Value below. It is further calculated to find the intrinsic value per share of Adaro Energy Indonesia based on their financial performance.

**Table 7** Adaro Intrinsic Value (Analysis, 2022).

<b>Intrinsic Value</b>	
Enterprise Value	104.905.051
Plus: Cash	25.886.320
Less: Debt	26.403.429
Equity Value	104.387.943
<b>Equity Value/Share</b>	<b>3.263,56</b>

In the intrinsic value calculation above, the total equity value is divided by the total shares outstanding which is 31.9 billion. It is found that the fair value of Adaro energy Indonesia is IDR3.363,56.

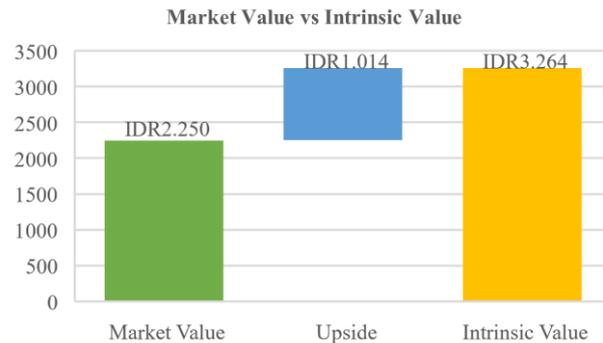
**Table 8** Adaro Market Value (Analysis, 2022).

<b>Market Value</b>	
Market Cap	71.968.392
Plus: Debt	26.403.429
Less: Cash	25.886.320
Enterprise Value	72.485.501
<b>Equity Value/Share</b>	<b>2.250,00</b>

However, the market value per share in the closing date of 2021 is IDR2.250. Thus there is an upside between the price on the market. It is resulted in the target price upside of 45% and internal rate of return IRR of 20%.

**Table 9** Adaro Rates of Return (Analysis, 2022).

<b>Rate of Return</b>		
Target Price Upside		45%
Internal Rate of Return (IRR)		20%
<b>Market Value vs Intrinsic Value</b>		
Market Value	IDR	2.250
Upside	IDR	1.014
Intrinsic Value	IDR	3.264



**Figure 7** Adaro Market Value Compared to Intrinsic Value (Analysis, 2022)

Thus, the stock price of Adaro Energy Indonesia is undervalued relatively to its fair value. The potential reward is 45% or IDR1.014,00.

#### 4 Conclusion and Recommendation

In conclusion, based on their historical financial performance, Adaro Energy Indonesia is a healthy and liquid company especially when the managed to increase their operating profit margin and now in a strong cash position. However, their Return on Asset and Return on Equity is outperformed by smaller sized company. Adaro just acquired Met Coal in 2016 and Kestrel 2018, they still have years ahead to utilize their asset to the maximum potential. For the PBV value, Adaro PBV is at 1,2 which is the lowest among others. It indicates that the company is more fair valued than others with higher PBV ratio.

Meanwhile, the intrinsic value is higher than the market value. Thus, the market value is considered undervalued. It is a good sign for investor to consider Adaro stock. From the calculation, the fair value is IDR3.264 which gives some room for return with the rates of 45% if using the price of closing date in 2021 at IDR2.250. As mentioned in the introduction and also business issue, the prospect of coal commodity is still quiet promising due to high demand from both domestic and international.

In conclusion, Adaro Energy Indonesia is considered a healthy and undervalued company referring to the comparison of market value and intrinsic value. However, investors should also pay attention to the current stock price and compared them to the intrinsic value calculation in this paper. In addition, it is advised to be watchful regarding the commodity price if investor is investing in commodity stock, as coal commodity price heavily influences the revenue and stock price as mentioned in the business issue.

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## Computational Modelling of Steady State Linear Elasticity using Least Square Moving Particle Semi-Implicit Method

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**Abstract.** Least Square Moving Particle Semi-Implicit (LSMPS) Method is a particle based spatial differential operator designed to solve various continuum mechanics problems by using particle-based method computation. LSMPS is able to solve the spatial derivative of a particle at any given locations when it has sufficient number of neighboring particles even if the neighboring particles is randomly distributed in contrast to standard finite difference method where the particle must be distributed in a typical cartesian grid. In this study, the LSMPS operator will be used to solve steady linear elasticity problems in both two-dimensional and three-dimensional domain. The result obtained from LSMPS numerical simulation is compared to the respective analytical solution, empirical solution, or available commercial software ANSYS. In this study, the simulation time required for each problem using the LSMPS discretization is also the research interest and is tabulated as a reference for the reader.

**Keywords:** *linear elasticity; particle-based simulation; and structure analysis.*

### 1 Introduction

Nowadays, the elasticity problems mostly are solved by applying the finite element method (FEM) on the elasticity governing equations. However, there are certain requirements in discretization by finite element method, such as the requirement to generate a proper mesh grid for the domain and the transformation of the governing equation into the weak-form or integral form in order to solve the elasticity governing equation by FEM. This Finite Element Method is very popular and many commercial software employs this method such as ANSYS®.

Particle based methods, unlike the mesh-based method counterpart has been long developed. In the last 20 years, there are many particle-based method developed for calculating spatial derivation as described by Chen et.al. in [1]. One of the popular particle-based method SPH (Solid Particle Hydrodynamics) are able to solve the elasticity differential equations without the usage of mesh and it is able to solve the governing equations directly in its strong form (differential form). This leads to a less complex discretization and solving procedure while also helps to support for large deformation simulation as the particle can move freely

compared to mesh-based method. Most of SPH methods implemented for elasticity problem however are designed to solve for dynamic elasticity problem such as Gray (2001) in [2]. However, the dynamic elasticity formulation is very inefficient to be used to solve for static elasticity problem due to the high computational effort required.

Therefore, a more efficient solution which solves specifically for the static elasticity problem is needed. One of the methods that has been used for solving the static elasticity problem is DC-PSE (Discretization Corrected Particle Strength Exchange) method developed by Bourantas (2018) in [3] has successfully applies this particle-based discretization method in hybrid with the standard finite difference method to solve for the static linear elasticity problems.

Another promising particle-based discretization method is the Least Square Moving Particle Semi-Implicit (LSMPS) Method introduced by Tamai & Koshizuka (2014) in [4] which are the further development using least square model of the older moving particle semi-implicit (MPS) method developed by Koshizuka & Oka (1996) in [5] that has been booked by Koshizuka et.al. (2018) in [6]. This method is mainly used for calculating particle-based spatial derivative for application in fluid dynamics, and nuclear dynamics.

Considering the other particle-based discretization method that discussed before, the author has decided to use a full LSMPS discretization method for the whole domain of the elastic solid. The author intends to measure the accuracy of full LSMPS discretization method and its computational time for solving the static elasticity problems.

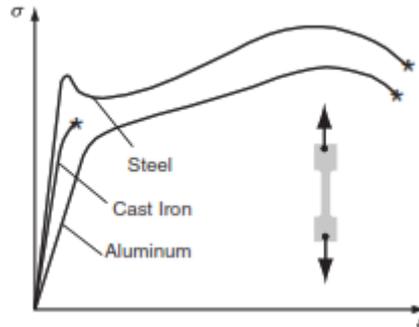
## 2 Theoretical Basis

### 2.1 Elasticity

Deformation of a solid material is caused by the application of load. While elasticity is the ability of a material to resist this deformation. A material is determined as an elastic material when its shape returns to its original shape when the applied load is removed. The measurement for elasticity is defined by elastic modulus such as the Young's modulus which connects the factor of stress and strain of the material due to compression or tension loading. The Young's modulus relation with stress and strain linearly calculated as in Eq. 1 as described by Bauchau & Craig (2009) in [7].

$$\sigma = E \cdot \varepsilon \quad (1)$$

Solid materials such as aluminum and steel undergoes this elastic deformation when deformation is sufficiently small and the material's stress does not exceed its yield stress value. When the deformation exceeds its elastic limit, plastic deformation occurs on the material and the stress-strain relationship cannot be approximated to be linear. This stress strain relation is shown using the general stress-strain curve for typical isotropic material in Figure 1 as described in Sadd (2021) in [8].



**Figure 1** General stress-strain curve in elasticity for selected materials.

## 2.2 Linear Elasticity

The linearization assumption of an elasticity model is only valid to be used for very small strain or deformations where the material does not exceed its yielding limit value (Yield Stress). Without using the linear assumption, the strain of a material is related to its displacement by Eq. 2 and 3 for lagrangian and eulerian space respectively as described by Sadd (2019) in [9].

$$\boldsymbol{\varepsilon} = \frac{1}{2} [\nabla \mathbf{u} + (\nabla \mathbf{u})^T - (\nabla \mathbf{u})^T \cdot \nabla \mathbf{u}] \quad (2)$$

$$\boldsymbol{\Sigma} = \frac{1}{2} [\nabla_x \mathbf{u} + (\nabla_x \mathbf{u})^T - (\nabla_x \mathbf{u})^T \cdot \nabla_x \mathbf{u}] \quad (3)$$

Using the linearization assumption, the relation can be simplified into the Eq. 4 as described by Sadd (2021) in [8].

$$\boldsymbol{\varepsilon} \cong \boldsymbol{\Sigma} = \frac{1}{2} [\nabla \mathbf{u} + (\nabla \mathbf{u})^T] \quad (4)$$

The constitutive equation is needed for the stress-strain relationship. The constitutive equation used is the Hooke's law for linear isotropic elastic material which is shown as Eq. 5 by Bower (2010) in [10].

$$\boldsymbol{\sigma} = \lambda \cdot \text{tr}(\boldsymbol{\varepsilon}) \cdot \mathbf{I} + 2\mu \boldsymbol{\varepsilon} \quad (5)$$

Where  $\lambda$  and  $\mu$  are the Lamé constants and shear modulus respectively defined by Bower (2010) in [10] as Eq. 6 and Eq. 7 respectively.

$$\lambda = \frac{\nu E}{(1+\nu)(1-2\nu)} \quad (6)$$

$$\mu = \frac{E}{2(1+\nu)} \quad (7)$$

These linear elasticity relations will be used to solve the Navier-Cauchy linear elasticity equations in terms of displacement.

### 2.3 Linear Elasticity Governing Equation

The general momentum equilibrium differential equations for elasticity problem consists of inertial forces, body forces, and the stresses acting on the material. This is shown in the following equation as in Bower (2010) in [10].

$$\rho \frac{\partial v}{\partial t} = \nabla \cdot \boldsymbol{\sigma} + \mathbf{f} \quad (9)$$

Using the linearization assumption, the relation can be simplified into the Eq. 10.

$$\nabla \cdot \boldsymbol{\sigma} = -\mathbf{f} \quad (10)$$

For the boundary conditions, the known property can either be the stresses applied on the surface (Neumann boundary conditions) or the displacement of the particles (Dirichlet boundary conditions). For the Neumann boundary condition, the equation is stated in Eq. 11.

$$\mathbf{u} = \mathbf{d} \quad (11)$$

For the Dirichlet boundary condition, the boundary equation is stated in Eq. 12.

$$\boldsymbol{\sigma} \cdot \mathbf{n} = \mathbf{t} \quad (12)$$

### 2.4 Least-Square Moving Particle Semi-Implicit Method

Least Squares Moving Particle Semi-implicit (LSMPS) Method was developed by Tamai and Koshizuka (2014) [4] to simulate flow in incompressible flow with free surfaces. This method is the improvement from the Moving Particle Semi-implicit (MPS) Method which was also developed by Koshizuka and has been written in a book by Koshizuka (2018) in [6]. The improvement of LSMPS method from MPS which had been made is minimizing the error using weighted least squares function. In this simulation the idea of LSMPS is adopted to calculate the spatial derivatives.

The main equation for LSMPS spatial approximation convolution as in Eq. 9.

$$\mathbf{D}_x f^h(\mathbf{x}_i) = \mathbf{H}_{r_s} \mathbf{M}_i^{-1} \mathbf{b}_i \quad (9)$$

The  $\mathbf{H}_{r_s}$  matrix is the monomial basis for the LSMPS method as in Eq. 10.

$$\mathbf{H}_{r_s} := \text{diag} \left( \left( r_s^{-|a|} a! \right)_{1 \leq |a| \leq p} \right) \quad (10)$$

The  $\mathbf{M}_i$  and  $\mathbf{b}_i$  matrix is the least square approximation measure as in Eq. 11 and 12 respectively.

$$\mathbf{M}_i := \sum_{j \in \Lambda_i} \left( \omega \left( \|\mathbf{x}_j - \mathbf{x}_i\| \right) \mathbf{p} \left( \frac{\mathbf{x}_j - \mathbf{x}_i}{r_s} \right) \mathbf{p}^T \left( \frac{\mathbf{x}_j - \mathbf{x}_i}{r_s} \right) \right) \quad (11)$$

$$\mathbf{b}_i := \sum_{j \in \Lambda_i} \left( \omega \left( \|\mathbf{x}_j - \mathbf{x}_i\| \right) \mathbf{p} \left( \frac{\mathbf{x}_j - \mathbf{x}_i}{r_s} \right) \left( f(\mathbf{x}_j) - f(\mathbf{x}_i) \right) \right) \quad (12)$$

The  $\omega$  is the weighting function used in the formulation, the weighting function used is as stated in Eq. 13.

$$\omega(\mathbf{x}, r_e) = \begin{cases} \left( 1 - \frac{\|\mathbf{x}\|}{r_e} \right)^2 & , 0 \leq \|\mathbf{x}\| < r_e \\ 0 & , \|\mathbf{x}\| \geq r_e \end{cases} \quad (13)$$

### 3 Computational Modelling

#### 3.1 Program Structure

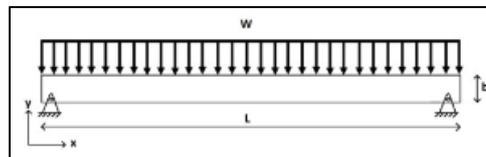
The code developed for this project is written in Python to obtain simple and efficient code by benefiting from the reliable and simple vectorization syntax in Python. For the linear algebra library, the scipy library is utilized, in order to calculate the sparse matrix manipulation feature. The plotting then will use matplotlib library.

#### 3.2 Test Case Problem

The test case problems are simulated using the code to be compared with analytical or commercial software available. The test cases consists of both 2D and 3D cases with variation in problem sizes and geometry.

### 3.2.1 2D Cantilever Beam with Distributed Load

The first test case is a simple 2D cantilever beam that given distributed loading on its top. The boundary used for this simulation is a no displacement boundary (Dirichlet boundary) on the left side of the beam to simulate the cantilever effect, with traction boundary (Dirichlet boundary) on the top side of the beam with traction value  $W$ , and traction-free boundaries (Neumann boundary) on bottom and right side of the beam. For this test case, the numerical deflection in  $y$ -axis is compared with its respective analytical solution using Euler's beam deflection equation by Hibbeler (2003) in [11]. The schematics for this test case and its details is given in Figure 2 and Table 1.



**Figure 2** Test Case 1: 2D cantilever beam with distributed load.

**Table 1** Mechanical Properties of Test Case 1.

Parameter	Value	Unit
Young's Modulus (E)	200	GPa
Poisson's Ratio ( $\nu$ )	0.3	
L	1	m
b	0.05	m
Thickness	0.001	m
$W_{\max}$	20000	kN/m <sup>2</sup>

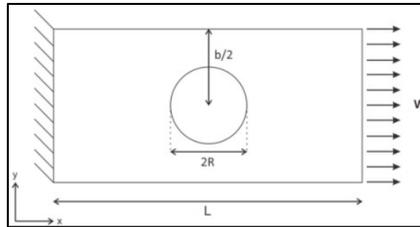
The analytical solution provided by Hibbeler (2003) in [11] is stated in Eq. 13.

$$w(x) = \frac{-Wx^2}{24EI} (x^2 - 4Lx + 6L^2) \quad (13)$$

### 3.2.2 2D Hollowed Plate with Tensile Load

The second test case is the stress concentration of a single hollowed plate given tension load on its longitudinal axis. The boundaries used for this simulation is a no displacement boundary on the left side of the plate, traction boundary on the right side of the beam, and traction free boundaries on the top, bottom, and the hole of the plate. For this test case, the stress concentration from the LSMPS numerical calculation is compared to the results from empirical formula by Pilkey (2005) in [12]. and commercial finite element software (ANSYS®). The maximum stress concentration of the plate is expected to occur directly above

and below the circular hole. The schematics for this test case and its details is given in Figure 3 and Table 2.



**Figure 3** Test Case 2: 2D hollowed plate with tensile load.

**Table 2** Mechanical Properties of Test Case 2.

Parameter	Value	Unit
Young's Modulus (E)	200	GPa
Poisson's Ratio ( $\nu$ )	0.3	
L	0.6	m
b	0.3	m
Thickness	0.001	m
$W_{\max}$	10000	kN/m <sup>2</sup>

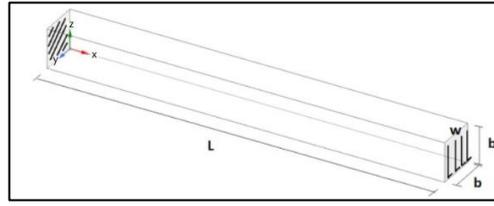
The analytical solution provided by Pilkey (2005) in [12] is stated in Eq. 14 and Eq. 15.

$$K_t = 3 - 3.14 \left(\frac{2R}{h}\right) + 3.667 \left(\frac{2R}{h}\right)^2 - 1.527 \left(\frac{2R}{h}\right)^3 \quad (14)$$

$$\sigma_{\max} = K_t \frac{1}{1 - \left(\frac{2R}{h}\right)} \quad (15)$$

### 3.2.3 3D Cantilever Beam with Shear Load

The third test case is a simple 3D cantilever beam that given shear loading on its side. The boundary used for this simulation is a no displacement boundary (Dirichlet boundary) on the left side of the beam to simulate the cantilever effect, with traction boundary (Dirichlet boundary) on the right side of the beam with traction value W, and traction-free boundaries (Neumann boundary) on top and bottom side of the beam. For this test case, the numerical deflection in z-axis is compared with its respective analytical solution using Euler's beam deflection equation by Hibbeler (2003) in [11]. The schematics for this test case and its details is given in Figure 4 and Table 3.



**Figure 4** Test Case 3: 3D cantilever beam with shear load.

**Table 3** Mechanical Properties of Test Case 3.

Parameter	Value	Unit
Young's Modulus (E)	200	GPa
Poisson's Ratio ( $\nu$ )	0.3	
L	1	m
b	0.05	m
W	10000	kN/m <sup>2</sup>

The analytical solution provided by Hibbeler (2003) in [11] is stated in Eq. 16.

$$w(x) = \frac{-Wx^2}{6EI} (3L - x) \quad (16)$$

### 3.3 Difference Calculation

In this research, the difference will be calculated using two different method, maximum relative difference, and RMSE (root means square error). The calculation for each difference calculation will be tabulated in Eq. 17 and Eq. 18 respectively.

$$Relative\ Difference = \left| \frac{y_{LSMPS} - y_{Euler}}{y_{Euler}} \right|_{\delta = \delta_{max}} \quad (17)$$

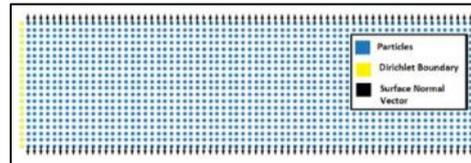
$$RMSE = \sqrt{\frac{\sum_{i=1}^n (y_{LSMPS} - y_{Euler})^2}{n}} \quad (18)$$

## 4 Results and Analysis

The numerical simulation for this research is done using a Python compiler from Jupyter Notebook on ASUS® ROG GL553VD Laptop with Windows 10 OS and equipped with 8 cores Intel® CORE™ i7 7700HQ processor and 12 Gb of RAM. Therefore, most of the computational time in this project is measured from start to finish by using the respective laptop specification. The result from LSMPS method then will be compared with the respective analytical, empirical, or commercial software ANSYS.

#### 4.1 2D Cantilever Beam with Distributed Load

For the beam geometry, the particle distribution is using cartesian grid with constant particle spacing  $h$ . This particle distribution is illustrated in Figure 5 with constant particle spacing of 0.00143 m with 24500 particles.



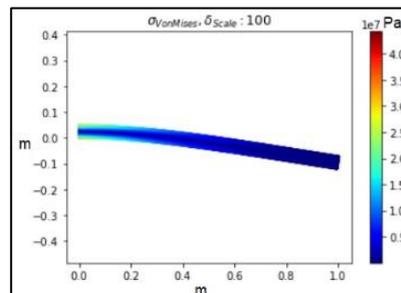
**Figure 5** Particle distribution of test case 1.

The simulation using LSMPS for this case is requiring a computational time of 235 seconds to simulate the model with 24500 particles with a relative difference of 0.28 % and RMSE of  $2.18\text{E-}6$ . The detailed report of the result is tabulated in Table 4.

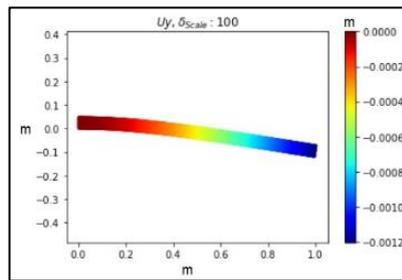
**Table 4** Summary of Test Case 1 Results

Parameters	Value	Unit
Number of particles	24500	
LSMPS maximum y-displacement	-0.001203	m
Analytical maximum y-displacement	-0.0012	m
Relative difference	0.28	%
RMSE	$2.18\text{E-}6$	

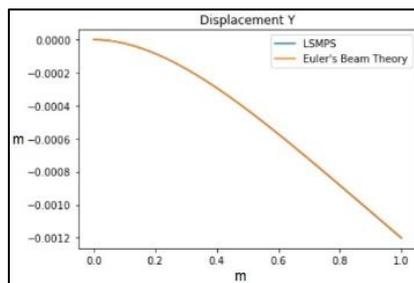
The von mises stress, y-displacement, and deflection comparison then can be tabulated in Figure 6, 7, and 8 respectively.



**Figure 6** Von mises contour of LSMPS method on test case 1



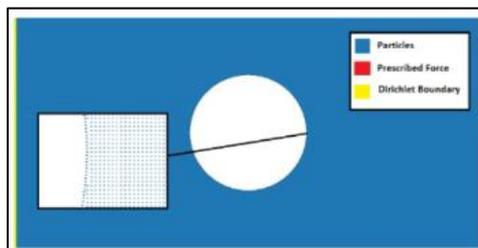
**Figure 7** Y-displacement contour of LSMPS method on test case 1.



**Figure 8** Y-Deflection comparison between LSMPS method and analytical.

### 4.2 2D Hollowed Plate with Tensile Load

For the plate geometry, the particle distribution is using cartesian grid with constant particle spacing  $h$ . This particle distribution is using constant particle spacing of 0.00133 m with 91754 particles as described in Figure 9.



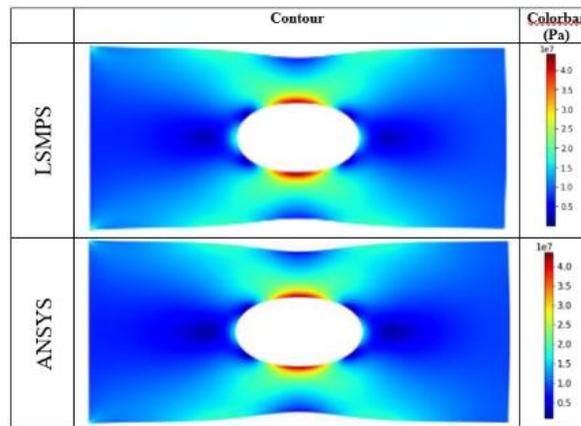
**Figure 9** Particle distribution of test case 2.

The simulation using LSMPS for this case is requiring a computational time of 1220 seconds to simulate the model with 24500 particles with a relative difference of 2.31 %. The detailed report of the result is tabulated in Table 5.

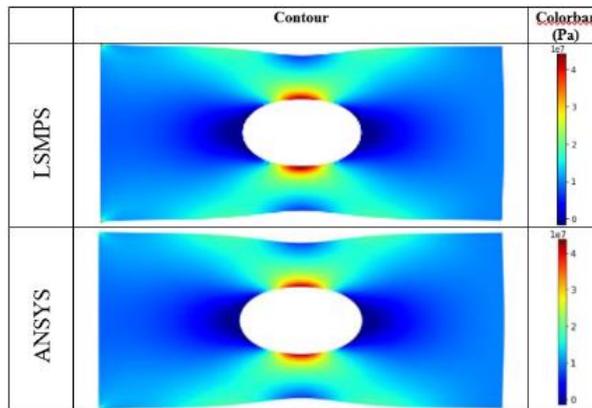
**Table 5** Summary of test case 2 results

Parameters	Value	Unit
Kt	2.1559	kN/m <sup>2</sup>
LSMPS maximum x-dir. stress	44114	kN/m <sup>2</sup>
Empirical maximum x-dir. stress	43188	kN/m <sup>2</sup>
ANSYS maximum x-dir. stress	43731	
Relative difference LSMPS to analytical	2.31	%
Relative difference LSMPS to ANSYS	0.87	%

The von mises stress, and x-direction stress comparison then can be tabulated in Figure 10, and 11 respectively.



**Figure 10** Von mises stress contour of LSMPS and ANSYS comparison on test case 1



**Figure 11** X-direction stress contour of LSMPS and ANSYS comparison on test case 1

### 4.3 3D Cantilever Beam with Shear Load

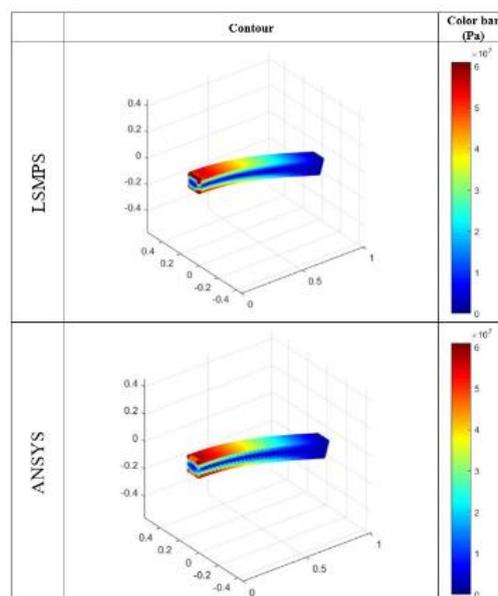
For the beam geometry, the particle distribution is using cartesian grid with constant particle spacing  $h$ . This particle distribution is using constant particle spacing of 0.005 m with 80000 particles.

The simulation using LSMPS for this case is requiring a computational time of 11794 seconds to simulate the model with 24500 particles with a relative difference of 2.04 % and RMSE of 1.99E-5 to the analytical result. Compared to the commercial FEM software ANSYS, the relative difference is 2.04%. The detailed report of the result is tabulated in Table 6.

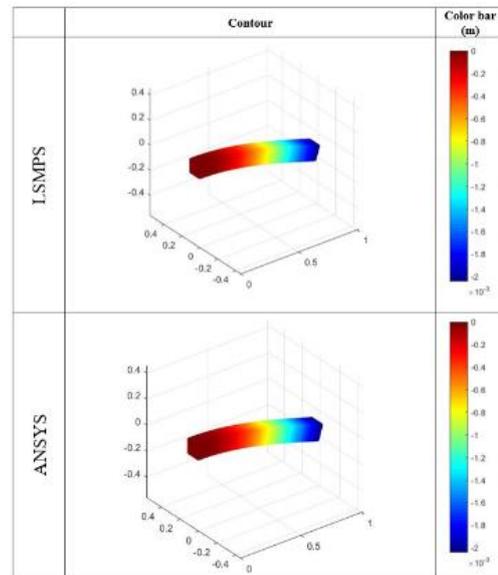
**Table 6** Summary of test case 3 results

Parameters	Value	Unit
LSMPS maximum z-displacement	-0.00199	m
Analytical maximum z-displacement	-0.00204	m
ANSYS maximum z-displacement	-0.00204	m
LSMPS relative difference to analytical	2.04	%
LSMPS relative difference to ANSYS	2.04	%
LSMPS RMSE to analytical	1.99E-5	

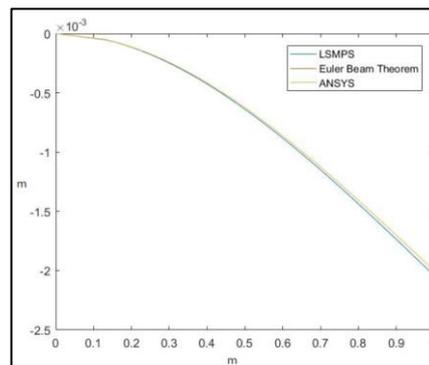
The von mises stress, y-displacement, and deflection comparison then can be tabulated in Figure 12, 13, and 14 respectively.



**Figure 12** Von mises contour of LSMPS method on test case 3.



**Figure 13** Z-displacement contour of LSMPS method on test case 3.



**Figure 14** Z-deflection comparison between LSMPS method and analytical.

#### 4.4 Summary

Based on the result of LSMPS method on solving both 2D and 3D cases, the results can be summarized in Table 7.

**Table 7** Mechanical Properties of Test Case 1.

Case	2D/3D	Particle Number	Relative Difference (%)	RMSE
1	2D	24500	0.28	2.18E-6
2	2D	91754	2.31	-
3	3D	64000	2.04	1.99E-5

## 5 Conclusion

Based on the LSMPS simulation result using the developed code, it can be concluded that the LSMPS differential operator is able to achieve high accuracy for steady-state linear elasticity problem. The static elasticity approximation result developed using LSMPS is yielding at most 2.31% difference with commercial software, analytical, or empirical result.

## Acknowledgement

We would like to thank Lab Flow Science and Engineering of Faculty of Mechanical and Aerospace Engineering, Bandung Institute of Technology for endless support and the continuous research program.

## Nomenclature

$E$ : Young's modulus	$\lambda$ : Lamé constants
$\epsilon$ : Strain in langrangian coordinate	$\mu$ : Shear modulus
$u$ : Deformation	$w(x)$ : Analytical deflection
$\Sigma$ : Strain in eulerian coordinate	$I$ : Moment of inertia
$\sigma$ : Stress	$L$ : Beam length
$f$ : Applied force	$x$ : x-coordinate position in beam
$H_{r_s}$ : Hrs matrix of LSMPS approximation	$W$ : Applied force in analytical solution
$M_i$ : Mi matrix of LSMPS approximation	$K_t$ : Plate constant
$\omega$ : Weight function of LSMPS approximation	$R$ : Radius
	$\nu$ : Poisson's ratio

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## Carcinogenic Risk Assessment of Inhaled Lead (Pb) on Batik Industry Workers

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**Abstract.** Synthetic colorants are still used in process of batik crafting. Heavy metals in colorants, including Lead (Pb) are potential environment pollutants and also hazardous to batik workers as they may expose workers through inhalation route, causing health problems. Lead is classified as probably carcinogenic (Group 2A) based on U.S. EPA (United States Environmental Protection Agency) and IARC (International Agency for Research on Cancer). This study aims to estimate carcinogenic risks of batik workers due to chronic occupational exposure to lead by inhalation exposure route using health risk assessment methodology. Inhalation exposure sampling was carried out using personal sampler pump (type: HFS-513A, flowrate: 2.5 L/min.) with MCE (Mixed Cellulose Ester, Ø25mm, 0,8µm) filter. Filters that retained lead are then analysed using XRF in laboratory. Carcinogenic risk was calculated by determining exposure concentration and IUR (Inhalation Unit Risk) according to Supplemental Guidance for Inhalation Risk Assessment by EPA. It was found that the maximum excess lifetime cancer risk (ELCR) found in all workers is  $7.07 \times 10^{-8}$ , implying acceptable risk. However, risk management is suggested, considering uncertainty and other carcinogens/routes of exposure outside the scope of this study. Actions to reduce exposure are recommended, including providing ventilation or considering outdoor settings to work.

**Keywords:** batik; cancer; carcinogenic; health; inhalation; lead; risk assessment.

### 1 Introduction

Heavy metals pollution in environment is caused by human's utilization in many processes. The increase of industrial activities is a factor that causes hazardous materials that may result in heavy metal pollution in environment, as found in wastewater or gas/particulate emission. The presence of toxic heavy metals in environment increases worries about increasing human health risk and environmental impacts.

Batik is an Indonesian cultural textile art heritage. In batik coloring process, both natural and synthetic colorants can be used. However, the use of synthetic

colorants are often preferred for its cheap price and a broad choice of colors to develop more of batik's pattern and design. The textile dyes used in textile industries, including batik production, is possibly carcinogenic [1]. Synthetic colorants used in batik coloring process contain some of heavy metals, such as Al, Ni, Cu, Zn, and Pb [2]. Lead (Pb) is one of five heavy metals that are prioritized to be controlled in public health issues for their high toxicity. Lead may damage various organs in human and cause effects even at small dose, and also classified as probably carcinogenic (Group 2A) based on U.S. EPA (United States Environmental Protection Agency) and IARC (International Agency for Research on Cancer). A toxicology study by Silbergeld & Rice in [3] found the mechanisms of lead carcinogenicity including direct DNA damage, clastogenicity, or inhibition of DNA synthesis or repair. Lead may also generate reactive oxygen species and cause oxidative damage to DNA.

Occupational chronic lead exposure in batik industry workers are likely to occur by inhalation route. The acute and chronic toxicity to textile dyes is caused by oral ingestion and inhalation, especially by exposure to dust/dye dust [4] that might be inhaled. Therefore, lead exposure monitoring on batik workers through inhalation route need to be carried out along with assessment of carcinogenic risk.

Based on the stated background, the objective of this study are to estimate carcinogenic risk of batik industry workers by means of EPA health risk assessment method and to find factors in batik craft work that significantly affect exposure concentration as consideration in risk management.

## **2 Methodology**

Data needed for analysis was acquired through interview (workers' profile: age, sex, working history, working hour). Air sampling was conducted in worker's breathing zone using personal sampler pump to estimate inhaled lead concentration while working. Based on NIOSH 7300 issue 2 in [5], sampling of metals in air may be conducted using personal sampler pump with Mixed Cellulose Ester (MCE) filter Ø 25 mm with pore size of 0,8 µm. Personal sampling pump type used in this study is HFS-513A. The personal sampling pump draws in air around worker's breathing zone, then metals in air will be retained on Mixed Cellulose Ester (MCE) filter. The air flowrate used was 2.5 L/minute and 4 hours sampling was carried out. Pb retained on MCE filters was analysed in laboratory using XRF (X-Ray Fluorescence) method.

Exposure data were then processed to acquire the exposure concentration in accordance with the methodology of health risk assessment. Evaluation of human exposure to heavy metals refers to the Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for

Inhalation Risk Assessment) [6]. Estimation of carcinogenic risks due to exposure is carried out in the risk characterization stage by calculating the ELCR (Excess Lifetime Cancer Risk) for characterizing carcinogenic risk. ANOVA test is used to compare exposure concentration of workers within different groups based on their characteristics and to find significant factors in batik craft work that significantly affect exposure concentration.

These methods involving human subjects has been reviewed and approved by Universitas Padjajaran's Research Ethics Committee, Bandung with approval number: 560/UN6.KEP/EC/2022.

### 3 Results

Three batik industries were visited and 30 workers were recruited for this study. Batik Industry "SAB", "BS", and "TT" are located near to each other, in Kulon Progo Regency, Yogyakarta. Table 1 below summarizes the characteristics of subjects. The characteristics were found by observation and interview. Other than four characteristics listed below, daily working hour and weekly working day were also asked to subjects. The interview results are needed in risk estimation and comparison across categories.

**Table 1** Summary of subject's characteristics.

No	Characteristic	Categories	n (Sample size/people)
1	Origin/Workplace	BS	11
		SAB	10
		TT	9
2	Workplace Condition	Indoor	10
		Semi-Outdoor	12
		Outdoor	8
3	Work Type	<i>Canting</i> (Drawing)	11
		<i>Cap</i> (Stamping)	5
		<i>Celup</i> (Dipping)	14
4	Experience	<3 Years	12
		3-6 Years	11
		>6 Years	7

#### 3.1 Exposure Assessment

Exposure assessment is one of steps in health risk assessment, just before risk characterization. To estimate exposure (the concentration of toxicant, lead in air which is inhaled) on workers, Eq. (1) was used. This equation is recommended

by EPA, as in Supplemental Guidance for Inhalation Risk Assessment Document, Part F.

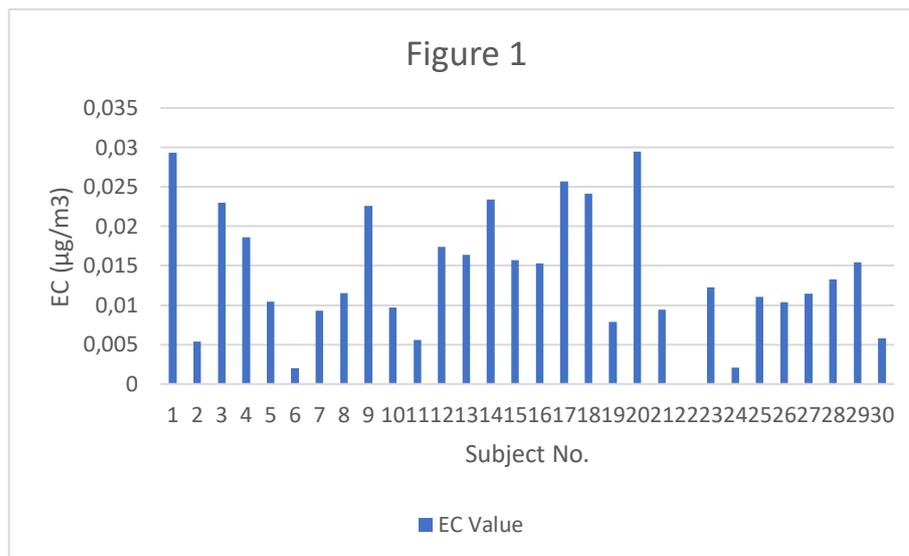
$$EC = (CA \times ET \times EF \times ED) / AT \quad (1)$$

CA is concentration of contaminant in air, specifically lead. ET is exposure time, the total working hour in a day, assuming that the exposure occurs as long as the workers are working with chemicals (dye). EF is exposure frequency, the total working day in a year, assuming that the degree of exposure are uniform all year long. ED is exposure duration, the predicted of total working years (50 is used). AT is averaging time, the lifetime expectancy in year (70 is used).

By exposure measurement using personal air sampler and interview, EC can be calculated. The result for EC calculation is shown below, in Table 2. EC for all workers are visually shown in a diagram in Figure 1.

**Table 2** Summary of EC calculation.

EC	Value ( $\mu\text{g}/\text{m}^3$ )
Max.	0.0294
Min.	0.00201
Average	0.0143
SD.	0.00767



**Figure 1** Diagram of workers' EC

The average inhaled exposure concentration of workers is  $0.0143 \mu\text{g}/\text{m}^3$  (95% CI,  $0.0115 - 0.017$ ). Values shown in Table 2 are the result of calculating 29 subjects' individual ECs. Subject 22 is excluded for invalid measurement of CA ( $0 \mu\text{g}/\text{m}^3$ )

and treated as an outlier/measurement error for it is unlikely for a worker to have zero exposure to lead all of the working years and assuming no exposure throughout many working years would be inaccurate.

ANOVA is used to compare exposure concentration across categories of subjects' characteristics as factor, based on Table 1. The results for ANOVA test is summarized in Table 3.

**Table 3** Summary of ANOVA test.

Factor	Sig.
Origin/Workplace	0.022
Workplace Condition	0.006
Work Type	0.092
Experience	0.813

ANOVA test on 4 hour-inhalation exposure data, the total inhaled lead (in ng) showed that workers' origin and the condition of the workplace significantly affect the degree of exposure ( $p=0.022$  and  $p=0.006$ , respectively) while work type (drawing, stamping, and dipping) and experience of workers don't. It means that no significant difference in average of exposure was found across categories of work type and experience. 95% confidence interval of exposure degree of each significant factors' categories are given in Table 4.

**Table 4** 4 hour-inhalation exposure data (mean $\pm$ SD).

No	Characteristic	Categories	Mean $\pm$ SD (ng)
1	Origin/Workplace	BS	25.425 $\pm$ 16.468
		SAB	35.047 $\pm$ 13.385
		TT	16.188 $\pm$ 6.872
2	Workplace Condition	Indoor	31.119 $\pm$ 12.182
		Semi-Outdoor	30.743 $\pm$ 15.458
		Outdoor	11.363 $\pm$ 14.936

It appears that TT industry workers receive the lowest exposure in average, followed by BS industry and SAB industry. This result may be explained by various differences between workplaces, such as differences in craft processes or chemicals used. However, it is known that all three industries are specialized in local batik production which is similar in their whole production processes and chemicals. Therefore, the significant difference is more likely caused by the condition of the workplace. 60% of SAB batik industry workers (highest inhalation exposure average) work in closed room and the rest work in semi-outdoor setting. Meanwhile, in TT batik industry, 66.6% of the workers work in outdoor settings such as garden, and the rest in semi-outdoor setting. This factor might be best explained in the next discussion about workplace condition.

If classification is done by workplace type/condition, outdoor workers (from all three industries) receive significantly lower exposure in average compared to indoor and semi-outdoor workers. This outcome is possibly due to better dispersion on outdoor settings. A recent study about ventilation by Benjamin, et al. related to air change, affect indoor pollutant concentration, such as volatile compound by providing better dispersion, in [7]. A similar result also was found in a risk assessment study by Cupr, et al. in [8] where indoor area scenario poses a higher excess cancer risk than outdoor area scenario. In batik industries discussed in this study, few specific works are done outdoor though not in all industries. When working outdoor with chemicals and dyes, lead in particulate/vapor in air may dispersed better, resulting in decreasing inhalation exposure to outdoor workers, which is favorable. It can be concluded then that outdoor setting is best for batik crafting works related to chemical dye use, whenever possible.

### 3.2 Risk Characterization

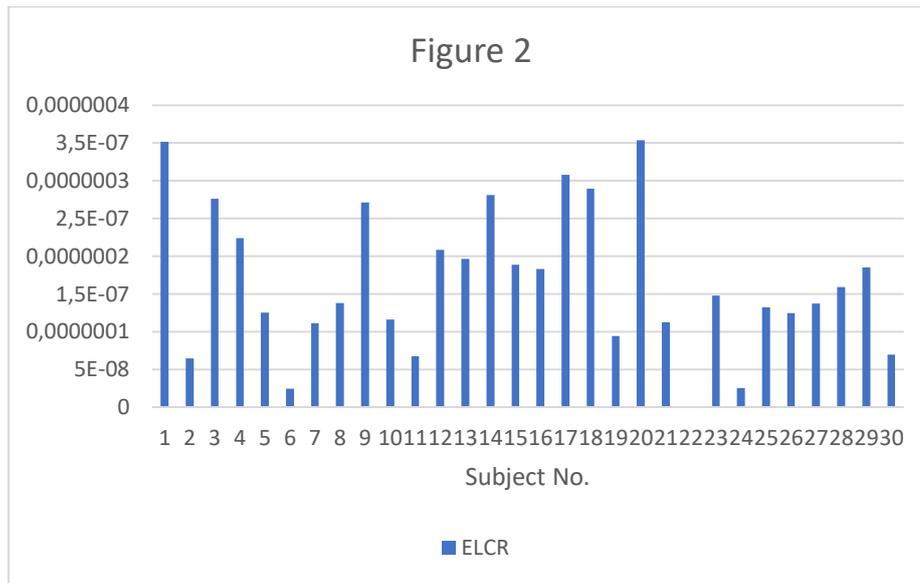
In this part, risk characterization step estimates the risk of exposure to lead based on exposure analysis. The output of this risk characterization is the value of cancer risk. Prior to characterizing carcinogenic risk, the IUR (inhalation unit risk) value was traced to determine the value of cancer risk. The IUR value is usually also determined at the dose-response analysis stage, by conducting research or tracing the results of existing quantitative toxicological studies. IUR used in this study is  $1.2 \times 10^{-5} \text{ m}^3/\mu\text{g}$ , as in a study conducted by Pavilonis, et al. in [9].

The ELCR (Excess Lifetime Cancer Risk) value is the value of the possibility/probability of developing cancer as a result of exposure to a specific carcinogenic substance and is expressed as an increase in cancer case in an exposed population compared to the unexposed population [10]. Eq. (2) below was used to calculate ELCR. The result for ELCR calculation is shown in Table 5 below, and ELCR values for all workers based on EC is shown visually in a diagram in Figure 2.

$$\text{ELCR} = \text{EC} \times \text{IUR} \quad (2)$$

**Table 5** Summary of ELCR calculation.

ELCR	Value
Max.	$3.538 \times 10^{-7}$
Min.	$2.423 \times 10^{-8}$
Average	$1.713 \times 10^{-7}$
SD.	$9.208 \times 10^{-8}$



**Figure 2** Diagram of workers' ELCR.

it was found that the average ELCR value is  $1.713 \times 10^{-7}$ . If this average value is interpreted, then it is estimated that there will be an increase in cancer cases of 1.7 ~ 2 cases in a population of  $10^7$  (10 million) people compared to an unexposed population. If the worst case occurs and the highest ELCR value is considered, then it is estimated that there will be an increase in cancer cases of 3.5 ~ 3 cases in a population of  $10^7$  (10 million) people compared to an unexposed population. In health risk assessment studies, the general accepted ELCR is below  $10^{-6}$ , that is, 1 case in a million people. However, Dankovic & Whittaker in [10] suggested even higher cancer risk ( $10^{-5}$  to  $10^{-4}$ ) as an acceptable level for occupational setting, considering small number of population, based on review of international policies. It can be concluded that the ELCR found for batik workers in this study is far lower than the maximum acceptance limit. Thus, the carcinogenic risk due to exposure to lead in batik industry is considered acceptable. However, a possibility of underestimated risk due to some uncertainties explained below should be considered.

### 3.3 Uncertainty & Recommendation

Uncertainties may be classified as qualitative or quantitative. This term refers to a lack of data or an incomplete understanding of the context of risk assessment. Uncertainties in a risk assessment study that affect the accuracy and reliability of this risk assessment need to be stated. The uncertainty in the risk assessment of inhaled lead for batik industry workers is related to the assumptions used.

Assumptions used includes uniformity in exposure degree and negligence of other possible routes of exposure (dermal, oral) and other pollutants/carcinogenic which are outside the scope of this study. Uncertainties can result as underestimated risk as outcome. It is then recommended to consider to reduce exposure to workers, starting from simple regulations or changes, such as wearing face mask when working and consider working in outdoor setting or ventilated room, whenever possible.

#### 4 Conclusion

Risk characterization of inhaled Pb on batik industry workers was done and the result implied that the incremental/excessive lifetime cancer risk is acceptable. Working setting (outdoor/indoor) significantly affects degree of lead inhalation exposure to workers. It is advised to use ventilation to support adequate air change to disperse pollutants in air.

#### 5 Acknowledgements

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## Place Attachment Study in Chinatown (Case Study: Pancoran Glodok Chinatown and Pantjoran PIK Chinatown)

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**Abstract.** Pancoran Glodok Chinatown is one of the oldest Chinatowns in Jakarta and West Java. It has been there since VOC Government relocated all Chinese people in Batavia (Jakarta) outside its city fortress and it is now becoming one of the best historical tourism destinations by *Kemenparekraf* (Creative Industry and Tourism Ministry) in 2022. The popularity of tourist destinations' distinctive characters often to be replicated in new development areas to attract the visitors and tourists. This 'copy-paste' strategy has been done by KML developer at Pantai Indah Kapuk 2 commercial district and named it Pantjoran PIK Chinatown. They adopted Chinese architecture style, landscape, and culinary specialty as part of their attractions. Even though it was opened during the pandemic covid-19 period in November 2020, it has successfully attracted so many visitors. Aside from the physical characteristics of the two Chinatowns, this paper aims for studying intangible aspects of its environmental psychology by using the *Place Attachment Theory* to compare human attachment to each Chinatown. This research approach uses a descriptive evaluative method to analyze primary and secondary data for understanding the place attachment level between humans and their place in both Chinatown.

**Keywords:** *chinatown; pancoran-glodok; pantjoran-PIK; place-attachment; tourism.*

### 1 Introduction

One of the most popular Chinatown destinations in Indonesia is Pancoran Glodok Chinatown, West Jakarta, which was previously a relocation area for the Chinese community outside the Citadel of Batavia and now it is promoted as the best Chinatown tourist village by the Indonesian Ministry of Tourism and Creative Economy (*Kemenparekraf*) on May 20<sup>th</sup>, 2022, [1]. Today it is being revitalized since 2021 by the West Jakarta City Government along with the revitalization of the Jakarta Old City heritage area project.

On the other hand, the strong characteristic of popular tourist destinations is often duplicated in a new development area to have a similar sense of place in the hope

of getting attraction. This 'copy-paste' strategy has been carried out by several developers. In Indonesia, also happen regional development practices by duplicating the physical and visual features of certain areas as an attraction for new developments.

The new development area, Pantai Indah Kapuk 2, by KML which is a joint venture by Salim Group and Agung Sedayu Group, was developed with residential, business, and commercial functions, covering an area of 1000 hectares in North Jakarta [2]. To attract visitors and property enthusiasts, some commercial areas are designed by incorporating tourist attraction features into each district theme. On Golf Island, there is a culinary district near the commercial waterfront area called Pantjoran PIK Chinatown. Pantjoran PIK tries to duplicate the famous Pancoran Glodok Chinatown in terms of architectural design, landscape, and Chinese food culinary as attraction features. It was officially opened on November 20<sup>th</sup>, 2020, during the Covid-19 pandemic [3]. However, the place is always crowded with visitors, especially on weekends. Pantjoran PIK was expanded to a total area of 13,141 square meters including an outdoor dining area, a pagoda-like building, and a few god statues as its landmarks [4].

This paper discusses the aspects of intangible related to environmental psychology through place attachment theory in two Chinatowns (Pancoran Glodok Chinatown and Pantjoran PIK Chinatown) and compares the extent to which this duplication effort can contribute to the human attachment to its place.

Place attachment was introduced by Altman and Low in [5], described as positive experience bonds formed by individuals and groups with their socio-physical environment, risen by behavior, cognitive and affective attachment. Brown *et al.* in [6] described that place attachment has some interrelated concepts which can be used interchangeably. For instance, (1) place identity focuses more on how place relates to self-identity. (2) Sense of place involves a complex of attachment, meaning, and satisfaction. (3) Place dependence refers to places that satisfy needs relative to alternative places. (4) Satisfaction with place involves fulfilling needs, not necessarily forging bonds. (4) Topophilia involves affective bonds from fleeting to enduring. (5) Human territoriality focuses more on perceived ownership. Thus, the definition of place attachment is a multifaceted phenomenon, somewhat different from other concepts used to understand people-place relationships.

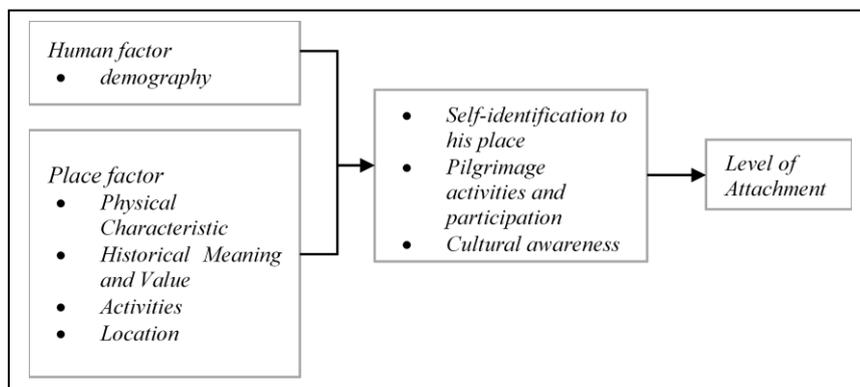
According to Sudrajat in [7], every research related to the concept of place attachment in eastern cultures, especially in Indonesia, should consider local perspectives, so that local characteristics can be understood to form their

attachment to places. The meaning and activities of that place can be the focus of attachment research.

Nurhijrah in [8] revealed that in developing a conceptual structure regarding coherent research about place attachment, Scannel and Gifford in [9] have made a theoretical framework composed of several definitions that explain three aspects to understand the concept of place attachment, those are humans, places, and psychological processes. Lewicka in [10] made a framework in three forms: place attachment factor/predictor, place attachment dimension, and result (a consequence of) place attachment.

- (1) Factor/ predictor of place attachment. There are some factors affecting place attachment formation for cultural valuable places:
  - (a) Human. In a group, attachment to place has shared meaning for each other according to Low in [11]. A group has an attachment to places where they are doing activities together, such as cultural activities as written by Marc Fried in [12]. Culture connects people with historical experiences, values, and symbols to share. Cultural-valuable places can have a different meaning for everyone depending on their attraction, motivation, and their demographic.
  - (b) Place. According to Stedman in [13], an individual has an attachment to a place due to its meaning which is represented by its place's feature. As written by Knez in [14] physical feature of a place can represent someone's memory and it grows attachment. In Low in [11], attachment to a place can be happened without any experience toward the place before by narrative and historical documentation, so it can influence someone to bond an attachment.
- (2) Place attachment. There are some indicators to identify attachment between individuals or groups to a cultural valuable place:
  - (a) Self-identification to a place. Prohansky et. al [15] explains this phenomenon as place identity. It happens when individuals can explain similarities between their place and themselves and connect the cognitive about their physical environment (memories, values, knowledge, preferences) into a definition of themselves. Twigger-Ross and Uzzell in [16] stated that the salient features of a place that make it so unique can be associated with an individual's concept. In the cultural aspect, Griaule in Low in [11] explains how a person will have an attachment to a place by identifying himself with elements that reflect a cosmological or mythological concept of a particular culture.

- (b) Participation and pilgrimage activities. Places with historical value or religious value will always attract people who are attached to that place as stated by Low in [11] and Mazumdar in [17]. Likewise, the level of one's participation in a ritual that is held at a place. Someone who feels he has an attachment will always participate in each ritual activity.
- (c) Cultural awareness. Low in [11] explains that information obtained by someone about the history or meaning of a place through narrative or writing will form an attachment to a place. Individuals will structure social information so that it can be connected and easy to process (Sears, Freedman, & Peplau, 1985). The information is then organized into a scheme, which involves knowledge and beliefs about an object. The scheme eventually fosters a sense of cultural awareness and forms an attachment to the place.



**Figure 1** Proposed Research Framework by Nurhijrah in [8].

## 2 Method

The research method used in this paper is a descriptive evaluative method. The descriptive research method is used to analyze data by describing collected data as they are without intending to make general conclusions as described by Sugiyono in [18]. The evaluation phase uses an evaluative research method to determine the level of place attachment related to culture in the Chinatown area in two study locations. According to Arikunto in [19] valuation is an activity to collect information about the work of something to determine the right alternative in decision-making.

The collected data includes primary and secondary data. Primary data was obtained directly from the source through field observations, such as data

describing the environmental condition of Chinatown and its activities. Secondary data is a data source obtained through intermediary media such as evidence records, or historical reports that have been neatly arranged in documentary archives that are published or not. This secondary data includes related regulations, standards, and knowledge through literature and studies of precedents.

After data has been collected, the analysis data process begins with these phases:

- (1) Data reduction. To sharpen, classify, direct, discard unnecessary and organize data so that conclusions can be drawn. In this case, the data is reduced, only those related to the place attachment theory indicator.
- (2) Data presentation. The collected information is structured so that conclusions can be drawn. The form of data presentation is in the form of narrative text and graphs that explain regional elements according to place attachment theory.
- (3) Conclusions. The results of the analysis can be used to act.

### **3 Analysis and Result**

#### **3.1 Pancoran Glodok Chinatown**

Pancoran Glodok Chinatown is located in Glodok, West Jakarta, adjacent to the Kota Tua Jakarta area, near Jakarta Kota train station, connected to the Kota Transjakarta bus stop, and relatively close to the Sunda Kelapa Harbor to the north.

Pancoran Glodok Chinatown is known as a center of Chinese community economic activities. In October 1740, there were social problems around the city of Batavia (Old Jakarta) by the Dutch [20]. When Adriaan Valckenier was General Governor of VOC, VOC soldiers killed ten thousand Chinese people, causing a rebellion in northern Java (the China War). As a result, when Baron van Imhoff became the new General Governor in Batavia, the Chinese communities were moved and concentrated in one place outside the city's fort for reasons of Dutch colonists and VOC Fort residents' safety as written by Hembing in [21]. Later, the place is called Glodok, taken from the name of the water sound of the spring nearby.

In Glodok, Chinese people began to build better settlements with more permanent buildings. Over time, this area began to be crowded and a trading center was created in the form of a market. This happened due to the location of Glodok being relatively close to the port. The popularity of Glodok's Chinatown in Batavia (Jakarta) lasted for more than two hundred years, and now it also transformed into one of the oldest Chinatowns as a tourist destination in Jakarta.



**Figure 1** Map of Pancoran Glodok Chinatown in the case study.

### 3.1.1 Pancoran Glodok Chinatown's Place Attachment Form Factors

#### (1) Human condition factor.

Based on the demographic conditions of the people in Pancoran Glodok, their religious backgrounds are quite diverse. Based on data from the Central Statistics Agency for the City of West Jakarta in 2020, the number of religious adherents in this village is 42,8% Buddhist, then Christian 37,9% (with a percentage of Protestants 22,1% and Catholic 15,8%), Islam 19,3% and a small percentage of Hindus 0,1%. The people who inhabit the Glodok area also vary between those who are residents to live, residents to work and live, and those who only come to work. The residents of Pancoran Glodok residential areas are mostly families that have lived there for generations, inheriting their family businesses, which most of whom have a trading background. The commercial business is quite diverse, from electronic trading, Chinese herbal medicine shops, local cuisine, Chinese worship equipment, ceramics, and daily necessities in the Petak Sembilan market.

In addition to trading activities as the main livelihood, there are daily activities such as God-worshipping at several temples and other religious houses around Glodok. Other activities that are publicly part of the tourism promotion include

the celebration of the Chinatown Festival held at Jalan Pancoran Petak Sembilan, Glodok which is enlivened by several Chinese and Betawi cultural attractions.

(2) Place condition factor.

Historically, Glodok has been the center of Chinese community settlements since the colonial era and an important trading center in Jakarta because its position is relatively close to the port. According to Suryananda Khameswara in [22], Chinese people believe that a good place always has elements of mountains behind and water in front. These things are fulfilled by the Glodok area which is close to the estuary. The head of the dragon which is a myth in the Glodok area is close to the estuary, the body is in the middle and the legs are in the south. According to *Feng Shui* philosophical belief, the head is suitable for business activities, while the body and tail area are suitable for residential areas. This is supporting the adherents of *Taoism* who see the surrounding environment as growing as a center of trading activity. This philosophy makes many Chinese people choose to live in North and West Jakarta areas, such as Pluit and Pantai Indah Kapuk (PIK).

Apart from trading at main corridors shop houses such as Jalan Pancoran to Jalan Pintu Kecil, there are trading activities at local streets like Jalan Kemenangan Raya where Petak Sembilan market is always busy, Jalan Toko Tiga dan Jalan Toko Tiga Seberang which is separated by Kali-Krukut River, Jalan Kemenangan III that's dominated by culinary shop houses, and some on Jalan Kemurnian IV.

On Jalan Pancoran as one of the Pancoran Glodok Chinatown icons, there is a shopping mall complex, namely Pancoran Chinatown Point. It's a new building that combines a shopping mall with rental apartments and hotels in a single building. In addition, there is also the Gedung Chandra shopping center which contains a lot of retail and is adjacent to the new culinary tourist spot, Petak Enam Di Chandra which is designed to resemble a Chinese village.

Religious activities are facilitated by several temples and monasteries in the Glodok Pancoran area, including Budhi Dharma Temple (at the T-junction of Jalan Perniagaan Timur), Ariya Marga Vihara (*Kwan Tee Bio*) located in Lamceng alley, Tanda Bhakti Jakarta Vihara (*Kai Zhang She Wang Miao*) which is about 257 years old and was made especially for the Chen (*Tan*) clan at first, Vihara Dharma Jaya (*Toa Se Bio*) at Jalan Kemenangan III which was crowded with worshippers, and Vihara Dharma Bhakti (*Kim Tek Le*) which is located at the T-junction of Jalan Kemenangan III as the oldest temple in Jakarta. In addition, there are also religious facilities like Gereja Kristen Indonesia Perniagaan and Gereja Pantekosta Isa Almasih at Jalan Perniagaan Raya, Gereja Santa Maria de Fatima which is located next door to Ricci School for local

education facilities from Playgroup to High School on Jalan Kemenangan III. Many religious facilities are placed at crossroads because local people believed it can purify the negative energy that is often present at the T-shape crossroad, commonly called as ‘*tusuk sate*’ road.

There is an interesting phenomenon where the cultural heritage building is located between a hotel and apartment development area, namely Candra Naya Building. The Candra Naya building was used as the residence of *Majoor der Chinezen* Khow Kim An, the last head of the Chinese community in Batavia after Major Tan Eng Goan [23]. Built in the 19<sup>th</sup> century, it is used by the Sing Ming-Hui social association building for outdoor public activities such as education, health, recreation, and culture. Currently, the Candra Naya heritage building complex is in the Green Central City (GCC) integrated commercial complex, which has two apartments and a hotel under the management of Novotel. In one of the Candra Baya buildings, there is a prayer room for Buddhist religious activity.

### **3.1.2 Pancoran Glodok Chinatown’s Place Attachment Indicator.**

#### (1) Self-identification to a place.

The Chinese people’s belief in *Feng Shui* and *Taoism* philosophies can be seen in their belief in the location of Glodok as part of the ‘dragon head’ which is good for their business and make them stay for hundred years in Glodok. This makes Glodok grows to meet its own needs such as religious facilities and celebration of the Chinese festival. The habit that’s passed down from generation to generation has formed a memory attachment of the Chinese Glodok community regarding their religious and worship activities, business, festivals, and celebrations. Based on a documentary video by Asumsi entitled ‘*Distrik: Mencari Kepala Naga di Glodok*’ on YouTube in March 2021 [24], it is now revealed that the Chinese people in Glodok feel more comfortable and proud to be in Glodok with their diverse backgrounds. According to Herry S. the head of Glodok’s local citizen’s association (*Kepala RW*), Glodok is the first Chinatown in Jakarta and maintains a good relationship with residents around Glodok. Thanks to the policy by President Gus Dur in his time in 2000 which abolished the prohibition on the use of Chinese cultural attributes, now the Chinese people in Glodok feel more comfortable and secure about their identity as part of the Chinese community in Jakarta. After the May 1998 riots, the Chinese community maintained their habit of putting iron gates both at home and each corridor of complex housing in Glodok, even though according to Herry S. in [24], Glodok is now always safe and there is no friction between local communities.

#### (2) Pilgrimage and participation activities.

For the Chinese community, the temple is an important asset as much as their business shops. For them, the temple is not only a place of worship but also a gathering place for activities and socializing across the Chinese community, the presence of many temples in Glodok as active cultural heritage buildings proves that the Chinese community of Pancoran Glodok is very religious.

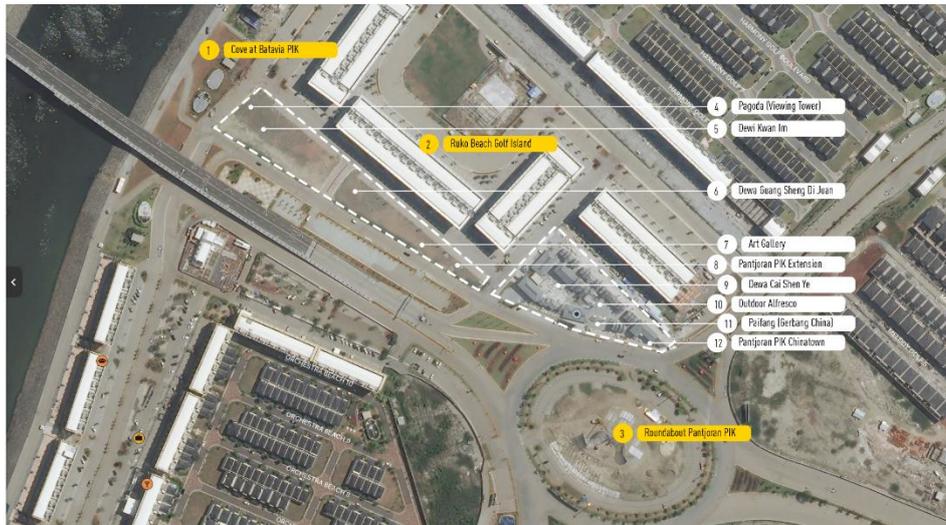
(3) Cultural awareness.

According to Herry S., the head of Glodok's local citizen's association (*Kepala RW*) [24], many Chinese people in Glodok are no longer practicing Mandarin, both verbally and in writing, due to the 32-year ban on the use of Chinese attributes under former President Suharto. Then after the ban was lifted in the era of President Gus Dur, in 2000 as written in [25], the use of the Chinese language and attributes began to be practiced again. The practice of naming, numbering, and kinship terms are still often used in daily communication and in several private schools including the Ricci Glodok school which is placed in the middle of Pancoran Glodok Chinatown settlement, and Mandarin is taught as part of the school's subject program. Moreover, the practice of celebrating major holidays such as Bacang Day, Chinese Lunar New Year, and so on is still practiced as part of Glodok Chinatown community tradition which is becoming the identity of their bond with their ancestors.

### **3.2 Pantjoran PIK Chinatown**

Pantjoran PIK Chinatown is located on one of the reclaimed islands by Agung Sedayu Group developer and Amantara, namely Golf Island. Pantjoran PIK Chinatown is a culinary retail area with an outdoor alfresco concept. It's inspired by the Pancoran Glodok Chinatown culinary specialty while the architecture and landscape design are adopted from Zhangzhou city, the capital of Zhejiang province, China [4].

Pantjoran PIK Chinatown officially opened on Friday, November 20<sup>th</sup>, 2020, during the Covid-19 pandemic. At its opening, this culinary area was built on 5,500 square meters and is considered successful in attracting many visitors to the PIK 2 (where the development is built) in addition to the beach view shophouses row of The Cove at Batavia PIK which is located nearby the Pantjoran PIK Chinatown.



**Figure 2** Map of Pantjoran PIK Chinatown in the case study.

### 3.2.1 Pantjoran PIK Chinatown's Place Attachment Form Factors

#### (1) Human Factor.

Demographically, there are no special records regarding the survey of people in Pantjoran PIK Chinatown. But in general, Pantai Indah Kapuk (PIK) is mostly inhabited by people with Chinese ethnic backgrounds. The main activity in the Pantjoran PIK Chinatown area is only commercial trading, so the practice of cultural activities such as Chinese Lunar New Year celebrations and art-cultural performance attractions on certain days other than for marketing needs will be very rare. However, the presence of statues of gods and goddess in the Pantjoran PIK culinary area introduces authentic Chinese religious culture. In addition, there is a two-story art gallery building that is functioned as a venue for cultural activities such as calligraphy workshops, traditional dances, and art artifact exhibitions in collaboration with the Indonesian Art Gallery Association (AGSI) to represent Chinese culture. The practice of language and other daily habits of the Chinese community is not visible in this area, practically because this area is not used 24 hours a day by the residents.

#### (2) Place condition factor.

The Pantai Indah Kapuk (PIK) area has the Jakarta Branch of Tzu Chi Center Foundation (a social foundation based on Buddhist teachings, but social practices

and donors come from various backgrounds) also occupies the PIK area around ten hectares containing Tzu Chi School, Studio DAAI TV Indonesia, Tzu Chi Learning Center, and Jing Si Books & Café. Tzu Chi Buddhist Humanitarian Foundation is a non-profit organization engaged in social and humanitarian with volunteers from diverse backgrounds across ethnicities, religions, races, nations, and groups. The Pantjoran PIK Chinatown itself is dominated by Asian cuisine retails, some of which are branches of restaurant shops in Glodok. Es Kopi Tak Kie for example, this old, iced coffee shop opened a retail branch in Pantjoran PIK Chinatown. Other food places that are quite popular are non-halal foods such as Wong Ku Kie and Hakka restaurant.

There is a pagoda-like building that is functioned as a viewing tower, but currently, it's not open for public access. This pagoda is located at the end of the Pantjoran PIK open plaza corridor, right behind the statue of Dewi Kwan Im. Several spots to be placed gods and goddess statues as an aesthetic feature as well as worshipping medium include the statue of the God Protector of Commerce, Guan Sheng Di Jun; the statue of God of Wealth and Fortune, Cai Shen Ye; and the statue of the Goddess of Mercy, Dewi Kwan Im. Worship facilities such as incense sticks and so on are provided in collaboration with the Indonesian Tridharma Council Paramita Fund Foundation (YDPMTI). Some of the visitors do worship here, although very rarely. Generally, these god and goddess statues are part of the attraction for visitors and some of them want to take selfies.

### **3.2.2 Pantjoran PIK Chinatown's Place Attachment Indicator.**

#### **(1) Self-identification to a place.**

Pantjoran PIK Chinatown is designed with an architectural style adopted from traditional Chinese architecture in Zhangzhou City, Fujian Province, China, and provides a variety of Asian cuisine (mostly Chinese food) with mandarin characters signage. As a result, the image of the area itself reflects Zhangzhou's Chinese culture rather than Indonesian Chinese culture, which mostly uses brick wall residential architecture and white paint. The memory of Jakarta Chinese visitors to their local culture (Indonesian Chinese) is not well connected. However, the Chinese cuisine presented is a branch of a restaurant that previously existed in Jakarta, so that visitors can have related memories to their culinary experience in the past with the same experience at Pantjoran PIK Chinatown.

#### **(2) Pilgrimage participation activities.**

The existence of a statue of God as a medium of worship as well as an aesthetic icon of the area is the only indicator of religious activity that remains alive in the Pantjoran PIK Chinatown area. Although not many people worship here, this is

natural, because the Chinese community in the PIK area is not only Taoist but also Christian and Buddhist. At least this practice of worship increases the intensity of communication between people of the same religion so that participation in ritual activities in groups happens even if it is low.

(3) Cultural awareness.

The Pantjoran PIK Chinatown is a commercial zone with specifically designated as a culinary center by the developer. The retail employees at Pantjoran PIK Chinatown mostly are not Chinese, even though the business is owned by Chinese ethnic people. Only some of them were the owner directly takes care of their restaurant stall or shops in Pantjoran PIK. This makes it unnecessary to use Mandarin or Hokkien as everyday language as well as for transactional language. Activities that are limited to trading activities also influence the cultural activities that are present in the Pantjoran PIK Chinatown. Only on big days of festival celebration, cultural arts attractions will be presented at Pantjoran PIK Chinatown.

**Table 1** Comparison of place attachment indicators between Pancoran Glodok and Pantjoran PIK Chinatown.

Place attachment indicators	Pancoran Glodok Chinatown	Pantjoran PIK Chinatown
<b>Self-identification to a place.</b> Describes the similarity of a place to oneself and incorporates cognitions about the physical environment in the form of memories, knowledge, and values.	The level of attachment is very good and is supported by history and habits carried out as a group.	The level of attachment is quite low because it has no historical value and the lack of cultural customs practices by the Chinese community.
<b>Pilgrimage participation and activities.</b> The level of participation of a person in a ritual and feeling attached to the activity.	The level of attachment is very high due to religious practices that are strongly held by the Glodok Chinese community.	The level of engagement is quite good, with efforts to present a media of worship for Taoism practices.
<b>Cultural awareness.</b> Information obtained by someone about the history or meaning of a place through narrative or writing forms an attachment to that place.	Cultural awareness is very good with people's understanding of their ancestral customs which are often carried out in Chinese ceremonies and festivals. Mandarin in small part is still used and be taught in local schools.	Cultural awareness is low due to not much and rarely practiced except only as promotion media for the Chinese Lunar New Year. No mandarin is either practiced in daily trading activities.

#### 4 Conclusion

The result of research and observation shows that the level of attachment of the Chinese community in those two Chinatowns is different. Pancoran Glodok Chinatown has a higher level of place attachment value, due to the diversity of activities in it. Areas with living activities (living as permanent residents) and trading activities for 24 hours a day through many years present regional facilities such as schools and places to worship. The Chinese community with turmoil past existence and currently has strongly supported condition makes the memories and bonds of Pancoran Glodok Chinese community with their location get stronger.

This is certainly different from Pantjoran PIK Chinatown condition. Pantjoran PIK is designed as a culinary center that has a low assessment of place attachment value. The diversity of activities is limited to trading and entertainment activities (during Chinese New Year celebrations) makes it lacks cultural activities that can provide personal bonds for the Chinese community in this area continuously. However, the presence of worshipping medium in the form of God statues is very helpful in providing a binding factor for religious participation activities for some Chinese who practice Taoist teachings while visiting Pantjoran PIK Chinatown.

There are recommendations to increase place attachment value through increasing cultural activities at both locations by (1) establishing Mandarin as one of the regional languages in Indonesia so that it will be used more commonly by people around Chinatown, in Glodok, and other Chinatown areas, (2) Pantjoran PIK Chinatown can present sustainable Chinese cultural activities in gallery building, like traditional Chinese tea-drinking experience.

This study has weaknesses such as (1) the assessment of attachment elements is currently limited and lacking in depth. It is necessary to observe through the eyes of the Chinese community in the form of direct interviews. This will provide a more accurate understanding, (2) the assessment of high and low levels of place attachment value indicators is not quite accurate due to the absence of the same cultural elements in both Chinatown. A more comprehensive comparison is needed so that can be seen the causes of the difference between place attachments value from both locations.

#### 5 Nomenclature

*Feng Shui* = is an ancient Chinese art of arranging buildings, objects, and space in an environment to achieve harmony and balance in a way that will bring peace and prosperity. [26]

*Taoism* = is an ancient Chinese philosophy and religion that instruct believers on how to exist in harmony with the universe. [27]

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## Evaluation of The Potential of Circular Compact City Concept in Kampung Kota (Case study: Kampung Braga, Bandung)

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**Abstract.** Current days, resources production and consumption behavior pattern within city is seen as one that called linear system, where resources are extracted, processed, distributed and consumed before being disposed as waste. This system burdens the environment in its all stages. Aside of it, there is another pattern called circular system, where resources in the production and consumption process will be rethought and processed back into the cycle, so that it will never be waste to the environment. Cities in Indonesia, mostly have the so called *kampung kota* as its integrated part in its development stage. It is a dense area within city which still have the traditional culture in it. It is mostly seen as an unplanned area, highly populated, and low-quality environment and infrastructure. Nevertheless, *kampung kota* is seen has quality of compactness and circularity which can be potential to the development of sustainable city. The aim of this study is to explore more about the potential of circularity and compact city concept in *kampung kota* with Kampung Braga as the case study, through further evaluation based on particular criteria, questionnaires, and observation. Therefore, the result of this study could contribute to the future discussion regarding circular compact city concept.

**Keywords:** *circularity, city development, compact city, kampung kota, sustainability.*

### 1 Introduction

From data published by UNEP in [1], cities globally occupy only about 2-3 % of the earth's surface, but consume around 70-75% of its natural resources. UN in [2] states that 55% of the world's population currently lives in urban areas, which is mentioned by World Bank Group in [3] as around 4.2 billion. This number is projected to increase around 68% by 2050, with an additional 2.5 billion people. It is further stated that 90% of the total population is in Asia and Africa. Given this trend, it is certain that cities will face major challenges to meet the needs of their growing populations. Natural resources will continue to be exploited in order to sustain the life of the population.

The perspective that exists in the city until now still assumes that the resources available in nature are unlimited. This perspective causes the formation of a linear “take-make-dispose” pattern of production and consumption, that is, resources are extracted, processed, distributed, consumed, then left over as pollution burdening the natural environment. The impact of this linear pattern on the environment, among others, will be the scarcity of non-renewable resources in nature due to continuous exploitation which will ultimately affect environmental condition and climate change. Apart from the linear perspective mentioned above, there is a circular concept, which in urban application is called a circular city. This concept views the city as a living organism, like nature, in which the cycle of life revolves and is closed. Organisms in nature live and develop and then die. The remains of organisms that die become a resource or nutrition for the survival of other creatures. Likewise with the circular pattern in urban areas, the resources extracted and processed in the production process for consumption do not end up as waste or pollution, but can be processed again to become resources for the needs of other sectors, and so on in a circular and closed cycle so as to reduce or ideally can get rid of trash.

## **2 Literature Review**

To support this study few literatures is needed to be reviewed regarding the basic theory of circular city and compact city to get an understanding of those concepts. This section summarizes it as follow.

### **2.1 Circular city**

The definition of circular city is summarized from few literatures by Ellen MacArthur Foundation in [4], ICLEI in [5] and Wenzel in [6] as a city that embeds the principles of a circular economy in all aspects of urban design and functions, namely by creating a compact city structure, which has increased density with a shorter reach to the city’s main facilities which shortens the distribution and mobility system thereby reducing pollution due to dependence on motorized vehicles, maintaining the highest value of assets in their use, encouraging city development by prioritizing the reuse of existing land rather than opening new land, regenerating natural systems and maximizing the use of digital technology to support circular processes, thereby creating prosperity and resilience economic, social and environmental for the city and its inhabitants. Ellen MacArthur Foundation in [4] mentioned the elements of circular city as built environment, energy system, an urban mobility system, an urban bioeconomy, and production system. Furthermore, they mentioned that at least there are three principles of circular economy, namely: design out waste and pollution in the cities, keep products and materials in use in cities and maintain their values, and regenerate natural systems in and around cities. Added to that,

the World Economic Forum in [7] mentioned 9R strategy in circular city known as refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, and recover.

## 2.2 Compact City

According to Grau in [8], circular city can be an alternative approach to sustainable urban design, by designing a compact city, where the main facilities for people needs can be reached on foot from wherever they work or live, so that trip will be shorten, energy consumption and pollution level will decrease in line with reduced dependence on motorized vehicles. The term compact city was first introduced by Dantzig and Saaty [9] in Kumar in [10] with three main characteristics, namely compact city based on morphology (high density, less dependence on motorized vehicle, clear boundary), based on spatial (mixed land use and heterogeneous lifestyle), and based on social function (social equality, independence in daily life, independent regional management).

There are various definitions of a compact city. Among them, as stated by Rogatka and Rebeiro in [11], a compact city is an urban spatial structure characterized by a compact urban area with urban agglomeration. In compact city, everything must be easily accessible by all residents because the shape of a compact city affects the urban environment and social quality. In addition, a compact city improves urban sustainability. Another definition from Burton [12] in Bibri, Krogstie and Karrholm in [13] is that the term compact city means a city with a relatively high density of mixed functions, based on efficient public transportation systems and dimensions that encourage walking and cycling activities. Furthermore, Rogatka and Rebeiro in [11] mentioned elements of compact city that is related to urban design concepts, those are: mixed land use and high density, comprehensive service facilities, short distances, reduced pollution, car dependency, encouraging cycling, social interactions, high population density, encouraging walking, accessibility, efficient public transport, well-organized urban infrastructure, and energy performance. On the other hand, Bibri, Krogstie, and Karrholm in [13] summarized the design principles of compact city as compactness, density, mixed land use, sustainable transportation, green structure, and intensification.

## 3 Methodology

The method in this study is exploratory-evaluative. According to Sheppard in [14], exploratory research is carried out on a topic to answer the researcher's curiosity about the subject and to better understand the phenomena that occur for further deeper studies. This study was conducted with a qualitative approach, where this approach is generally process-oriented. True understanding, rather

than information based on prediction, is based on understanding action and on interpretive meaning of that action.

The method was conducted on stages as mentioned below:

1. Conduct a literature review on the theories of the the characteristic of circular city and compact city as the basis used to determine the evaluation criteria.
2. Study location selection based on the criteria of *kampung kota* typology.
3. Collecting information through interviews with related parties, such as RW leaders and several administrators or residents, followed by field observations to see the real conditions of Kampung Braga.
4. The collected information is then evaluated based on the predetermined circular city and compact city concept criteria.

The expected result is to known the characteristic and application of the circular compact city concept in the *kampung kota* through a case study of Kampung Braga.

### 3.1.1 Location Selection

Based on *kampung kota* typology mentioned by Widjaja in [15], which is then determined as location selection criteria. Kampung Braga is one of *kampung kota* that meet those criteria, namely being in a very strategic location in supporting city function; is a residential area of the majority of low-income people; is a densely populated environment; is a village that is passed by the river and the main access; and is an environment that is largely inaccessible by four-wheeled vehicles. Table below shows that Kampung Braga's condition meets the criteria of location selection.

**Table 1** Summarized analysis of study location selection of Kampung Braga based on *kampung kota* typology by Widjaja in [15] as criteria

<i>Kampung Kota</i> Typology as Location Selection Criteria	Kampung Braga
<ul style="list-style-type: none"> <li>• <b><i>Kampung kota</i> that existed on the very strategic location in supporting city functions.</b> For this location, the community can possibly improve the environmental conditions at their own expense by taking advantage of the strategic location.</li> </ul>	√
<ul style="list-style-type: none"> <li>• <b><i>Kampung kota</i>, which is the residential environmental of the majority of low-income people,</b> who are in transition areas or suburbs. In general, it began to be developed around the 1940s to 1950s on private communal land. Village density can reach 500 people /Ha. Usually, most of the villagers live on private land which is sometimes not officially registered or without a permit because at first it was communal. Community with strong social ties who develop their own environmental infrastructure and facilities independently.</li> </ul>	√

<ul style="list-style-type: none"> <li>• Inner city slum, namely <i>kampung</i> is a community environment that existed before the colonial period, where they were workers to serve the European population. <b>Due to urban development, these villages are isolated and stagnate and subsequently experience environmental degradation into slums. These <i>kampung</i> are usually close to access points or traffic lanes, mostly clustered in river areas that cross the city and are located in downtown areas.</b> It has a density of 100,000 people/Km<sup>2</sup>.</li> </ul>	√
<ul style="list-style-type: none"> <li>• <b>The type of <i>kampung</i></b>, with houses located inside, is mostly inaccessible by car or motorbike. This type is the type of old or original settlement of cities in Indonesia.</li> </ul>	√

### 3.1.2 Questionnaires and Field Observation

In conducting interview, questions are divided into categories with particular purpose. This table below gives the sample of questions in each category with its purpose.

**Table 2** Sample of categorized questions for interview

Categories	
Social	Facilities
<p><b>Purpose:</b></p> <ul style="list-style-type: none"> <li>• To get an idea of the socio-cultural character of the people who live in Kampung Braga.</li> </ul>	<p><b>Purpose:</b></p> <ul style="list-style-type: none"> <li>• To find out the life behavior of the residents in Kampung Braga.</li> <li>• To find out the extent of the availability of life support facilities that exist in Kampung Braga.</li> </ul>
<p><b>Question samples:</b></p> <ul style="list-style-type: none"> <li>• Is there any unused vacant land in this area? Why?</li> <li>• Is every land in this area is used as residential/living space or also for other function such as shop, restaurant, rent room, <i>warung</i>, etc?</li> </ul>	<p><b>Question samples:</b></p> <ul style="list-style-type: none"> <li>• Do you stay in your own house or in a rented house or room?</li> <li>• How do you do your daily activities and reach the place you work?</li> </ul>
Transportation	Circularity
<p><b>Purpose:</b></p> <ul style="list-style-type: none"> <li>• To get an overview of the movement pattern of residents and the form of transportation used as support.</li> <li>• To find out the ease of access and movement of Kampung Braga's residents in reaching the location of their daily activities.</li> </ul>	<p><b>Purpose:</b></p> <ul style="list-style-type: none"> <li>• To find out the behavior of Kampung Braga's residents in accordance with the application of the circular city concept.</li> </ul>
<p><b>Question samples:</b></p> <ul style="list-style-type: none"> <li>• Can this area be accessed by car or four-wheeled vehicles?</li> <li>• Do you use public transportation to reach destinations?</li> </ul>	<p><b>Question samples:</b></p> <ul style="list-style-type: none"> <li>• Is there any gardening activity by the residents? If so, is this activity carried out together or separately?</li> </ul>

	<ul style="list-style-type: none"> <li>• Is there any recycling activity carried out in this environment, either individually or collectively?</li> </ul>
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To complement the information obtained from interviews, field observation was carried out with several focused on the physical conditions of Kampung Braga's environment, such as: street structure (finishing material, condition, etc.), nodes within *kampung*, distances between *kampung*'s edges, infrastructure condition, river function which cross the *kampung*, the connectivity inside the *kampung*, the most utilized street or corridor by the residents, condition of walking on outdoor space in this *kampung* environment, ease of accessibility from and to *kampung*, quantity of main access from and to *kampung*. The information obtained from interviews and observation is then analyzed as supporting data for further evaluation.

### 3.1.3 Evaluation Criteria

The criteria used to evaluate *kampung kota* in this study is determined by referring to the principles, elements, and strategies of compact city and circular city. The principles are referred as criteria, while the elements and strategies are referred as indicators. Those criteria can be seen in tables below.

**Table 3** Evaluation criteria and indicators of compact city concept referred to Rogatka & Rebeiro in [11], and Bibri, Krogstie, & Karrholm's principles, elements and strategies of compact city in [13]

Criteria	Indicators	
Design Principles	Elements	Compact City Strategy for Sustainability (Environment, Economy, Social)
<b>Compactness</b>	Short distances, social interactions, Mixed land use and high density, Comprehensive service facilities, Well-organized urban infrastructure	Build and develop centrally, concentrate on strategic nodes, complement and mix, strengthen public transport, reserve outer city areas for future development.
<b>Density</b>	High population density	High density of built objects in designed and emergent compact urban form, diverse scales of built objects, distribution of building footprints with frequent larger buildings, greater density in strategic nodes, prioritization of density close to the central points of strategic nodes, high-density hand in hand with multidimensional mixed land use.
<b>Mixed land use</b>	Mixed land use and high, Comprehensive service facilities	Physical land use mix, economic mix, social mix, greater mix of housing, business, and facilities in strategic nodes, multidimensional mixed land use hand in hand with sustainable transportation.

<b>Sustainable transportation</b>	Short distances, Well-organized urban infrastructure	Cycling and walking, public transport, mobility management, increased accessibility through public transport infrastructure improvements, sustainable transportation hand in hand with multidimensional mixed land use and high density, network structure of link areas to connect the major nodes of the transport system, separate lanes for the public transport for faster journey time and a punctual and reliable system, more service along the main corridors for greater frequency, an easy to understand, safe, and secure system for guaranteeing quality and service, multi-model travelling in strategic nodes to support their dense, mixed use central points.
<b>Green structure</b>	Social interactions	Green areas and parks, green areas hand in hand with density, protection and integration of natural, agricultural, and cultural areas through intensification.
<b>Intensification</b>	Comprehensive service facilities, Energy performance, High population density.	Increase in population, increase in redevelopment of previously developed sites, subdivisions and conversions, and additions and extensions, increase in development of previously undeveloped urban land and buildings, increase in density and diversity of sub-centers, investment in and improvement of transport infrastructure and services.

**Table 4** Evaluation criteria and indicators of circular city concept referred to Ellen MacArthur Foundation and WEF's principles, elements and strategies of circular city.

Criteria	Indicators	
	Principles	Elements
<b>Design out waste and pollution from cities</b>	An urban bioeconomy	<b>R9 Strategies:</b> (R0) refuse, (R1) rethink, (R2) reduce, (R3) reuse, (R4) repair, (R5) refurbish, (R6) remanufacture, (R7) repurpose, (R8) recycle, (R9) recover
<b>Keep products and materials in use in cities and maintain their values</b>	Production system, an urban bioeconomy, built environment.	
<b>Regenerate natural systems in and around cities</b>	Energy system, an urban mobility system, an urban bioeconomy.	

#### 4 Location Overview

Braga is an area that has a long history and has been known since colonial times. Initially, the function of land in Braga area was in the form of housing intended for Europeans. Behind the splendor of Jalan Braga which has a very European impression, there is a traditional indigenous village that was founded in 1826. In 1925, it became the residence of official horse guards, wagon drivers, and laborers. At this time, the area of the village is a dense settlement in the middle of the city of Bandung called Kampung Braga [16].

Kampung Braga is a part of Braga sub-district, Sumur Bandung District, Bandung. Of the 8 RWs in Braga sub-district, RW 03, 04, 07 and 08 were determined as the focus of research locations. From measurements using Google Earth software, the study location has an area of about 12 Ha, which consists of residential areas including 2.2 Ha covering RW 03 and 07, 1.5 Ha covering RW 04 and 08, and 8.3 Ha is a commercial block area at its perimeter. From the information obtained from the RW's administrator, the total population in Kampung Braga is 3,124 people.

According to its location, this study area has a very strategic position, where within a 2 Km radius of the location existed several landmarks of the city of Bandung, such as the *Alun-alun* and the Great Mosque in the South, Paskal Mall in the West, and the Bandung City Government Office in the North. This location is also surrounded by main roads, such as Asia Afrika road and Jendral Sudirman road in the South and Ottista road in the West, including several other main routes that surround it as area boundaries, namely Suniraja road on the North side, Braga Road on the East side, ABC road on the South side and Banceuy road on the West side. Inside this location flows the Cikapundung river which divides the two areas into the East side (RW 04 and 08), and the West side (RW 03 and 07). Both sides of the area are connected by a bridge on the Cikapundung alley section.



Figure 1 Kampung Braga Map. Source: Google Earth map.

## 5 Study Result

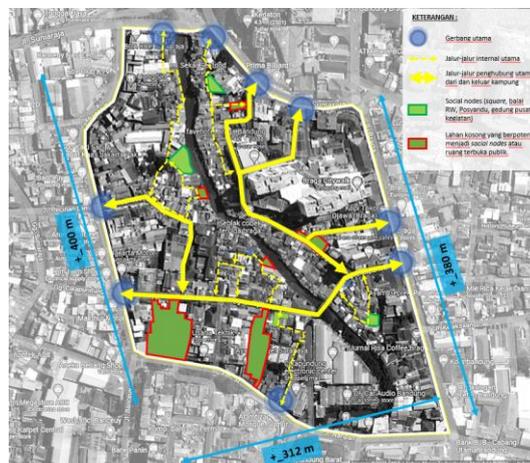
From the evaluation, there are findings regarding the potential of compact city and circular city concept in Kampung Braga as discussed in this section.

### 5.1 Evaluation Based on Compact City Criteria

- **Criteria 1 – Compactness:** There are few findings in Kampung Braga based on these criteria, such as Kampung Braga can be said as a walkable area with the distance affordability from its edge to edge is approximately 380 to 400 m

away. Kampung Braga is an area with high permeability, where there are eight main gates spread on all of its sides, with one connector bridge for two divided areas by the river, and many internal narrow alleys, approximately 1 m wide, functioned like neural network that connects all parts of the *kampung* which can bring users anywhere within it. There are few public open spaces which are functioned as social nodes and center for activities and facilities (*PAUD*, *Karang Taruna*, *POSYANDU*, etc.). In Kampung Braga can be found many local economic units such as stalls or *warung*, food stalls, food shops, etc., as an indication of the local economy sustainability which is reciprocal between residents (buyers and sellers are from residents themselves), as well as the availability of daily necessities which can be reached at any time on foot. Kampung Braga also can be seen as a very strategic location where city's main facilities, such as schools, mosques and churches, *puskesmas* and hospitals, police stations, fire fighters, etc., exist in the radius of 1 to 1.5 Km and can possibly reached on foot.

From the interviews, it was found that most of the residents carried out their activities in the village, such as trading fried foods, organizing, or doing any kind of business. For residents who work outside the village, they still have other small business activities in Kampung Braga area. This confirms the previous statement, that there is a reciprocal economic cycle in the village, namely sellers and buyers or producers and consumers are residents of the village itself. With this reciprocal cycle, the village has the potential to become an independent area in the middle of the city, not a burden but a resource.



**Figure 2** Structure of Kampung Braga, analyzed from google earth map photo.

- **Criteria 2 – Density:** The very dense condition of Kampung Braga makes some parts of the environment dark and crowded. Air and sunlight needed for healthy environmental conditions cannot be obtained in these corners. In addition, the very crowded conditions do not leave many spaces for social nodes which are ideal for residents and can be dangerous in the event of a fire, because it will quickly spread.

However, if viewed from the perspective of compact city potential in Kampung Braga, in other parts of it, a more ideal density condition can be found, where houses are adjacent to the width of the street that is not too narrow still allows for active space in front of the residence, without a motorized vehicle, as a space for social interaction between residents. Given this condition, several positive things can be noted for further study, including: the formation of compactness and strong social bonds between residents, the rapid exchange of information that is useful for the development of citizens' knowledge, the potential to create a pollution-free environment motorized vehicles, as well as the creation of a safe environment because the front of the neighborhood is active and supervised by all residents.



**Figure 3** Narrow alley as social space of residents in Kampung Braga. Photo's taken from personal collection.

- **Criteria 3 - Mixed Land Use:** The discussion related to these criteria is closely related to the discussion on the compactness section and some of the findings that have been presented previously, namely the discovery of heterogeneous functions in *kampung* other than residential homes, namely in the form of business units of *warung*, food stalls, workshops or electronic service providers, etc. From the results of interviews, several residents mentioned that there are other functions besides housing in Kampung Braga besides those mentioned above, namely home-based businesses such as cake making and catering, and boarding houses or rented houses. In addition, if we look at the overall delineation of the study locations, the composition between

the functions of commercial and residential land is almost balanced. Thus, the whole area of Kampung Braga can be said to be an area with mixed functions.

- **Criteria 4 - Sustainable Transportation:** From the information obtained, it shows that most residents carry out daily mobility by walking, then by public transportation or online taxi to reach places far outside the *kampung* for reasons of practicality and affordability. Around this location, there are also Trans Bandung Raya bus stops which can still be reached on foot. From this, it can be identified the potential of Kampung Braga as an environmentally friendly area, where some of its residents feel comfortable and safe walking in the *kampung* area so that it meets the potential of public transportation criteria as a sustainable mode of transportation for economic and environmental aspects.
- **Criteria 5 - Green Structure:** The discussion of the green structure criteria does not only indicate green open areas in the form of parks and green paths planted with plants or flowers as a greening of the environment, but further looks at the existence of open spaces where social interaction can occur in the middle of the Kampung Braga area. In Kampung Braga, there are open spaces that have functioned as a centre for social activities and a common garden of medicines and spices. Judging from its composition, the open space as a centre for social activities is quite minimal in the midst of the density of existing settlements. However, there is also an indication of the potential to increase green areas from the behaviour of residents who are willing to use the remaining land around the *kampung* as green areas such as gardens and parks. Another potential is that there are still abandoned vacant lands in the middle of the *kampung* that can be considered as green open spaces for its residents.



**Figure 4** Utilizing residu space in Kampung Braga as green structure for common use. Photo's taken from personal collection.

- **Criteria 6 – Intensification:** From the results of interviews with residents, it was stated that there were houses that were used as rental accommodation, such as boarding houses and contract houses, as well as the existence of small houses occupied by more than one family head. This is an indication of an increase in population in the Kampung Braga. Strategic location in the middle of the city, which is passed by various public transportation modes, with

affordability to major facilities, especially the location of Kampung Braga which is directly adjacent to the old town commercial area, making Kampung Braga a very attractive location for many migrants who work in the vicinity and need a temporary place to live. This is one of the potentials of *kampung kota* as a support for the sustainability of urban development.

## 5.2 Evaluation Based on Circular City Criteria

From the evaluation conducted through interviews and observations in the field, it was found that there were residents' behaviors that were in accordance with the circular city criteria. However, this behavior has not been carried out based on knowledge and awareness of the circular city concept itself, so that the benefits of this activity are not known for oneself and more broadly for the sustainability of the urban environment. However, this can be seen as potential that needs to be encouraged so that it has a more significant impact on the life of the urban environment. Below is the evaluation of circularity behavior that found in Kampung Braga based on the three criteria of circular city concept.

- **Criteria 1 - Design Out Waste and Pollution from Cities:** waste centralization to be sorted and resold as additional income for residents; the creativity of plastic waste into decoration; utilization of plastic waste or used objects, such as tires as children's toys; reuse of plastic waste as ornamental planting media in small gardens, both in residual land and in the yard.
- **Criteria 2 - Keep Products and Materials in Use in Cities and Maintain Their Values:** activities of buying and selling used tires; the creativity of cardboard or used paper becomes a costume that is contested between RWs, reuse of used wood into LINMAS post furniture or hedges; reuse of used objects as supporting tools for daily needs; processing coffee packaging into new creative works for resale.
- **Criteria 3 - Regenerate Natural Systems in and Around Cities:** utilizing the remaining land in the *kampung*, such as streetside land, the dividing walls of the *kampung* and the surrounding buildings, river bank walls, as a garden for medicines and common kitchen spices processed by the PKK organization; utilization of disputed land for gardening and raising laying hens and raising catfish which is managed by the RW and supervised by the city government, where the results are sold back to the residents at a more economical price; establishment of a clean water system that can be shared by residents.



**Figure 5** Kampung Braga's residents' behavior of reusing used material and utilizing residu space as green structure. Photo's taken from personal collection.

## 6 Conclusion

From this study, we can have conclusion as below:

1. From the perspective of compact city, based on the evaluation, despite all of its advantages and disadvantages, Kampung Braga can be seen as a compact area. This table below contents the evaluation of Kampung Braga based on compact city criteria.

**Table 5** Summarized of evaluation result of compact city concept in Kampung Braga.

Evaluation Criteria of Compact City	Evaluation Result of Kampung Braga
<b>Compactness</b>	<ul style="list-style-type: none"> <li>• Kampung Braga meets the criteria of compactness due to its affordable distance both within the village area and to various city's main facilities which are still less than 1.5 Km away.</li> <li>• Although the composition of the ideal open space is lacking, Kampung Braga can still be a compact area where the existing outdoor spaces, including the streets in front of the house, become a flexible space where social interaction of its residents takes place and creates an active frontage.</li> <li>• Kampung Braga is a compact area with its local commercial units called <i>warung</i>, which support the daily need of its residents, as well as support the economic sustainability of the kampung itself.</li> </ul>
<b>Density</b>	<ul style="list-style-type: none"> <li>• Kampung Braga is a settlement area with high density so that brings various impacts, such as creating some dark and narrow parts where not an ideal environment to live, lack of public open spaces for social interaction, and the potential for fire hazards that can quickly spread.</li> <li>• If it is seen from the perspective of compact city, the density of Kampung Braga can be potential, namely the formation of community cohesiveness because of the strong social ties among its citizens.</li> </ul>
<b>Mixed land use</b>	<ul style="list-style-type: none"> <li>• Kampung Braga is a compact area with its mixed land use. Overall, the area is dominated by the commercial function on its block perimeter and residential on its center.</li> <li>• Within its dense settlement area has been mixed of land use of residential and local commercial, such as one building has living space on its upper floor and informal commercial on the ground floor such as <i>warung</i>, <i>warteg</i>, etc.</li> <li>• The existence of this mixed function supports the sustainability of life and the development of Kampung Braga in the middle of the city.</li> </ul>

<b>Sustainable transportation</b>	<ul style="list-style-type: none"> <li>• From this criteria's point of view, Kampung Braga is a compact area, where most of its residents have the feeling of comfortable and safe doing their daily activities within kampung area with only on foot.</li> <li>• Kampung Braga is a compact area due to its very strategic location, where city's main facilities are located within affordable distance in 1 to 1.5 Km away, and it is traversed by Bandung's public transportation routes.</li> </ul>
<b>Green structure</b>	<ul style="list-style-type: none"> <li>• Kampung Braga has none ideal area for green and public open space. However, it is indicated that the behavior of residents needs to be encouraged in terms of using the remaining land within kampung as gardens or parks that are useful for common purposes.</li> <li>• There still can be found the potential abandoned vacant land within kampung that can be used by residents as green spaces or spaces for social activities.</li> </ul>
<b>Intensification</b>	<ul style="list-style-type: none"> <li>• Kampung Braga is a very attractive area for many people from Bandung and also newcomers, due to its strategic location in the middle of the city with easy access to the city's main facilities.</li> <li>• The intensification of density in Kampung Braga has the potential to increase its economic sustainability.</li> </ul>

2. From the perspective of circular city, in Kampung Braga has already existed circular economy activities by its residents based on its three principles and 9R strategy. Nevertheless, those activities haven't done with basic knowledge and awareness regarding the benefits and impacts of circular economy for their life and urban environment sustainability.

## 7 Propositions

By looking at the findings in this study, it is important to follow up on further input and discussion. Below are the propositions from the author:

1. With the many potentials of Kampung Braga, in term of its existence as a compact area and the circular behavior of its residents but without awareness and correct knowledge of its benefits and contributions to personal life and urban environment, various kinds of support as well as from the government is urgently needed to encourage this existing potential to become a contribution to the sustainable development the city of Bandung.
2. Further studies and discussion from researchers regarding Kampung Braga need to be encouraged and then the results need to be campaigned to the residents to build their awareness of their potentials based on the correct knowledge.
3. Cooperation is needed from all residents in terms of improving the quality of the environment in Kampung Braga.

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## Identification of Residual Space: A Case Study of Sumur Bandung District

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**Abstract.** Nowadays, the urbanization phenomenon is consistent with the increasing demand for land availability. On the other side, there is more residual space found in several cities, one of them is Bandung. This residual space is mainly caused by the conversion of land use as urbanization occurs. Moreover, this space has caused some informal appropriation which caused unsettling conditions. Using the literature review and satellite image analysis, this research is focused on the identification of residual space in Sumur Bandung District as a small sample of Bandung. Several studies are reviewed to obtain a theoretical basis of analysis such as typology, forming factors, and qualities of residual space. This research is conducted to find a new manifestation of residual space according to the context of Bandung. The access of transportation modes and pedestrians becomes the scope limitation of this study. As a result, there are six manifestations of residual space found in Sumur Bandung District, such as *space above the alley; pedestrian way without significant activities; utility box infrastructure; transitive area; unused entrance; and pedestrian platform*. These manifestations will become the objects of advanced study to be processed as a more efficient utilization for the city.

**Keywords:** *urbanization; land-demand; appropriation; sumur-bandung; residual-space; manifestation.*

### 1 Introduction

The massive rate of urbanization has caused a significant population increase in the cities. In 2050, United Nations (UN) has projected about 68% of the world's population will live in cities [1]. This trend will lead to a high urban density and followed by an increasing demand for urban land. The urgency of optimizing land use will intensify alongside the escalated disparity of urban density and its population. The rise in land prices is intended as this issue could not be resolved. Some of the efforts by the government is adopting the land use to the current trend. This effort is aimed to provide land for people and maintain price stability in the market. However, this will be inefficient as commercial functions increased from time to time.

Trancik [2] defines residual space (lost space) as a space that is not related to its surrounding environment and an unidentified space. Several definitions mention residual space as space that is neglected, not used properly, or space resulting from infrastructure development that is not designed or used properly. In addition, this space has the potential to be intervened due to unmaintained conditions by those who own or manage the space. Various references define residual space in various ways. The tendency of residual space in utilization is space that lacks use and maintenance by stakeholders and shareholders thus informal communities intervene. Meanwhile, based on its physical quality, residual space is a space that is not and/or has not been well planned so it creates ambiguity that causes a decrease in the aesthetic value of urban space [2].

In line with the limited land, several actors whose conditions are unable to afford properties financially have conducted interventions in various residual spaces. Those residual spaces are alley corridors, riverbanks, sidewalks, and junctions which often become prominent locations for informal activities. Oftentimes these activities will lead to conflicts between each actor in urban areas. Feldman and Stall [2] stated this appropriation is an ownership of a space carried out by a group or individual forcibly. Rapoport (1985) in [2] states that this situation is influenced by several elements, one of which is the availability of space to be exploited.

Residual spaces become important because over time, limited space forces stakeholders and shareholders to optimize the space thus it can be utilized properly. Although residual space has been a common phenomenon in various cities in the world, this space is still considered an unwanted and unresolved issue. The contextuality of residual space becomes an important aspect to consider. This context will form different typologies from the earlier studies as the theoretical foundation. Therefore, it is necessary to learn the context of the urban area to determine the typology of the residual space from one city to another. Thus, stakeholders alongside shareholders could provide solutions precisely in the future.

## **2 Methodology**

This study is aimed to find the typology and/or manifestation of the residual space in District (*Kecamatan*) Sumur Bandung as a sample of residual space in Bandung with several different characteristics. To obtain its purpose, this study is conducted by literature study and data collection through Google Street Map. The theoretical foundation is elaborated from several literature reviews as the main reference for assessment. Furthermore, the results of the analysis are classified based on the conclusion variables from the literature study. This study is conducted using a comparative qualitative analysis technique, which is comparing one phenomenon with a related phenomenon [3]. The variables in the reviewed literature are compared with field data as proof of the suitability of the theory with the existing field context.

### 3 Results and Discussion

Overall, residual space could be defined in terms of physical appearance and quality of its use [2]. Space that is not used properly is generally irrelevant to the situation or space demand in a city. Informal activities that intervene are usually blurred space between legal and illegal so that it will require solutions both top-down and bottom-up.

Residual space, based on its utilization, refers to an area that is not used properly, or maintained by stakeholders, and thus is intervened by private parties. Wikstrom stated that residual space is a space that could be exploited or appropriated, thus the activities characteristic is often temporary and illegal [4]. Meanwhile, the utilization qualities mentioned by Hwang [5] are about how a space is unused, exploited, and abandoned. The most common perception of residual space is about the informality and temporality of activities which becomes into conflict in several cases.

The physical term of residual space is defined as a space that has not been well planned so that it creates ambiguity, thereby decreasing the aesthetic value of urban space. The terms of ambiguity in space namely unclear geometry, space with low visibility (not visible from the movement space), and space with boundaries that are considered easy to intervene (low fences and not maintained, or spaces without fences). The definition of residual space is based on these physical appearances which are usually tangible for actors and stakeholders. According to Wikstrom himself, the existence of Residual Space is created as a background space in the 'figure and background' so that physically it becomes a complimentary space for the designed 'figure' [4]. With this 'background' space, it becomes a liaison between several 'figure' spaces surrounding it.

#### 3.1 The Formation of Residual Space

According to the factors that form residual space, it could be concluded that an urban space that is not cared for, not controlled, and not cared for properly become the background reason for residual space [2]. In addition, a study of the factors forming the residual space was conducted based on references during the last 10 years. Overall, the residual space could be formed due to minimal maintenance, space that is not controlled by the land owner, not properly cared for by the owner, geographical factors, irrelevant initial functions, or space that is intentionally vacated for future use.

Some factors form residual space in several different contexts. Trancik, Morallis, Loukitou-Sideris, Doron, Alanyali, and Carmona describe the main factor of residual space forming as the lack of maintenance either by the stakeholders or shareholders [2]. As Winterbottom stated, a space with minimal control is mostly caused by the lack of access directly to the space. Therefore, this space is the potential to be intervened [6].

Factors as geographical and renewal utilization of land use would be other issue. The fitness of the current function of space to the demanding activities in the existing era becomes the main issue predictable in several cities. A steep topography or a different leveling of the existing environment is less preferable so that the utilization given tends to be minimal other than the flatter topography [5]. Therefore, a lot of steeper topographies become the most common residual space in several cities.

Various activities related to the issue of the changing land use trends could also be different issue regarding unused space. The flexibility of designers in responding to the issue of changing local land-use trends can also be a separate issue that can make a space unused. Evolution in the activities of the people from time to time conducted the change of space. Oftentimes the space is unable to adapt to the new function thus it is inflexible to be reused. The scarcity of form and scale relevance have formed a leftover space in an urban context.

The surplus landscape is the most common factor as the intended space allocated as the expansion space of a property. This unplanned space has resulted from space being left over from the surrounding development. Prediction of future land use or expansion allocation which often takes a long time will decrease the value of this space so that it is intervened as an informal activity.

### **3.2 Qualities of Residual Space**

Kevin Lynch in *The Good City Form* [7] stated that the performance of urban space can be measured by several aspects, namely *Vitality*; *Sense*; *Fit*; *Access*; and *Control*. Meanwhile, according to M Khalil and D. Eissa [2], a residual space can possess physical qualities and utilization qualities. These qualities will be juxtaposed with the performance of urban space by Lynch (Table 1) and thus could be elaborated to the existing conditions.

The physical characteristics of a residual space is differentiated one space from another. There are two types of factors that affect the quality of the residual space, *internal* and *external*. *Internal quality* is an inward orientation and thus could be intervened either by the designer or informal actors. Otherwise, *external quality* is an outward orientation to the urban macro scale. In urban space, this physical quality can be associated with urban design elements as the main identification of quality.

There are indicators for identifying the physical quality of the residual space. Those are accessibility; level of security; visibility; site boundaries; site topography; uniformity of shape; the scale of site location; site location; facilities/assets that support activity generation; and proximity to high-intensity movement activity. These indicators serve as a reference for designers to intervene in the residual space in urban area. Meanwhile, the utilization qualities of residual space are divided by accessibility; security level; visibility; site boundaries; site topography; uniformity of shape; the scale of site location; site

location; facilities/assets that support activity generatio; and proximity to high-intensity movement activities [2]. These indicators become the baseline of intervention analysis for designers and stakeholders to resolve the residual space issue.

Juxtaposing qualities indicator with Lynch's performance dimensions in The Good City Form, it is stated in Table 1 that the total performance highlighted in residual space is *Fit*; *Access*; and *Sense*. This also proves the perception of the surrounding community which focuses on visual aspects, affordability, and usability. These aspects are considered contradictive to the vision of the impacted city. Apart from these dimensions, other aspects also take a role in keeping the residual space intervention under control. Meanwhile, the *vitality* aspect is an additional performance that is the output of the other such as *control* from stakeholders and access to areas that will create a sense of security for users. In the end, the solution of the residual space as an urban space could be conducted by improving the quality according to the performance preferred to highlight according to the context. So that the interventions taken can be adjusted to the indicators that have been found in the related references.

**Table 1** Physical Qualities of Residual Space by Khalil and Eissa [2] and Lynch [7]

Physical Qualities										
Khalil dan Eissa	Internal Factors						External Factors			
	1	2	3	4	5	6	7	8	9	10
	Accessi- bility	Security	Visibility	Boundary	Topo- graphy	Uni- formity	Scale	Site Location	Asset	Access to circulation
	High	High	Exposed	Defined	Flat	Regular	Wide	Edge	Views	Road
	Low	Low	Hidden	Undefined	Sloped	Irregular	Narrow	Center	Facilities	Pedestrian Way
Lynch	Access	Vitality	Access, Sense	Vitality, Control	Fit	Sense	Fit	Sense	Sense	Access, Control
Utilization Qualities										
Khalil dan Eissa	11	12	13	14						
	Current Activities	Users	Time	Late Land-Use						
	Merchant	Local	Morning	Industrial						
	Recreation		Afternoon	Commercial						
	None	External Visitor	Night	Residential						
	Etc.			Green Area	Etc.					
Lynch	<b>Fit</b> , the function suitability with the current activity that is relevant to the time, users, and social activities in it.									

### 3.3 Typology of Residual Space

The typology of residual space is divided into several terms, such as urban voids; leftover space; to residual space. According to Winterbottom [6], residual space is discovered in the residential context of Seattle and it is classified as non-spaces; leftover space; and dual/multi-purpose space. By this typology, Winterbottom also mentions the solutions of the three typologies, namely Re-adapted; Re-inhabited; and Re-imagined.

Doron in [2] classified residual space based on the affected area, such as *dead zones* and *dead edges*. More detail on the typology mentioned by Villagomez in [8] classified residual space based on the type and location of the affected infrastructure. There is *void space*, *infrastructure that is not re-used*, *space under the circulation path*, and so on in Table 2. Different contexts create different types of residual space manifestations. This is reflected in the publication by Khalil M. [2] which has summarized the residual space manifestations based on the existing reference set.

**Table 2** Typology of Residual Space

Author	Year	Category	Typology		
Winterbottom [6]	2000	Forming Factor	<b>Non-Spaces</b> The residual space due to proximity to the movement corridor	<b>Leftover Spaces</b> An improperly programmed space that is separated from its surroundings. Example: odd geometry space adjacent to the intersection, the front of the setback, and the traffic island	<b>Dual Spaces / Multipurpose Spaces</b> Areas with scheduled activities, which become residual space at different time
Doron [2]	2007	Location	<b>Dead Zones</b> Residual space is created due to the absence of relevant functions	<b>Dead Edges</b> Residual space is connected to corridors and is usually located along roads, railroads, riverbanks, and sidewalks.	
Villagomez, Eric [8]	2010	Infrastructure typology	<b>Void Spaces</b> Unused spaces between buildings	<b>Redundant Infrastructure</b> Unfunctional infrastructure	
			<b>Oversized Infrastructures</b> An infrastructure with excessive space for traffic (over-estimated)	<b>Rooftops</b> The unused part of the roof in a building	
			<b>Spaces around</b> A space between new development in an old context (intermediary zone) or between the public street and the interior area of the building.	<b>Spaces Below</b> Spaces under infrastructure such as elevated railroad tracks, motorcycle flyovers	
			<b>Wedges</b> Result of conflicting intersections such as urban grids or infrastructure lines		

Various studies show that there are different manifestations according to the urban spatial context discussed. This difference also makes the residual space a distinctive feature of other cities. Trancik in [2] mentioned several residual spaces related to movement spaces such as areas under bridges and plaza areas that are far from pedestrian activity. Aside, Rivlin in [2] discussed the manifestation of residual space far from movement space, such as lanes that are in line with the public environment, road medians and junctions, and squares that are intervened by merchant activities. Campbell [9] added parking space as one of the residual spaces related to movement space. This is due to the scheduled use of parking

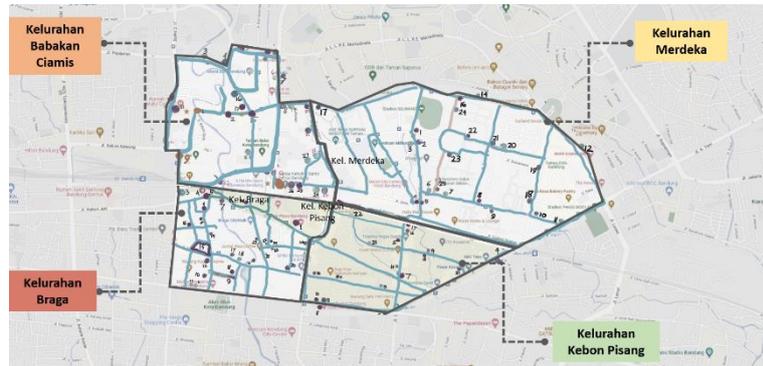
spaces depending on the function it serves, which causes activities at other times. Other manifestations also found in this large-scale public space are closely related to the movement area and visibility to pedestrians. For instance, a park and playground which is fenced and damaged thus create an isolated public space. In addition, open spaces which conflicted between scale and usability are also reasons for abandonment by users [2].

Residual space is also often found in areas that are intentionally vacated by land owners or power holders. This space is usually a buffer space, from conservation activities such as rivers, railroads, and other zones that are eventually intervened by informal activities. This is also related to former industrial zones, ports, and barracks which are not relevant to the needs of existing functions due to reduced land vitality. The essence of this buffer zone will also be disrupted by the intervention of external parties which will end up reducing the effectiveness of this buffer zone. Transitional zones are also intervened by informal activities, such as transitions between districts, buildings, and boundaries between land use. This zone becomes ambiguous due to the vacancy of land which can be a gap for certain elements. In addition, Campbell stated that corridors and alleys that tend to be narrow and invisible are examples of in-between space [9].

There are some studies about residual space in Indonesia, one of them is located in Kebayoran Lama, Jakarta Selatan [10]. Based on the context of urban space, the main typology (location) found in the related context are under the bridge, sidewalk, roadside, and in-between space. These residual spaces are spread out in a linear and clustered pattern. A hypothesis is conducted grounded on this finding in Kebayoran Lama as the similar context found in Sumur Bandung District, Bandung.

### **3.4 Identification of Residual Space in Sumur Bandung District**

According to the literature review of residual space, the hypothesis presented by the author is: There is a possibility of new manifestations of different typologies from both theory and case studies that have been discussed. This hypothesis is conducted based on the contextuality that has been stated in many references before. That context of residual space could be related to the form of residual space. As a discussion of the hypotheses above, the process of analyzing the urban spatial structure of Sumur Bandung District is carried out partially through Google Street Map satellite imagery. Overall, the identification process is conducted by distributing observations based on the village (*kelurahan*), namely Braga, Kebon Pisang, Merdeka, and Babakan Ciamis. Identification is done in the form of a typology, physical quality, and quality of use according to the theoretical study in the previous chapter.



**Figure 1. Observation Area of Sumur Bandung District**

Land use in Sumur Bandung tends to be mixed with the majority composition of housing/complex, followed by institutions, then stadiums/fields, industry, and the lowest in the form of mixed gardens [11]. As the result, it was found that the dominance of land use in the four *kelurahan* is;

- Braga with a mixture of residential complexes
- Kebon Pisang with a mixture of complexes and settlements
- Merdeka with a mix of institutions
- Babakan Ciamis with a mixture of residential complexes – institutions

Sumur Bandung is also crossed by the Cikapundung River which is one of the regional attractions. The land use around the Cikapundung River is dominated by housing and trading services. The highest intensity of road is located on the streets of Kebon Pisang and the lowest intensity is located in Merdeka. Sumur Bandung sub-district has 12 (twelve) *Rukun Warga* (RW) with a high-density level, 5 (five) of which are located in Kebon Pisang. The highest density is found on roads leading to arterial roads. On the other hand, low density was found in the center of the sub-district in clusters of central government offices. In addition, low intensity is also found in a wider area. The highest road accessibility is found in Braga with tourism activities and its surroundings, as well as Babakan Ciamis with commercial trading activities. [12]

The first observation area is **Braga** with 34 samples of the residual space documented according to the *Google Street Map* shown in Figure 2. Mostly, the typology found in Braga is *non-spaces*, which is a leftover space as a result of proximity to the movement corridor. *Dead edges*, namely the residual space connected to corridors such as river banks, railroads, roads, and sidewalks.



**Figure 2. Samples of Residual Space (A3, A9, & A20)**

Source: Google Street Map, 2022.

The building density in Braga also causes residual space with the typology of *spaces around*. As shown in Figure 2, sample A3 with *space above* the movement corridor is the manifestation of rooftop typology. It is different from sample A9 where the residual space is in the form of a courtyard which is an intermediary room for the old building (BCA KCP Suniaraja) with the residential area of RW 07 Braga. This residual space is often used as a parking lot equipped with semi-permanent buildings as a business area for residents. With high accessibility and visibility, this residual space is very easy for the community to intervene. Another interesting asset of this sample is the riverbank which is often a 'utility' area for residents. The impression of disorder is very closely related to this residual space considering the non-uniformity of the surrounding buildings and also the furniture of the facilities that are left in the middle of the residual space. Another manifestation of the residual space found in the context of Braga is the utility box in sample A20 which is usually not covered with pavement materials. This space with dimensions ranging from 1.00 to 1.50 meters is easy for the community to intervene as a motorbike parking or street vendor that fits the dimensions of the related space as in sample A20. These samples from Braga show one of the characteristics of the intervention on the use of the residual space in the city of Bandung to the micro-scale. Overall, there are 3 (three) new manifestations of residual space, such as *space above the alley gate* (A3 & A16), *sidewalks with minimal pedestrian activity* (A9), and *utility boxes* (A20).



**Figure 3. Sample of Residual Space in Babakan Ciamis (B6, B7, and B9)**

*Source: Google Street Map, 2022.*

In the observation area of **Babakan Ciamis**, 4 (four) new manifestations were found in the type of residual space in urban areas. With the characteristics of Babakan Ciamis, the residual space in this area is mostly in the form of *non-spaces* and *leftover spaces*. Leftover spaces are not properly programmed and separated from their environment. Usually, it is a space with odd geometry adjacent to the intersection, so that is not easy to put it to good use.

In this observation area, 3 (three) contextual manifestations were found. Sample B6 shows the existence of an unlimited transitive space, which is a space between buildings that is not in the form of a corridor. The boundary of the B6 is blurred as a result of semi-permanent stall activities intervening in the building area. The actor's activity as a form of intervention is the activity of street vendors attached to one wall of the building with the orientation of access to other buildings (Figure 3 left). Meanwhile, sample B7 (figure 3 middle) is a narrow space measuring approximately 1(one) meter below the pedestrian crossing bridge which is one of the spaces intervened by street vendors. Hence, sample **B9** is one of the residual

spaces caused by changes in the owner's land requirements. As result, the late entrance route is closed and unused by the land owner. This results in the death of movement activities and makes the space an easy space to be intervened as a car park and street vendor space. In addition, some shades such as trees make this residual space easy for certain elements to intervene if not controlled properly.



**Figure 4.** Sample of Residual Space in Kebon Pisang (C9 and C15)

Source: Google Street Map, 2022.

**Kebon Pisang** possesses 22 samples of the residual space with many characteristics and office typologies found. These residual spaces are shown in *non-spaces* and *dead edges* like the samples in Braga. In addition, several samples were found in the form of *redundant infrastructure* that is no longer used. Street vendors as actors who intervene in the residual space are often found in Kebon Pisang. Several materials of the green spaces have been switched into pavements for merchant activities. The characteristics of Kebon Pisang as an observation area also have a tourist attraction at Asia Africa St. In this area, the residual space tends to be a *multi-purpose space*, namely a space with a different use at certain times. These spaces are communal parking spaces (as shown in sample C9) reserved for local office workers. Besides, street vendors are found in the corridor of this road. Street vendors tend to intervene in the narrow alley without interrupting the traffic in this corridor.

The last observation is conducted in **Merdeka** with 25 samples of the residual space. These spaces are dominated by *leftover space* which tends to be unsuitable with the 'background'. In addition, the residual space associated with the high-density road is commonly found in this area. Merdeka is characterized by its military service, namely, Siliwangi Military Regiment Area. Interestingly, the common typology of its residual space is *leftover space*. There are many odd geometries found in this area, for instance, samples D1, D3, D9, and the other ten samples. These spaces are the residual parcels of buildings that are usually developed into green spaces. Moreover, no intervention such as street vendors was found in the area within a radius of 5 km from military parcels. Utility Box is left open by the community thus it could not generate residual space as in the previous areas. Merdeka did not exhibit any new manifestations compared to those discussed in the literature review. The residual space conditions discussed in Merdeka also tend to be in regular shape. The only weakness of this area is the lacking of regular maintenance such as vegetation and pavement. As a result of the externality of this military area, this area would likely have an effective residual space organization.



**Figure 5. Sample of Residual Space in Merdeka (D1, D3, and D9)**  
 Source: Google Street Map, 2022.

### 3.5 Findings

As the results of the analysis and discussion in the previous chapter, there are 7 (seven) new manifestations of the residual space from the four observation areas. These manifestations will be classified according to the quality assessment of the residual space in the previous literature review. These findings provide insight into the solution of residual space in the city of Bandung and as an answer to the hypothesis stated before.

The first manifestation is *space above alley* with characteristics such as high accessibility and visibility. Samples A3 and A16 are located close to major roads with high vehicle activity. The type of boundary that limits it is the alleyway itself, so it depends on the thickness of the surrounding buildings. The thicker the surrounding buildings, the larger the scale of the residual space above the gate. The shape of the residual space also tends to be a square geometry alongside the boundaries of the building. Its location tends to be in the middle of the city with a high density of buildings. This is due to the factors that form the residual space due to the lack of land that can be utilized.

**Table 3** Quality Assessment of Space Above Alley

Physical Qualities				
Accessibility	Security	Visibility	Boundary	Topography
High	High	High	Defined	Flat
Uniformity	Scale	Location	Assets	Proximity to Circulation
Regular	Narrow	Center	Road, Commercial	Sidewalk, Main Road
Utilization Qualities (Pre-Intervention)				
Land-use	Users	Time	Frequency	
Seating area	Local	All-day	Not routine	

Source: Google Street Map with personal analysis, 2022.

The second manifestation is *pedestrian way without significant activities*. This manifestation is usually located on the sidewalk at a different level from the road. With this level difference defines the limit of the residual space that can be intervened by street vendors. The scale of the residual space is linear following the existing sidewalk path. However, there are specific characteristics of the sidewalks to be intervened by an informal activity. The residual space characteristics for this manifestation are activity assets, accessibility, and visibility of the sidewalk. Examples of this manifestation are samples A9 and B4.

In sample A9, it was found that the access quality is high with asset activities in the form of office and commercial activities. With the lack of pedestrian activity, street vendors can easily appropriate this sidewalk. The forms of appropriation in this manifestation are semi-permanent stalls and street vendors carts lined up along Belakang Factory St.

**Table 4** Quality Assessment of Pedestrian Way Without Significant Activities

Physical Qualities				
Accessibility	Security	Visibility	Boundary	Topography
High	Moderate	High	Defined	1 step rise level
Uniformity	Scale	Location	Assets	Proximity to Circulation
Linear Patterned	Narrow	Center	Commercial, Office	Less Traffic Road
Utilization Qualities (Pre-Intervention)				
Land-use	Users	Time	Frequency	
Seating area	Local	Work Hour	Work Days	

*Source: Google Street Map with personal analysis, 2022.*

Third manifestation found in the observation area is a *utility box infrastructure*. The location of this manifestation is adjacent to pedestrian paths and highways. With the characteristics of utility lines that usually follow the circulation of the path, the scale of this residual space is linear along the way. However, the points usually depend on the activity assets, accessibility and visibility of the location. In samples A20 and B15, residual space was found on the line of utility box. The cover with dimensions of approximately 1 (one) meter can accommodate one street vendor cart so that it is easy for street vendors to intervene.

In this sample, the accessibility of the location is fairly high, with the location of the residual space at the intersection of Markoni St. However, due to the isolated location of the road, the distribution of street vendors is only approximately 100 meters from the entrance of the alley. The furnitures and equipment from these street vendors are often placed at the location of the residual space due to the high intensity of sales activities. In locations that do not have utility covers tend not to be intervened by street vendors.

**Table 5** Quality Assessment of Utility Box Infrastructure

Physical Qualities				
Accessibility	Security	Visibility	Boundary	Topography
High	Low	Low	Undefined	Flat
Uniformity	Scale	Location	Assets	Proximity to Circulation
Linear Patterned	Very Narrow	Center	Commercial, Road	High Traffic Road
Utilization Qualities (Pre-Intervention)				
Land-use	Users	Time	Frequency	
Merchants	Local	Varied	All day	

*Source: Google Street Map with personal analysis, 2022.*

*Transitive area* is a space whose boundaries cannot be defined. The factor that generates this residual space is the intervention of informal commercial activities. The transition in this space tends to be blurred according to the intervention area of the semi-permanent building. Accessibility and visibility of this residual space is quite high with minimal pedestrian activity.

**Table 6** Quality Assessment of Transitive Area

Physical Qualities				
Accessibility	Security	Visibility	Boundary	Topography
High	High	High	Undefined	Flat
Uniformity	Scale	Location	Assets	Proximity to Circulation
Nodal Patterned	Narrow	Center	Commercial, Road	High Traffic & Pedestrian way
Utilization Qualities (Pre-Intervention)				
Land-use	Users	Time	Frequency	
Merchants	Local	Work Hour	Everyday	

*Source: Google Street Map with personal analysis, 2022.*



Another manifestation found is *unused entrance*. Usually building parcel has 2 (two) entrances and exits to create continuous circulation. However, over time and changes in land use, one of both entrances is often unused. The decision to close the door made the allocated space in front of it become the residual space. Alongside the boundaries of building, the definition of scale and the boundaries of the residual space depends on the pavement. In sample B9, this residual space is supported by the presence of shade and low visibility of the location, making it easy to intervene either as a car park or as a stall for street vendors. The activity assets of the B9 location are in the form of government agency facilities on Kebon Sirih St., such as the Sumur Bandung Police Station and Pakuan Building.

**Table 7** Quality Assessment of Unused Entrance

Physical Qualities				
Accessibility	Security	Visibility	Boundary	Topography
High	High	Low	Defined	Sloped
Uniformity	Scale	Location	Assets	Proximity to Circulation
Nodal Square	Narrow	Center	Commercial	Less Traffic Road
Utilization Qualities (Pre-Intervention)				
Land-use	Users	Time	Frequency	
Car Parking, Merchants	Local	Everyday	Everyday	

*Source: Google Street Map with personal analysis, 2022.*



*Pedestrian Platform* is the last manifestation found that is formed due to the minimal effectiveness of the sidewalk. Sidewalks with different pavement levels and the dimensions of the sidewalks is relatively small (approximately 1.5 x 1.5 meters) creating the impression of a stage compared to other sidewalks. In sample C15, the quality of accessibility and site visibility is very high with space connection with Sunda St. The intervention of this residual space tends to be

nodal or point in accordance with the existing 'platform' dimension. The generation from the location that became the asset is Sunda St. itself and the surrounding commercial area. With the availability of shade from trees, possible interventions that can be carried out can be in the form of temporary furniture and stalls from street vendors.

**Table 8** Quality Assessment of Pedestrian Platform

Physical Qualities				
Accessibility	Security	Visibility	Boundary	Topography
High	Low	High	Defined	1 step rise level
Uniformity	Scale	Location	Assets	Proximity to Circulation
Nodal patterned	Narrow	Center	Commercial, Green space	High Traffic Road
Utilization Qualities (Pre-Intervention)				
Land-use	Users	Time	Frequency	
Merchants, Street Furniture	Local	N/A	Everyday	
<i>Image Source: Google Street Map, 2022.</i>				

#### 4 Conclusion

The tendency of residual space in terms of use is a space that is not used properly nor maintained by stakeholders and shareholders so that it is intervened by informal actors. Residual space is a space that is not well planned so that it generates ambiguity which causes a decrease in the aesthetic value of urban space. In its application in urban areas, the performance dimensions that need to be highlighted are the performance of *Fit*; *Access*; and *Sense*. Another dimensions would be *Vitality* and *Control* as an addition dimensions.

There are several variables of physical quality such as accessibility, security level, visibility, site boundaries, site topography, uniformity of shape, scale of site location, facility assets, and proximity to circulation. Besides, there are utilization qualities that can be identified with current activities, users, times, and previous land uses. There are various typologies that have been studied by previous authors, that becomes the base theory of this study.

This study learns residual space located in District (*Kecamatan*) Sumur Bandung with 2 (two) limitations of accessibility level and diversity level of land use. The typology of the residual space in Bandung is similar to the previous study, with slight difference in manifestations. There are six new manifestations found in the city of Bandung, namely:

1. Space above alley
2. Pedestrians way without significant activities
3. Utility box infrastructure
4. Transitive area
5. Unused Entrance
6. Pedestrian Platform

This study still has many shortcomings, such as the lack of primary data as data validation to be used in further research. Primary data is needed to provide recommendations for handling residual space in the city of Bandung. This study only targeted in finding contextual residual space in the city of Bandung (Sumur Bandung District). This study requires another variable as limitation other than accessibility and land-use, such as open space and activity assets for 24 hours.

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## Study of Physical Carrying Capacity of Tourism Objects in Anticipating Post-Pandemic Over-tourism in Magelang Regency (Case Study: Borobudur Temple and Mendut Temple)

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**Abstract.** Tourism sector is the country's leading sector and a significant contributor to the country's foreign exchange. However, COVID-19 pandemic resulted in declining the number of tourists visiting in 2020, only 25% from the previous year. After the post-pandemic recovery has been carried out, the planning and development of tourist areas are not accompanied by good management can cause various problems. Magelang Regency has unique characteristics due to its historical background, one of which is the site of temples from ancient kingdoms, namely Borobudur and Mendut Temple. As a tourist attraction with a high number of visitors, it has an impact on its planning. This paper aims to identify the maximum capacity of Borobudur and Mendut Temple tourism objects by applying quantitative analysis methods using time series analysis and supported by literature studies to provide objective information. The results obtained are that the number of tourists to Borobudur and Mendut Temple is slowly increasing, but the carrying capacity of the Borobudur Temple has exceeded the maximum limit, while for Mendut Temple, it is still possible to increase tourists. Some alternatives must be applied to increase attractiveness, reduce, and limit tourist visits to prevent over-tourism.

**Keywords:** *borobudur temple; mendut temple; physical carrying capacity; tourism; over-tourism.*

### 1 Introduction

Tourism is the leading sector and a significant contributor to foreign exchange, even the largest in many countries [1]. Tourism has many elements that can be developed, starting from the attractiveness of the tourist attraction, accommodation, supporting infrastructure, etc. All these elements provide significant input for regional and national income. Not only that, but tourism can also be a sector that accelerates other sectors to develop and contribute to the

development of facilities and infrastructure for the basic needs of the community [2].

However, starting in 2020, the COVID-19 pandemic decreased the number of tourists visiting in 2020 to only 25% from the previous year [3]. This decline had impacted the level of the economy. At the pandemic's beginning, all tourism activities stopped; many tourist objects were closed, and no tourists came. The decline in revenue from the tourism sector was also due to decreased tourist visits, the cancellation of various activities such as national and international tourism exhibitions and events, and even some of the tourism industry losses because they could not finance their operations such as hotels. As a result, the economy of the people who depend on the tourism sector is disrupted. However, in 2021, the tourism sector will begin to recover, and government efforts such as Cleanliness, Health, Safety and Environmental Sustainability (CHSE) certification are expected to accelerate the recovery of the tourism sector.

The COVID-19 pandemic has forced the tourism sector to shift its focus to sustainability [4]. After the post-pandemic recovery has been carried out, the planning and development of tourism areas are continuing to shift toward ecotourism [5]. The concept of ecotourism fulfils both the tourism development and environmental protection requirements by using carrying capacity as the essential tool [6]. Therefore, tourism planning and development strategy must also notice the carrying capacity to hampers and even stops tourism development due to a significant increase in the number of tourists [7]. The concept of carrying capacity can also be used as a barrier to prevent over-tourism conditions where the number of tourists has exceeded the maximum capacity of the tourist attraction so that further it will provide complex problems (Cifuentes, 1992; [9]; [10]; [11]; [12]. The carrying capacity of a tourist attraction provides an overview of the maximum capacity of visitors who can visit a tourist attraction within a certain period [13]. Carrying capacity can also provide a further picture of the level of visitor satisfaction with the tourist attraction so that the transmission of COVID-19 can be avoided [14].

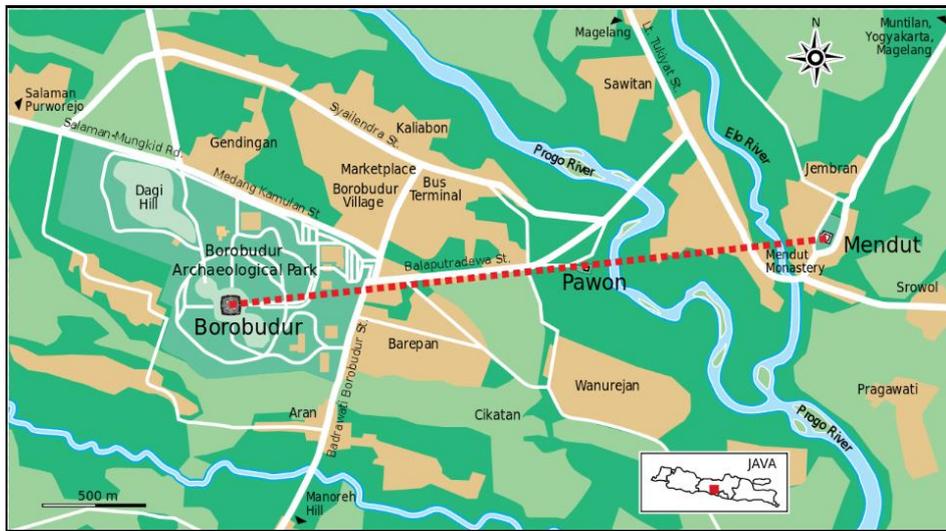
Magelang Regency, Central Java, has unique characteristics of its historical background. With this background, various historical or cultural sites are scattered in Magelang Regency. One of these historical site complexes is the Borobudur Temple. Since 1974, Borobudur has become Indonesia's most visited tourist attraction and continues to increase yearly [15] [16]. In 2019, the number of Borobudur Temple tourists increased to 3,989,839. This large number of tourists visiting can have various positive and negative impacts and will continue to grow in the future. This phenomenon happened not only in Borobudur Temple but also in another temple three kilometres from Borobudur Temple, one of which

is Mendut Temple. Mendut Temple also has enormous potential to be visited by tourists. It shows that Mendut Temple has good potential due to the development of the number of tourists, which has increased significantly [17]. In addition, it is also said that the location of Mendut Temple is also quite strategic, coupled with easy accessibility. However, with these potentials, the lack of promotion makes the number of tourists visiting Mendut Temple relatively lower than Borobudur Temple.

In normal conditions, especially during holiday sessions, the Borobudur Temple tourist attraction will be crowded, leading to the density of the tourist attraction area [18]. The density of tourists at one time resulted in the emergence of other problems such as waste, congestion, air pollution, physical damage such as vandalism and other environmental damage, which certainly had a negative impact on the tourist attraction itself [19]. Therefore, it is necessary to assess the maximum visiting capacity that can be reached and accepted by the Borobudur Temple and Mendut Temple tourism objects to reduce the negative impact caused by the high number of visitors and to prevent the transmission of Covid-19. To answer the formulation of the problem, the purpose of writing this article is to identify the maximum capacity of the Borobudur Temple and Mendut Temple attractions, which can be answered through several stages, namely the identification of tourist projections for Borobudur Temple and the identification of the maximum capacity of Borobudur Temple and Mendut Temple to provide output planning recommendations. Tourism of Borobudur Temple and Mendut Temple provides benefits as a consideration in planning tourism.

## **2 Methods**

The study cases in this article are Borobudur Temple and Mendut Temple, located in Magelang Regency, Central Java, Indonesia. Both Borobudur Temple and Mendut Temple are the famous Buddhist temple destination in Magelang Regency. Borobudur Temple has become Indonesia's leading destination for tourists domestically and abroad. Located a short distance from Borobudur, the largest Buddhist shrine in the world, there is also Mendut Temple. Borobudur Temple and Mendut Temple are within one reach and are in a straight line. For more details, see the following map.



**Figure 1** Borobudur and Mendut Temple Map

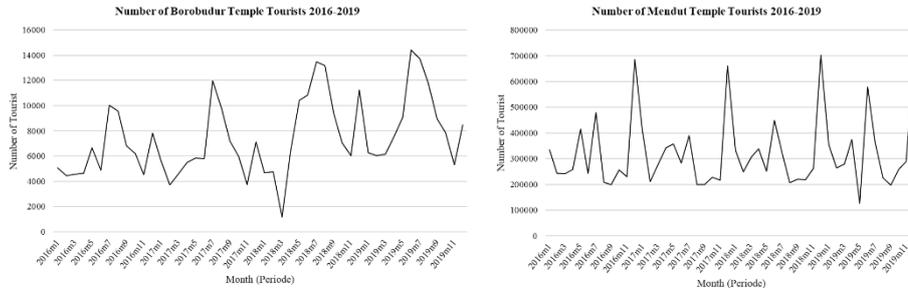
To support the article writing, data was taken from Central Statistics Bureau (BPS) to collect the information about temple tourist data, as well as other data obtained from popular media, articles, laws and regulations, and others as sources to support the analysis. On the other hand, the data analysis process is carried out through quantitative analysis by using the time series method to forecast the number of tourists in the future and understand the growth and condition of tourism visitors. Furthermore, the carrying capacity analysis is also adopted as a quantitative analysis tool for this research to determine the maximum capacity of tourists that can be accommodated which will also be compared to the policy during the pandemic. From these results, recommendations for tourism planning will be discussed.

### **3 Data Analysis**

#### **3.1 Projected Number of Tourists for Borobudur Temple and Mendut Temple**

To understand how the conditions of Borobudur Temple and Mendut Temple are in the context of planning and developing tourist destinations, it can be seen from the number of tourists who visit these tourist objects or destinations. Based on data from the Central Bureau of Statistics of Magelang Regency, the trend of growth in the number of Borobudur Temple tourists always increases every year, although not significantly. In more detail, the peak season at Borobudur Temple is December-January. Annual events such as Christmas Eve, New Year's Eve,

and school holidays have impacted higher tourism activities in those months. Aligned with this finding, the growth trend in the number of Mendut Temple tourists also tends to increase. In Mendut Temple's case, the peak season occurs around July-August, which differs from Borobudur Temple. During that mid-year period, there are also semesters or national school holidays, which allow higher



**Figure 1** Number of Tourist in Borobudur and Mendut Temple 2016-2019

tourism activities to occur in that period. More details can be seen in the following image.

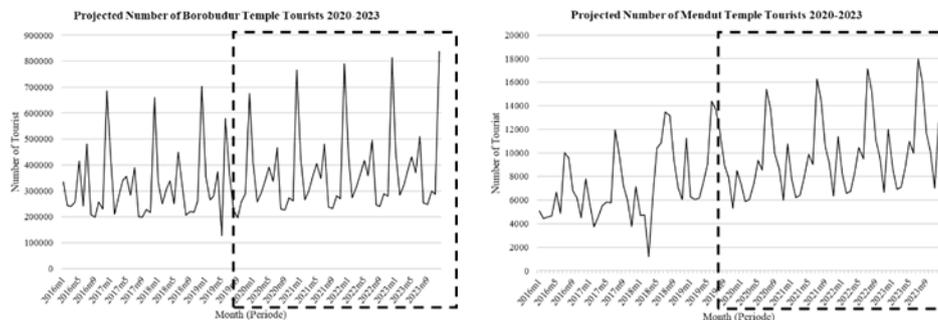
Furthermore, a time series projection analysis was carried out using several methods to forecast the number of tourists at both destinations. The Triple exponential smoothing winter method was qualified as the best method for this analysis. This method has a minor error value explained by the MAPE (Mean Average Percentage Error) value. The MAPE value for the Borobudur Temple case is 0.1695, in other words, the error percentage is around 16.95% for the projection of Borobudur Temple. Meanwhile, for Mendut Temple, the MAPE value is 0.1812, in other words, the error percentage is around 18.12%. The following table presents the selection methods' results and the error values generated in forecasting (projections) for the number of tourists at Borobudur Temple and Mendut Temple.

**Table 1** Method Comparison for Projection

Metode	Borobudur Temple		Mendut Temple	
	Theil's U	MAPE	Theil's U	MAPE
<b>Smoothing Average</b>				
1. Single Moving Average Smoothing	0.91	0.39	0.74	0.42
2. Double Moving Average Smoothing	0.81	0.40	0.68	0.49
<b>Exponential Smoothing</b>				
1. Single Exponential Smoothing	0.81	0.33	0.58	0.37

Metode	Borobudur Temple		Mendut Temple	
	Theil's U	MAPE	Theil's U	MAPE
2. Double Exponential Smoothing Brown	0.87	0.35	0.73	0.35
3. Double Exponential Smoothing Holt	0.84	0.34	0.69	0.43
<b>4. Triple Exponential Smoothing Winter</b>	<b>0.52</b>	<b>0.17</b>	<b>0.44</b>	<b>0.18</b>
<b>Decomposition</b>				
1. UCM	-	-	0.36	0.23

Based on the results of time series analysis using triple exponential smoothing winter as the best method, the results of forecasting the number of tourists who will visit Borobudur Temple and Mendut Temple can be seen in the image below. The growth rate of tourist demands for both temples, both Borobudur and Mendut temples, is expected to increase every year. At the projected growth below, it can also be seen that the peak season period is still the same as the primary data, for Borobudur Temple in December-January, while for Mendut Temple, it is in July-August.



**Figure 2** Projected Number of Tourist in Borobudur and Mendut Temple 2020-2023

### 3.2 The Timeline of Planning and Development of Borobudur and Mendut Temple

#### 1900-1970 Early Discovery and First Restoration

During this period, both Borobudur Temple and Mendut Temple are still in the stage of restoration after being rediscovered, and the initial stages of the preservation process are carried out simultaneously [21]. Mendut Temple is

estimated to be older than Borobudur Temple [21]. Subsequently, the Government of the Netherlands East Indies formed a commission to handle and research the discoveries of Borobudur Temple and Mendut Temple. From 1907 to 1911, the first restoration process was carried out, but there were incidents and a lack of budget, so the restoration was only carried out on a small scale to clean the existing statues and stones [21]. In the end, in the late 1960s, the Indonesian government proposed to carry out a major international restoration which was carried out to preserve the Borobudur and Mendut temples.

### **1970-2000 Massive Restoration and World Heritage Site**

During this period, the Government of Indonesia collaborated with UNESCO to complete a significant and comprehensive restoration and turn it into a major project [21]. This restoration was carried out by dismantling all five square terraces and improving the drainage system by embedding waterways into the monument. After the renovation, in 1974, as many as 260,000 tourists visited Borobudur Temple, and it became the most visited tourist attraction in Indonesia and continues to increase yearly [15] [16]. At its peak/stupa, UNESCO acclaimed Borobudur Temple as one of the world heritages in 1991 [22].

### **2000-2010 Internal and Disaster Planning Issues**

By the beginning of 2000, the community criticised tourism planning, especially at Borobudur Temple, because it was considered not to involve the community in the process [23]. In those years, it was planned to redesign the Borobudur Temple area, and this condition made some people who traded souvenirs, food and others (informal sector) lose their jobs. The eruption of Mount Merapi occurred in 2010, which had a considerable impact on Borobudur Temple and Mendut Temple so that a large-scale rehabilitation was again carried out with assistance from UNESCO while maintaining the preservation of Borobudur Temple and Mendut Temple and the surrounding environment by afforestation to maintain temperature stability.

### **2010-present Growing Number of Tourists Until the Pandemic**

There was national restlessness due to terrorist incidents from 2009-2015. However, this did not stop the restoration activities of Borobudur Temple, which continued to be carried out on a large scale. The development of infrastructure and mobile phone networks throughout Indonesia has also begun to develop visa exemptions for several countries to attract more tourists who come to Indonesia. In 2016-2017, several priority destinations were set, including the Borobudur Temple as one of the priority destinations. The increase in the number of tourists is significant and better than in 2018. However, in early 2020, the Covid-19

pandemic entered Indonesia and stopped all local and national activities, and Borobudur Temple and Mendut Temple were forced to close for some time to prevent the transmission of Covid-19.

## 4 Findings and Discussion

### 4.1 Carrying Capacity of Borobudur Temple and Mendut Temples

Generally, the carrying capacity analysis helps determine the maximum level an environment can support. At this point, the development and use of attraction features, facilities, and services in a tourism destination have also reached the optimum level. In this tourism context, this carrying capacity assesses the maximum limit of tourists that can be accommodated at one time; thus, the result of this carrying capacity is also beneficial in indicating whether the destination ends up in an over-tourism condition or not. Besides that, it can also be used as input to generate recommendations for tourism planning. This research will focus on assessing the Physical Carrying Capacity (PCC). This carrying capacity uses the maximum limit of tourists who can visit tourist objects in one day as the primary consideration. By using the formula developed by Cifuentes (1992) with modifications by Fandeli and Muhammad (2009), the formula for PCC is obtained as follows [8] [7]:

$$PCC = A \times \frac{1}{B} \times Rf \quad (1)$$

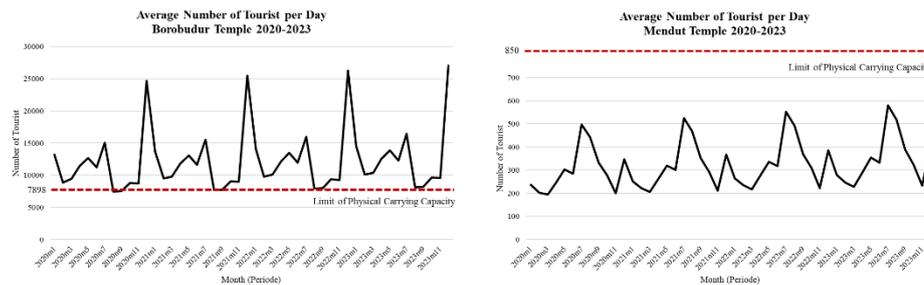
Where, A is the area of the tourist attraction, B is the minimum space requirement required by tourists (assuming 65 m<sup>2</sup> per visitor) and Rf is the rotation factor obtained from the duration of open time divided by the average time spent by tourists (assuming 3 hours). From these provisions, the results obtained are as in the table below:

**Table 2** Physical Carrying Capacity Calculation of Borobudur and Mendut Temple

Tourism Object	Area (m <sup>2</sup> )	Opening Hour	Closing Hour	Duration*	Average Spending Time**	Rf	Tourist Space Needs (m <sup>2</sup> )	PCC
Candi Borobudur	220000	8 am	15 pm	7	3	2.33	65	7897.44
Candi Mendut	13800	7 am	19 pm	12	3	4	65	849.23

Based on the calculation of carrying capacity using the PCC formula above, the maximum limit of visitors per day that Borobudur Temple can accommodate is

around 7.898 per day (rounded up). Meanwhile, in Medut Temple, the maximum limit of visitors per day that can be accommodated is around 850 visitors per day (rounded up). The amount of PCC in Borobudur Temple and Medut Temple is used as a benchmark to assess whether those temple destinations are surplus or deficit. The calculation of tourists number from the projections is generated by calculating the average number of tourists per day. The following figure is a breakdown number of tourists per day for each month and the status of their carrying capacity:



**Figure 3** Physical Carrying Capacity of Borobudur and Mendut Temple

Based on the results in the tables above, Borobudur Temple is in a deficit condition from 2020 to 2023, which means that the number of projected tourists exceeds the maximum capacity that Borobudur Temple destination can accommodate. This condition may cause damage to facilities and the environment at Borobudur Temple, as well as the impact of the over-tourism phenomenon. Therefore, a strategy to prevent the adverse effects of over-tourism is needed. However, in 2020, the COVID-19 pandemic resulted in the cessation of tourist activities, with zero visitors in the first few months of the first outbreak. Thus the forecast result in 2020 will be different from the existing conditions and need some adjustments. Besides that, the limit on the maximum number of tourists also needs to be adjusted for the pandemic conditions. In this sense, the maximum limit per se day that has been obtained from the calculation becomes less relevant and needs to change lower than the calculation results. However, in 2021, the Indonesian government has issued a vaccine policy that will cause the number of tourists to bounce back to normal and reach the maximum limit of visitors to the destination.

Furthermore, by taking one of the forecasted month periods, January 2022, the number of visitors is predicted to reach 14081 tourists with a maximum capacity of only 7898 tourists. From this, the condition of carrying capacity in Borobudur Temple has been in a deficit stage. Thus it is necessary to set the limit on tourist arrival in Borobudur Temple.

On the other hand, at Mendut Temple, the carrying capacity is in a surplus condition during the entire month from 2020 to 2023, which means that the number of projected tourists can grow until the maximum level (850 tourists per day). This number of tourists can still be increased twice to three times by 2023. However, in the existing conditions in 2020, the number of tourists in several months became zero due to the closure of tourist destinations and activities limitations, so the forecast result is different from the existing conditions and needs to be adjusted.

Borobudur Temple has not applied visitor restrictions before the pandemic because the number of tourists and income for the region will be significant and increase GRDP and regional revenue, mainly for Magelang Regency. However, this causes an over-tourism condition which will substantially impact the tourist attraction itself. On the other hand, the number of tourists at Mendut Temple is not as large as the number of tourists at Borobudur Temple, which causes a lack of interest in visiting Mendut Temple even though the distance between the two temples is only about 3 kilometers. The Magelang Regency Government needs to make a policy regarding the distribution of the number of tourists by limiting tourists at Borobudur Temple and maximizing the potential and attractiveness of Mendut Temple.

#### **4.2 Relevance of Tourism Planning to Borobudur Temple and Mendut Temple in Preventing Over-tourism**

Based on the stages in Butler, we can say that Borobudur and Mendut Temple have passed, this tourist attraction has passed the exploration, involvement, development, and consolidation stages [24]. Currently, Borobudur Temple and Mendut Temple have entered a stagnation phase, where the next phase is the rejuvenation phase (increase) or the decline phase (decreased). This is exacerbated by the Covid-19 pandemic, which caused the cessation of tourism activities at Borobudur Temple and Mendut Temple in 2020. Despite the restoration and the existence of a national policy regarding health protocols, the number of tourists and the development of Borobudur and Mendut Temples may increase or decrease according to the tourism area life cycle diagram. Moreover, based on the analysis that has been carried out, it is known that the maximum number of tourists per day in Borobudur Temple that can be accommodated is 7898 visitors per day. Then, based on the forecasting result, the number of tourists will exceed the maximum number or limit, so over-tourism events will occur post-pandemic and reach 2 to 4 times the maximum limit at Borobudur Temple. However, it does not apply to Mendut Temple, where the condition is still in surplus and has no potential for over-tourism. During the pandemic, the number of tourists visiting was limited to only a few visitors who could enter the Borobudur Temple and Mendut Temple attractions.

Over-tourism condition, if not addressed, will significantly impact Borobudur Temple itself in the future. UNESCO identified the primary and most crucial problems in efforts to preserve Borobudur Temple, such as vandalism or damage done by visitors, soil erosion in the southeastern part of the temple site, and disasters that occurred around Borobudur Temple. Problems also originate from visitors, such as vandalism crossing out rocks and supporting facilities. Those problems happened in 2009 when there was no system to limit the number of tourists allowed to visit per day. Because of that, visitors had to be accompanied by a guide, so they were constantly under surveillance [25].

With the over-tourism condition, there is a need to limit the number of tourists who come to Borobudur Temple, in addition to preventing physical and environmental damage, as well as avoiding the transmission of Covid-19 that is still happening. Blazquez-Salom explain that over-tourism occurs in Spain by looking at three existing spatial locations, Barcelona, Valencia, and the Island of Mallorca [26]. With the same conditions as the Borobudur Temple, which has a solid cultural background, this area and the Borobudur Temple both become a unique attraction as a tourist attractions. This spatial area is planned to have growth restraint or degrowth to avoid further damage to the area with several existing instruments. One of the instruments used to control tourism growth is PEUAT (Special Urban Plan for Tourist Accommodation in Barcelona). This instrument is regulated by dividing zones with accommodation distribution throughout the region. In addition, restrictions on the number of beds provided were also enforced so that the number of tourists who came was detained. From here, policies like PEUAT that aim to reduce over-tourism can be applied to the Borobudur Temple area, where in Magelang Regency and its surroundings, there are other tourist objects with the same characteristics and types of tourism, namely temples. With the precise handling in Barcelona, Spain, growth restraint or degrowth for tourism can be carried out, and growth can be more controlled, especially during a pandemic. The development of lodging accommodations also needs to be controlled so that there are no more inns like Airbnb (turning a residence into an inn).

The restriction policies in the surrounding area of Magelang Regency also need to be carried out because there are a lot of cultural heritages, not only Borobudur Temple but also Prambanan Temple and other Hinduism and Buddhism Temples, so there needs to be cooperation between local governments. In addition to controlling the area outside the Borobudur Temple and its surroundings, restrictions also need to be carried out from within or internally of tourist objects, such as limiting the number of tourists per day. If it reaches the maximum limit, the tourist attraction is closed (at one time), limiting the number of tourists who come in a day. A certain period with restrictions on the length of the duration (for example, based on peak time, 11.00 WIB is the peak time at Borobudur Temple,

so there is a need for restrictions on tourists entering the tourist attraction), providing attractions in each time (every hour) to distribute tourists who enter the tourist attraction. Visiting (minimizing the possibility of peak times), the implementation of health protocols also needs to be tightened. These alternatives are expected to be a tool to restrain the growth of tourism or over-tourism so that there is no physical or environmental damage, as well as to prevent the transmission of COVID-19.

In contrast to the condition of Borobudur Temple, which has exceeded its maximum capacity during the peak season and exacerbates over-tourism conditions, Mendut Temple does not indicate over-tourism. This condition will be an excellent benefit for Mendut Temple. Mendut Temple can increase its tourism attractiveness to attract more tourists while maintaining control and monitoring. The number of visitors can increase twice to three times from the number of tourists visiting Mendut Temple. However, due to the existence of Borobudur Temple, which has already become a world-known heritage site, Mendut Temple is considered less attractive enough to engage tourists. The situation is getting worse because of the imbalanced distribution of the number of tourists between Mendut Temple and Borobudur Temple. This will also result in a different concentration of activities and visitor density so that the impact is different. However, at Mendut Temple, physical and environmental conditions are still within normal limits. From here, several steps or alternatives can be taken to increase the number of tourists to Mendut Temple and maximize its potential to reach the maximum number that Mendut Temple can accommodate. Some of these alternatives include providing additional attractions and special tourism packages on certain days or times so that visitors will be interested in visiting Mendut Temple. Massive promotions can also be done through online media or online platforms provided by the Magelang Regency government to attract and engage more tourists. However, on the other hand, because of the short distance between Borobudur Temple and Mendut Temple, it is also possible that a surge in tourists' arrival at Borobudur Temple will also affect Mendut Temple. In this sense, it is necessary to set a limit if the capacity will reach the maximum level.

On a regional scale, in the context of Magelang Regency, other possible impacts on Borobudur Temple and Mendut Temple surroundings could be the growth of Airbnb and other accommodations, which need to be controlled because they can cause changes in spatial activities and changes in the zoning area which was originally residential to trade and services or other possible zones. These zoning changes or spatial designations also affect the spatial plans that have been planned for those areas. Spatial control due to the massive development of the tourism sector must be firmly implemented to avoid environmental and other impacts that cannot be predicted. By looking at the same incident and happening in other areas,

it is necessary to have inter-regional cooperation to overcome uncontrolled regional growth. Moreover, Magelang Regency and Yogyakarta Province are relatively close to having quite similar tourist destinations (temples). Thus, enabling growth will be very high and strong because of the attractiveness of the two regions in developing tourist destinations. Therefore, it is necessary to have good cooperation to prevent a surge in the number of tourists and uncontrolled regional growth in the context of recovering the tourism sector after the pandemic.

## **5 Conclusion and Recommendations**

Based on the results of the analysis that has been done, it is found that the number of tourists to Borobudur Temple and Mendut Temple has increased slowly and with the same peak time conditions in December-January (the highest increase) every year. This condition is influenced by school and national holidays as well as holidays and religious celebrations. The carrying capacity of the Borobudur Temple tourism object based on the analysis was found that the number of tourists that can be accommodated is 7898, and in 2020-2021 the number of visitors has reached and exceeded the maximum limit, resulting in a deficit. Moreover, from 2022 to 2023, all months of the year are in a deficit. However, the carrying capacity for the Mendut Temple tourist attraction is still in surplus, so it is still possible to increase the number of tourists while observing health protocols. With these conditions, increasing tourists by promoting and adding attractions is necessary so that visits to Mendut Temple can reach the maximum number.

Currently, Borobudur Temple and Mendut Temple have entered a stagnation phase, where the next phase is the rejuvenation phase (increase) or the decline phase (decreased). However, the condition is that the number of tourists visiting Borobudur Temple has reached the maximum limit. It will cause some damage if the number of tourists is not controlled, and the damage will get worse so that there is a need for handling so that the growth of Borobudur Temple can lead to the rejuvenation phase even with tourist restrictions. Several alternatives must be applied to reduce and limit the number of tourist visits to prevent over-tourism. Some of these alternatives are the need to limit the number of tourists visiting Borobudur Temple, the distribution of attractions at certain times to avoid peak times or peak seasons, the implementation of strict health protocols to prevent the transmission of Covid-19, as well as cooperation with the local government to prevent the spread of COVID-19. Support tourism containment and degrowth. As for Mendut Temple, where there is no indication of the over-tourism phenomenon, it is still possible to develop and attract more tourists, but its implementation still requires strict health protocols. Increasing the number of tourists at Mendut Temple can be done by promoting through various tourism platforms and providing unique attractions on certain days or certain times so that

it can attract more tourists and an even distribution of tourists with Borobudur Temple. In a broader context, Magelang Regency, it is necessary to limit activities and control spatial planning to prevent unwanted space growth so that spatial planning deviations occur as planned. The Magelang Regency Government needs to collaborate with the surrounding regional governments to control growth, especially with Yogyakarta, where the area also has the same attractiveness as Magelang Regency. It needs to be controlled to allow for a relatively massive regional growth and not cause environmental impacts or impacts. Other impacts that may occur in Magelang Regency.

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# Numerical Simulation of Two-dimensional Vortex-Induced Vibration of Circular Cylinder Using Least Square Moving Particle Semi-Implicit – Vortex Particle Method (LSMPS-VPM)

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**Abstract.** Interaction between fluid and structure is a complex problem that is often encountered in various engineering fields. One of the fluid-structure interaction (FSI) phenomena is vortex-induced vibration (VIV). In this research, a particle-based numerical method known as the Least square moving particle semi-implicit – Vortex particle method (LSMPS-VPM) was improved to be able to simulate the VIV of a solid rigid object. LSMPS-VPM utilized multi-resolution particles, LSMPS spatial operator, and the Brinkmann penalization method for directly solving Navier-Stokes equations in vorticity form. The LSMPS-VPM was improved by adding a VIV solver which employed the 4<sup>th</sup> order Runge-Kutta method to solve the one-degree-of-freedom vibration equation. The numerical method was tested with two benchmark problems: the flow past a static two-dimensional circular cylinder and the VIV of a two-dimensional circular cylinder. The results of the static simulation show that the present method is already capable of producing results that agree with past simulations. On the other hand, from the results of the VIV simulation, the present method is capable of predicting the motion of the solid body immersed in the fluid, however, some parameters still show inaccurate results compared with the references.

**Keywords:** *particle-based simulation; least square moving particle semi-implicit; vortex-induced vibration.*

## 1 Introduction

Vortex-induced vibration (VIV) of a structure is one of the practical interests of many engineering fields. VIV is classified as a complex fluid-structure interaction (FSI) case where the vibration is induced by the generation of vortex shedding from the structure. VIV phenomenon can cause damage and sometimes can lead to structural failures. Hence, a comprehensive understanding of VIV is very important in designing and improving a structure's strength.

VIV phenomenon has been studied intensively in the past two decades. Comprehensive reviews of the fundamentals of VIV can be found in many

publications such as Sarpkaya [1] and Williamson [2]. Recently, various numerical simulations have been widely used to contribute to studying the nature of VIV and FSI in general. Most of the numerical simulations that are used in studying the VIV phenomenon are based on the grid-based method. Shen et al. [3] utilized the SIMPLEC algorithm coupled with immersed boundary method to simulate case studies for a static and a one-degree-of-freedom (1DOF) circular cylinder immersed in a fluid. Zhao et al. [4] investigated the VIV of a circular cylinder in oscillatory flow using Petrov-Galerkin finite element method. Pan et al. [5] utilized Reynolds averaged Navier-Stokes simulation code to simulate the VIV of a circular cylinder at a low mass-damping configuration. Pastrana et al. [6] simulated a VIV of a low-mass ratio two-degree-of-freedom circular cylinder at subcritical Reynolds numbers using Large-eddy simulation.

Although the use of the grid-based method is more prevalent in VIV simulation, the method may encounter difficulties when dealing with problems involving large deformation or complex body shapes [7]. To overcome the difficulties, a particle-based method can be utilized. The particle-based method provides advantages for complex domain simulation or high deformation simulation due to the usage of freely moving particles inside the simulation domain.

In this research, a particle-based simulation program for a simulation of VIV will be developed. The Least square moving particle semi-implicit – Vortex particle method (LSMPS-VPM) developed by Pristiansyah [8] will be used as the base program for this research. The LSMPS-VPM utilizes Least square moving particle semi-implicit (LSMPS) spatial operators [9] and the fast multipole method (FMM) [10], allowing multi-resolution particles and faster computational time compared with the classical VPM [11]. The present numerical method will be validated using benchmark test cases that have been done in the past research: simulation of a flow past static and 1DOF circular cylinder at Reynolds number 100. The remainder of this report is organized as follows: the present numerical method is explained in Section 2, the simulation details are presented in Section 3, and the results are discussed in Section 4, followed by the conclusions in Section 5.

## 2 Numerical Methods

### 2.1 Vortex Particle Method

The continuity and momentum equations for a viscous incompressible fluid are expressed as

$$\nabla \cdot \mathbf{u} = 0 \quad (1)$$

$$\frac{\partial \mathbf{u}}{\partial t} + (\mathbf{u} \cdot \nabla) \mathbf{u} = -\frac{1}{\rho} \nabla p + \nu \nabla^2 \mathbf{u} \quad (2)$$

where  $p$  is the pressure,  $\mathbf{u}$  is the velocity vector,  $\nu$  is the kinematic viscosity, and  $\rho$  is the fluid density. The vorticity form of Eq. (2), can be obtained by taking the curl operation on both sides of Eq. (2)

$$\frac{\partial \boldsymbol{\omega}}{\partial t} + (\mathbf{u} \cdot \nabla) \boldsymbol{\omega} = (\boldsymbol{\omega} \cdot \nabla) \mathbf{u} + \nu \nabla^2 \boldsymbol{\omega} \quad (3)$$

where  $\boldsymbol{\omega}$  is the vorticity defined by the curl of the velocity

$$\boldsymbol{\omega} = \nabla \times \mathbf{u} \quad (4)$$

For two-dimensional simulation in a Cartesian coordinate plane,  $\mathbf{u} = (u, v)$  and  $\boldsymbol{\omega} = \omega_z \hat{k}$ , the stretching term  $(\boldsymbol{\omega} \cdot \nabla) \mathbf{u}$  in the right-hand side of Eq. (3) disappears. Therefore, the momentum equation can be rewritten into

$$\frac{\partial \boldsymbol{\omega}}{\partial t} + (\mathbf{u} \cdot \nabla) \boldsymbol{\omega} = \frac{D\boldsymbol{\omega}}{Dt} = \nu \nabla^2 \boldsymbol{\omega} \quad (5)$$

where  $\frac{D}{Dt}$  is the material derivative. In the Vortex particle method (VPM), particles carrying vorticity are used to discretize the fluid. The discretized particle can be written mathematically as follows:

$$\omega_i = \Gamma_i V_i \quad (6)$$

where  $\Gamma_i$  and  $V_i$  are the vorticity strength and the volume of the corresponding  $i$ th particle. To obtain the solution of Eq. (5), the viscous splitting algorithm [12] is utilized. The algorithm includes two steps: convection and diffusion steps. These steps are described mathematically as follows:

$$\frac{d\mathbf{x}}{dt} = \mathbf{u}(\mathbf{x}, t) \quad (7)$$

$$\frac{d\boldsymbol{\omega}}{dt} = \nu \nabla^2 \boldsymbol{\omega}(\mathbf{x}, t) \quad (8)$$

where  $\mathbf{x}$  is the particle position vector. The Forward time-stepping scheme is used as the time integration method for Eq. (7) and (8). The stability condition of the scheme will be following the condition used by Ploumhans and Winckelmans [13].

To solve Eq. (7) and (8), the value of velocity field  $\mathbf{u}$  must be known. The velocity field is obtained by solving the Poisson equation constructed from the continuity equation (Eq. (1)) and the vorticity definition (Eq. (4))

$$\nabla^2 \mathbf{u} = -\nabla \times \boldsymbol{\omega} \quad (9)$$

One of the approaches to solve Eq. (9) and obtained the velocity field is to utilize the Green’s function method [14]. Using this approach, the velocity field can be divided into several contributions, namely, irrotational velocity  $\mathbf{u}_\infty$ , and rotational velocity  $\mathbf{u}_\omega$ .

$$\mathbf{u} = \mathbf{u}_\infty + \mathbf{u}_\omega \tag{10}$$

For two-dimensional flow simulation,  $\mathbf{u}_\infty$  is the summation of the uniform flow velocity  $U_\infty$  and the solid body velocity  $\mathbf{u}_s$ . On the other hand,  $\mathbf{u}_\omega$  can be calculated as the sum of vorticities of the vortex elements,

$$\mathbf{u}_\omega = -\frac{1}{2\pi} \sum_{i=0}^N \frac{(x-x_i)}{|x-x_i|^2} \times \Gamma_i \mathbf{e}_z \tag{11}$$

where  $\mathbf{e}_z$  is the unit vector in the z-direction of a Cartesian coordinate system. The most common way to effectively compute Eq. (11) is by using the Fast multipole method (FMM) introduced by Greengard and Rokhlin in [15]. The detail of the FMM algorithm can be referred to in more detail in [15] and [10]. In this research, a well-developed FMM program is utilized to drastically reduce the computational time.

## 2.2 Least Squares Moving Particle Semi-Implicit Spatial Operators

Least squares moving particle semi-implicit (LSMPS) method is a meshfree Lagrangian approach for numerical analysis of incompressible flow that was developed by Tamai and Koshizuka [9]. The LSMPS method utilizes a weighted least square function to reduce errors that surface in the Moving particle semi-implicit method. There are two types of LSMPS spatial operators: LSMPS type A and type B. The main difference between type A and B is that LSMPS type B can be used to calculate operators at an arbitrary position.

In this research, the spatial derivatives calculation of LSMPS is used to replace the discretization-correction method (DC-PSE) that was commonly used in the VPM. By using LSMPS spatial operators, multi-resolution simulation can be done easily without the need for additional modeling [16]. The LSMPS spatial operators are also used in the remeshing process of the VPM, replacing the previous redistribution technique due to the LSMPS capability in interpolating field values. The formula of LSMPS spatial operators is as follows:

$$D_x f^h(x_i) = \mathbf{H}_i \mathbf{M}_i^{-1} \mathbf{b}_i \tag{12}$$

where  $D_x$  is a differential operator,  $\mathbf{H}_{r_s}$  is matrix coefficient,  $\mathbf{M}_i$  is a moment matrix, and  $\mathbf{b}_i$  is a moment vector. For a two-dimensional case, the second-order formulation of LSMPS type A for a particle with diameter  $L_i$  are as follows:

$$D_x = \left[ \frac{\partial}{\partial x} \quad \frac{\partial}{\partial y} \quad \frac{\partial^2}{\partial^2 x} \quad \frac{\partial}{\partial x \partial y} \quad \frac{\partial^2}{\partial^2 y} \right]^T \quad (13)$$

$$\mathbf{H}_i = \begin{bmatrix} L_i^{-1} & 0 & 0 & 0 & 0 \\ 0 & L_i^{-1} & 0 & 0 & 0 \\ 0 & 0 & 2L_i^{-2} & 0 & 0 \\ 0 & 0 & 0 & L_i^{-1} & 0 \\ 0 & 0 & 0 & 0 & 2L_i^{-2} \end{bmatrix} \quad (14)$$

$$\mathbf{M}_i = \sum_{j \in \Lambda_i} \left[ w(\|x_j - x_i\|) \mathbf{P} \left( \frac{x_j - x_i}{r_s} \right) \mathbf{P}^T \left( \frac{x_j - x_i}{r_s} \right) \right] \quad (15)$$

$$\mathbf{b}_i = \sum_{j \in \Lambda_i} \left[ w(\|x_j - x_i\|) \mathbf{P} \left( \frac{x_j - x_i}{r_s} \right) \{f(x_j) - f(x_i)\} \right] \quad (16)$$

$$\mathbf{P} = [x \quad y \quad x^2 \quad xy \quad y^2]^T \quad (17)$$

$$w(x, r_{eff}) = \begin{cases} 1 - \frac{\|x\|}{r_{eff}} & , 0 \leq \|x\| < r_{eff} \\ 0 & , \|x\| \geq r_{eff} \end{cases} \quad (18)$$

where  $r_{eff}$  is the mean support radius of the particle,  $r_s$  is the residual size of the particle,  $\Lambda_i$  is a set that contains the  $i$ th particle neighbors, and  $w$  is the weight function. The support radius of a particle can be calculated using Koshizuka and Tamai formulation suggested in [16].

$$r_{eff} = 3.5L_i \quad (19)$$

On the other hand, the LSMPS type B formulation can be found by changing Eq. (13), (14), (16), and (17) into the followings:

$$D_x = \left[ 1 \quad \frac{\partial}{\partial x} \quad \frac{\partial}{\partial y} \quad \frac{\partial^2}{\partial^2 x} \quad \frac{\partial}{\partial x \partial y} \quad \frac{\partial^2}{\partial^2 y} \right]^T \quad (20)$$

$$\mathbf{H}_i = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & l_i^{-1} & 0 & 0 & 0 & 0 \\ 0 & 0 & l_i^{-1} & 0 & 0 & 0 \\ 0 & 0 & 0 & 2l_i^{-2} & 0 & 0 \\ 0 & 0 & 0 & 0 & l_i^{-1} & 0 \\ 0 & 0 & 0 & 0 & 0 & 2l_i^{-2} \end{bmatrix} \tag{21}$$

$$\mathbf{b}_i = \sum_{j \in \Lambda_i} \left[ w(\|x_j - x_i\|) \mathbf{P} \left( \frac{x_j - x_i}{r_s} \right) \{f(x_j)\} \right] \tag{22}$$

$$\mathbf{P} = [1 \quad x \quad y \quad x^2 \quad xy \quad y^2]^T \tag{23}$$

where  $l_i$  is the average particle diameter around the position  $x$ . In a multi-resolution particle simulation, the mean support radius of  $i$ th particle  $r_i$  could be different with its neighboring particles  $r_j$ . This could make a one-way interaction between particles [16]. Therefore, the support domain radius of multi-resolution  $r_{ij}$  must be calculated by considering the size of neighboring particles surrounding the  $i$ th particle,

$$r_{ij} = \frac{r_i + r_j}{2} \tag{24}$$

With the implementation of LSMPS operators in the VPM, the numerical method will be further referenced as LSMPS-VPM.

### 2.3 Brinkmann Penalization Method

To provide the no-slip condition for the solid boundary in the simulation, LSMPS-VPM utilized the Brinkmann penalization method. The Brinkmann penalization method works by adding the penalization term into Eq. (5). This addition will penalize the difference between the solid and fluid to be as close as zero. The penalized momentum equation is as follows:

$$\frac{D\boldsymbol{\omega}}{Dt} = \nu \nabla^2 \boldsymbol{\omega} + \nabla \times (\lambda \chi (\mathbf{u}_s - \mathbf{u})) \tag{25}$$

where  $\lambda$  is the porosity of the solid,  $\chi$  is the characteristics function that defines the region of penalization, and  $\mathbf{u}_s$  is the solid body velocity. The values of  $\chi$  is following a mask function introduced by Gazzola et al. [17],

$$\chi = \begin{cases} 0 & , r_n < r_e \\ \frac{1}{2} \left( 1 + \frac{r_n}{r_e} + \frac{1}{\pi} \sin \left( \pi \frac{r_n}{r_e} \right) \right) & , -r_e \leq r_n \leq r_e \\ 1 & , r_n > r_e \end{cases} \quad (26)$$

where  $r_n$  is the normal particle distance to the nearest discrete solid body particles and  $r_e$  is the affected region distance. The  $r_e$  length used in the two-dimensional case is  $r_e = 2\sqrt{2}\sigma$ , where  $\sigma$  is the smallest particle size used in the simulation. In the LSMPS-VPM, the penalization process will be evaluated semi-implicitly using a split-step algorithm similar to the advection and diffusion process.

$$\mathbf{u}_{pen} = \frac{\mathbf{u} + \lambda \Delta t \chi \mathbf{u}_s}{1 + \lambda \Delta t \chi} \quad (27)$$

$$\boldsymbol{\omega}_{pen} = \nabla \times \mathbf{u}_{pen} \quad (28)$$

where  $\mathbf{u}_{pen}$  is the penalized velocity,  $\boldsymbol{\omega}_{pen}$  is the penalized vorticity, and  $\Delta t$  is the time increment. For the calculation of the curl of  $\mathbf{u}_{pen}$ , LSMPS spatial operators will be used.

#### 2.4 Aerodynamic Forces Calculation

The aerodynamics forces computed from the LSMPS-VPM utilized the penalization force due to the implemented Brinkmann penalization. The penalization force calculation method is expressed as

$$F = \rho \int_{\Omega} \lambda \chi (u - u_s) dS \quad (29)$$

where  $S$  is the area of the penalized domain. The lift ( $Cl$ ) and drag ( $Cd$ ) coefficients can be calculated by using the following equations,

$$Cl = \frac{F \cdot e_y}{\frac{1}{2} \rho U_{\infty}^2 D} \quad (30)$$

$$Cd = \frac{F \cdot e_x}{\frac{1}{2} \rho U_{\infty}^2 D} \quad (31)$$

where  $e_x$  and  $e_y$  are the unit vector in  $x$  and  $y$  direction of the Cartesian coordinate, and  $D$  is the reference length of the simulated object.

## 2.5 Vortex-Induced Vibration

The VIV simulation in this research will be considering the case of a structure that is attached to a spring and damper. The vibration of a structure in the traverse  $y$  direction in a Cartesian coordinate is governed by an ordinary differential equation as follows:

$$M\ddot{y} + C\dot{y} + Ky = F_y \quad (32)$$

where  $M$  is the mass of the structure,  $C$  is the damping constant,  $K$  is the spring constant, and  $F_y$  is the fluid force felt by the structure in the  $y$ -direction. The non-dimensional form of Eq. (31) is often used to perform numerical simulation because it provides a more valid definition for a certain occurring limitation.

$$M^*\ddot{y}^* + C^*\dot{y}^* + K^*y^* = F_y^* \quad (33)$$

where  $M^*$  is the non-dimensional mass,  $C^*$  is the non-dimensional damping constant,  $K^*$  is the non-dimensional spring constant, and  $y^*$  is the non-dimensional traverse  $y$ -direction. To solve Eq. (32), the 4<sup>th</sup> order Runge-Kutta method will be utilized.

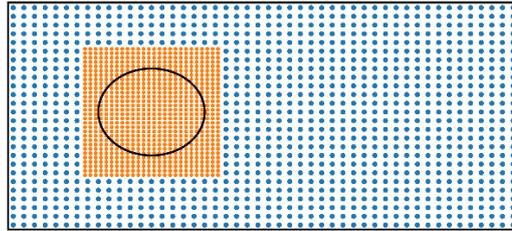
## 2.6 Numerical Procedure

To provide a clearer picture of the developed program calculation procedures, assuming the particle vorticity, the uniform flow velocity, and the solid body velocity values at time  $t$  are known, the values at  $t + \Delta t$  can be computed as follows:

- Compute  $\mathbf{u}_\omega$  using Eq. (11), then compute  $\mathbf{u}$  using Eq. (10).
- Penalize the obtained velocity field using Eq. (27).
- Correct the particle vorticity using Eq. (28) with the help of LSMPS spatial operators.
- Compute the forces exerted on the simulation object using Eq. (29)
- Do the advection step by integrating Eq. (7) and update the particle location
- Do the diffusion step by integrating Eq. (8) and update the vorticity value for each particle.
- Compute the effect of the force on the vibration of the object by solving Eq. (33) and update the solid object's location and velocity for the next time step.
- Remesh the particles back to their initial location and repeat the calculation for the next time step.

### 3 Problem Descriptions

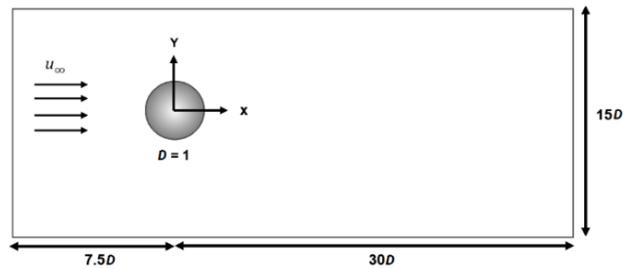
The developed program is first evaluated using a simulation case of a flow around a static circular cylinder at Reynolds number ( $Re = \frac{u_\infty D}{\nu}$ ) 100. The uniform flow velocity is set to be  $U_\infty = 1$ . The simulation domain is discretized by using a uniform multi-resolution particle arrangement, with the smallest particle size  $\sigma$ . The fluid density  $\rho$  will also be set to 1.



**Figure 1** Example of multi-resolution particle distribution in LSMPS-VPM. Particle distribution is denser near the simulation object. The size of the smaller particles represented in orange is  $\sigma$ . On the other hand, the size of the bigger particles represented in blue is  $4\sigma$

Next, the VIV simulation of a circular cylinder will be conducted at the same  $Re$ . The particle size from the previous simulation which produced the most accurate results compared with the references will be used in the VIV simulation. The example of the particle distribution is shown in Figure 1.

In all of the simulation cases, a computational domain  $[-7.5D, 30D] \times [-7.5D, 7.5D]$  will be used. The value of  $D$  refers to the diameter of the circular cylinder. The center of the cylinder will be placed at  $(0,0)$  for both simulation cases. The non-dimensional time is expressed as  $T = \frac{U_\infty t}{D}$ . To fulfill the stability condition, a non-dimensional time increment of  $\Delta T = 0.007$  is selected for all the simulations. The simulations will be set to run for  $T = 120$ . The schematics of the simulation can be seen in Figure 2.



**Figure 2** Schematics of the computational domain of flow past a circular cylinder.

## 4 Results and Discussions

### 4.1 Flow Around a Circular Cylinder

The present numerical simulation accuracy is investigated in this section using particle size convergence test. The test is carried out by using 3 different values of  $\sigma$ , mainly 0.05, 0.025, and 0.02. In the convergence test, the maximum lift coefficients  $Cl_{max}$ , mean lift coefficient  $\bar{Cl}$ , mean drag coefficient  $\bar{Cd}$ , and the Strouhal number  $St$  are the main parameters that will be analyze. The mean value of the variables is obtained at the fluctuation region of the simulation where the vortex shedding behind the cylinder is already in stable condition. The results of the simulations are shown in Table 1. From the results, it can be seen that the coefficients are getting closer to a certain number with the smaller value of  $\sigma$ . Therefore, the results of  $\sigma = 0.02$  will be used as the LSMPS-VPM representative for comparison with other references.

**Table 1** The results of particle size convergence test of LSMPS-VPM for flow around a static circular cylinder

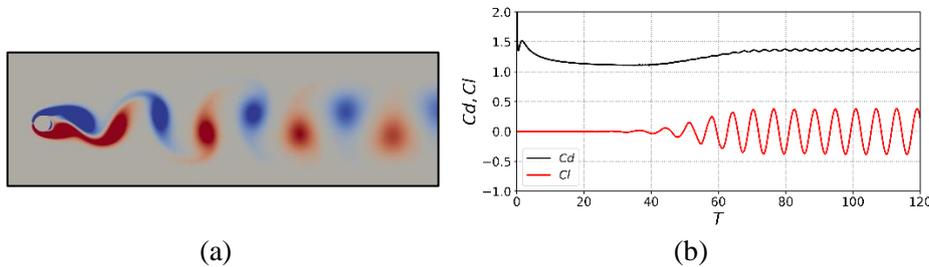
No	$\sigma$	$Cl_{max}$	$\bar{Cl}$	$\bar{Cd}$	$St$
1	0.05	0.531	0.335	1.554	0.149
2	0.025	0.408	0.253	1.398	0.158
3	0.02	0.382	0.233	1.363	0.158

Table 2 shows the comparison of LSMPS-VPM with other references. From the comparison, it can be seen that the  $\bar{Cd}$  result of the present LSMPS-VPM is in good agreement with Shen et al. [3], and Nguyen et al. [18]. The  $St$  result of LSMPS-VPM is close to Nguyen et al. [18]. On the other hand, the  $Cl_{max}$  result of LSMPS-VPM shows a bigger result compared with the other references. However, the difference is not that high, with the highest being only 19.3% higher compared with Mimeau et al. [19]. With these results, it can be concluded

that the LSMPS-VPM can predict the  $Cd$  value well for a flow around a circular cylinder. LSMPS-VPM can also predict  $Cl$  and  $St$  values, but with a lower accuracy than the prediction of  $Cd$ .

**Table 2** Maximum lift ( $Cl_{max}$ ), mean lift ( $\bar{Cl}$ ), mean drag ( $\bar{Cd}$ ) coefficients and Strouhal number ( $St$ ) of a static circular cylinder immersed in the flow at  $Re = 100$

<i>Authors</i>	$Cl_{max}$	$\bar{Cl}$	$\bar{Cd}$	$St$
Present authors	0.382	0.233	1.363	0.158
Shiels et al. [20]	–	0.30	1.33	0.167
Shen et al. [3]	0.364	–	1.376	0.166
Mimeau et al. [19]	0.32	–	1.4	0.165
Yan et al. [21]	0.34	–	1.387	0.166
Nguyen et al. [18]	0.34	–	1.36	0.16



**Figure 3** (a) Instantaneous vorticity distribution of the flow around a circular cylinder at  $Re = 100$ . Colorbar for the distribution is plotted in the range -1 to 1. (b) Time history of lift and drag coefficients ( $Cl$  and  $Cd$ ).

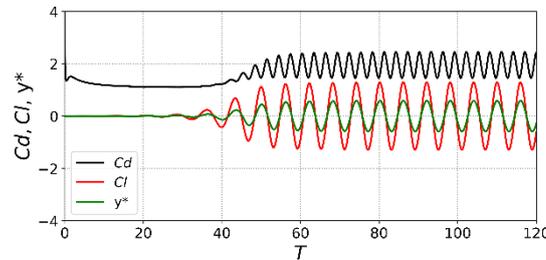
Figure 3, shows the vorticity contours and the time history of  $Cl$  and  $Cd$  of the circular cylinder simulation. It is observed that the flow pattern behind the cylinder is resembling the Karman vortex street pattern. The fluctuations of the lift and drag coefficients are because there is a generation of vortex shedding behind the circular cylinder. From Figure 3(b), it can be seen that the vortex behind the cylinder is starting to shed at around  $T = 40$ .

## 4.2 Vortex-Induced Vibration of a Circular Cylinder.

In the VIV simulation, an elastically mounted rigid circular cylinder is constrained to move transversely to a uniform free-stream velocity. To observe the vibration of the cylinder due to the effect of the flow, an undamped simulation will be set. Similar parameters with the simulation of flow past a circular cylinder will be used in the VIV simulation. The smallest particle size inside the simulation domain will be set to be 0.02. For the mass and spring constant, the non-dimensional values from Shiels et al. [20] are selected. The vibration parameters used in the VIV simulation are listed in Table 3.

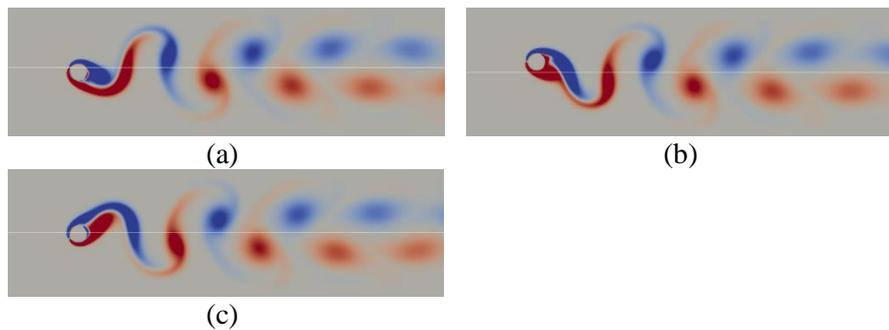
**Table 3** Parameters for the VIV simulation

No	Parameters	Value
1	Non-dimensional mass $M^*$	2.5
2	Non-dimensional spring constant $K^*$	4.96
3	Non-dimensional damping constant $C^*$	0.0



**Figure 4** Time history of  $Cl$ ,  $Cd$ , and  $y^*$  of two-dimensional VIV simulation of a circular cylinder at  $Re = 100$ .

At the start of the simulation, the cylinder was held steady until the flow passed the instability region at  $T \geq 5$ . After that, the vibration will be taken into account and the circular cylinder is allowed to move in  $y$ -direction. The  $Cl$ ,  $Cd$  and  $y^*$  time history can be seen in Figure 4. The up and down motions of the cylinders are shown in Figure 5. These cylinder motions are followed by the generation of vortex sheds behind the wake of the cylinder. From Figures 4 and 5, it can be seen that the upward motion of the cylinder is followed by the increased value of  $Cl$  and vice versa. These phenomena are consistent throughout the simulation time. The vibration of the circular cylinder is already in stable condition at around  $T = 60$ .



**Figure 5** Vorticity distributions of the VIV simulation of a circular cylinder at  $Re = 100$ : (a) at  $T = 96.25$ , (b) at  $T = 98$ , and (c) at  $T = 99.75$ . The white line in the middle of each figure is the horizontal line where  $y^* = 0$ .

Table 4 shows the results of  $Cl_{max}$ ,  $\bar{C}d$ , vibration amplitude  $A$ , and the motion frequency  $f$  of the circular cylinder for the current LSMPS-VPM and the selected references. The results of  $\bar{C}d$  and  $A$  from LSMPS-VPM are slightly similar to both of the references. The results from Shiels et al. [20] show the largest difference in results for both  $\bar{C}d$  and  $A$  of LSMPS-VPM with a difference of 10% and 1.38%, respectively. On the other hand, the LSMPS-VPM  $\bar{C}l$  and  $f$  values are not in agreement with the references. The LSMPS-VPM result of  $Cl_{max}$  is way off compared with the references; with a difference of 68.83% higher compared with Shiels et al. [20] and 56.6% higher compared with Shen et al. [3]. Similarly, the LSMPS-VPM result of  $f$  is around 15.3% smaller compared with Shiels et al. [20]. From these results, it can be concluded that the present LSMPS-VPM is already capable of simulating the VIV phenomenon. However, several parameters still show results that are not in agreement with the references.

**Table 4** Maximum lift ( $Cl_{max}$ ), mean drag ( $\bar{C}d$ ) coefficients, Amplitude of vibration ( $A$ ), and vibration frequency ( $f$ ) of the VIV simulation of a circular cylinder immersed in the fluid at  $Re = 100$ .

<i>Authors</i>	$Cl_{max}$	$\bar{C}d$	$A$	$f$
Present authors	1.3	1.998	0.588	0.166
Shiels et al	0.77	2.22	0.58	0.196
Shen et al.	0.83	2.15	0.57	0.19

## 5 Conclusions

The LSMPS-VPM has been successfully developed to be able to simulate a simple two-dimensional VIV simulation. The present numerical simulation has also been tested and validated with several references. The results of the static simulation are found to agree well with those available in the literature. The LSMPS-VPM is also accurately capable of simulating the vorticity generation behind the cylinder wake. Similarly, the VIV simulation results show a good representation of vorticity generation behind the circular cylinder. However, several results of the VIV simulation are not in good agreement with the selected references. This is because the movement of the cylinder adds more complexity to solving the Brinkmann penalization term. Thus, the penalization region did not penalize completely to as close as zero, making the force calculation slightly higher or lower compared to the references. Overall, the LSMPS-VPM is already capable of reproducing a representative natural phenomenon of vortex generation past a bluff body in both static and VIV simulation.

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## The Effect of Pastel Colors on Interior Elements of the Dental Examination Room on Children's Psychology

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**Abstract.** Color in the interior is one of the factors that affect the emotional condition of children. There are several types of color groups with different characters and influences on human emotions, one of which is the pastel color group. This study aims to determine the effect of pastel colors on the interior of children's emotions and the application of the right pastel colors according to children's preferences in the pediatric dental examination room. This study used a mix-methods exploratory sequential approach in the form of visual experiments by presenting 4 space simulations with monochromatic pastel color compositions of red, blue, yellow, and triadic colors of the three as well as 1 control room. Respondents are students of the Abdurrahman bin Auf Homeschooling Group in Cibinong with an age range of 4-8 years. All data were analyzed through correlation test methods, T-test, and ANOVA. Results identified that children tend to like the basic colors found in the rainbow to be applied to the dental clinic, there are differences in assessment based on education level. This is due to children with higher levels being more able to judge based on visual perception of their environment so that they have stronger color preferences.

**Keywords:** *children emotion; interior; pastel color; dental examination room.*

### 1 Introduction

According to Atwater (1983) quoted from Pratiwi and Budisetyani [1], emotions arise in individuals due to a stimulus in the environment that is received by the senses. Likewise, what happens to children, the emotions that arise in them are caused by the stimuli in their environment. One example of such a stimulus is color. In their daily activity, children are always exposed to color through various objects such as the things they have, the food they eat, and the room they occupy.

The colors found in the environment such as in interior spaces can have a certain effect on their emotional state, including providing calm, joy, increasing anxiety, tension, and others. For example, Harini [2] mentions that green colors can have a calming effect, bright colors such as red and yellow affect joy, and dark colors

such as black or brown give the effect of anxiety and sadness. In a study conducted by Diette et al. [3], Eisen [4], and Schneider et al. (2003) in Hathorn [5], explained that images of natural landscapes such as forests and nature scenes with a color composition dominated by green and blue are considered to have a positive effect on the patient's feelings, such as feeling calm, relieving stress, reducing stress, releasing anxiety, even makes a person able to control his emotions. Previous studies have shown that children prefer bright colors to dark colors. However, according to June McLeod in Abbasi [19] babies and children prefer to be surrounded by soothing pastel colors. This is because pastel colors affect the atmosphere of the room to be calming and comfortable.

Currently, it is not uncommon to apply color to interior spaces without considering the effect that color will have on room users, in this case, the dental treatment room. In the dental treatment room, children are directed to feel calm and comfortable to facilitate the examination process. Therefore, the researcher wanted to analyze pastel color preferences for pediatric dental treatment rooms. It is important to understand the effect of color on children's emotions, to determine and apply the right color composition to the interior space so that it can have a positive effect on children.

### **1.1 Formulation of the Problem**

Based on the description of the background above, the problem can be formulated as follows:

1. How does the application of pastel colors in children's environment affect their emotions?
2. What pastel colors are suitable to be applied to the dental examination room to provide a sense of calm and reduce anxiety?

### **1.2 Scope of Problem**

For this research to be more focused, several things are limited, including:

1. The subjects studied were children aged 4-8 years who were divided into two age groups, namely 4-6 and 7-8 years.
2. The interior room that will be identified is the dental clinic examination room.

### **1.3 Objective Study**

Based on the background and problem formulation that has been described, the objectives of this research are:

1. Can understand the effect of pastel colors on children's psychology, especially children aged 4-8 years.
2. Can identify pastel colors and the right composition to be applied to the dental clinic examination room.

#### **1.4 Literature Review**

#### **1.5 Emotions in Children**

According to Mashar [6], it turns out that there is another side that is no less important in children's development, namely emotions. Emotions in children are considered unique. This can be seen from one of the emotional characteristics in children, namely several different emotional patterns shown by the same behavior, Hurlock [7]. Children's emotions generally consist of anger, fear, joy, sadness, jealousy, affection, curiosity, and envy which are expressed with the same expression, Pratiwi & Budisetyani [1]. Emotions are divided into positive emotions, namely joy, excitement, and surprise, and negative emotions, that as anger, sadness, fear, and disgust. Positive emotions are often associated with bright colors and negative emotions are associated with dark colors. The role of emotions in children is one form of communication so that children can express all their needs and feelings to others and play a role in influencing the personality and adjustment of children to their social environment, Pratiwi & Budisetyani [1]. According to (Suriadi & Yuliani, 2006) quoted by Dewi, et al., [8] At the age of 7-8 years, children already understand the shame and pride of something and children can express the emotions they feel.

#### **1.6 Color**

Color can be interpreted as a visual language that can provide a picture or reflection of mood and represent emotions. There are a wide variety of colors with varying effects on a child's emotions. The emotional effects on children that can be caused by color in interior spaces include providing calm, and joy, and increasing anxiety, tension, and others. In a clinical context, the use of color can assist intervention by activating and promoting positive emotions, which can then have a higher therapeutic and preventive effect and which can ultimately increase motivation to heal, Izard (2002) quoted by Pope, et al [9]. Color can also be used as an accepted therapeutic tool with various medical applications, Babu, et al [10].

## 1.7 Color Types

The famous physician and mathematician Sir Isaac Newton, through his experiments, designated the seven colors reflected from a prism on a white panel as the Visible Specture. The colors are red, orange, yellow, green, blue, indigo, and purple, Zelanski & Fisher [11]. In nature there are three basic colors, there are red, yellow, and blue. Another classification for color is based on the effect color has on humans, namely cold and warm. Warm colors are red, orange, and yellow, while cool colors are blue, green, and purple. (Artut, 2004) quoted from Çiçek [12]. Warm colors usually have the effect of liveliness, excitement, and action. Cool colors are more about calm, comfort, and relaxation (Altınçekiç, 1994) quoted from Çiçek [12]. Color luminance can be increased by adding white and lowered by adding black. The addition of white gives rise to light colors or so-called pastel colors, Sari [13]. This color type has a bright character but the color intensity is not so strong because it is mixed with quite a lot of white.

## 1.8 Interior Color

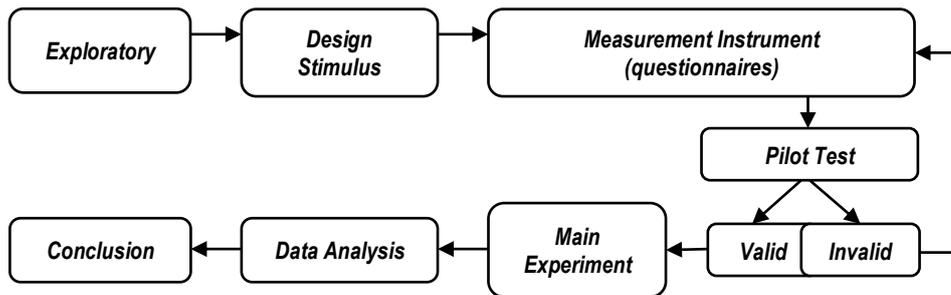
Color is one aspect that can liven up or create an impression in a space. John Pile says that the use of color is the main focus in interior design and is also an important factor in determining the success of a project [14]. In addition, the color in the interior also has the ability to affect the function of the body, mind, and human emotions when they are in the interior space. One of the ways to get a positive atmosphere and impression is by composing the right colors on the interior elements of the room. Improper application of color can cause uncomfortable feelings and can even have a negative impact on a person's psychology. For example, applying the color composition to images posted in the pediatric inpatient room in Hathorn & Nanda's research [5] can improve children's mood based on their preferences.



**Figure 1.** The highest rating image. (Source : Hathorn & Nanda, 2008).

## 2 Experimental Method

The method that is used in this research is a mix-methods exploratory sequential which prioritizes qualitative methods such as literature study, observation, and interviews with participants. Then it is connected with processing data from the questionnaire quantitatively through a comparative test (t-test) and correlation to analyze the results and get conclusions from the research.



**Figure 1.** Experimental method step. (Source: Pramesti, Ashri)

### 2.1 Experimental Design

This research uses mixed methods to get a comprehensive understanding and results from the aspects studied. Exploratory deepening was carried out to find research variables, starting with literature studies and observation as the basis for research, then designing stimulus based on the results of literature studies. In this case, pastel colors act as independent variables so that this aspect manipulates the interior elements of the children's dental clinic through 3D Modeling. Followed by formulating a questionnaire related to emotional state, attitude, and perception response as the dependent variable. Pilot tests were conducted on respondents to obtain the validity of the stimulus and questionnaire designs as well as an overview of effective procedures in terms of duration. All data will be processed in the form of statistical data through the SPSS program for further correlation tests, t-tests, and ANOVA.

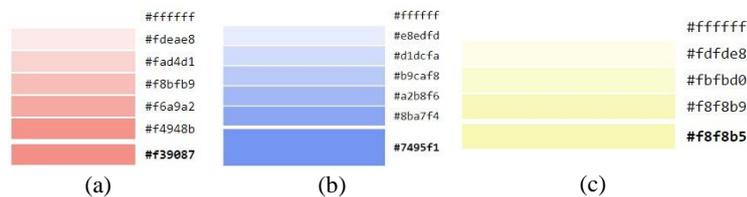
### 2.2 Experimental Preparation, Stimulus, and Equipment

In this experiment, we use digital simulation by considering the practicality and effectiveness of the experiment. The visual simulation that will be given to participants is in the form of a 3D image of a pediatric dental clinic examination room by applying two pastel color compositions in a monochrome and triadic. The dental examination room will be divided into four 3D visual simulation

conditions and one control or no stimulation condition. The four simulation conditions are distinguished based on their color composition, namely:

1. Red pastel monochromatic color composition.
2. Blue pastel monochromatic color composition.
3. Yellow pastel monochromatic color composition.
4. Triadic pastel color composition of red, blue, and yellow.

These four simulation conditions will be displayed on Virtual Reality Goggles in which a smartphone is installed which will show a visual simulation of the dental examination room with sequential conditions starting from the control conditions, followed by monochromatic color composition until finally the triadic color composition.



**Figure 2.** Range schematic red pastel(a), blue pastel (b), and yellow pastel (c). (Source : ww.w3schools.com)

*Pre-test: Control Condition*

Participants were given a children's dental clinic examination room with color conditions and layout arrangements as in the existing one without the addition of color stimuli to the interior elements. This room is used to get the concentration comparison data before and after the test.



(c)

**Figure 3.** Condition of pediatric dental clinic control. (Source :Pramesti)

*Post-test: Virtual Environment*

A simulation in the form of a pediatric dental clinic examination room with cool daytime lighting and the application of pastel colors to the composition of monochromatic and triadic schemes as a stimulus, made in the form of 3D images using the Sketchup program and rendering using the Enscape program. The color schemes applied to these images have been determined based on some of Mussel's color harmony principles. The color specifications for each scheme are taken from [www.w3schools.com](http://www.w3schools.com), with explanations and views as follows.

**Table 1** Color scheme in visual experiment room simulation.

<b>Dental Examination Room</b>	
<p>Wall (RGB: 253,234,232), (RGB: 243,144,135), &amp; (RGB: 255,255,255)            Floor (RGB: 255,255,255)            Ceiling (RGB: 255,255,255)            Furniture (RGB: 248,191,185), (RGB: 244,148,139), &amp; (RGB: 255,255,255)</p>  <p><b>Figure 4</b> Red pastel monochromatic room. (Source: Pramesti)</p>	<p>Wall (RGB: 232,237,253), (RGB: 116,149,241), &amp; (RGB: 255,255,255)            Floor (RGB: 255,255,255)            Ceiling (RGB: 255,255,255)            Furniture (RGB: 162,184,246), (RGB: 209,220,250), &amp; (RGB: 255,255,255)</p>  <p><b>Figure 5</b> Blue pastel monochromatic room. (Source: Pramesti)</p>
<p>Wall (RGB: 253,253,232), (RGB: 246,241,166), &amp; (RGB: 255,255,255)            Floor (RGB: 255,255,255)            Ceiling (RGB: 255,255,255)            Furniture (RGB: 246,241,166), (RGB: 248,248,185), &amp; (RGB: 255,255,255)</p>  <p><b>Figure 6</b> Yellow pastel monochromatic room. (Source: Pramesti, Ashri)</p>	<p>Wall (RGB: 253,253,232), (RGB: 251,251,208), (RGB: 243,144,135) &amp; (RGB: 253,253,232)            Floor (RGB: 255,255,255)            Ceiling (RGB: 255,255,255)            Furniture (RGB: 162,184,246), (RGB: 244,148,139), &amp; (RGB: 244,148,139)</p>  <p><b>Figure 7</b> Triadic pastel room. (Source: Pramesti, Ashri)</p>

### 2.3 Participants

Research participants were selected from the Abdurrahman bin Auf Homeschooling Group in Cibinong with the criteria of age 4-8 years which were divided into two age groups, namely 4-6 and 7-8 years. The first group consisted of 4 girls and 4 boys, but one boy was invalid because he did not follow the procedure completely, the second group consisted of 2 girls and 5 boys, the total respondents were 14 children. The age range was chosen to see if there was a difference between the two groups when given a stimulus. The selected participants had a normal color vision. In addition, there is no physical or mental condition that can prevent them from participating. As a sign of gratitude, respondents were given a gift containing various kinds of snacks.

### 2.4 Measurement

To identify the effect of a given color stimulus, a questionnaire was created using a graphic rating scale. 4 emotional variables use 3 emoticon images as a simple size scale that is easy for children to understand.

**Table 2** Emotional Scale.

Emotion Scale	1 	2 	3 
<b>Children's Dental Examination Room</b>			
<b>Feeling</b>	Sad	Neutral	Happy
<b>Likeness</b>	Don't Like	Neutral	Like
<b>Braveness</b>	Not Brave	Neutral	Brave
<b>Willingness</b>	Don't Want	Neutral	Want

(Source: Pramesti)

### 2.5 Experimental Procedure

The experiment was carried out for two days, the first day the experiment was carried out by the 4-6 year age group, and on the second day by the 7-8 year age group. This is done so that the implementation time is not too crowded and participants are not in a hurry to observe the simulation room. The experiment was carried out in a classroom in a sitting position. They were told the purpose and direction of the experiment. Then a visual simulation was carried out using VR Goggles worn by the participants. Each participant was asked to rate the control condition room and 4 rooms with a pastel color composition stimulus. Participants were allowed to move their heads in various directions to get a comprehensive visual experience and were asked to share their feelings when

observing these spaces. Each image is displayed for 1-2 minutes. After the experiment was completed, a questionnaire was given by showing the 5 pictures of the simulation room on A5 paper. Children are guided by a friendly and interactive approach, to make it easier and more comfortable for children to make assessments.

### 3 Result

The correlation test was conducted to determine the effect of the stimulus on the elements of the examination room on the psychological state of the respondents. In this case, there are 4 color composition variables and one control condition. The results of data processing show the correlation coefficient values of the five rooms which are similar to each other, as shown in table 3. While whether or not a strong relationship can be known from the value of the correlation coefficient (Table 4).

#### 3.1 Correlation analysis

**Table 3** Correlation test results of the pediatric dental clinic.

	Pre-Test	Mono Red	Mono Blue	Mono Yellow	Triadic
<b>Feeling</b>	0.831	0.933	0.763	0.767	0.857
<b>Likeness</b>	0.829	0.973	0.832	0.743	0.963
<b>Braveness</b>	0.784	0.703	0.369*	0.687	0.901
<b>Willingness</b>	0.899	0.916	0.906	0.914	0.871

(Source: Pramesti)

**Table 4** Correlation coefficient of product Pearson moment.

Value	Correlation Coefficient
0	No correlation
0 to 0.25	Very weak
0.25 to 0.5	Enough
0.5 to 0.75	Strong
0.75 to 0.95	Very strong
1	Perfect

(Source: Pramesti)

Table 3 shows the results of the correlation test in the dental clinic examination room showing similar results between the simulation rooms. The dental clinic room with a pastel red monochrome color composition has the strongest influence on each emotion variable compared to the other four rooms. The emotional

variables such as feeling happy or sad, liking the room, the level of courage to do a dental examination, and the level of their willingness to be examined. However, there is one value that does not show the significance of the effect of a room with a pastel blue monochrome composition on the respondent's level of courage, this shows that children are more stimulated by the level of the courage of the four rooms with other color compositions, such as control conditions, pastel yellow monochrome, red pastel and triadic.

### 3.2 T-Test

A T-test was performed using SPSS to evaluate the difference in the mean by pairing the control condition room (pre-test) with the stimulated color space (post-test) (table 6). The significance level is alpha 5% or 0.05.

**Table 5** Room comparison pair for the t-test.

<b>T-test 1</b>	<b>PreTest – Mono Red</b>
<b>T-test 2</b>	<b>PreTest – Mono Blue</b>
<b>T-test 3</b>	<b>PreTest – Mono Yellow</b>
<b>T-test 4</b>	<b>PreTest – Mono Triadic</b>

(Source: Pramesti)

**Table 6** Average total score of the pediatric dental clinic.

<b>Classroom</b>	<b>DP</b>	<b>DR</b>	<b>DB</b>	<b>DY</b>	<b>DT</b>
<b>Mean</b>	8.64	9.50	10.57	8.86	9.57
<b>Standard Deviation</b>	2.620	2.710	1.697	1.994	2.954

(Source: Pramesti)

In the results of the T-test analysis, the total score in the dental clinic room where the room with pastel blue composition has the highest average score, but the lowest average is owned by the dental clinic room with control conditions (Table 6), and the value is less than 0.05 (table 7) so that there

is a significant difference in values between the control condition dental clinic room and the pastel blue dental clinic room. This means that in the dental clinic, children tend to like rooms with shades of blue and feel anxious about dental clinic rooms that do not have color accents in them.

**Table 7** Result of t-test total score of the pediatric dental clinic.

Correlation	DP-DR	DP-DB	DP-DY	DP-DT
<b>Total Score Value</b>	0.497	0.004	0.844	0.397

(Source: Pramesti)

### 3.3 Anova Test (Based on education level)

Analysis of the ANOVA test was carried out to determine the existence of a significant difference of a variable in several groups. In this case, the researcher wants to know whether there are differences in respondents' assessment and preference for color based on the respondent's education level. The first group is a Kindergarten education level with an age range of 4-6 years. While the second group is an elementary school level with an age range of 7-8 (grades 1 and 2).

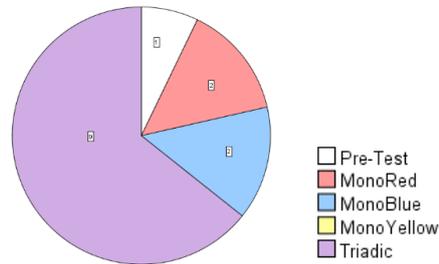
**Table 8** The results of the ANOVA test in the pediatric dental clinic are based on education level.

		ANOVA				
		Sum of		Mean		
		Squares	df	Square	F	Sig.
Total D-PreTest	Between Groups	37.786	1	37.786	8.817	.012
Total D-Red	Between Groups	44.643	1	44.643	10.534	.007
Total D-Blue	Between Groups	2.571	1	2.571	.885	.365
Total D-Yellow	Between Groups	28.571	1	28.571	14.815	.002
Total D-Triadic	Between Groups	7.143	1	7.143	.806	.387

(Source: Pramesti)

ANOVA analysis in the pediatric dental clinic (Table 8) shows that the control room, the composition of pastel red, and pastel yellow have significant differences. This proves that there are differences in the assessment of children aged 7-8 years who better understand their color preferences with kindergarten children who still do not have a strong color preference.

### 3.4 Interview Result



**Figure 8.** *Pie chart* Favorite Dental Room.  
(Source : Pramesti).

Based on the results of the interviews, the researchers found different facts from the experimental process and the questionnaire, as seen from the pie chart above, the majority of respondents chose a room with a triadic color composition as their favorite exam room. From several interview questions, the researcher asked about what respondents would like to add to the interior of the pediatric dental polyclinic examination room. The result was found that most of the respondents wanted the addition of color accents or rainbow images in their room.

## 4 Discussion

Research related to the effect of interior color on child psychology is considered to need further study. Despite the diversity of results obtained by researchers, it is proven that the composition of pastel colors can affect emotions in children. This diversity of results is caused by the selection of respondents' age ranges that are too far apart (4-8 years). In this case, the respondents are divided into two age groups based on their level of education. The first group is children - children at an early age of development who just received information or knowledge related to basic colors with objects that are often used as illustration media are rainbows enthusiasm of children who are curious about the environment makes them easy to accept and like these objects. The second group with a slightly more mature age has been able to think more complexly and have stronger preferences, therefore they are able to express their opinion on the objects presented. Terwogft and Hoeksman [15] also found that the relationship between color and perceived emotional preferences varied according to age and gender this preference can be influenced by the experience of each individual's visual perception, Hotwani & Sharma [16]. In addition, another factor is the focus of the respondent's

distraction. The respondents are Abdurahman Bin Auf Homeschooling Group students who are very cheerful, active, and enthusiastic. Regarding the enthusiasm of the respondents, the instrument used by the researcher (VR Goggles) was something new for the children so they were more impressed with how the instrument was played. The drawback of this study is that it only uses three emotions as a measurement scale (happy, neutral, sad) that is evaluated. It would be more effective if more emotions were evaluated for better correlation. Subsequent studies with larger sample sizes and different ages, more diverse color samples, and different emotions are recommended to be able to form a strong relationship between colors and different emotions of children. This research will have important implications for people involved in the process of designing a room for children. Research results can also help healthcare providers and professionals understand which colors are appropriate for the pediatric population.

## **5 Conclusion**

Based on the results of the analysis that has been done, the researchers found quite diverse results from each type of test. The first is in the correlation test, the data shows that the color that has the biggest influence on the dental clinic examination room on children's emotions is pastel red. This is due to the character and appearance of the strong pastel red color compared to other pastel color compositions. Then on the results of the T-test, the comparison of the control condition room with the pastel blue composition room showed a significant difference. In other words, many respondents gave a high value to a room with a pastel blue composition. Researchers concluded that pastel blue is safe to apply to the interior of a dental clinic for children because pastel blue can provide positive energy such as a sense of calm and reduce anxiety.

Furthermore, through the analysis of the ANOVA test, the researchers found that the control condition room, the composition of pastel red, and pastel yellow had significant differences. This proves that there is a difference in the assessment of children aged 7-8 years who better understand their color preferences with kindergarten children who still do not have a strong color preference. Then based on the results of interviews with respondents, it was found that respondents tend to like rooms with triadic color compositions and want to add color accents and rainbow images in their rooms.

## **Appreciation**

The researcher expresses gratitude to the Abdurrahman bin Auf Cibinong Homeschooling Group and all respondents who have actively participated in this study.

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## Synthesis of Sulfonated Polystyrene from Styrofoam Waste as Manufacturing Material Polymer Electrolyte

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**Abstract.** The synthesis of polymer electrolyte of sulfonated polystyrene (sPS) has been carried out from Styrofoam waste. The polystyrene was sulfonated using various concentrations of acetyl sulfate at 40 °C for 1 hour. The resulting sulfonated polystyrene was characterized using FTIR, thermal analysis, and cationic exchange capacity (CEC). FTIR data show the success of sulfonation with the appearance of sulfonate groups in PST. The thermal data showed that the addition of sulfonic agents decreased the thermal stability of polystyrene. The highest CEC was obtained for 25 mmol of acetyl sulfate addition, with a CEC of 6.610 meq/g. The characteristics of the resulting product show that sulfonated polystyrene from Styrofoam waste potentially is used as a material for advanced technology of polymer electrolytes such as fuel cells and Li-Battery separator.

**Keywords:** *acetyl sulfate; PEMFC; polystyrene; Styrofoam; sulfonated polystyrene.*

### 1 Introduction

Styrofoam (SF) or also called expanded polystyrene (EPS) is a type of plastic that is widely used for single-use food packaging, preventing damage to electronic goods during the shipping process and as an insulator material, causing a lot of waste to be generated. SF cannot be degraded without the help of solvents, so it can cause environmental pollution problems. Its light nature can be carried away by water currents which will cause water pollution. In fact, SF consisting of benzene and styrene can cause health problems (Baig et al in [1]). In addition to the need to overcome the problem of water pollution, SF has the potential to be applied in the field of renewable energy. The increasing demand for fuel is inversely proportional to the availability of fossil fuels which are actually getting depleted. The use of fossil fuels in various fields causes environmental problems such as the greenhouse effect.

PEMFC can efficiently produce high power density which can convert energy efficiently into a compact and robust form and can operate at low temperatures

(Garrain et al in [2]). The advantages of using fuel cells such as high energy efficiency, low emission contaminants, and being a clean energy source make its development more promising. One of the important components in PEMFC is an ion exchange membrane or polymer electrolyte membrane which can deliver protons from the anode to the cathode. This type of membrane should have high thermal resistance and good mechanical stability (Pali-Cassanova et al in [3])

Polystyrene (PS) can be used for the manufacture of cation exchange material due to good mechanical properties and high thermal stability (Pramono et al in [4]). In addition, recyclable PS is a low-cost material and can reduce the potential for environmental pollution (Al-sabagh et al in [5]). Although it has good mechanical properties and high thermal stability, hydrophobic PS needs to be modified so that it can produce charged materials and can exchange protons. One of the modifications that can be done is the sulfonation process. The sulfonating agents that are often used for the sulfonation of aromatic compounds include acetyl sulfate, sulfur trioxide, and complexes, fuming sulfuric acid, sulfuric acid, chlorosulfonic acid, and trimethylsilyl chlorosulphonate (Khoemin et al in [6]). Acetyl sulfate is used as a sulfonating agent because it is more efficient than other sulfonating agents, and can be considered more environmentally friendly because the reaction can be carried out at a relatively low temperature, in a short time with less sulfonating reagents and the formation of sulfone does not occur (Wolska & W.Kulikowska in [7]). The use of acetyl sulfate as a sulfonating agent has been applied to Chitosan (Bagaskara et al in [8]), Polystyrene – Polyethylene (PS-PE) dispersed with sulfonated graphene oxide (SGO) (Mandanipour in [9]), Poly(styrene – isobutylene – styrene) (SIBS) combined with ionic liquid (IL) (Ortiz – Negrón in [10]) and irradiated Polystyrene (PS) / Poly(ethylene vinyl acetate) (PEVA) (Ghobashy in [11]) applied in manufacture of polymer electrolyte membrane fuel cell (PEMFC). So far, there has been no reports on the use of polystyrene from Styrofoam waste and its sulfonation products as electrolyte material.

Based on these problems, in this research, SF waste as a source of polystyrene modified using acetyl sulfate. Modified polystyrene was analyzed on functional groups, thermal properties, and cation exchange capacity to determine the ability of acetyl sulfate-modified polystyrene to exchange cations.

## **2 Experimental**

### **2.1 Materials**

Styrofoam waste from food wrappers, aquadest, chloroform (Merck), dichloromethane (DCM) (Merck), 2-propanol (Merck), sulphuric acid (Smart-Lab, 96-98%), and acetic anhydride (Merck).

## 2.2 Polystyrene Insulation from Styrofoam Waste

Referring to the study of Salim et al [12], modification of PS isolation from SF waste was carried out with 13 g of SF, dissolved in 50 mL of chloroform, then stirred until dissolved. The mixture is then isolated by dripping over hot distilled water. The results of the isolation were then placed in an oven at 60 °C for 24 hours.

## 2.3 Sulfonated Polystyrene Synthesis

The sulfonation of PS followed previous report of Salim et al in [12], about 5 g of polystyrene was added to a three-neck flask, then 40 mL of dichloromethane was added, stirred until dissolved. The mixture was then added with acetyl sulfate with a certain variation, and refluxed at 40 °C for one hour. Variations in the addition of acetyl sulfate used were 5, 10, 15, 20 and 25 mmol. Termination was carried out by adding 10 mL of 2-propanol and stirring continuously for 10 minutes. Stirring was continued without heating for 30 minutes. The mixture is then isolated by dripping over hot distilled water. The resulting sulfonated polystyrene was then oven-dried at 60 °C for 24 hours. The acetyl sulfate used was prepared using a mixture of anhydrous acetic acid dissolved in dichloromethane, stirred until dissolved and cooled to 0 °C, then sulfuric acid was added, and stirred until a yellowish color appeared in the solution.

## 2.4 Characterization of Sulfonated Polystyrene

The functional group of sulfonated polystyrene were analyzed by using *Fourier Transform Infrared* (FTIR, IRPrestige-21 Shimadzu) with KBr plate in the range of 400 – 4000  $\text{cm}^{-1}$ . Thermal analysis was performed by using *Thermogravimetric Analyzer* (TGA, Linseis PT-1600) with heat rate of 10 °C per minute.

## 2.5 Cation Exchange Capacity

A total of 0.1 g PS and sPS were immersed in 25 mL of 1 M HCl for 24 hours. Then dried in the oven for 1 hour at 60°C. After that, the sample was immersed in 25 mL of 0.5M NaCl for 24 hours. The solution was then taken and titrated using 0.02 M NaOH using phenolphthalein as an indicator. The value of the cation exchange capacity is determined using the formula (1).

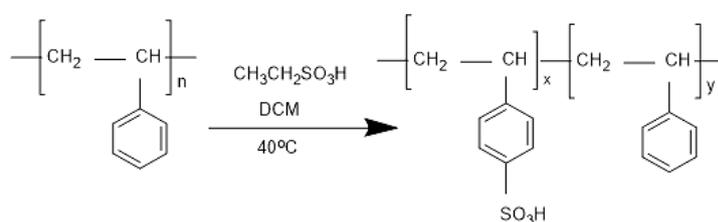
$$\text{CEC} = \frac{V_{\text{NaOH}} \times M_{\text{NaOH}}}{W_{\text{sample}}} \quad (1)$$

Where V is the volume of NaOH required (mL), M is the concentration of NaOH (mol/L), and W is the weight of the sample (g).

### 3 Result and Discussion

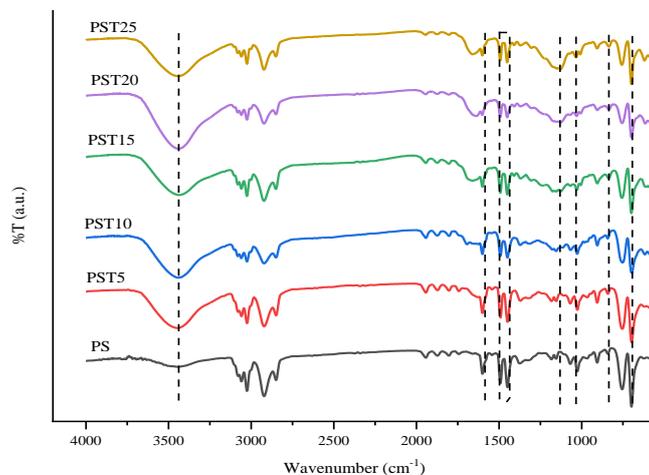
#### 3.1 Characterization of Sulfonated Polystyrene

Acetyl sulfate as a sulfonating agent is prepared by reacting acetic anhydride with a certain amount of sulfuric acid resulting in a side reaction of acetic acid. The use of acetic anhydrous aims to remove excess water in the reaction mixture. Acetyl sulfate is used because the polymer degradation effect is negligible and the sulfone is not formed. (Wolska & Walkowiak-Kulikowska in [7]). Sulfonation reaction of acetyl sulfate with polystyrene at 40°C was presented at Figure 1.



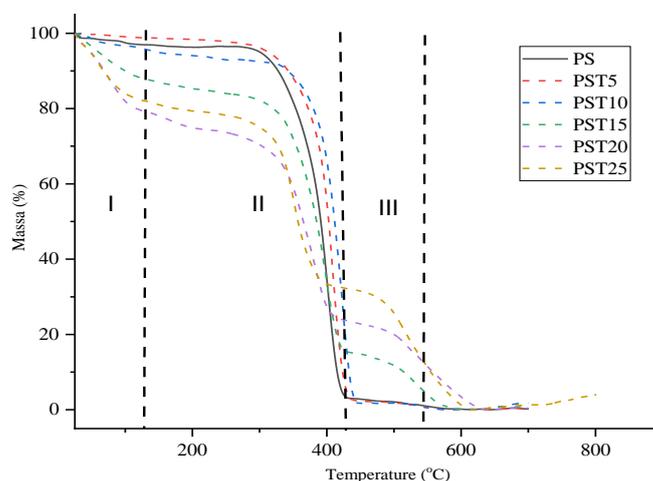
**Figure 1.** Schematic illustration of the sulfonation reaction (Wolska & Walkowiak-Kulikowska in [7]).

Functional groups of PS sulfonation from styrofoam waste were analyzed using FTIR which is shown in Figure 2. An absorption of 698  $\text{cm}^{-1}$  appeared in the PS FTIR spectra which indicated the presence of bonding characteristics in aromatic C-C, where this value was not much different from Baig et al in [1] which showed the characteristic of aromatic C-C bond at 695  $\text{cm}^{-1}$ . In addition, absorption of 1600  $\text{cm}^{-1}$  appears which indicates an aromatic in PS. The success of the sulfonation process was indicated by the appearance of an absorption of 835  $\text{cm}^{-1}$  which indicated the presence of para substitution on the benzene ring. Absorption of 1033, 1127, and 1149  $\text{cm}^{-1}$  indicates of the  $-\text{SO}_3$  group and absorption of 3443  $\text{cm}^{-1}$  which is the absorption of  $-\text{OH}$  on  $-\text{SO}_3\text{H}$  group. The resulting FTIR absorption is not far from the reference. According to Andreade et al in [13], the success of the sulfonation process was indicated by the absorption of 1040 and 1180  $\text{cm}^{-1}$  which was the  $-\text{SO}_3$  absorption which indicated the presence of a bound  $-\text{SO}_3\text{H}$  group, and the absorption of 840  $\text{cm}^{-1}$  which indicated the presence of benzene substitution at the para position. The effect of sulfonation causes the intensity of  $-\text{OH}$  absorption in the sPS FTIR spectra to be more intense and prominent (Rath et al in [14]).



**Figure 2.** FTIR spectra of polystyrene and sulfonated polystyrene.

Thermal stability of PS and sPS were analyzed using TGA. Figure 3 and Table 1 show the thermogram and the degradation temperature ranges of PS and sPS. PS degradation occurs through one stage of the degradation process, while in sPS occurs three stages of the degradation process. In addition, it can be seen on the thermogram that, sPS5 and sPS10, have a similar degradation appearance to PS. However, there was an increase in thermal stability in sPs 5 and sPS 10 which was indicated by the increase in thermal stability after the addition of sulfonic agents to PS. The presence of intra and intermolecular interaction hydrogen bond in the sulfonate group causes an increases thermal stability (Luo et al in [15]).



**Figure 3.** TGA curve of PS and sPS.

The addition of 15 – 25 mmol sulfonic agents showed a significant effect on polymer degradation. Table 1 shows the degradation temperature ranges of sPS 15, sPS 20, and sPS 25. The first stage of degradation occurs in the temperature range up to 100 °C due to the evaporation of water bonded to the sulfonate group (Barrios – Tarzona & Suleiman in [16]). The second stage of degradation shows the degradation of the sulfonate groups in the polymer chain, while the third stage of degradation shows the degradation of the PS main chain. The thermal degradation of cationic sulfonates occurs in several stages, namely dehydration, functional group destruction with loss of SO<sub>2</sub> and oxidative degradation of the polymer matrix (Singare et al in [17]). The degradation temperature ranges of sPS 15, sPS 20 and sPS 25 that occur at temperatures above 100 °C indicate that this material can be used for the manufacture of polymer electrolyte. This shows that the addition of a sulfonic agent can reduce the degradability of the material. The presence of sulfonate groups in the polymer matrix provides characteristics such as increasing hydrophilicity and increasing proton exchange performance so that it can be used as a material for making polymer electrolyte (Jalal et al in [18]).

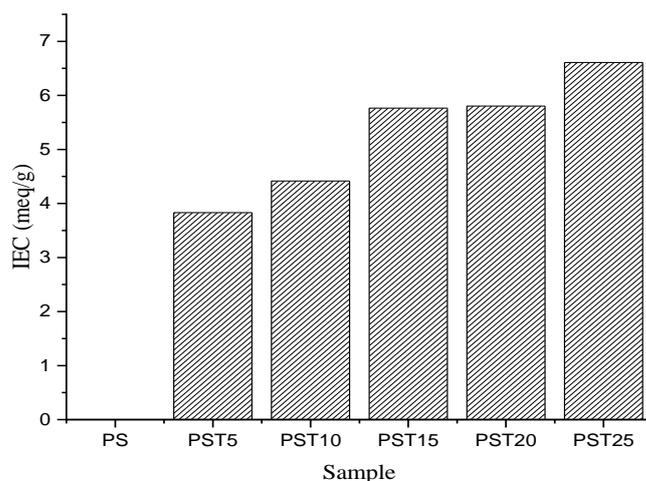
**Table 1** Degradation temperature of PS and PST.

Sample	Degradation Step					
	I		II		III	
	Onset – offset (°C)	Weights loss (%)	Onset – offset (°C)	Weight loss (%)	Onset – offset (°C)	Weight loss (%)
PS			295 – 430	92.28		
PST5			292 – 438	94.27		
PST10			325 – 445	90.24		
PST15	30 – 130	11.72	183 – 426	70.25	426 – 570	14.11
PST20	30 – 125	18.62	195 – 423	51.14	423 – 632	23.99
PST25	30 – 123	16.02	173 – 411	47.23	411 – 606	32.30

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### 3.2 Cation Exchange Capacity



**Figure 4.** Effect of acetyl sulphate concentration to the cation exchange capacity.

The determination of cation exchange capacity of sulfonated polystyrene was determined using the titration method. This test aims to determine the ability of sulfonated polystyrene to exchange cations bound to the functional group with other cations (Ngadiwiyana et al in [19]). The value of the cation exchange capacity is shown in Figure 4. It can be seen in the figure that the more sulfonating agents are added, the value of the cation exchange capacity is increasing with a maximum value of 6.610 meq/g at sPS 25 with a minimum value of 3.830 meq/g at sPS 5. The increasing CEC indicates an increase in the number of sulfonate groups and the cation-exchange ability of the polymer and that this is better in the application of material polymer electrolyte (Holder et al 2017 in [20]).

## 4 Conclusion

The synthesis of sulfonated polystyrene was carried out using styrofoam waste using acetyl sulfate as a sulfonating agent. The appearance of the  $-\text{SO}_3\text{H}$  group spectra on FTIR indicates the success of the sulfonation process. Polystyrene

undergoes one stage of degradation, while the addition of acetyl sulfate reduces the thermal stability of the material, with thermal resistance still above 100 °C. The value of CEC sPS is proportional to the amount of sulfonic agent added. The highest CEC value is 6.610 meq/g at sPS 25. On a final note, sPS from styrofoam waste can be used as a material for making polymer electrolyte.

### Acknowledgments

Author(s) would like to acknowledge Sebelas Maret University for provide facilities in conducting research and testing.

### Nomenclatures

- CEC* = Cationic Exchange Capacity  
*PS* = Polystyrene  
*sPS* = Sulfonated polystyrene

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## Rainfall-runoff Analysis Using Satellite Data in The Majalaya Watershed

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**Abstract.** Majalaya is a flood-prone area with a minimum of six flood events every year. There have been several efforts made by the government and residents for flood prevention and early warning efforts. One of them is the AWLR which was built to monitor the water level of the Upper Citarum River. However, the results of the recording of the AWLR itself are still in doubt because of the difference between the AWLR data and the observations of residents. Using the 2018 flood incident data as a reference, the hydrological analysis in this study was conducted by combining ground data and satellite data using the HEC-HMS application. The results of the modeling show that the difference between ground data and satellite data is quite significant. This is one of the validations of an error in the AWLR recording so that it gives different results.

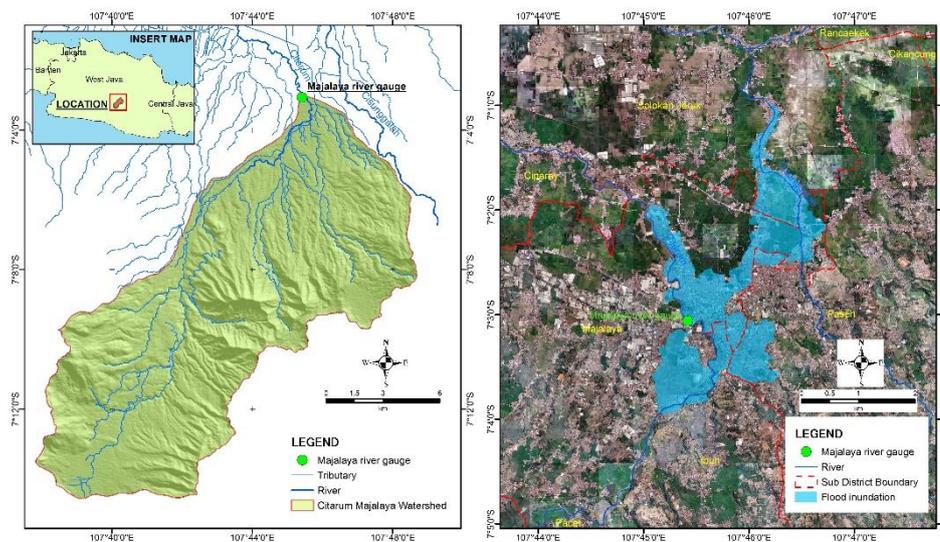
**Keywords:** *satellite data; GSMaP; AWLR; water level; majalaya.*

### 1 Introduction

Majalaya is a small city located in the central part of the West Java Province (Figure 1). It is home to 169,000 people, more than 2000 medium, small, and micro-scale enterprises, as well as 2,200 ha of paddy fields [1]. Majalaya area is known for its textile industry since the 1960s [2]. Despite its significant role in West Java's economy, Majalaya experiences recurring floods from the Citarum river, where Majalaya is located at the first 13% (35 km) of the entire 270 km of Citarum River. The local flood mitigation community recorded at least six yearly flood events [3]. The local rainfall gauge shows that the recurring floods are typically caused by a maximum daily rainfall of around 70–90 mm. However, the 2017 and 2018 floods exceeded previous years' records. The 2017 flood paralyzed the city's road transportation network [4], while the 2018 flood, on top of making road transportation infeasible, the flood inundated the town to the

extent of 5 square km, damaged dozens of houses, injured many, and claimed one life [5].

Despite its importance and severity, the flood characteristics in Majalaya are not well studied. On the Scopus indexing service, there were only eight publications discussing the topics related to the Majalaya flood [2], [3], [6], [11], with two of them explicitly discussing the Majalaya flooding problem [3], [7]. Junnaedhi *et al.* [3] discussed the general overview of the Majalaya flood and how the community organized themselves to anticipate and mitigate flood hazards. Safarina *et al.* [7], on the other hand, discuss the rainfall threshold characteristics that could lead to flood inundation in a larger study area where Majalaya is included. Although the study could be improved using a well-calibrated dataset, the study indicated Majalaya Area is prone to inundation should a minimum of 70.44 mm gauge rainfall occurs.



**Figure 1** Majalaya catchment location with Majalaya stream gauge as the outlet (left figure); crowdsourced February 22<sup>nd</sup>, 2018, flood inundation map with Majalaya stream gauge as the reference location.

The recurring pattern of the Majalaya flood hazard necessitates a comprehensive study to understand the mechanism of the flood. While the prior studies are commendable, the need to assess Majalaya flood mitigation strategies requires studies to fill the gaps in its understanding. One of the fundamental components is to study the rainfall-runoff relationship in the area. This study will discuss the modeling of Majalaya rainfall-runoff model using GSMaP rainfall data and stream gauge using HEC-HMS. This study aims to serve as a baseline study for future works related to managing the Majalaya flood.

## 2 Materials and Methods

Data is one of the essential aspects of planning for the future in any area. Lack of completeness of data can affect any assessment such as development planning and evaluation of infrastructure. Various innovations have been carried out on how to complete the current shortcomings.

For water resource planning, rainfall record data is a crucial aspect. But unfortunately, there are still many areas in Indonesia that have inadequate facilities for recording rainfall regularly every year. Often empty data is obtained and there is not enough rain station in various areas.

The use of remote sensing data and the use of current technology is one of the means to complete the incomplete data on the manual ground data. An example of the benefits of satellite data is to simplify the calculation of the flood warning system, which estimates the time of flood and disseminated it to the public. This is evidenced by the results of research [12] which states that the concept of time lag is physically reasonable and consistent so that it gives reasonable results. So in this study, a hydrological analysis was carried out combining two types of data, namely ground data and satellite data. The advantage of combining the two types of data is that it can shorten the time of data calculation and fill in the blank data on the ground data.

## 3 Results

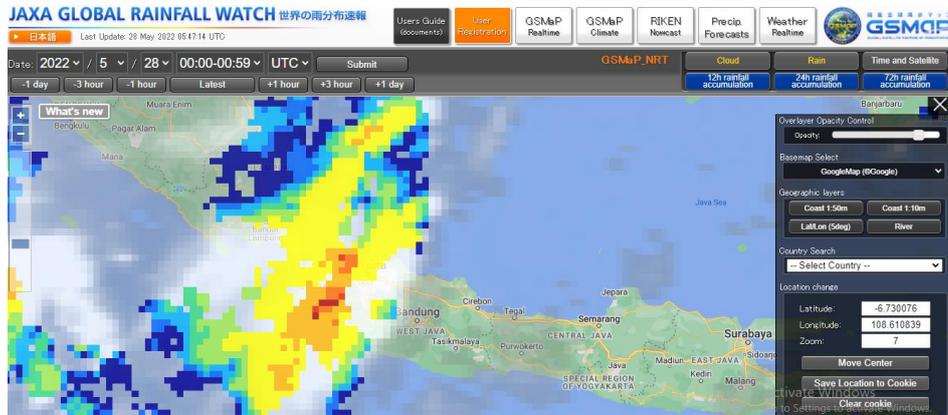
### 3.1 Hydrologic Data

In this study, two types of data are needed: water level data from the Paseh Rain Station and AWLR in Majalaya and satellite data. AWLR data can be accessed online on the website (<http://103.110.9.91/>) which is managed by the Citarum River Basin Agency (BWS), and GSMaP satellite data can be downloaded by accessing (<https://sharaku.eorc.jaxa.jp/GSMaP/>).

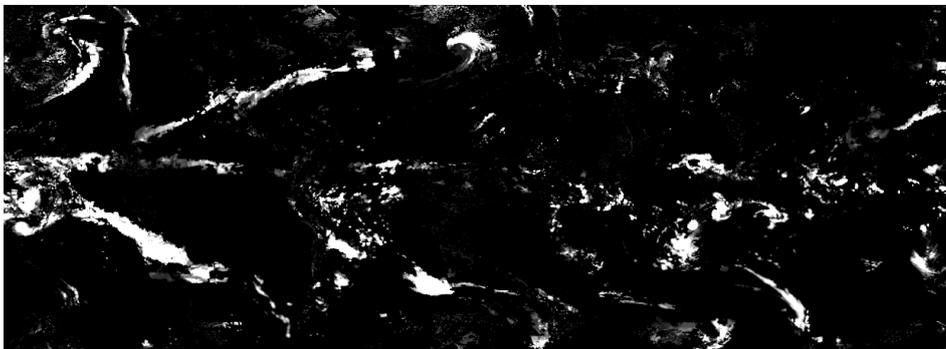
*Automatic Water Level Recorder* (AWLR) or stream gauges is a tool to measure the water level in rivers, lakes, and irrigation flows and can automatically record water level records. Where this tool is used as a substitute for a conventional system that has to manually record data so that data storage is precise and accurate [14]. The available data are the water level (TMA) from the AWLR recording and the discharge which has several different periods, namely: 10 minutes, 1 hour, and 1 day.

GSMaP (Figure 2) data is a combination of several rainfalls taken from the Tropical Rainfall Measuring Mission satellite (TRMM), Aqua, DMSP, and

NOOA) and an algorithm so that it becomes one of the satellite data that has high resolution. GSMaP has a spatial scale of 11.06 x 11.06 km and can cover all regions in Indonesia [15]. Managed by Japan Science and Technology Agency (JST) and Japan Aerospace Exploration Agency (JAXA).



**Figure 2** JAXA Global Rainfall Watch (GSMaP) Display.



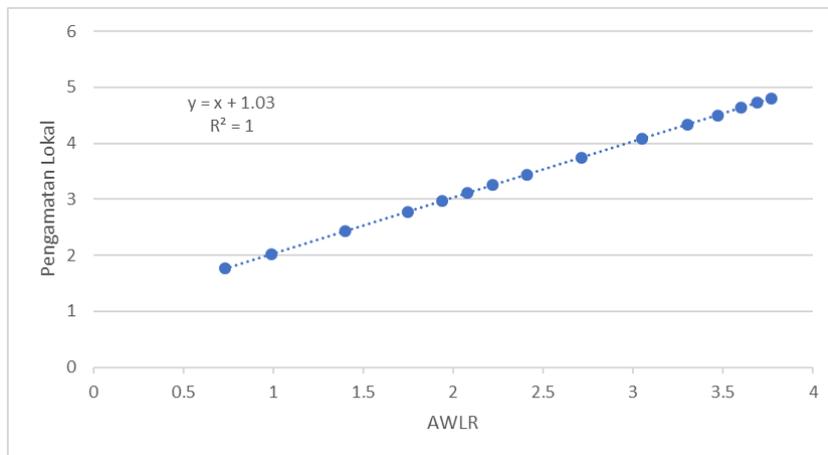
**Figure 3** Cloud Pattern Map from GSMaP.

The website shows the movement or pattern of clouds and rain around the world. And in this study using GSMaP v.7 data from March 2014 to May 2022 per hour that has been calibrated, then access the data using the FileZilla application. The downloaded image still has to be extracted from the GEO format into a TIF format file so that it can be processed to get hourly rainfall data (Figure 3). To change the format of the data use the Format Conversion Tool application. The GSMaP map is on a World Map scale but what is needed is rainfall data in the area of the Majalaya watershed. In processing the GSMaP map into rainfall data, the R Studio programming language is used. The required input data are GSMaP maps and Majalaya watershed maps in SHP format. Some results that are

important to note are that GSMaP data has a time unit of 00:00 GMT so it must be changed to West Indonesia Time (WIB). And the results will be in the form of hourly rainfall data in mm.

#### 4 Hydrology Analysis

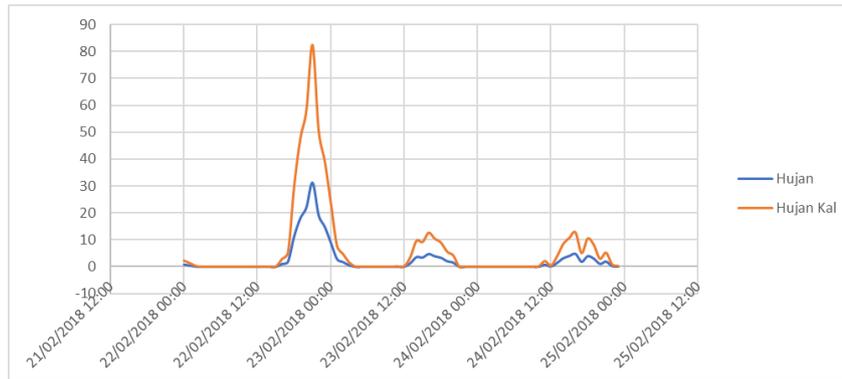
The analysis is carried out to see the accuracy of the AWLR data and satellite data. For AWLR data, it is known that there are differences between the data recorded by AWLR and events in real time. Taking the case of the flood in Majalaya on February 22, 2018, at that time the local community recorded the water level seen on the river measuring board at the time of the peak of the flood. It can be seen in Figure 4 that the difference between the AWLR water level and the actual incident is about  $\pm 1$  m. Therefore, it is suspected that the results of the AWLR data are not exactly like the actual event.



**Figure 4** Comparison of AWLR Results with Observation Data.

##### 4.1 Data Calibration

To use the GSMaP data calibrated with ground data or direct measurements. Calibration is done by looking at the results of linear graph equations so that the GSMaP data times factor is known to resemble soil data or direct measurements.



**Figure 5** GSMaP Calibration Data Results.

In Figure 5, it can be seen that the GSMaP data after being calibrated produces a value that is too large so that it cannot be used. Because it is too far from the actual events that occurred during the 2018 floods. GSMaP rainfall data is closer to direct measurement rainfall data. So, we use GSMaP data without recalibration.

For this reason, the modeling using HEC-HMS was carried out. Where the rainfall input data used is from GSMaP data and debit data is calculated from AWLR data.

To calculate the discharge, based on the water level from the AWLR by using the debit equation, the results of the Neo Perdas Program Package Analysis are:

$$Q = 3,52(H - 0,03)^{2,355} \quad (1)$$

Description:

Q = discharge (mm<sup>3</sup>/second)

H = water level (mm)

The discharge equation above is a curved formula resulting from the rating curve for flow measurement data from 2006 to 2012.

## 4.2 HEC-HMS Modelling

Next is the HEC-HMS modeling by taking the 2018 Flood event from February 22, 2022 at 00:00 WIB to February 24, 2022 at 23:00 WIB (Figure 6).

To calculate the Hydrograph Unit on HEC-HMS using the Snyder Equation [16], where:

$$t_p = C_1 \cdot C_t(L \cdot L_c)^{0.3} \quad (2)$$

Description:

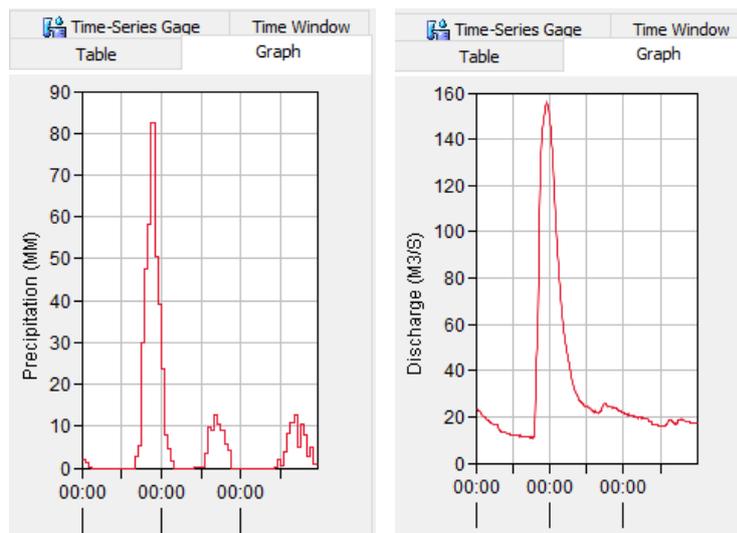
$t_p$  = time peak

$C_1$  = coefficient

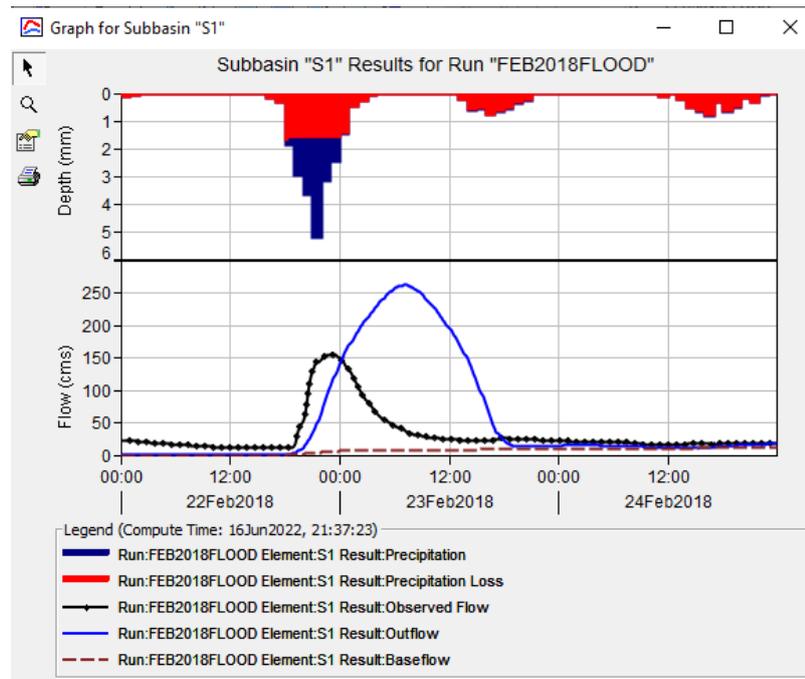
$C_t$  = time coefficient

$L$  = main channel length (km)

$L_c$  = length of the main stream channel from the outflow point of a watershed to a point opposite the centroid of the watershed (km)



**Figure 6** (left) GSMaP time graph (right) Majalaya AWLR time graph.



**Figure 7** Running Program HEC-HMS Result.

In Figure 7, it can be seen that the hydrographs of the two types of data, namely soil and satellite data, give significantly different results. Even the peak times of both data are also different.

### 4.3 Discussion

Due to the density of settlements and the textile industry, the Majalaya area is one of the contributors to river pollution due to its effluent and inefficient IPAL. Of the 600 existing textile industries, only 10% operate standard IPALs [17]. Meanwhile, the upstream area of the Citarum river is an area for cattle farming and agriculture, which causes river pollution due to the dumping of cow dung waste into the river. Then the excess fertilizer (nitrogen and phosphorus) is not absorbed by plants [17].

Annual floods almost always occur in Majalaya, flooding has occurred since 2008 and occurs several times a year. The number of flood events in a year is at least six times, namely in 2012 and the most is 20 events occurring in 2008. One of the influencing factors is serious land subsidence, where Majalaya is one of the areas where groundwater extraction has exceeded the ideal limit. [17].

Precipitation assessment carried out, shows that extreme rainfall has increased over the years. And the impact of climate change is the worsening of flooding. Generally, the depth of the flood ranges from ankle-deep to one meter, caused by sedimentation, and the build-up of garbage, the effect of uncontrolled urbanization [3], [13].

## 5 Summary

This research uses GSMAp satellite data as an alternative to ground data. Which ground data tends to have a lot of blank or unrecorded data. And there are also allegations of inaccuracies in the recording of the AWLR compared to ground data so that satellite data is expected to be used as a substitute for ground data in the future.

In the HEC-RAS modeling results, it can be seen that the two hydrographs of satellite data and AWLR data have significant differences. Where the water level results from satellite data and the resulting ground data are far different that the resulting hydrograph is different as well. It is estimated that there was an error in the rating curve which could be caused by several factors. Among them are the differences in water level used with events in real time, so that there is an error in the value of the graph curve in the rating curve. Thus, it is concluded that the water level data from the AWLR is underestimated and still needs to be reviewed further.

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## Effect of Flexible Joint and Rigid Segment Variation on Soft Robotic Finger Kinematics

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**Abstract.** The latest development in the robotic hand is the application of highly deformable materials for a hand structure known as a soft robotic hand. Soft robots have many advantages over conventional rigid bionic hands due to their lightweight and compliant characteristics. Although there are various designs of a soft robotic hand that could produce compliance mechanisms, one design that resembles a human finger's structure is a manipulator that uses flexible joints and rigid segments. The combination of these two elements would affect the finger's bending angle and motion range. This article reports the design and parametric study of the manipulator, which has four main components: silicone rubber, strain limiting layer, fiber reinforcements, and 3D print structures from polylactic acid (PLA). In addition, we deliver the optimum design manipulator model, which will be manufactured in the subsequent research.

**Keywords:** *robotic hand; soft robot; finger; manipulator; parametric study; flexible joint; rigid segment.*

### 1 Introduction

Robotic hands have expanded and have been utilized in various sectors. In the medical field, robotic hands substitute the amputated hand due to an accident or congenital disability. This robot is usually called a prosthetic hand/bionic hand [1]. Commercial Bionic hands (the i-Limb<sup>1</sup>, the Bebionic<sup>2</sup>, and the Michelangelo<sup>3</sup>) have robust mechanisms to accomplish hand functions with the EMG sensor, which is mounted onto the skin of the residual limb. Regardless of

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<sup>1</sup> <http://www.touchbionics.com>

<sup>2</sup> <http://www.bebionic.com>

<sup>3</sup> <http://www.living-with-michelangelo.com/home>

their satisfactory ability, the products are quite heavy ( $> 420$  g) [1] and expensive ( $> \text{US\$}10,000$ ) [2]. Soft robots are emerging and rapidly growing to handle established robots issue constructed by unbending structures [3]. These new robots are interesting because they could easily deform while being resilient, adapt to the surroundings without harming humans, and allow low-cost production [4]. Furthermore, elastic components could decrease the robot's weight.

An anthropomorphic hand design based on soft robotics technology could achieve dexterous grasping capabilities [5]. 1-chamber tube manipulator with a tapering shape at the tip and a thread winding is used on the robot, which weighs 178 g. However, the entire manipulator structure is fully elastic, unlike human fingers, which have rigid-bone anatomy. In one study, the manipulator is attached with plastic lamination as a rigid structure to mimic the human finger [2]. The addition of this rigid structure increases grip strength because of the wider manipulator's outer surface contact with the gripping object. Inspired by this configuration, we designed a finger manipulator with flexible joints and rigid segments.

The finite element analysis with Abaqus was conducted to optimize the kinematics of the soft robot finger. The simulation provides an effective solution to vary the component dimension and predict the performance of the model without manufacturing the robots, which could take a considerable amount of time. Finally, by the parameterization of wall thickness, fiber angle, fabric width, elastic section, and rigid section length, we could find the optimized design of soft manipulator from this method [6].

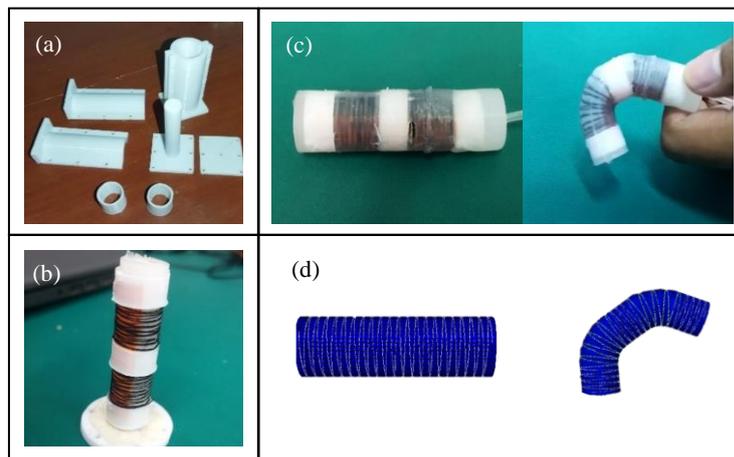
In this article, we start off with conceptual design of the model and conduct a finite element modelling. After that, the design variables are analyzed to understand their effect to the manipulator. The last is the simulation result and kinematics performance explanation about the robot.

## 2 Conceptual Design

Chamber design is an essential feature in which, upon pressurization, the air/fluid would press in all directions of the inner chamber wall and deform the manipulator. Although forming a multi-chambered manipulator could be made to control the manipulator's bending in a particular desired direction [7], the finger robot only requires the actuator to turn in one direction. Therefore, it does not need more than one chamber. There are three types of the manipulator [6]. The first type is the corrugated membrane which has a folds/fins on the actuator that expand under the pressure to make a bending motion. The second is the eccentric void asymmetries leading to different layer thicknesses in the actuator. And the

third is the multi-material types that is assembled from a combination of elastomeric and inextensible materials. This type possesses simpler tubular geometry that offers ease of manufacture [8]. In addition, we provided a fiber-reinforcement to avoid the radial expansion for optimizing the bending motion [9].

A design model arranged by two flexible joints and three rigid segments is manufactured and experimented with to prove the conceptual design. The casting process uses 3D printed molding (Figure 1a). The rigid structure from PLA is partially attached to the manipulator, fabric as a strain limiting layer is embedded into it, and fiber is wound along it (Figure 1b). A proof-of-concept prototype was then manufactured (see Figure 1c). During pressurization, the prototype achieved an appropriate bending movement, which demonstrates the feasibility of this design. Then, the finite element simulation is conducted to mimic the experiment (Figure 1d). From this early result, it is found that the specimen produced larger bending angle in the experiment than in the simulation.



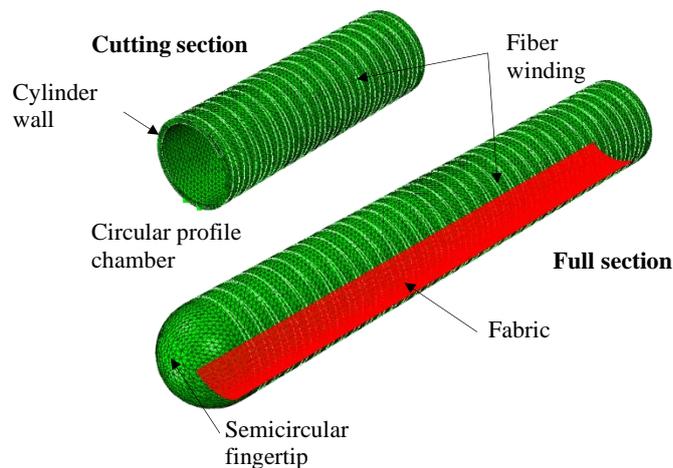
**Figure 1** Manufacture, experiment, and finite element model of conceptual design approval. (a) 3D printed molding. (b) Manipulator model that has been attached by fabric layer, fiber winding, and rigid structure. (c) A proof-of-concept prototype. (d) Finite element simulation.

### 3 Finite Element Modelling

At the beginning stage of simulation, five variables were defined as independent variables, i.e. cylinder wall thickness, fiber winding angle, fabric width, elastic section length, and rigid section length. Then, the material properties of each component were explained to show the specific data that are utilized in the

simulation. The last stages were meshing, defining constraints, loads, and boundary conditions.

The finger manipulator model is presented in Figure 2. The main form of the manipulator is a single tubular and semicircular adjustment on the fingertip. The finger's length and diameter dimensions were adapted to the Indonesian's anthropometry [10]. Then, the fiber loops and a strain limiting layer were implanted and were simulated to achieve the optimal design.



**Figure 2** Full and cutting section of manipulator design.

### 3.1 Material Properties

In the simulation, the materials were determined based on secondary data [6]. The main part of the manipulator used one of the most widely used silicone rubbers, i.e., Ecoflex 30. The silicone will be partially wrapped using polylactic acid (PLA) as a rigid structure that resembles a finger segment. Ecoflex and PLA are the solid features that use Yeoh and Elastic model respectively. Then two fiber windings that used Kevlar material as beam feature were assigned with Elastic model, and the fabric used elastic material with Neo Hooke model and modifications to simulate a strain limiting layer that could withstand tensile loads but not bending loads. The detailed data applied in the simulation is shown in Table 1.

**Table 1** Material properties and section assignments.

Material	Model	Coefficients	Section
Ecoflex 30	Yeoh	$C_{10} = 0.11 \text{ MPa}, C_{20} = 0.02 \text{ MPa}$	Solid, type: Homogeneous

PLA	Elastic	$E = 3000 \text{ MPa}, \nu = 0.3$	Solid, type: Homogeneous
Kevlar	Elastic	$E = 31067 \text{ MPa}, \nu = 0.36$	Beam, type: Constant
Fabric	Neo Hooke	$C_{10} = 100 \text{ Mpa}$	Shell, type: Homogeneous

### 3.2 Meshing and Constrain

Ecoflex and PLA materials are the main construction of the manipulator modelled component. These two components are applied to tetrahedron mesh which is formulated in hybrid and quadratic geometric order because of the complex geometry. In Kevlar, the order linear geometric is utilized with a global meshing size of 0.3. This size is smaller than the Ecoflex/PLA meshing because Kevlar will be tied with the manipulator as the master surface. Fabric as an embedded region on the manipulator wall uses quad-dominated mesh control with a reduced integration method. A summary of the meshing process is presented in the following table.

**Table 2** Meshing properties in each component.

Material	Mesh Control	Element Type Code	Global Size (mm)
Ecoflex 30	Tetrahedron	C3D10H	1
PLA	Tetrahedron	C3D10H	1
Kevlar	-	B31	0.3
Fabric	Quad-dominated	S4R	0.5

The constraint between the inner and outer wall of the manipulator is defined as self-contact with 0.3 frictional force coefficient. If no constraint is specified, the simulation will stop at low pressure due to a lack of definition.

### 3.3 Boundary Condition and Load

Boundary conditions are placed at the base point of the manipulator finger, which has a circular surface with a fixed end so that the manipulator does not translate and rotate in that point. At the same time, the pressure load is given gradually from 0 to 1 MPa with 0.1-second increments, which exceeds the model's capability. Therefore, the simulation will abort when the manipulator has reached the maximum load.

## 4 Parametric Study

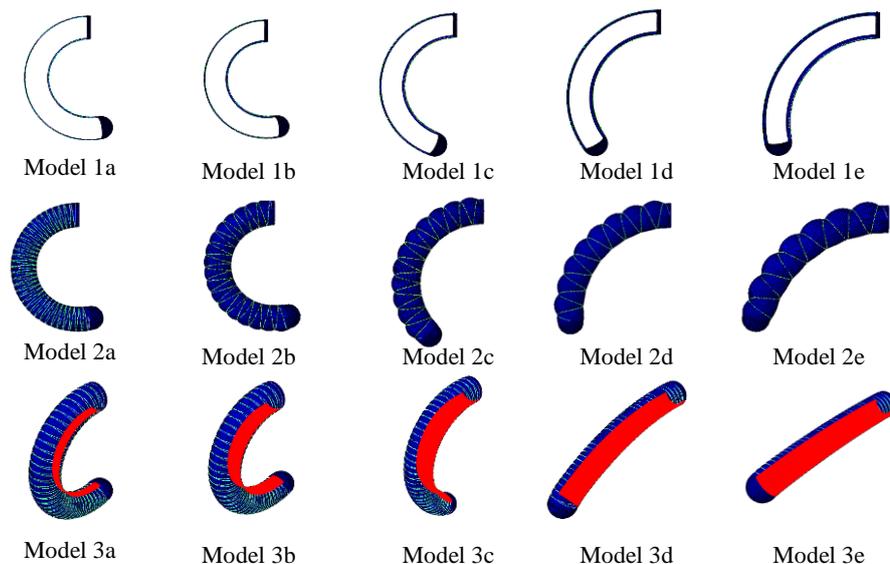
Modeling is accomplished in two processes and gradually from one design variable to another. First, the model is fully elastic, varying the wall, fibers, and fabric layer. This modeling obtains the optimal model design that

performs bending. Second, the simulation is carried out by varying the length of the elastic and rigid sections for kinematics analysis.

#### 4.1 Wall Thickness, Fiber Angle, Layer Width

Figure 3 shows a visual illustration of the modeling carried out. In Model 1, the manipulator wall thickness is varied (1-3 mm) to observe the changes. With the same pressure input, the thicker wall has a small deformation but does not affect the fingertip trajectory. This wall thickness will affect how much pressure the manipulator can withstand and will be directly proportional to the compressive force that will be applied when later used to grip objects. Model 2 is a model with variations in the angle (3-15 degree) of the fiber winding. It could be seen that the tight winding of the fiber will resist the deformation in the radial direction so that the strain will be focused on the bending motion.

The parametric method used in Model 3 is the variation of the width of the strain limiting layer (12-60 mm). The wider the layer, the higher the stiffness of the manipulator because the elastic part is covered, so it cannot be deformed. However, if the fabric width is too small, the manipulator could bend out of the axis.

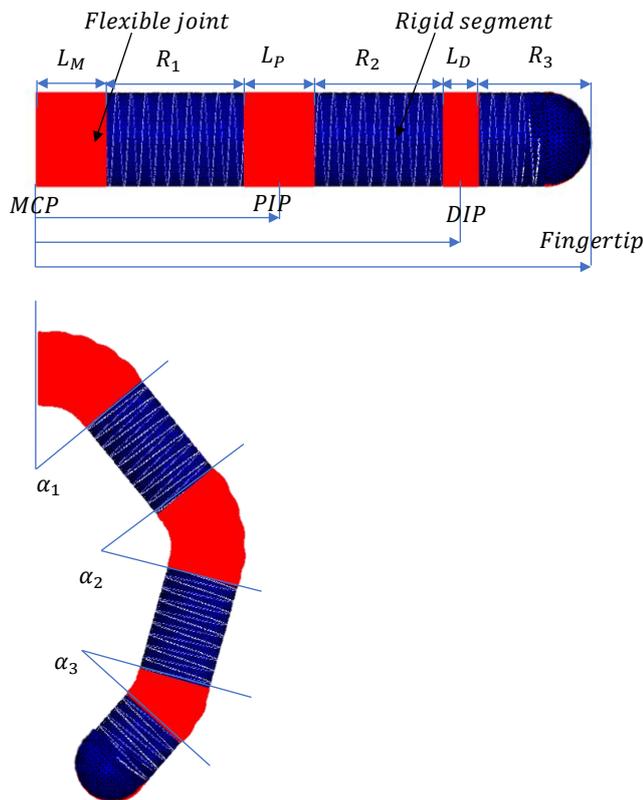


**Figure 3** Finite element results for varying wall thickness, fiber angle, and fabric width.

## 4.2 Flexible Joint and Rigid Segment

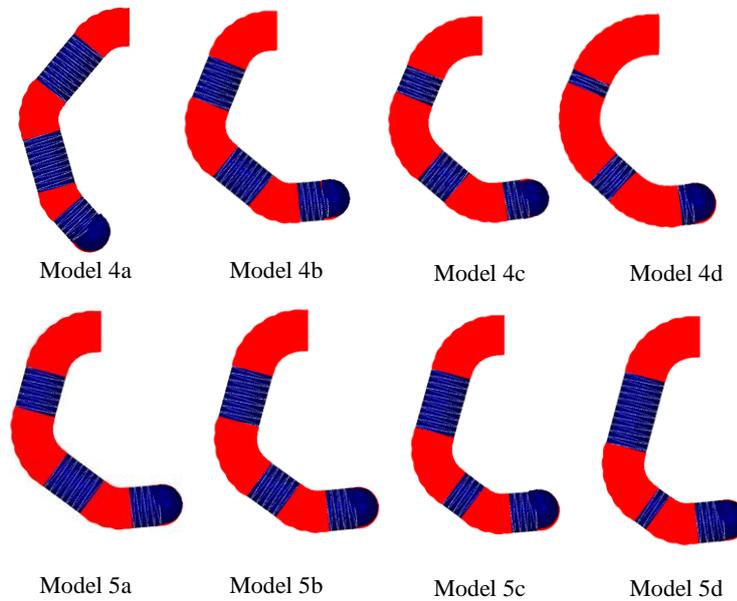
Two critical elements, flexible joint and rigid segment, are rarely analyzed for how they affect the movement of the manipulator. Three independent variables  $L_M$ ,  $L_P$ , and  $L_D$  are varied. The subscripts marked the length of the metacarpophalangeal, proximal interphalangeal, and distal interphalangeal. By obtaining the proportion of each length variable from the previous experiment [2], this variable is increased periodically by the initial length. This flexible joint difference will cause the dependent variable of the angle at the joints  $\alpha_1$ ,  $\alpha_2$  and  $\alpha_3$  to change. The capital letters *MCP* (metacarpophalangeal), *PIP* (proximal interphalangeal), and *DIP* (distal interphalangeal) are indicating the location of the finger joints.

After obtaining the optimum length of the manipulator model, the length of the rigid segment was varied without changing the length of the flexible joint. This rigid segment variable is defined as  $R_1$ ,  $R_2$ , and  $R_3$ . The variable definition can be seen in Figure 4.



**Figure 4** Variable design determination.

Visually, the simulation results can be seen in Figure 5. Model 4 is a design with variations in the length of the elastic section. While model 5 is a variation of rigid parts. Detailed data for each simulation will be presented in the next paragraph.



**Figure 5** Visual illustration of flexible and rigid section modelling.

The elastic section simulation data can be seen in Table 3. The variation of elastic length is available along with the angle and maximum pressure that can be simulated. It could be seen that the longer the elastic section, the lower the pressure when the simulation stopped. There are two possibilities for this phenomenon, the material could no longer be deformed, or the material has failed. The assumption is supported by the total bending angle data, which can be seen in the  $\alpha_{total}$  column. The simulation stops at a relatively close total angle in models 4b, 4c, and 4d. Model 4b was chosen as the optimal model based on the data and visual results from this modeling.

**Table 3** Flexible joint model data.

Model	$L_M$ (mm)	$L_P$ (mm)	$L_D$ (mm)	$\alpha_1$ (°)	$\alpha_2$ (°)	$\alpha_3$ (°)	$\alpha_{total}$ (°)	$P_{max}$ (kPa)
4a	15	15	7.5	50.1	55.4	25.8	131.3	158
4b	20	20	12.5	66.9	71.8	43.6	182.3	150
4c	25	25	17.5	67.5	71.7	49.3	188.6	112
4d	30	30	22.5	66.6	70.2	49.6	186.4	90

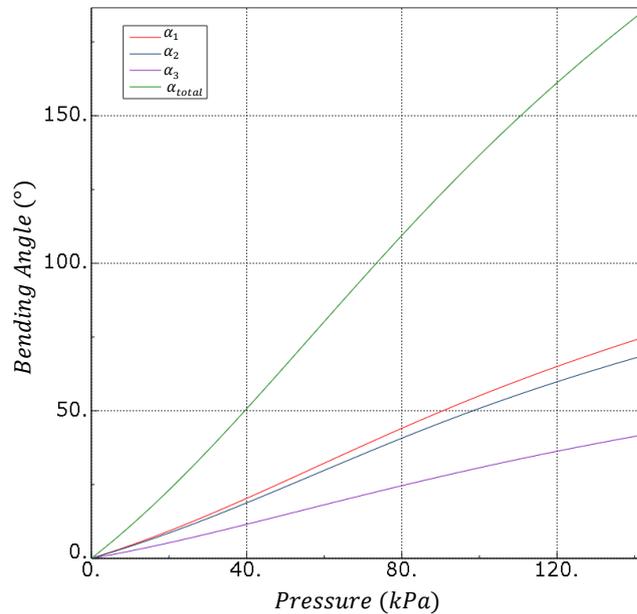
From the flexible length section that has been obtained from the previous modeling, the variation data on the rigid section can be seen in Table 4. The variation is carried out on the variables  $R_1$  and  $R_2$ , where  $R_3$  is a controlled constant. This simulation found that the length change in this rigid structure does not significantly affect the total angle of indentation. However, the difference is only seen in Model 5a, at angles  $\alpha_2$  and  $\alpha_3$ . So, the model selection is based on the location of the rigid structure close to finger joint anthropometry, which is Model 5b.

**Table 4** Rigid segment model data.

Model	$R_1$ (mm)	$R_2$ (mm)	$R_3$ (mm)	$\alpha_1$ (°)	$\alpha_2$ (°)	$\alpha_3$ (°)	$\alpha_{total}$ (°)	$P_{max}$ (kPa)
5a	20	25	19.5	74.9	41.9	68.9	185.8	142
5b	25	20	19.5	74.4	68.6	41.6	184.6	141
5c	30	15	19.5	74.9	68.7	41.9	185.6	142
5d	35	10	19.5	74.6	68.7	41.7	185.1	141

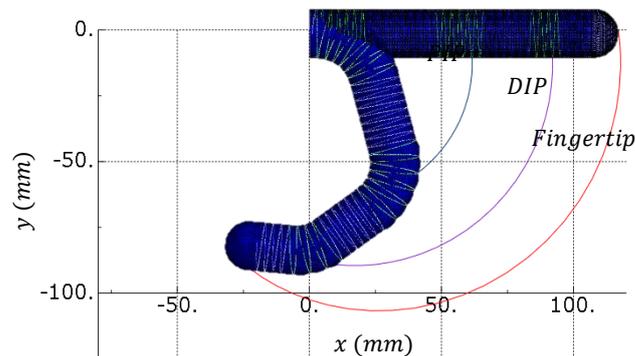
## 5 Kinematics Performance

In this section, some of the kinematic performances of the optimum model that have been obtained are discussed. The bending angle at each joint is plotted and presented in Figure 6. It could be seen that the model maximum pressure could achieve 141 kPa. Moreover, the bending angle at the fingertip or  $\alpha_{total}$  is 184.6 degrees, indicating that the finger manipulator could bend backward.



**Figure 6** Bending angle of the manipulator.

The joints and fingertip movement of the manipulator are traced in the simulation. Then their line-trajectory model is illustrated in Figure 7. The curved line represents the manipulator finger motion range which assembles human finger kinematics [11]. This soft finger will be adaptive if there are objects that block the movement of the lower knuckles. Then the additional rigid structure of the finger will strengthen the manipulator.



**Figure 7** The line-trajectory model design of each joint.

## 6 Conclusion

A parametric study of the manipulator effect on each change in the design variable geometries is explained in this research. The design, which based on flexible joints and rigid segments are satisfying design that could mimic the kinematic performance of an adaptive human finger. It should be noted that the model of the strain limiting layer is still an assumption. Additionally, there is still a problem while performing the simulation at high pressures (e.g. more than 160 kPa). The validation of the simulation with experiments will be part of our future works. This research is the initial stage of making a soft robot hand. It is challenging to make a prototype of the finger and its mechanical and control system.

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## Lyapunov Stability Analysis and Simulation of SIR Modelling for COVID-19 Dynamics in Indonesia

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**Abstract.** The COVID-19 outbreak began to spread in the world in early 2020 and in Indonesia it began to occur in March 2020. The ability to predict potential transmission of COVID-19 will help the government and health workers to prevent and reduce transmission of COVID -19 and as a simulation of the global trend of this pandemic. One of the models that can be used to model epidemiology is SIR modeling. SIR modeling divides the population into three classes, namely Suspect, Infected, and Recovered. By doing a simulation using virus spread parameters such as contact rate, recovery rate can be known how the spread of the virus will occur. In the estimation, you will also get a reproduction number. Reproduction Number ( $R_0$ ) is the number of people who can be infected or contracted a disease caused by 1 person who has had the disease. If the value of  $R_0 > 1$  then each infected individual can infect more than one other individual. If the value of  $R_0 < 1$  then an infected individual infects less than one other individual. By constructing the lyapunov function for the SIR model, the disease-free equilibrium state of the model will be found.

**Keywords:** COVID-19; SIR model; reproduction number; lyapunov.

### 1 Introduction

In December 2019, a mysterious case of pneumonia first appeared in Wuhan, Hubei Province, China. From 18 December to 29 December 2019, it was reported that five patients were treated with Acute Respiratory Distress Syndrome (ARDS). In less than a month, this disease has spread in various other provinces in China, even to other countries such as Thailand, Japan, and South Korea. According to Hui, *et.al* in [1]. The samples studied showed the etiology of the novel coronavirus. Initially, this disease was temporarily named as 2019 novel coronavirus (2019-nCoV), then WHO announced a new name on February 11, 2020, namely Coronavirus Disease (COVID-19) caused by the Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-CoV-2). The virus can be

passed from person to person and has spread widely in China and more than 190 other countries and territories.

COVID-19 was first reported in Indonesia on March 2, 2020 with 2 initial cases detected. This virus mainly infects animals, including bats and camels. But currently COVID-19 is spreading through human to human being the main transmission so that the spread of this virus is becoming aggressive. Transmission of the virus occurs from symptomatic patients through droplets that come out when the patient coughs and sneezes. The virus can also be transmitted by touching the hands or face of an infected person, as well as touching the eyes, nose, or mouth after handling items that have been splashed by the saliva of an infected person. Symptoms experienced by patients infected with COVID-19 are divided into 2, namely mild and severe symptoms. For mild symptoms such as headache, cough, sore throat, runny nose, fever, feeling unwell. Then the symptoms can turn into severe symptoms, such as fever which may be quite high if the patient has pneumonia, cough with mucus, shortness of breath, chest pain or shortness of breath and cough, Susilo, *et al.* in [2]

The case of the COVID-19 pandemic that has spread throughout the world has become a topic that is widely discussed by researchers. Researchers do a lot of modeling to be able to find out how COVID-19 will spread in the future. As in the case of the spread of the virus that has happened before, the spread of the COVID-19 virus can be modeled using mathematical models. The model that is commonly used to model cases like this is the SIR model. As done by Kermack and McKendrick in [3]. This model divides the population into several compartment classes.

## **2 Literature Review**

### **2.1 SIR Model**

The SIR model is a mathematical modeling method to model a pandemic case, one of which is COVID-19. In the SIR modeling the population is grouped into 3 classes, namely, Susceptible (S), Infectious (I) and Recovered (R). The susceptible class (S) is an individual who is healthy but has the opportunity and is susceptible to contracting the disease. Infectious (I) class or infected are individuals who are tested positive for infection and have the potential to infect susceptible classes, and Recovered (R) are individuals who are declared cured or died and are assumed to have immunity to the virus so they cannot be infected again. In the Infected class, individuals can cause other individuals to become infected by Cooper, *et.al* in [4].

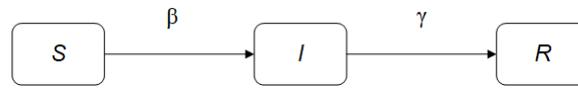


Figure 1 SIR Model

Figure 1 shows a flowchart of the dynamics of the SIR model. Furthermore, the SIR model can be expressed in equation (1).

$$\frac{dS}{dt} = -\frac{\beta SI}{N} \tag{1}$$

$$\frac{dI}{dt} = \frac{\beta SI}{N} - \gamma I$$

$$\frac{dR}{dt} = \gamma I$$

Figure 1 shows a flowchart of the dynamics of the SIR model. Furthermore, the SIR model can be expressed in equation (1). Where  $N$  is the total population and according to the existing assumption, namely the population is fixed, then  $S + I + R = 1$ . There are parameters  $\beta$  and also  $\gamma$ . Parameter  $\beta$  is the infection rate or it can also be called the contact rate. This parameter controls the speed of spread of the virus which is represented by the probability or probability of transmission from someone who has been infected to someone who is still susceptible or suspected of being in contact with each other. The parameter  $\gamma$  is the healing rate or it can also be called the recovery rate. The parameter  $\gamma$  can also be reversed to  $1/\gamma$  which is the period of virus infection. The presence of a negative sign on  $dS$  indicates the change in people who have not been infected with the virus to become infected is always negative. This means the number of healthy people will continue to decrease. From this reduction in the value of healthy people to the addition of the number of people in the equation  $dI$  who will become sick people and the changes are proportional. The negative sign contained in the  $dI$  equation indicates the rate of change of a person who was initially infected to recover or die will also always be negative which means that it continues to decrease. This reduction in the number of people will be accommodated in the  $dR$ , which means the number of people who have recovered from the disease or who died.

## 2.2 Reproduction Number ( $R_0$ )

Reproduction Number ( $R_0$ ) is the number of people who can be infected or contracted a disease caused by 1 person who has had the disease. This parameter indicates how contagious a disease is. Diseases that have been transmitted to people can be transmitted to other people and then the disease will reproduce

itself. For example, if a disease with a value ( $R_0$ ) of 3 means that naturally people who have been infected with the disease can transmit the disease to 3 other people.

Reproduction Number ( $R_0$ ) is mathematically also included in the concept of compartmental modeling as in the SIR model. The calculation of ( $R_0$ ) is obtained from the infection period and also the contact rate. Assuming the total population ( $N$ ) is 1 and each person is divided into three classes of SIR compartments, the  $R_0$  equation can be written as in equation (2).

$$R_0 = \beta\gamma^{-1} \quad (2)$$

The value of  $R_0$  is obtained by dividing the level of contact by the period of infection. There are three possibilities for the reproduction number  $R_0$  value.

- If the value of  $R_0 > 1$  then each infected individual can infect more than one other individual. Thus, the epidemic can spread throughout the population.
- If the value of  $R_0 < 1$  then an infected individual infects less than one other individual. Therefore, there is no risk of an epidemic.
- If the value of  $R_0 = 1$  then an infected individual can infect, on average only one other individual. The disease will persist with a steady spread but will not result in an epidemic/pandemic.

### 2.3 Related Search

The following are some of the studies that also serve as references in this section.

a). The outbreak of COVID-19: An overview by Yi-Chi, *et.al* in [5]

In this research describes the current COVID-19 virus. Also described this type of virus. How the spread of this virus and how much mortality rate can be generated by this virus.

b). Mathematical analysis of COVID-19 by using SIR model with convex incidence rate by [6]

In this study, modeling COVID-19 with the SIR model, then carried out a stability analysis, "the disease-free and endemic equilibrium" Also, the basic reproduction number  $R_0$  is derived for the model. Furthermore, the Global Stability is calculated using the Lyapunov Function construction, while the Local Stability is determined using the Jacobian matrix.

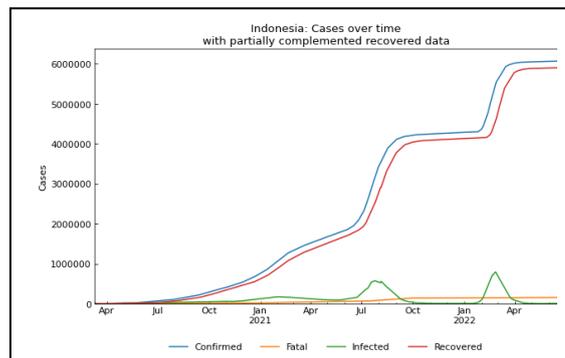
### 3 Exploratory Data Analysis

The data set used was taken from the COVID-19 Data Hub [7]. This data includes all data on COVID-19 in the world. From the data hub, the data used in this study is the COVID-19 Data Repository by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU) [8]. In this JHU dataset, it includes all COVID-19 data in the world. Table 1 shows the detailed features of the JHU dataset.

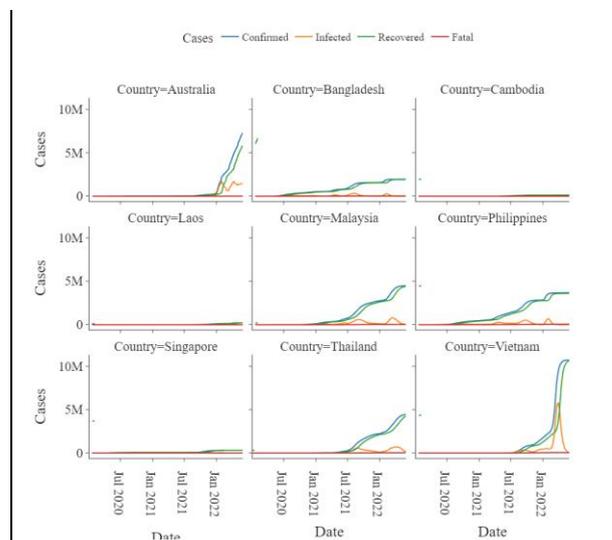
**Table 1** Detailed features of JHU dataset

No	Feature	Feature type
1	<i>ObservationDate</i>	Numerical
2	<i>Confirmed</i>	Numerical
3	<i>Infected</i>	Numerical
4	<i>Fatal</i>	Numerical
5	<i>Recovered</i>	Numerical
6	<i>Susceptible</i>	Numerical
7	<i>ISO3</i>	Categorical
8	<i>Country/Region</i>	Categorical
9	<i>Province/State</i>	Categorical

In Exploratory Data Analysis, the data from JHU will produce data on the dynamics of COVID-19 in Indonesia and dynamics in neighboring countries such as in Southeast Asia and the Australia Region as shown in figures 2 and 3.



**Figure 2** Spread of COVID-19 in Indonesia



**Figure 3** Spread of COVID-19 in nearby country in Southeast Asia and Australia

## 4 Modelling and Analysis

The modeling carried out will use the SIR model for cases of the spread of COVID-19 in Indonesia until May 31, 2022. The first step is to detect the phase that has been passed so far in Indonesia. Then proceed with the estimation of virus spread parameters for each phase obtained. The distribution parameters include (contact rate, recovery rate and reproduction number). Furthermore, an evaluation of the estimated data with real data is carried out. Then a simulation for the spread of COVID-19 was also carried out with the developed model. Finally, Lyapunov's analysis was carried out on the data results.

In this SIR modeling using python programming with the Covsirphy library in [9]. This library makes it easier for researchers to find out the analysis for COVID-19 in Indonesia and the scenarios created.

### 4.1 Analisis Trend

S-R trend analysis is used to determine the phases formed during the COVID-19 pandemic. This is used to identify the phases formed during the spread of COVID-19 in Indonesia. Susceptible S and Recovered R show the relationship between the derivatives of the SIR model as follows.

$$\log S_{(R)} = -aR + \log N$$

Where N is the total population,  $a = \frac{\beta}{N\gamma}$  is a constant, Balkew in [10]

From equation (3) log S will decrease constantly when there is an increase in R, when the records follow an SIR-derived model, and the parameter values of the model are constant. With logarithmic y-axis scale, plot of (x,y) = (R,S) shows a line. This property is used to determine the phase. A new phase is determined from the change in the slope of the line. S-R slope analysis is performed using Rupture: change point detection in Python [11].

Figure 4 depicts the trend for Susceptible and Recovered until May 30, 2022.

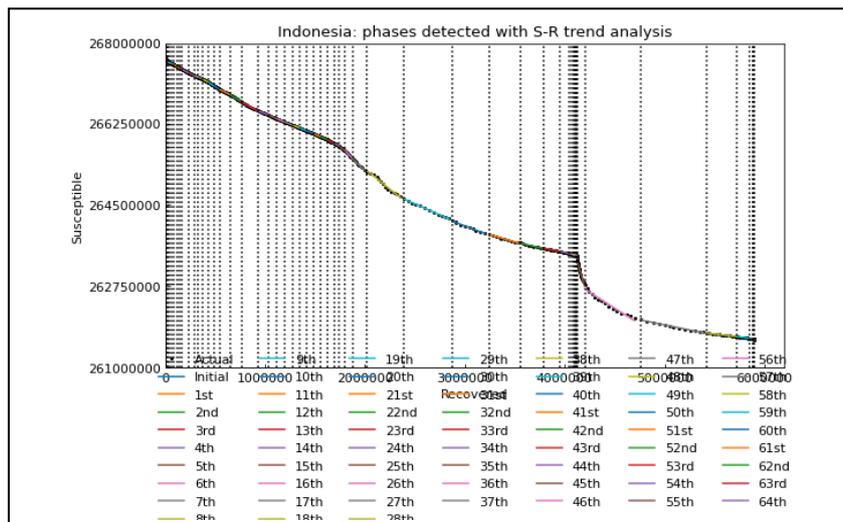


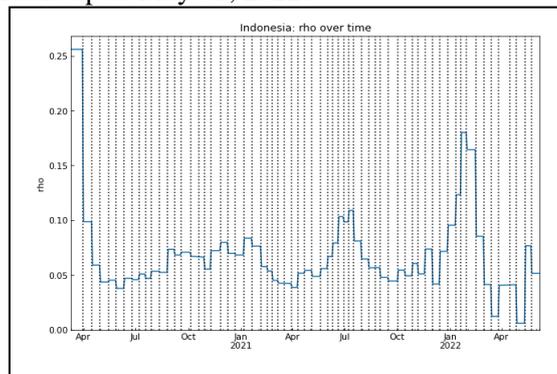
Figure 4 Disease Trend Analysis as of May 31, 2022

From Figure 4 it can be observed that the Susceptible – Recovered trend for COVID-19 in Indonesia consists of 64 phases until May 30, 2022. The phases will change quickly when there is a significant change in Covid cases.

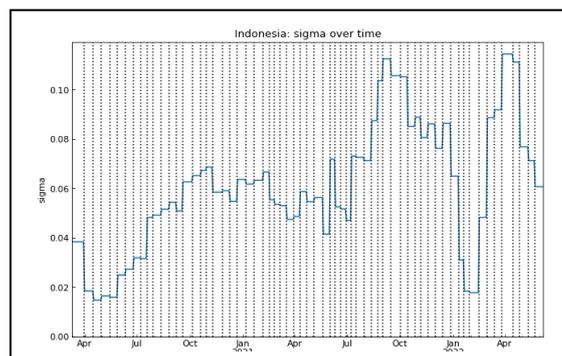
### 4.2 Parameter Estimation

In making estimates for the SIR model, the parameters that have been obtained in the previous phase determination are used. Parameters estimated in this study include contact rate  $\beta$ , recovery rate  $\gamma$ . In Optuna using method which is a Hyperparameter Optimization Framework written in Python language. Optuna uses TPA + CMA – ES mixed method (tree-structured Parzen estimators + Covariance matrix adaptation evolution strategy) to find the best estimation of the parameters [12].

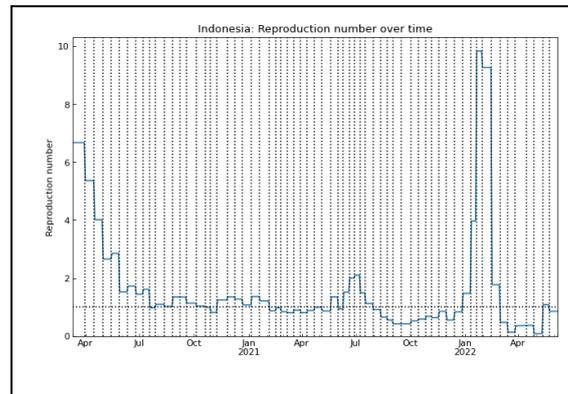
In the SIR model, there are 3 estimation parameters, namely contact rate  $\beta$ , recovery rate  $\gamma$  and reproduction number  $R_0$ . In Figure 5, it can be observed that the estimated values for the contact rate  $\beta$ , recovery rate  $\gamma$  and reproduction number  $R_0$  parameters up to May 31, 2022.



**Figure 5** Contact rate COVID-19 in Indonesia



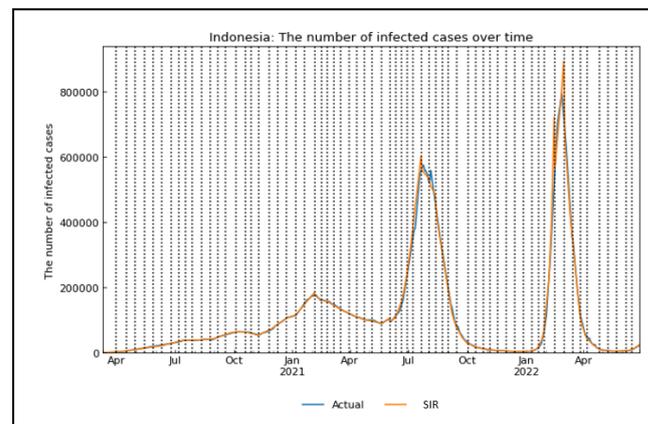
**Figure 6** Recovery rate COVID-19 in Indonesia



**Figure 7** Reproduction number COVID-19 in Indonesia

### 4.3 Model Evaluation

From the estimation results obtained, it is necessary to evaluate the data results by comparing them with the actual data available. This evaluation is carried out on the following matrices including MAE, MSE, MSLE, RMSE, RMSLE, and MAPE. In Figure 8, it can be seen that the comparison of the estimation results to the actual data from the infected cases.



**Figure 8** Number of Infected cases in Indonesia

From table 2, an error matrix is obtained for cases of the spread of COVID-19 in Indonesia. The value of each matrix obtained can be said to be quite small, this indicates that the estimation results compared to the actual data are quite close.

**Table 2** SIR model evaluation for COVID-19 in Indonesia

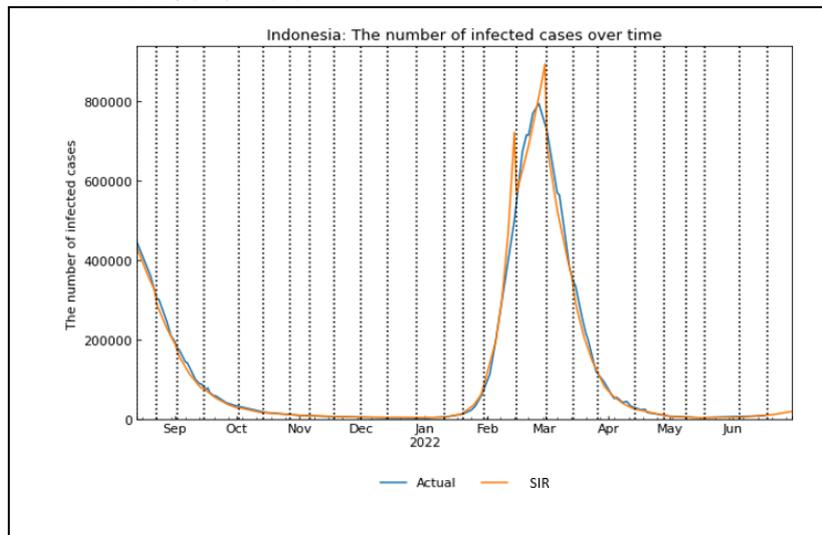
Metrics	SIR
MAE	51851.520
MSE	6646987632.895
MSLE	36.175
RMSE	71302.102
RMSLE	6.014
MAPE	0.394

#### 4.4 Simulation pandemic with SIR model

The simulation for the pandemic in Indonesia has several limitations, including:

- Scenario simulation using the SIR model to predict cases of the spread of COVID-19 in Indonesia
- The parameters used for the last simulation use the parameters from the last phase.
- The simulation is carried out with a time span of 30 days after May 30, 2022. It is necessary to limit the time range due to changes in parameters within a certain time so that it cannot be carried out with a long time span.

The simulation results as shown in Figure 8 are known after 30 days of infected cases, there will be 19540 cases.



**Figure 9** Simulation result with SIR model

#### 4.5 Lyapunov Analysis

The classic SIR model assumes the individuals recover with immunity. We can define  $x_1 = S/N$ ,  $x_2 = I/N$ , and  $x_3 = R/N$ , we can rewrite the SIR model into the form such as equations (5)

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} -\beta x_1 x_2 \\ \beta x_1 x_2 - \gamma x_2 \\ \gamma x_2 \end{bmatrix} \quad (5)$$

with  $0 \leq x_1 \leq 1$ ,  $0 \leq x_2 \leq 1$ ,  $0 \leq x_3 \leq 1$ , and  $x_1 + x_2 + x_3 = 1$ .

Since the first two equations do not depend on the third equation (constant population size), it is possible to focus on the first two equations as mentioned by Gui and Yong in [13] so the equation is simplified to

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -\beta x_1 x_2 \\ \beta x_1 x_2 - \gamma x_2 \end{bmatrix} \quad (6)$$

and the closed set  $\Gamma = \{(x_1, x_2) \in \mathfrak{R}_+^2: x_1 + x_2 \leq 1\}$

Equilibria are points where the states do not change with time, i.e.,

$$\begin{bmatrix} -\beta x_1 x_2 \\ \beta x_1 x_2 - \gamma x_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} \quad (7)$$

The epidemiological interpretation requires the solution of equations. (5) with an initial value of  $x_1 = 1$ , that is, all individuals are free of disease (healthy). This state is an equilibrium point,  $E_0 \Leftrightarrow [x_1 = 1, x_2 = 0]$ , usually named as disease free equilibrium point. Furthermore we show that the system have a continuum of equilibria which are solutions  $(x_{1\infty}, x_{2\infty})$  of  $x_{1\infty}x_{2\infty} = 0$ ,  $x_{2\infty}(\beta x_{1\infty} - \gamma) = 0$ , where  $x_{1\infty} = \lim_{t \rightarrow \infty} x_1(t)$  and  $x_{2\infty} = \lim_{t \rightarrow \infty} x_2(t)$ . There is a continuum of equilibria  $(x_{1\infty}, 0)$  with arbitrary  $x_{1\infty}$ ,  $0 \leq x_{1\infty} \leq 1$ , or in other word, the equilibria are non-isolated, Fraser, *et.al* in [14]

*Theorem* : The disease free equilibrium point,  $E_0$ , is stable if  $\mathfrak{R}_0 < 1$ .

*Proof* : If  $\mathfrak{R}_0 < 1$  the dominant eigenvalue is 0, so we conclude that the linearization method is inconclusive. To prove the stability of  $E_0$ , when  $\mathfrak{R}_0 < 1$ , we can define  $\xi_1 = x_1 + 1$ , such that the function (6) can be translated as shown in (8)

$$\begin{bmatrix} \dot{\xi}_1 \\ \dot{\xi}_2 \end{bmatrix} = \begin{bmatrix} -\beta(\xi_1 + 1)\xi_2 \\ \beta(\xi_1 + 1)\xi_2 - \gamma\xi_2 \end{bmatrix} \tag{8}$$

We consider candidate for the Lyapunov function such as:

$$V(\xi_1, \xi_2) = \frac{1}{2}(\xi_1 + 1 + \xi_2)^2 + \frac{1}{2}\xi_2^2 - \frac{1}{2} \tag{9}$$

The function in (9) is a globally positive definite. Evaluating the time derivative of  $V(\xi_1, \xi_2)$  along Eqs. (8), which is applied to the disease-free equilibrium point

$$\frac{dV}{dt} = (\xi_1 + 1 + \xi_2) \left( \frac{d\xi_1}{dt} + \frac{d\xi_2}{dt} \right) + \xi_2 \frac{d\xi_2}{dt} \tag{10}$$

$$\frac{dV}{dt} = (\xi_1 + 1) \left( \xi_2 - \frac{\gamma}{\beta} \right) \beta \xi_2 - \gamma \xi_2 - \gamma \xi_2^2 \tag{11}$$

Since  $0 \leq \xi_1 \leq 1$  and  $0 \leq \xi_2 \leq 1$ , the value of  $\xi_2 - \frac{\gamma}{\beta} < 0$  when  $\frac{1}{\mathfrak{R}_0} = \frac{\gamma}{\beta} > 1$ , such that  $\frac{dV}{dt} < 0$ . It is shown that  $\frac{dV}{dt}(\xi = 0) = 0$ , this implies that  $\frac{dV}{dt}(\xi)$  in (11) is a negative definite. Therefore, by Mahayana, et.al in [15], we may conclude that the disease-free equilibrium point  $E_0$  is stable when  $\mathfrak{R}_0 < 1$ .

## 5 Conclusion

The conclusions obtained from this research are.

- a) The SIR epidemiological model is a machine learning concept that can be used for simulation and analysis of cases of the spread of COVID-19 in Indonesia. Modeling is done by dividing the time of the pandemic in Indonesia into several phases with each spreading parameter. These parameters are contact rate, recovery rate and reproduction number.
- b) From the estimation results with MAPE value 0.394, it is found that the evaluation value is good compared to the actual data, this shows that the estimation are close to the actual data.
- c) Lyapunov's analysis also shows that when the reproduction number value is less than 1 ( $R_0 < 1$ ) it is said that the disease-free equilibrium point is stable.

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## **Courier Rating Viability on Online Food Delivery Platform: A Case on GoFood Users in Bandung**

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**Abstract.** Rising competition and growing consumer awareness in the online food delivery (OFD) market, led many businesses, including GoFood, to rely on customer rating surveys to get feedback on how they are performing. This paper takes an exploratory mixed methods approach through interviews and online questionnaires to explore reasons why users give and not give ratings when the rating is invisible to other users; to determine whether Gojek should retain its rating systems; and to propose recommendations to ensure that it keeps its users satisfied. Findings show that users give ratings to express disappointing or amazing experiences or show appreciation or empathy towards the driver, were triggered by reminders, or affected by personal circumstances. Alternatively, users do not give ratings due to the absence of a notable experience or benefit, no spare time, forgetfulness, laziness, unwillingness to express disappointing experience. Consequently, GoFood's rating system should be retained with limitations and purposes as the ratings obtained is not a true representation of the driver's actual service performance. Gojek can also attempt to improve its chatbot features, integrate its split bill features with GoFood or introduce the anonymous rater feature. However, considering the complexity of Gojek's operations, further studies must be conducted.

**Keywords:** *online food delivery; service quality; satisfaction; ratings; survey; drivers.*

### **1 Introduction**

With approximately 201 million internet users in 2021, Indonesians can now access a wide range of services over the Internet (Nurhayati-Wolff in [1]). One of the services that is now widely accessible is the online food delivery (OFD) services, which has greatly benefited the food and beverages (F&B) industry. In 2021, Indonesia managed to record a gross merchandise value (GMV), that is, the total value of goods or services transacted on the OFD platforms, of \$4.6 billion with a growth rate of 24.3% from the previous year, making it the largest market for OFD in Southeast Asia (Snapchart in [2]). Besides that, the nation's OFD industry is also predicted to continue growing at a rate of 11.5% each year until 2024 (Aprilianti and Amanta in [3]).

Gojek, established in 2010, is known as Indonesia's first decacorn company and the world's largest Super App, integrating more than twenty products and services in a single platform, with three separate applications for consumer, driver, and merchants. GoFood, which debuted in 2015, is an online meal delivery service of Gojek that acts as a platform connecting users to a variety of eateries while also handling the delivery logistics (Aprilianti and Amanta in [3]). As of 2022, GoFood became the largest online food delivery platform in Indonesia and Southeast Asia, as well as the third largest in the globe, with over 550,000 registered merchant partners on its platform and a presence in 74 cities across the country with a total menu count of over 16 million items (IDN Financials in [4]). However, OFD companies are now constantly pushed to meet the increasing requirements and expectations of their customers better than their competitors as the degree of competition in the OFD business rises, especially given that customer tolerance for poor service is also decreasing as consumer awareness of the OFD market improves over time (Ghobadian in [5]). For that reason, OFD companies, like GoFood, must realize the importance of always providing high-quality services to users in order to please and maintain them, so that they can retain their market leading position (Ghobadian in [5]). In fact, as simple as late deliveries can be harmful to the business, as delays of only 10 minutes can result in approximately three fewer orders per customer in the subsequent months (Mao, *et.al* in [6]). Thus, many businesses frequently rely on customer rating surveys to get feedback on how their personnels are performing in order to identify and fix any service deficiencies. Unfortunately, because rating surveys are prone to numerous forms of biases, verifying the trustworthiness of such surveys remains a crucial and difficult challenge (Yang, *et.al.* in [7] and Peterson and Wilson in [8]). Hence, the aims of this study are to explore why consumers decide to give or not give ratings to drivers in order to determine whether Gojek should retain its current rating system. A number of recommendations will also be proposed to ensure that Gojek continues to keep its users satisfied.

## 2 Literature Review

### 2.1 Online Food Delivery (OFD) Industry in Indonesia

The emergence and success of OFD platforms, which enable consumers to browse and order food listed on the application and have it delivered to them, was strongly facilitated from better internet connectivity and the high adoption of digital technologies in the country (Marsudi, *et.al* in [9] and Aprilianti and Amanta in [3]). In Indonesia where there is a strong culture of being served, added with the increasing need for convenience and time savings orientation, which created a habit of buying prepared food from outside, many OFD providers, like GoFood, have then commercialized people's willingness to spend money for such reasons (CNN Indonesia in [10]). Also, as disposable income grows, electronic

payments become more trustworthy, and the number of OFD providers and the size of their delivery network expands, consumers are also increasingly embracing online services (Li, *et.al* in [11]). By 2021, 69% of Indonesians purchase meal delivery online at least once a week, which pushed the growth of the OFD industry in Indonesia even further (Liew in [12]).

## **2.2 Service Quality as a Sustainable Competitive Advantage**

Today's service firms face a variety of obstacles as a result of increasing competition, rising consumer expectations, and customers' subsequent requests as service improves (Kandampully in [13]). Fulfilling client expectations will not only give satisfaction, but it will also be a strong driver of repurchase intention and aids in establishing customer loyalty, lowering customer loss rates and increasing retention rates as well as the spread of positive word of mouth (Fida, *et.al* in [14]; Quddus and Hudrasyah in [15]; Pollack in [16]). Thus, as a good service quality is expected to develop customer satisfaction and make companies more competitive in the market, the development of a company is greatly dependent on how effectively they sustain their customers through service excellence (Slack and Singh in [17]; Suciptawati, *et.al* in [18]). This is especially true to OFD providers that are primarily concerned with providing customers with food delivery services via delivery men who will be in direct contact with users, because all service quality factors will influence the customer's decision whether or not to continue to purchasing meals from the OFD company in the future, not to mention that consumers are also becoming increasingly critical of the quality of service they receive (Kandampully in [13]; Saad in [19]; Cheng, *et.al* in [20]).

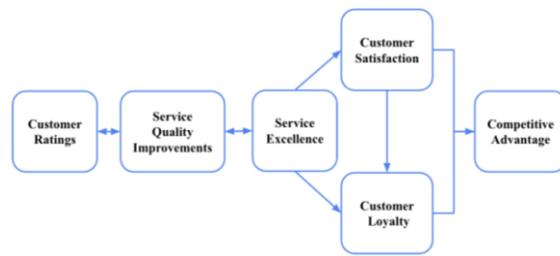
## **2.3 Customer Satisfaction Rating Surveys**

Over the last decade, customer rating survey that measures customer satisfaction have become commonly utilized in many industries as a means to gather customer feedback, manage for service quality and measure corporate performance, with the idea that these metrics are predictors of customer loyalty, profit, market share, and growth (Hurley and Estelami in [21]; Han and Anderson in [22]). Users' numeric ratings, usually using a 5-point Likert scale ranging from "very dissatisfied" to "very satisfied", have become one of the most popular sources of influence among Internet users and are regarded as credible information; in fact, they are now the second most credible source of information after recommendations from friends and family (Bouzas, *et.al* in [23]). With the available information, consumers will also be more willing to spend extra for products with an "excellent" rating of 5, as opposed to products with a "good" rating of 4 (Bouzas, *et.al* in [23]). The value placed on service quality and customer satisfaction surveys has also grown to the point that some organizations,

including OFD providers, use these measures to determine bonuses and performance evaluations (Hauser, *et.al* in [24]).

**2.3.1 Limitations of Customer Rating Surveys**

Despite the popularity of customer ratings, understanding customer evaluations is a difficult task since they are influenced by a variety of factors, including how the user perceives such quality in relation to their expectations, which are influenced in turn by their prior expectations and experiences with services on other applications (Hu, *et.al* in [25]). Previous research has also found that customer ratings may be systematically biased for a number of reasons, which prevented the generalization of the results. Firstly, acquisition-led selection bias caused ratings to be more positive than the ground truth, because they come from purchasers who are likely to be positively predisposed; and secondly, due to under-reporting bias, in which consumers who are extremely satisfied or dissatisfied are more likely to report a rating. This is a classic example of positivity bias in which positive input is more likely to dominate the entire rating system (Park, *et.al* in [26]). This is also supported by Peterson and Wilson in [27] that "virtually all self-reports of customer satisfaction possess a distribution in which the majority of the responses indicate that customers are satisfied and the distribution itself is negatively skewed". Moreover, the majority of customers also do not answer rating surveys, making the results less representative (Park, *et.al* in [26]). This skewness in the satisfaction rating distribution jeopardizes analysis and interpretation, because it makes it look that the majority of consumers are satisfied, but customer loyalty may not be strong even among these seemingly satisfied customers (Kordupleski, *et.al* in [28]). As a result, if a company is not attentive, it can become a source of erroneous direction, poor decisions and money wasted (Parvatiyar and Shainesh in [29]).



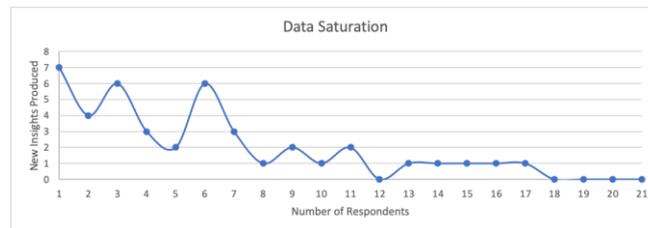
**Figure 1.** Conceptual Framework.

Figure 1 suggests that the customer ratings system will guide OFD providers to improve their service quality to achieve service excellence that satisfies and keeps customers loyal to their business and eventually achieving competitive

advantage. However, little is known about what motivates people to give ratings to service personnel when such ratings will not be visible to other users; hence, the aim of this study is to find out why users give and not give ratings for drivers, considering that such ratings will not be visible to other GoFood users.

### 3 Methodology

As the research questions have not been previously studied, an exploratory sequential mixed research approach will be adopted, where qualitative data is gathered and processed first, and the obtained themes are then used to guide the development of a quantitative instrument to further investigate the research problem (Edmonds and Kennedy in [30]). Here, primary qualitative data is obtained by interviewing random GoFood users in Bandung to explore reasons why they give or not give ratings to drivers. The interview stopped at 21 users as data saturation has been reached and there is no longer new information obtained, as shown in Figure 2. The qualitative data is then interpreted using an inductive thematic analysis method following the steps of Braun and Clarke in [31], which involve familiarizing with data, generating initial codes, searching for themes, reviewing themes and defining and naming themes. Applying the inductive approach to analysis, the codes produced will be solely reflective of the content of the data to represent meaning as communicated by the participants and free from any preconceived theory or conceptual framework.



**Figure 2.** Data Saturation.

Subsequently, the obtained themes are used to guide the development of a quantitative instrument to further investigate the research problem (Edmonds and Kennedy in [30]). The online questionnaire obtained responses from 209 random GoFood users in Bandung that had made at least 1 order in the previous week, with a margin of error of around 6.27% with a confidence level of 95%. The results were then analyzed descriptively, including cross tabulations of data, using MS-Excel and SPSS statistical programs.

#### 3.1. Validity & Reliability Testing

The validity test (Pearson's bivariate correlations) and reliability test (Cronbach's Alpha) were undertaken on the 7 Likert-scale questions, for which the results

showed that all the items are valid and reliable, as shown in Table 1, because the obtained correlation coefficients are higher than the critical values with a degree of freedom of 167 and 181 with a two-sided tail and a standard alpha value of 0.05; and because the Cronbach Alpha values are higher than the standard acceptable value of 0.7. The questionnaire also underwent pilot testing to determine whether the questions are valid on its face, which resulted in the rewording of some question items for added clarity.

**Table 1.** Validity & Reliability Statistics

Variable	Items	P-value (two-tailed)	Correlation Coefficient	Critical Value	Remark	Cronbach's Alpha	Remark
Empathy (N=169)	Q4: I gave 5 star ratings, because I feel pity towards the drivers.	0.000	0.914	0.151	Valid	0.938	Reliable
	Q5: I gave 5 star ratings, because I want to help drivers with the continuity of orders.	0.000	0.964	0.151	Valid		
	Q6: I gave 5 star ratings, because I knew drivers rely on ratings.	0.000	0.954	0.151	Valid		
Disturbed by Pop-up Rating Box (N=183)	Q7: I gave ratings, because I merely want to get rid of the pop-up rating box.	0.000	0.987	0.145	Valid	0.971	Reliable
	Q8: I gave ratings, because I feel disturbed by the pop-up rating box.	0.000	0.986	0.145	Valid		
Feel Forced (N=169)	Q9: I wanted to give a low rating, but still give 5-star ratings, because I feared angering the driver.	0.000	0.988	0.151	Valid	0.977	Reliable
	Q10: I wanted to give a low rating, but still give 5-star ratings, because I feared offending the driver.	0.000	0.989	0.151	Valid		

## 4 Results & Discussion

### 4.1 Qualitative Findings

After conducting inductive thematic analysis on qualitative data acquired from interviewing 21 GoFood users, insights were successfully obtained about why customers decide to give or not give ratings for the driver’s service after completing an order with GoFood. There are a total of 12 themes on why users decide to give or not give ratings to GoFood drivers, shown in Table 2, which includes the sub-themes and codes that are relevant for each theme. For example, those that give ratings due to triggers from reminders include those that were notified by the in-app pop-up rating box and those that were asked by drivers to leave ratings.

Based on qualitative findings, the three most striking reasons for giving ratings to drivers are due to feelings of empathy, fear of drivers as well as due to the pop-up rating box. Hence, the questionnaire was designed to revolve around the three items above.

**Table 2.** Themes on Why Users Give & Give No Ratings

Reasons Why Users Give & Give No Ratings			
6 Themes on Why Users Give Ratings	Sub-Themes/Codes	6 Themes on Why Users Give No Ratings	Sub-Themes/Codes
<b>Express Disappointing Experience</b>	<ol style="list-style-type: none"> <li>Inaccurate order</li> <li>Driver struggles to find the delivery location</li> <li>Driver is rude</li> <li>Want to give negative feedback</li> <li>Want to express anger</li> </ol>	<b>No Notable Experience</b>	
<b>Express Amazing Experience</b>	<ol style="list-style-type: none"> <li>Want to give tips</li> <li>Want to give positive feedback</li> <li>Driver is kind                             <ol style="list-style-type: none"> <li>Driver apologizes when making an mistake</li> <li>Driver is honest about their mistake</li> <li>Driver is willing to help when there is an issue</li> </ol> </li> <li>Driver is helpful                             <ol style="list-style-type: none"> <li>Driver fulfills additional requests</li> <li>Driver does not trouble the customers</li> <li>Driver is willing to help when there is an issue</li> </ol> </li> </ol>	<b>No Spare Time</b>	<ol style="list-style-type: none"> <li>Too many ratings to give</li> <li>Busy</li> </ol>
<b>Triggered by Reminders</b>	<ol style="list-style-type: none"> <li>Want to clear the pop-up rating box.</li> <li>Requested by driver</li> </ol>	<b>Forgetfulness</b>	<ol style="list-style-type: none"> <li>Usually puts away phone after finishing the order</li> <li>Rating is no longer compulsory</li> </ol>
<b>Personal Circumstances</b>	<ol style="list-style-type: none"> <li>Spare time to give ratings</li> <li>Remember to give ratings</li> <li>Want to give tips</li> <li>Still on the application</li> <li>Habit of giving ratings</li> </ol>	<b>Laziness</b>	<ol style="list-style-type: none"> <li>Belief hat rating is not going to affect the driver</li> <li>Too many ratings to give</li> <li>Away from phone</li> <li>Closed the application after finishing the order</li> </ol>
<b>Appreciation Towards the Driver</b>	<ol style="list-style-type: none"> <li>Driver is helpful</li> </ol>	<b>Unwilling to Express Disappointing Experience</b>	<ol style="list-style-type: none"> <li>Feel forced to give rating by driver</li> <li>Fear of driver confrontation</li> <li>Empathy towards the driver                             <ol style="list-style-type: none"> <li>Prevent drivers from getting into trouble</li> <li>Believes rating to be important for driver</li> </ol> </li> </ol>
<b>Empathy Towards the Drivers</b>	<ol style="list-style-type: none"> <li>Driver delivers during rain</li> <li>Driver delivers from far away</li> <li>Believes rating to be important for drivers</li> <li>Prevent drivers from getting into troubles</li> <li>Requested by the driver</li> </ol>	<b>No Benefit for Me</b>	

### 4.2 Quantitative Findings

An online questionnaire with 17 questions was distributed and responded to by 209 GoFood users in Bandung. Figure 3 clearly illustrates that the customer rating results are negatively skewed with 12.4% being non-raters, 6.7% give between 1 to 4 stars, yet a striking 80.9% stated to have given 5-star ratings, which was mostly contributed by those that ordered GoFood between 1 to 3 times last week. Nonetheless, correlation is not established between the two, so frequency of order will not affect what star ratings will be given to drivers.

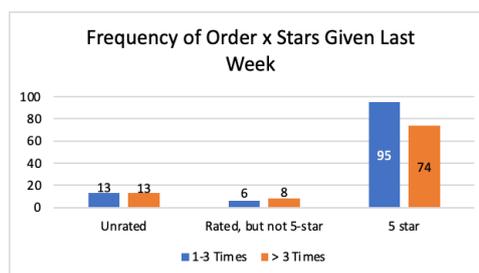


Figure 3. Frequency of Order Against Given Ratings

### 4.2.1 Reasons Why Users Give Ratings

Amongst 169 5-star raters last week, at least 79.3% agreed or strongly agreed to have given such high ratings due to empathy towards drivers, either because they knew ratings were relied on by drivers or to ensure driver’s continuity of orders or to show pity to drivers. At least 46.1% also agreed or strongly agreed to have given 5-star ratings, when they honestly wanted to give less than 5-star ratings, either due to fear of angering the driver or offending them. The result is shown in Figure 4. These findings are fundamental insights to the company, because it shows that the ratings obtained by GoFood drivers may not be a true representation of driver’s actual performance, because users may give 5-star ratings, because they felt forced to do so or felt empathetic towards drivers. Furthermore, out of 183 respondents that gave ratings last week, at least 38.3% gave ratings either to get rid of the pop-up rating box or due to it being disturbing, regardless of how often they order from GoFood. This may also impact the rating’s accuracy as users may randomly pick a star without much consideration of the driver’s actual performance.

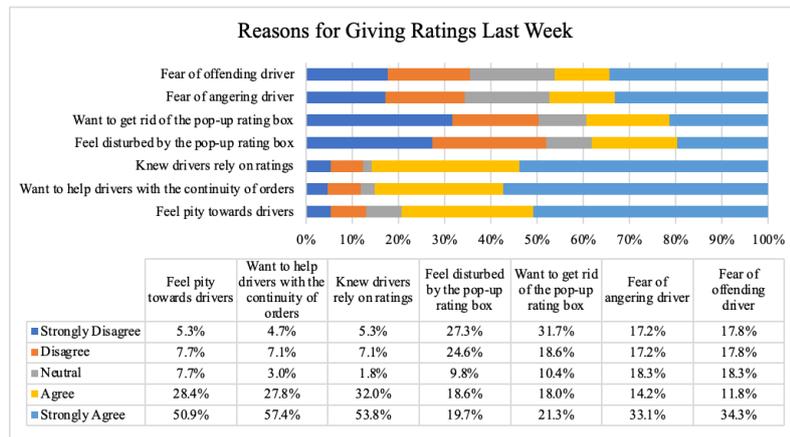


Figure 4. Reasons Why Users Give Ratings

### 4.2.2 Reasons Why Users Give No Ratings

The most frequently mentioned reasons for not participating in giving ratings amongst the 26 non-raters, as shown in Figure 5, include forgetfulness (64.5%), laziness (50%), and saw no benefit for them to do so (30.8%). Other reasons include the unwillingness to express their disappointing experiences (26.9%), no notable experience (23.1%) and no time (11.5%). Despite forgetfulness and laziness frequently mentioned sequentially during the interview stage with users, so those that were lazy cannot generally translate to forgetting about giving ratings as no significant correlation was established. Furthermore, those that did

not participate due to the absence of benefits or notable experience also will not generally translate to forgetfulness and laziness, as there is no correlation between these reasons. Other than that, those that are unwilling to express disappointing experiences are also uncorrelated to those that did not participate due to the lack of benefits for raters. Hence, the separation of these non-participation reasons are valid.

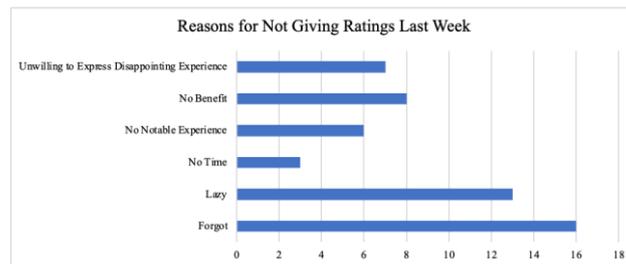


Figure 5. Frequency of Order Against Given Ratings

#### 4.2.3 Features Users Want GoFood to Introduce

Amongst the 209 respondents, findings in Figure 6 show that: 1) 93.3% wants to have a 24/7 live chat feature to report problems during ordering, regardless of how often they ordered last week; 2) 89% wants to be served by a driver rated 4.8 and above, regardless of their order frequency and the stars given last week; 3) 88.5% wants to rate anonymously, regardless of the ratings given last week and even to those that did not give 5-star ratings due to feeling forced; 4) 88% wants to give tips to drivers, regardless of their order frequency and the stars given last week; 5) 67% wants to have a precise split bill feature, especially those that buys food often with friends using one phone; and 6) 54.5% wants to be served by a subscription driver, regardless of how frequent these users purchase on Gojek’s platform.

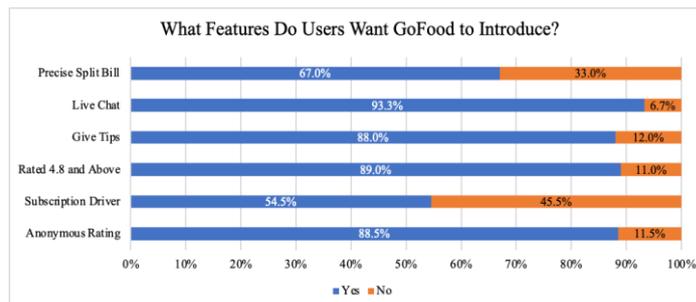


Figure 6. Frequency of Order Against Given Ratings

## 5 Conclusion

In summary, consumers give ratings for a number of reasons, including 1) to express disappointing experience; 2) to express amazing experience; 3) being triggered by reminders from pop-up rating box or from the driver; 4) personal circumstances, like wanting to give tips; 5) to show appreciation; and lastly but most importantly, 6) to show empathy towards the drivers. Alternatively, consumers do not give ratings, due to 1) lack of notable experience; 2) no spare time; 3) forgetfulness; 4) laziness; 5) unwillingness to express disappointing experience; and 6) absence of benefit for them.

### 5.1 Retain Rating System With Limitations & Purpose

Gojek should continue using its star rating systems, but it should not blindly trust the number of 5-star ratings that it has collected. Based on 209 surveyed respondents, 80.9% gave 5-star ratings, yet at least 79.3% gave such high ratings due to empathy, either due to the knowledge that ratings were relied on by drivers, or to ensure the continuity of orders or to show pity to drivers. These figures indicate that the rating system of GoFood may not be an accurate measure of service excellence as most people chose to give 5-star ratings, which should have meant “Excellent service”, based on empathy towards the drivers that served them, rather than based on how the driver actually performed when serving them. Furthermore, it is not only empathy that can affect users into giving ratings without considering the actual performance of the drivers. In fact, raters may also feel forced, as at least 46.1% of those that gave 5-star ratings gave such high ratings, when they honestly wanted to give less than 5-star ratings, due to fear of upsetting or offending the driver. Moreover, although it is found that the majority of the sampled respondents gave ratings not because of the pop-up rating box, there are still at least 38.3% that gave ratings to get rid of the pop-up rating box or because it is disturbing. Overall, these factors will greatly impact the accuracy of ratings obtained by drivers as obtaining approximately 80% 5-star ratings may not translate to 80% fully satisfied customers, so Gojek will need to conduct a separate and periodic customer satisfaction survey if it wants to obtain a more accurate measure of its service quality.

However, the rating system cannot be eliminated in its entirety from the system for a number of reasons. Firstly, users still rely on ratings to express their disappointing experience, and collecting such negative feedback will be most convenient using a star-rating system as users will be less likely to report problems if they have to go the extra mile to call or send an email. Secondly, the rating system can be maintained to continue encouraging drivers to deliver excellent service, especially because drivers that deliver bad quality service will eventually receive less orders. Moreover, considering that 89% of the total surveyed respondents want to be served by a high-quality driver, it is clear that

the rating system is important to users, because they expect excellent service from drivers, which can only be driven by the rating system. Hence, eliminating the rating system may have a negative impact consumer's level of trust on drivers, as they might start to think that drivers will no longer focus on delivering excellent services as ratings are no longer important to drivers and that the level of service will eventually deteriorate.

## **5.2 Introduce Highly Feasible & Potential Features**

Based on findings about the features that are highly desired by users, Gojek may also introduce highly feasible and potential features to continue satisfying users.

### **5.2.1 Improve Its Chatbot Feature**

The most important and feasible effort that Gojek can implement to keep its customers satisfied is by improving its chatbot feature, because the chatbot feature is currently not fully utilized to its potential and not easily accessible by users on the platform. Gojek should improve its chatbot feature to help users deal with unique and complex issues, like changing an ongoing order, rather than merely redirecting users to a specific page on the application. This is important as a chatbot is also a cost effective customer service tool that can improve relationships with customers and retain them, which is what Gojek aims to do. Most importantly, this recommendation is very feasible to be implemented as soon as possible, because the chatbot already exists and just requires additional enhancement efforts into its AI technology. As a technology company, Gojek has the capability to create a smarter chatbot compared to other companies.

### **5.2.2 Integrate Split Bill Feature With GoFood**

Gojek can also integrate its split bill feature with its food services, considering that a lot of people often purchase food with friends using the same phone, so this feature will not only provide added convenience that can satisfy users, but can also encourage users to use GoFood instead of other OFD platforms due to the simplicity of splitting and making payment among friends that are processed conveniently via the digital payment gateway, GoPay. Based on this understanding, the feature will be beneficial for GoFood as it will increase the number of transacting users as well as improving its gross merchandise value. Moreover, this recommendation is also feasible to be implemented soon as the feature already exists in the platform and will merely require linking the split bill feature with GoFood's ordering system. This will also require less budget compared to introducing an entirely new feature for users. Once this is a success, the split bill feature can also be linked to Gojek's transport services like GoCar and GoRide.

### **5.2.3 Integrate Split Bill Feature With GoFood**

Gojek can also introduce an anonymous rater button, so users are more willing to give feedback, including bad reviews, about the driver's performance without fear of the driver being offended or angry. This feedback will be very beneficial and insightful for the company as it allows the company to identify any service deficiencies and make improvements accordingly. This way, Gojek will be able to monitor its service quality level better, compared to when users opt out of the rating system due to fear. This is also a feasible feature that Gojek can implement quickly and without heavy budget allocation, yet the benefit that comes from obtaining that feedback will be valuable.

### **5.2.4 Additional Alternatives**

Other initiatives, like introducing an option to connect with the same driver based on the rating system or the option to give tips only, can also be implemented by the company, but are not emphasized as top priorities, due to doubts about their potential in providing benefits to the company. It can be assumed that requesting ratings before allowing users to choose the amount of tips to give only brings forth a slight inconvenience to users. Other than that, connecting with the same driver based on the rating system can build trust between the user and the driver, but will not bring financial benefits to the company, because the majority of GoFood drivers are already doing an excellent job. Hence, these recommendations may not provide the most optimal benefits, unless Gojek undergoes additional studies to disprove the above hypotheses.

## **6 Implementation Plan**

As the current research and finding is only focused on Bandung users and that the number of surveyed respondents are considered small, it is necessary that Gojek undergo another stage of studies, supervised with experts in the field, in order to make sure that the findings are consistent, accurate and worth considering before making decisions based on it. Gojek should continue exploring and observing raters behavior in order to improve the accuracy and value of driver ratings.

## **7 Acknowledgment**

Appreciations to the Institut Teknologi Bandung's School of Business and Management and the 2nd ITB Graduate School Conference for supporting this research.

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## Fatigue Behavior and Analysis Modeling of Three-Layered Strips of 316L Stainless Steel-PVDF-4130 Steel for Flexible Pipe Material Development: Basic Methodology Review

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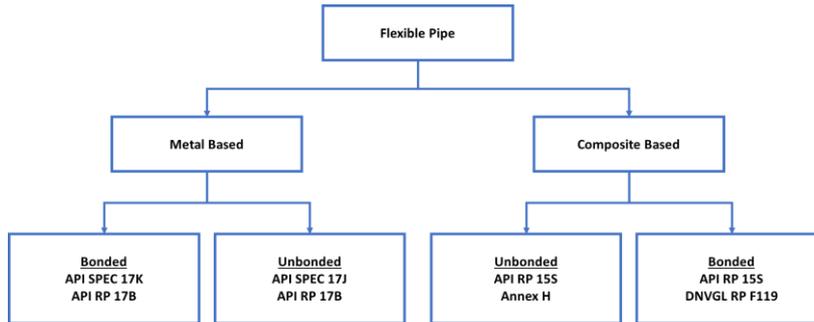
**Abstract.** Flexible pipes required for deepwater oil and gas exploitation that will be installed have many challenges from operation conditions and environment. Indonesian deep-water potential to explore for national energy resources. In deepwater application flexible pipe face the force from internal and external in terms of damage such as bird caging, deformation of the armor layer, erosion on the surface of the carcass, damage to the polymer layer, and other forms of defects in flexible pipes. Material selection for research scope and testing using carcass (316L stainless steel)-polyvinylidene fluoride (PVDF)-4130 steel. 3 (three) layered of unbonded system material for simulation in finite element analysis (FEA) software ABAQUS. S-N Curve and estimated fatigue life analysis calculation in Mathcad.

**Keywords:** *fatigue analysis; FEA; flexible pipe; deepwater; carcass.*

### 1 Introduction

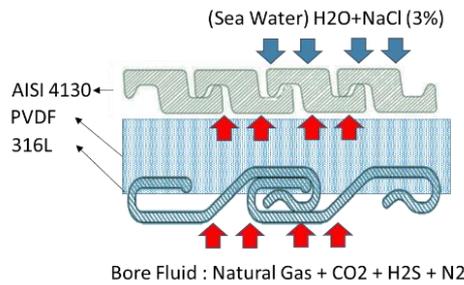
Flexible pipe system with the rapid development of pipeline engineering technology, flexible pipes have been widely used in the oil and gas industry, both onshore and offshore. For example, from Bai's in [1] its pipe can be used as any type of riser, jumper line, flow line, export line, loading/unloading pipe, umbilical's, kill and choke line. They are considered to be an efficient solution in terms of technical as well as economic performance due to their easy and fast laying procedure, durability, and recoverability. Based on the type of material, flexible pipe is divided into two categories shown in Figure 1, namely metal based and composite based, also divided into two class of un-bonded and bonded technology which are covered by applicable codes and standards such as API RP 15 and 17 series.

This paper as preliminary research scope and related field data base analysis for screening applicable methodology of numerical analysis and simulation. the specimen strips form by three-layered prototype of metal based flexible pipe material referred to specification for unbonded type illustrated concept shown in Figure 2. From inside to outside layer, first layer which it is contact to fluids is corrosion resistance alloy (CRA) material for performed during fluids transport with assumed any corrosive gas impurities in oil and gas production such as CO<sub>2</sub>, H<sub>2</sub>S, H<sub>2</sub>O and also solid particle potentially.



**Figure 1** Flexible Pipe Classification [1].

Polymer layer has function for protecting the annulus of CRA material from gas permeation from internal bore fluid flow to armor steel layer. Its layer requirement and specification based on API 17J, 2016: Extruded Material, Minimum thickness 1 mm, Minimum diameter 40 mm, Design range temperature, Fluids permeability minimum for CH<sub>4</sub>, CO<sub>2</sub>, H<sub>2</sub>S, Methanol, H<sub>2</sub>O. ISO 2556, Blistering resistance based on API 17 TR1.



**Figure 2** Three-Layered 316L-PVDF-4130 Steel of Typical Flexible Pipe

For compare polymer layer properties for flexible pipe shown in Table 1 below. PVDF in have higher bore maximum operating temperature and young modulus is 1380 MPa.

**Table 1** Polymer Mechanical Properties Data A [4], B [5], C [6] D [7][8]

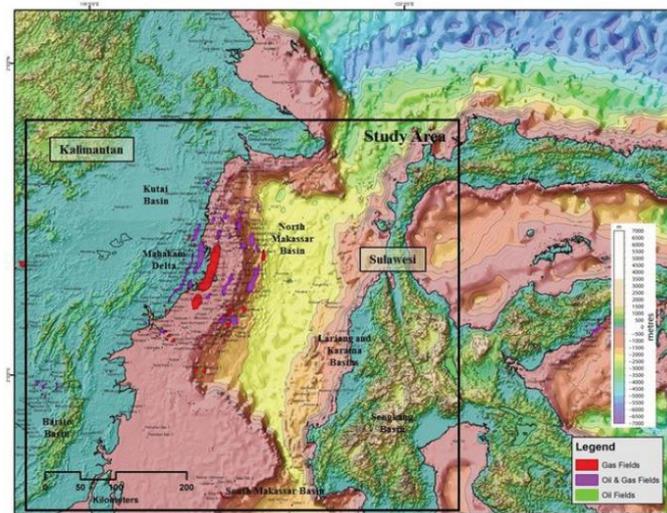
Polymer Properties	HDPE	XLPE	PA-11	PVDF
Fracture Tension (MPa)	27-29	28-32		
Yield Strength/Tensile (MPa)	YS 19	YS 26	UTS 40 (D)	
Young Modulus (MPa)	1002	1039 (A)	1220 ( $\pm 25$ ) (B)	1380 (C)
Bore Max. Temp. ( $^{\circ}$ C)	65	90	100	130

Load characteristic polymeric material in flexible pipe, from Davidson's *et. al.* in [3] using category load as in manufacture, installation (topside & subsea) and normal/abnormal operation. The testing temperature at 20 $^{\circ}$ C. Safety margin for PVDF calculate by maximum strain minus required strain multiply by 100 and divide by required strain. For comparison of applicable polymeric material shown in Figure 3 below.

HDPE	XLPE	PA	PVDF
<ul style="list-style-type: none"> <li>• High density polyethylene</li> <li>• Low design temp. &amp; press.</li> </ul>	<ul style="list-style-type: none"> <li>• Crosslinked polyethylene</li> <li>• Medium design temp. &amp; Low design press.</li> </ul>	<ul style="list-style-type: none"> <li>• Polyamides</li> <li>• Low design temp. &amp; high design press.</li> </ul>	<ul style="list-style-type: none"> <li>• Polyvinylidene fluoride</li> <li>• High design temp. &amp; press.</li> </ul>

**Figure 3** Polymer Comparative of Basic Properties [2].

Shuttle Radar Topography Mission (SRTM) map plotted in Google Earth showing the Sundaland Craton out-lined by dashed blue line, The study area is in the southeastern end of the craton as described in [9].



**Figure 4** Bathymetry of Study Area in Indonesia Deepwater Field [9].

Bathymetry condition in study area show yellow color is the deepest area of the strait shown in Figure 4. Exploitation area shown in purple and red zone in map. In this area oil and gas exploitation and transport using any kind of platform type. Based on data shown in Figure 5 the depth of those area operated by three type of floating production facility, there are floating production offloading unit (FPSO), floating production unit (FPU) and tendon leg platform (TLP). Two of Indonesia project for deepwater (DW) exploitation was area DW1 deepwater development with -975 to -1800 meters, DW2 -900 meters, DW3 deepwater development with -100 to -460 meters and the new area for next development area DW4 is -800 meters depth [10] In DW1 gas pipeline use 16 and 20-inch diameter and 8-inch for condensate, In DW3 field export gas pipeline use 14-inch diameter in [11].



**Figure 5** Water Depth in Several Indonesia Deep Water Fields [12].

Data gathering for environment condition shown water depth was -100 meter and other shown in Table 2 below.

**Table 2** Sea Water Environment Data [13]

Parameter	Value	Unit
Water depth	(-100)	M
Gas flow velocity	1	m/s
Frequency	30.5	Hz/(m/s)

Bore fluids gas chromatography sample for simulation range from 79.3 bar a to 101.3 bar a, 45 °C and maximum flow 241.5 MMscfd of gas, for data detail shown in **Error! Not a valid bookmark self-reference.**

**Table 3** Fluids and Operation Data [13]

No	Flow (MMscfd)	Pressure (bar a)	Temp. (deg C)
1	241.5	101.3	45
2	219.5	97.4	45
3	75.0	79.3	45

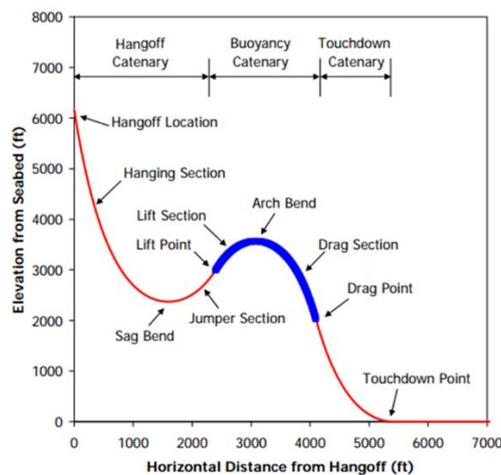
Gas composition sample for this study and material selection consideration. In Table 4 bore representative fluid is methane with 97.2338 % mole with impurities to consider carbon dioxide 1.1447 % mole and water 0.0249 % mole. Based on methane content over from 85%, its bore fluid category is in dry gas condition. In offshore design based on Norsok-M501/M-506 typically corrosion allowance for carbon steel approximately from 1 to 3 mm.

**Table 4** Gas Composition [13].

No	Composition	% Mole	No	Composition	% Mole
1	C1	97.2338	11	nC8	0.0022
2	C2	0.7082	12	nC9	0.0007
3	C3	0.4168	13	nC10	0.0002
4	iC4	0.1010	14	C7*	0.0294
5	nC4	0.1310	15	C8*	0.0100
6	iC5	0.0588	16	C9*	0.0011
7	nC5	0.0443	17	C10*	0.0003
8	C6*	0.0430	18	H2O	0.0249
9	nC6	0.0027	19	N2	0.0400
10	nC7	0.0069	20	CO2	1.1447

## 2 General Analysis and Modeling

Flexible pipe application in deepwater environment have a configuration type such as simple catenary, lazy wave, pliant wave, step wave, step S and lazy S. Lazy wave catenary riser configuration as shown in Figure 6. The position of critical point from flexible pipe configuration at hangoff location, touchdown point, and any bending condition such in Sag bend, Arch bend, drag section and also at touchdown point bend.



**Figure 6** Lazy-wave catenary riser and critical position in riser [16].

Internal condition in straight and curved pipe potentially have flow induced pulsation (FLIP). From Cabrera's in [14] and Chatjigeorgiou's in [15] riser in bend or straight condition assumed as beam cross section to figure different effect in bend and straight pipe by the forces and moments in flexible pipe section.

Environment condition based on sample measuring from flexible riser structure in study field have value of Force (N) to Frequency (Hz) in three orientation FZ ( $\Delta$ ), FY( $\square$ ), FX ( $\circ$ ). The force value and frequency for FZ ( $\Delta$ ) and FY( $\square$ ) shown in Figure 7 have similarity level, the highest force 52000 N in 100 Hz. For orientation FX ( $\circ$ ) have lowest for or in negative direction 200 Hz with force -12000 N. In scope of analysis and simulation the force and frequency data required for simulation input parameter to give bending force to specimen in FEA model. This data gives 3 orientations of bending effect to specimen in FEA model.

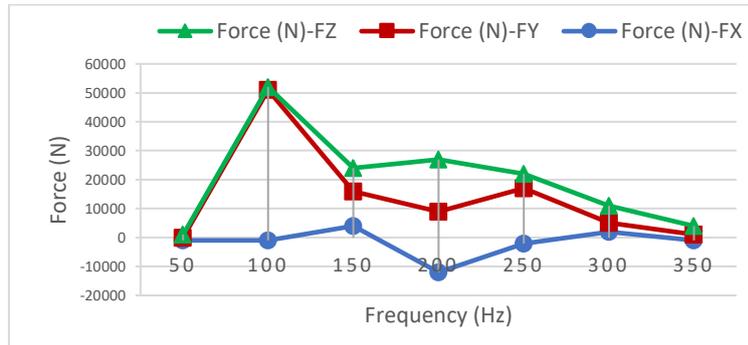


Figure 7 Applied Force and Frequency in sample deepwater field.

Environment condition based on sample measuring from flexible riser structure in study field have value of Moment (Nm) to Frequency (Hz) correlation to moment orientation of MZ ( $\Delta$ ), MY( $\square$ ) and MX ( $\circ$ ). The highest moment in orientation MZ ( $\Delta$ ) and frequency 250 Hz is 8300 N. In MY( $\square$ ) direction moment have value 3000 N, and in MX ( $\circ$ ) have highest negative value -4000 N and frequency 100 Hz as shown in Figure 8 below.

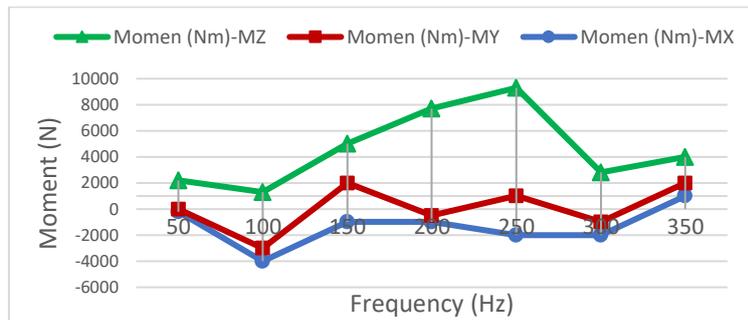
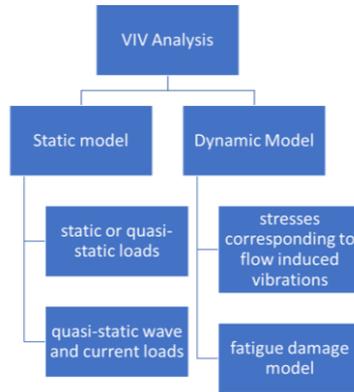


Figure 8 Applied Moment and Frequency in sample deepwater field

### 3 Fatigue Life Calculation

Fatigue calculation for tubular geometry like flexible pipe in deepwater application affected by hydrodynamic condition from seawater environment. Parameter for calculation vortex induced vibration to flexible pipe is reduced velocity of wave and current, natural frequency of span, and total outside diameter of flexible pipe. Bai's in [17] using chart shown in Figure 9 and formula shown in Eq. (1) below.



**Figure 9** Hydrodynamic effect in VIV analysis [17].

Where,  $V_R$  is reduction velocity parameter,  $U_c$  is current velocity normal to pipe,  $U_w$  is wave velocity normal to pipe,  $f_0$  is natural frequency of the span for given vibration mode, and  $D$  is total outside diameter of the pipe including coating.

$$V_R = \frac{U_c + U_w}{f_0 \cdot D} \tag{1}$$

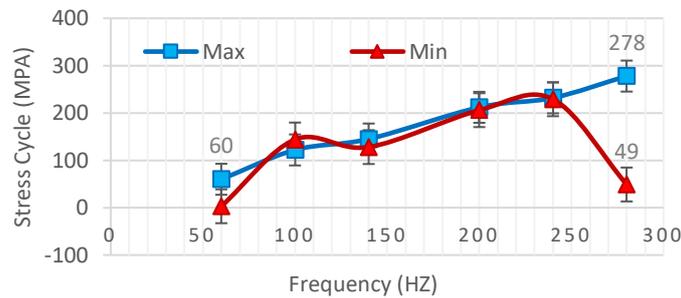
$$m_e = m_{str} + m_c + m_a + m_{con} \tag{2}$$

Where,  $m_e$  is effective mass,  $m_{str}$  is structural mass including coating,  $m_a$  is added mass which combined with following formula shown in Eq. (3) with  $D$  is pipe diameter,  $\rho$  is seawater density,  $C_a$  is added mass coefficient and  $m_{con}$  is mass of fluids content. For Eq. (4),  $\zeta_T$  is total modal damping ratio at a given vibration.

$$m_a = \frac{\pi}{4} D^2 \cdot \rho \cdot C_a \tag{3}$$

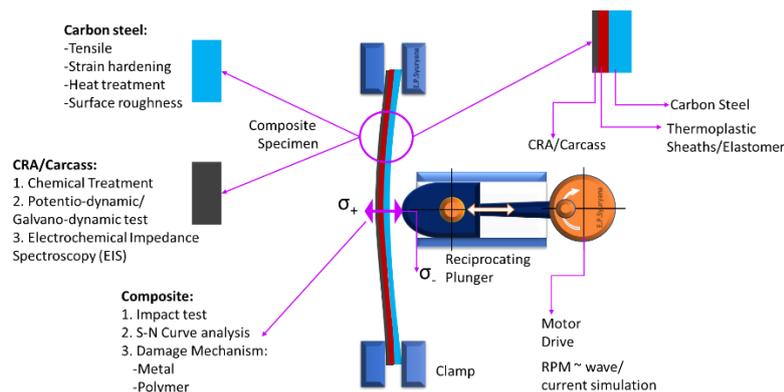
$$K_s = \frac{4 \cdot \pi \cdot m_e \cdot \zeta_T}{\rho \cdot D^2} \tag{4}$$

Based on field sample and condition data minimum stress cycle 3 MPa to maximum stress 278 MPa in range of frequency 250 to 300 Hz as shown in Figure 10 below. Bai's in [1] data for flexible pipe layer material have combination strength and capabilities such as for steel wire grade strength from 750 – 1400 MPa, for polymer material sample as shown in Table 1 have higher value from PVDF material.



**Figure 10** Stress-Cycle and Frequency

Testing apparatus conceptual for three-layered specimen with three-point bending fatigue testing using a reciprocating plunger to bend the specimen as wave force simulation to flexible pipe material. As shown in Figure 11 below, the reciprocating plunger drive by a motor for adjust the rotation per minutes (rpm) and it stroke length can adjusted by plunger size replacement or motor position adjuster.



**Figure 11** Conceptual design and test for three-point bending fatigue testing apparatus.

The cycle for bending test in Epsztein's and Demanze's in [18] research from 10 to 100 times. In research plan the test of Armor steel material, PVDF and carcass corrosion resistance alloy material also tested for corrosion stress cracking condition in the three-layered strip system. For testing apparatus setup, In the system attached three sensor electrodes for measuring corrosion rate of metallic material with simulative environment as flexible pipe contact condition with seawater and gas/fluids. Testing apparatus illustration shown in Figure 12 below.

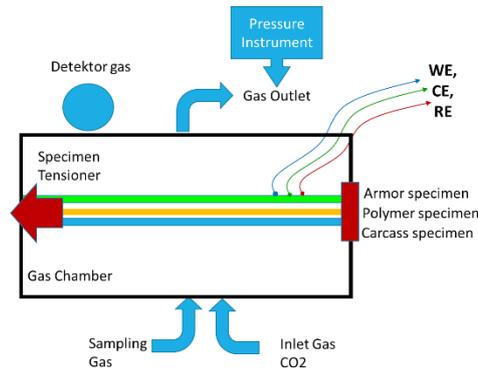


Figure 12 Stress corrosion testing and potentiodynamic testing apparatus

#### 4 Fatigue Life Assessment

Safety requirement in flexible pipe application required high fatigue capabilities from each layered of flexible pipe material. In subsea and deepwater environment with different characteristic of force and pressure from seawater it pipes materials also affecting by internal pressure of bore fluids. For considering the horizontal force, Huang's in [19] using predicted formula by calculate viscous drag and inertia for is generally expressed in following Eq. (5).

$$f_H = f_D + f_I = \frac{1}{2} C_D \rho D u_x |u_x| + C_M \rho \frac{\pi D^2}{4} \dot{u}_x \quad (5)$$

Where, h is Water depth, a is Cartesian Coordinate,  $f_H$  is horizontal component,  $f_D$  is viscous drag,  $u_x$  is water particle velocity,  $f_I$  is inertia force,  $\dot{u}_x$  is water particle's acceleration, CD is drag coefficient,  $\rho$  is sea water density, D is cylinder diameter,  $C_M$  is inertia force coefficient.

#### 5 Conclusions

Basic principles for stress and fatigue of three-layered flexible pipe specimen required strength and corrosion resistance properties for deepwater application. Seawater as environment of flexible pipe application have many characteristics in flow and force can affected to flexible pipe tubular structure as reciprocating force in any direction as bending moment, vortex induced vibration and also from internal fluids pressure. The preliminary research purpose in this scope of analysis has multidisciplinary knowledge to identified the material fatigue and

corrosion characteristic in three-layered combination of flexible pipe prototype in first development phase.

### Acknowledgement

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## Increasing Brand Awareness and Intention to Use Pospay Digital Wallet

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**Abstract.** Indonesia has been actively doing digitalization, marked by the increase in mobile connections and internet users. In 2020, more people were using them due to the spread of the COVID- 19. Because of the pandemic, government encourages the public to make transactions using cashless payments. One of the cashless payment methods that are growing is digital wallet. PT Pos Indonesia saw this as an opportunity to develop its digital wallet called Pospay. Since its launch, on 13<sup>th</sup> April 2021, Pospay has faced several challenges. 98.5% of Pospay's users are an employee of PT Pos Indonesia. It shows that brand awareness and intention to use of Pospay are still relatively low outside the company. This study will focus on how Pospay could increase its brand awareness and intention to use. The analysis was conducted using external and internal analysis that will be used to formulate TOWS matrix. The results show there are three strategies that can be implemented by the company based on the company's resources and capabilities. The strategies are using Instagram, Youtube and Tiktok ads, collaborating with the popular merchants to offer discounts or cashback, and collaborating with education program by the government such as scholarship to distribute the funding.

**Keywords:** *brand awareness; digital wallet; intention to use; marketing strategy; TOWS matrix.*

### 1 Introduction

The global industry is experiencing a new digital era 4.0, and Indonesia is no exception. In this digital era, almost all public activities have shifted to digitalization, including payment activities that shifted to cashless payment methods from the conventional. One of the cashless methods that are growing in Indonesia is the digital wallet industry [1]. In 2020, there is COVID-19 that occurred in Indonesia and even in all parts of the world. The WHO warned the world's citizens that the COVID-19 virus could live and stick to inanimate objects, including money. This virus can live and survive for days on paper money. Therefore, WHO urges the public to use non- cash payment instruments when making transactions. Based on the statement of WHO, the Governor of Bank Indonesia, Perry Warjiyo, appealed to the public to transact using cashless

payment when paying in-store, paying bills, or making purchases on delivery food, online transport, e-commerce, websites, or online shopping. This situation has led to a growth in the use of digital wallets.

As one of the financial service providers, Pos Indonesia saw this as an opportunity to develop. Pos Indonesia created a digital-based payment service that categorizes as a digital wallet called "Pospay" to make transactions easier for everyone, and it launched on April 13, 2021. Pospay offers several features payment such as QRIS, transfer, sharia services (BAZNAS and Rumah Zakat), bpjs, bpjstk, online shopping (mnc shop, Mataharimall, blibli.com, tokopedia, elevenia, and Bukalapak), multi-finance, cable tv, taxes, insurance, teacher's room, electricity, PDAM, gas, credit, data, and telco.

Since its launch, Pospay has faced several challenges competing in the digital wallet industry. Based on the number of accounts (NOA) data, 98.5% of Pospay's users are an employee of PT Pos Indonesia. It shows that Pospay's brand awareness and intention to use are still relatively low outside the company. Meanwhile, Pospay has the goal to be the top of mind of digital wallet in Indonesia. Currently, Pospay has reached 1.535.218 number of accounts (NOA) and planning to increase its number of accounts to 5 million users and target a new target market of people between 12-24 years old. In order to achieve its goal, the company needs to develop improved business and marketing strategies to increase its brand awareness and intention to use of Pospay applications.

## 2 Literature Review

Pospay was launch its applications on April 2022, it is counted as late if we compare to the competitors. Since its launch, Pospay has already operationing for one year and 2 months. In order to know the position of Pospay in the potential customer minds, we have to measuring the brand awareness. Brand awareness can be assessed on several levels such as unaware of brand, brand recognition, brand recall, top of mind and brand dominance (the only brand remembered). Brand awareness is the first and most important facet of the overall brand knowledge system [2].

In order to create brand awareness, we must enhance brand familiarity through repeated exposure to create brand awareness. The more a consumer "experiences" a brand through seeing, hearing, or thinking about it, the more likely they are to remember it strongly. The brand's elements, advertising and promotion, sponsorship and event marketing, publicity and public relations, and outdoor advertising are all things that the customer experiences [3].

Besides lacking on brand awareness, the intention to use of Pospay also still relatively low. According to Davis (1989), the cause of people using or not using an application is related to perceived usefulness and the extent they believe it will help their job perform better. Also, even though an application is helpful for

potential users, it doesn't mean they would use it. Because at the same time, the potential users may believe that the application is not easy to use and the effort of using the app is not comparable with the benefits they get [4]. This is how usage is influenced by perceived ease of use.

Based on the Technology Acceptance Model (TAM), perceived usefulness and ease of use are the keys to technology acceptance or adoption. An extension of the classic TAM model by Leiva et al (2016) and Shalini Chandra et al (2010) show how trust is also considered a decisive factor in application adoption [5][6]. Furthermore, perceived security also influence the intention to use an application [7]. According to several literature, there are four factors that can influence the intention to use an applications which are perceived usefulness, perceived ease of use, trust and perceived security.

This study is discuss about how to create the most suitable business and marketing strategy for a company or a brand. In that case, we can't just look at the factors affect brand awareness and interest in using the application. We have to consider other factors such as the external and internal environment of the company itself. The external environment can be explain through PESTEL analysis, Porter Five Forces and competitor analysis. PESTEL is important to recognize the factors that influence of the organisation and the impact of it [8]. Then, Porter Five Forces is used to xamines the business domain or industry within which an organisation operates, and identifies the business pressures that maybe brought to bear upon that organisation [9]. Furthermore, the purpose of competitor analysis is to identify all of the company's competitors, both direct and indirect.

Meanwhile, the internal analysis can be explain trough Resource Based View analysis, VRIN Framework, existing Business Model Canvas and marketing mix 7p. According to Hitt et al., (2016), Resource- based view and VRIN Framework are related and aims to examining a company's unique resources and capabilities that can be used to gain a competitive advantage. Then, business model canvas is used to determine how a organization creates, delivers and capture its value to attract the potential customers. Furthermore, marketing mix 7p's is a set of marketing tools to pursue its target market or influencing the consumers [10].

### **3 Research Method**

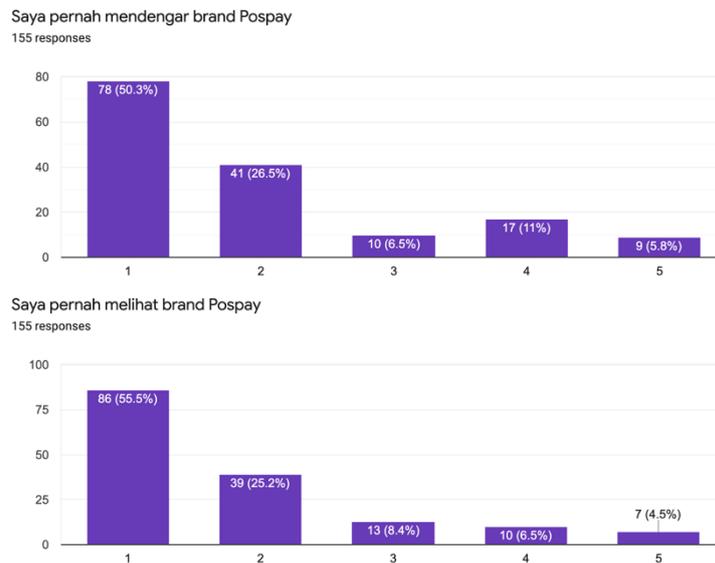
This study uses a mixed-methods approach, in which qualitative and quantitative data will be collected and analyzed in parallel or sequential phases. Quantitative data is often closed-ended, as seen on surveys or psychological instruments, but qualitative data is frequently open-ended, with no predefined responses [11]. Qualitative data were collected to analyze PESTEL framework, Porter's Five Forces Analysis, and Competitor Analysis in external environment also Resource Based View analysis, VRIN Framework, Existing Business Model Canvas, and Marketing Mix 7p in internal environment. Meanwhile, quantitative data were collected to analyze the consumer Analysis. The quantitative method for

consumer analysis is carried out using Structural Equation Modeling (SEM) and using Partial Least Square (PLS) as a tool.

This study uses two points of view, which are from the company's internal and external conditions. The researcher uses four methods to analyze the company's external conditions: PESTEL analysis, Porter's Five Forces, competitor analysis and consumer analysis. Meanwhile, the company's internal analysis using VRIN Framework, existing Business Model Canvas, and marketing mix 7p. External analysis is done to find out the opportunities and threats for the company. Meanwhile, internal analysis is done to find out strengths and weaknesses of company. The internal and external analysis results are used to formulate SWOT analysis and then used as guidance to formulate the TOWS matrix. Then, this TOWS matrix is used to create a proposed marketing strategy.

#### 4 Result and Discussion

According to the calculation, the questionnaires must to distributed to the 151 respondents using the unknown population. The limitations of respondents are people in 12-24 years old and have made transaction used digital wallet. The author distributed the questionnaire and obtained 155 respondents. The questionnaire using short answers and likert scale with the intervals of 1 to 5.



**Figure 1** Brand recognition of Pospay.

The author asked the respondents with two statements “I have seen Pospay brand before” and “I have heard Pospay brand before”. Based on the results of Fig. 1, the result from the first statement is 80.7% of the respondents said they are disagree and strongly disagree that they have seen Pospay brand before. Then, the result from the second statement is 76.8% of the respondents said they are

disagree and strongly disagree that they have hard Pospay brand before. This indicates that most of the respondents are they do not know about Pospay. Based on this surveyed, Pospay in brand awareness pyramid is categorize as unaware of the brand.

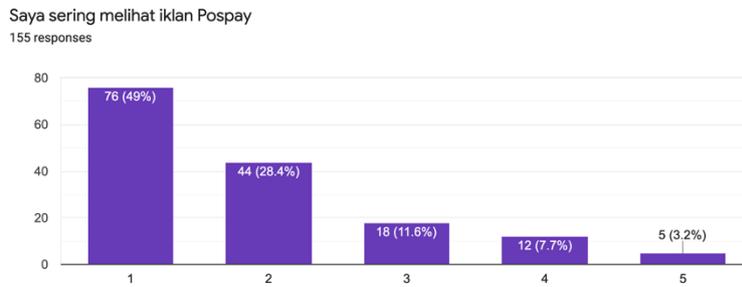


Figure 2 Potential customer’s respond to advertisemnt of Pospay.

The author asked the respondents with the statement “I often see Pospay ads”. Based on the Fig. 2, 77.4% of respondents disagreed and 11.6% of respondents said netral with the statements. It shows that respondents rarely see the advertisements of Pospay and the digital marketing that already done by Pospay not reach the potential customer yet. According to external and internal analysis that has been done, there are 19 point in SWOT analysis that used to create the TOWS matrix.

Table 1 TOWS Matrix.

	Strength	Weakness
	<p><b>S1.</b> Financial fully supported by government</p> <p><b>S2.</b> Offices spread almost all over Indonesia</p> <p><b>S3.</b> Strong partnership with government</p>	<p><b>W1.</b> Free transfer fee</p> <p><b>W2.</b> Users can not top-up the balance in minimart</p> <p><b>W3.</b> Cannot be used in ride-hailing applications</p> <p><b>W4.</b> There is no payment channel on transportation, event, attraction</p> <p><b>W5.</b> There is no discount merchant and cashback on sales promotion</p> <p><b>W6.</b> There is no paid advertisement</p> <p><b>W7.</b> Difficult to open the apps</p>
Opportunity	S-O Strategies	W-O Strategies
<p><b>O1.</b> This business is supported and in line with government programs and regulations</p> <p><b>O2.</b> The decrease in card transactions</p> <p><b>O3.</b> The increase of</p>	<p><b>SO1.</b> Expanding the business services by adding more features to meet customer’s needs (S1, O2, O3, O4, O5, O6)</p> <p><b>SO2.</b> Collaborating with education program by government such as</p>	<p><b>WO1.</b> Partnership with minimart to provide top-up balance services to make access easier (W2, O3, O6)</p> <p><b>WO2.</b> Partnership with ride-hailing applications (W3, O2, O3, O4, O6)</p> <p><b>WO3.</b> Collaborate with</p>

<p>cashless society <b>O4.</b> The growth of technology <b>O5.</b> The increase in paperless behavior <b>O6.</b> Trusted by potential customers</p>	<p>scholarship to distribute the funding (S2, S3, O1, O2, O3, O4, O6)</p>	<p>government in transportation to make selling ticket feature such as Damri, KAI, ASDP and others (W4, O1, O2, O3, O4, O5, O6) <b>WO4.</b> Collaborating with event organizer to make pospay as payment method such as concert, PRJ, exhibition (W4, O1, O2, O3, O4, O5, O6) <b>WO5.</b> Using paid advertisement such as Instagram, Youtube and Tiktok ads to get more knowledge and attract more the cashless society (W6, O1, O3, O4, O6) <b>WO6.</b> Develop the applications (user experience), so user does not have to input username and password everytime opening the apps (W7, O4)</p>
<p><b>Threat</b></p>	<p><b>S-T Strategies</b></p>	<p><b>W-T Strategies</b></p>
<p><b>T1.</b> Threats of new entrants <b>T2.</b> Low switching cost of users and high competition in the digital wallet industry <b>T3.</b> Threat from substitutes</p>	<p><b>ST1.</b> Develop the applications to make it as payment aggregator, so it can make a payment or receive payment from other digital wallets (S1, S3, T1, T2, T3) <b>ST2.</b> Develop new feature of overseas e-commerce payment, no minimum transfer fee, split bill, joint accounts, and parking payment (S1, T1, T2, T3)</p>	<p><b>WT1.</b> Collaborating with popular merchant to make discount or cashback (W5, T1, T2, T3) <b>WT2.</b> Collaborating with e-commerce to make discount or cashback (W5, T1, T2, T3) <b>WT3.</b> Collaborating with e-commerce to make discount or cashback (W5, T1, T2, T3)</p>

Based on the Table 1, there are thirteen alternative strategy that has been formulated in the TOWS Matrix. These strategy can be implemented by the company to develop its business. However, not all of the strategies can be applied at this time based on the capabilities and resources owned by the company, such as:

1. The limited ability of the company from a financial perspective cannot be allocated as a whole only for marketing activities
2. Human resource must be prepared in advance to implement new strategies in developing the technology or creating new feature
3. Many parties must be involved in carrying out a collaboration or partnership strategy, so it takes a long time
4. Some strategies require great effort and may not have a significant effect on the company

## 5 Conclusion

According to the analysis results, there are thirteen alternative strategies that the company can implement. But based on the company's resources and capabilities, not all of the strategies can be implemented in the near future. Three strategies are chosen based on the discussion with the company: using Instagram, Youtube and Tiktok ads for digital marketing, collaborating with the popular merchants to offer discounts or cashback, and collaborating with education programs by the government such as scholarships to distribute the funding.

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## Identification of Residual Space: A Case Study of Sumur Bandung District

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**Abstract.** Nowadays, the urbanization phenomenon is consistent with the increasing demand for land availability. On the other side, there is more residual space found in several cities, one of them is Bandung. This residual space is mainly caused by the conversion of land use as urbanization occurs. Moreover, this space has caused some informal appropriation which caused unsettling conditions. Using the literature review and satellite image analysis, this research is focused on the identification of residual space in Sumur Bandung District as a small sample of Bandung. Several studies are reviewed to obtain a theoretical basis of analysis such as typology, forming factors, and qualities of residual space. This research is conducted to find a new manifestation of residual space according to the context of Bandung. The access of transportation modes and pedestrians becomes the scope limitation of this study. As a result, there are six manifestations of residual space found in Sumur Bandung District, such as *space above the alley; pedestrian way without significant activities; utility box infrastructure; transitive area; unused entrance; and pedestrian platform*. These manifestations will become the objects of advanced study to be processed as a more efficient utilization for the city.

**Keywords:** *urbanization; land-demand; appropriation; Sumur-Bandung; residual-space; manifestation.*

### 1 Introduction

The massive rate of urbanization has caused a significant population increase in the cities. In 2050, United Nations (UN) has projected about 68% of the world's population will live in cities [1]. This trend will lead to a high urban density and followed by an increasing demand for urban land. The urgency of optimizing land use will intensify alongside the escalated imparity of urban density and its population. The rise in land prices is intended as this issue could not be resolved. Some of the efforts by the government is adopting the land use to the current trend. This effort is aimed to provide land for people and maintain price stability

in the market. However, this will be inefficient as commercial functions increased from time to time.

Trancik [2] defines residual space (lost space) as a space that is not related to its surrounding environment and an unidentified space. Several definitions mention residual space as space that is neglected, not used properly, or space resulting from infrastructure development that is not designed or used properly. In addition, this space has the potential to be intervened due to unmaintained conditions by those who own or manage the space. Various references define residual space in various ways. The tendency of residual space in utilization is space that lacks use and maintenance by stakeholders and shareholders thus informal communities intervene. Meanwhile, based on its physical quality, residual space is a space that is not and/or has not been well planned so it creates ambiguity that causes a decrease in the aesthetic value of urban space [2].

In line with the limited land, several actors whose conditions are unable to afford properties financially have conducted interventions in various residual spaces. Those residual spaces are alley corridors, riverbanks, sidewalks, and junctions which often become prominent locations for informal activities. Oftentimes these activities will lead to conflicts between each actor in urban areas. Feldman and Stall [2] stated this appropriation is an ownership of a space carried out by a group or individual forcibly. Rapoport (1985) in [2] states that this situation is influenced by several elements, one of which is the availability of space to be exploited.

Residual spaces become important because over time, limited space forces stakeholders and shareholders to optimize the space thus it can be utilized properly. Although residual space has been a common phenomenon in various cities in the world, this space is still considered an unwanted and unresolved issue. The contextuality of residual space becomes an important aspect to consider. This context will form different typologies from the earlier studies as the theoretical foundation. Therefore, it is necessary to learn the context of the urban area to determine the typology of the residual space from one city to another. Thus, stakeholders alongside shareholders could provide solutions precisely in the future.

## **2 Methodology**

This study is aimed to find the typology and/or manifestation of the residual space in District (*Kecamatan*) Sumur Bandung as a sample of residual space in Bandung with several different characteristics. To obtain its purpose, this study is conducted by literature study and data collection through Google Street Map. The theoretical foundation is elaborated from several literature reviews as the main reference for assessment. Furthermore, the results of the analysis are classified based on the conclusion variables from the literature study. This study is conducted using a comparative qualitative analysis technique, which is

comparing one phenomenon with a related phenomenon [3]. The variables in the reviewed literature are compared with field data as proof of the suitability of the theory with the existing field context.

### **3 Results and Discussion**

Overall, residual space could be defined in terms of physical appearance and quality of its use [2]. Space that is not used properly is generally irrelevant to the situation or space demand in a city. Informal activities that intervene are usually blurred space between legal and illegal so that it will require solutions both top-down and bottom-up.

Residual space, based on its utilization, refers to an area that is not used properly, or maintained by stakeholders, and thus is intervened by private parties. Wikstrom stated that residual space is a space that could be exploited or appropriated, thus the activities characteristic is often temporary and illegal [4]. Meanwhile, the utilization qualities mentioned by Hwang [5] are about how a space is unused, exploited, and abandoned. The most common perception of residual space is about the informality and temporality of activities which becomes into conflict in several cases.

The physical term of residual space is defined as a space that has not been well planned so that it creates ambiguity, thereby decreasing the aesthetic value of urban space. The terms of ambiguity in space namely unclear geometry, space with low visibility (not visible from the movement space), and space with boundaries that are considered easy to intervene (low fences and not maintained, or spaces without fences). The definition of residual space is based on these physical appearances which are usually tangible for actors and stakeholders. According to Wikstrom himself, the existence of Residual Space is created as a background space in the 'figure and background' so that physically it becomes a complimentary space for the designed 'figure' [4]. With this 'background' space, it becomes a liaison between several 'figure' spaces surrounding it.

#### **3.1 The Formation of Residual Space**

According to the factors that form residual space, it could be concluded that an urban space that is not cared for, not controlled, and not cared for properly become the background reason for residual space [2]. In addition, a study of the factors forming the residual space was conducted based on references during the last 10 years. Overall, the residual space could be formed due to minimal maintenance, space that is not controlled by the land owner, not properly cared for by the owner, geographical factors, irrelevant initial functions, or space that is intentionally vacated for future use.

Some factors form residual space in several different contexts. Trancik, Morallis, Loukitou-Sideris, Doron, Alanyali, and Carmona describe the main factor of residual space forming as the lack of maintenance either by the stakeholders or

shareholders [2]. As Winterbottom stated, a space with minimal control is mostly caused by the lack of access directly to the space. Therefore, this space is the potential to be intervened [6].

Factors as geographical and renewal utilization of land use would be other issue. The fitness of the current function of space to the demanding activities in the existing era becomes the main issue predictable in several cities. A steep topography or a different leveling of the existing environment is less preferable so that the utilization given tends to be minimal other than the flatter topography [5]. Therefore, a lot of steeper topographies become the most common residual space in several cities.

Various activities related to the issue of the changing land use trends could also be different issue regarding unused space. The flexibility of designers in responding to the issue of changing local land-use trends can also be a separate issue that can make a space unused. Evolution in the activities of the people from time to time conducted the change of space. Oftentimes the space is unable to adapt to the new function thus it is inflexible to be reused. The scarcity of form and scale relevance have formed a leftover space in an urban context.

The surplus landscape is the most common factor as the intended space allocated as the expansion space of a property. This unplanned space has resulted from space being left over from the surrounding development. Prediction of future land use or expansion allocation which often takes a long time will decrease the value of this space so that it is intervened as an informal activity.

### 3.2 Qualities of Residual Space

Kevin Lynch in *The Good City Form* [7] stated that the performance of urban space can be measured by several aspects, namely *Vitality*; *Sense*; *Fit*; *Access*; and *Control*. Meanwhile, according to M Khalil and D. Eissa [2], a residual space can possess physical qualities and utilization qualities. These qualities will be juxtaposed with the performance of urban space by Lynch (Table 1) and thus could be elaborated to the existing conditions.

The physical characteristics of a residual space is differentiated one space from another. There are two types of factors that affect the quality of the residual space, *internal* and *external*. *Internal quality* is an inward orientation and thus could be intervened either by the designer or informal actors. Otherwise, *external quality* is an outward orientation to the urban macro scale. In urban space, this physical quality can be associated with urban design elements as the main identification of quality.

There are indicators for identifying the physical quality of the residual space. Those are accessibility; level of security; visibility; site boundaries; site topography; uniformity of shape; the scale of site location; site location; facilities/assets that support activity generation; and proximity to high-intensity

movement activity. These indicators serve as a reference for designers to intervene in the residual space in urban area. Meanwhile, the utilization qualities of residual space are divided by accessibility; security level; visibility; site boundaries; site topography; uniformity of shape; the scale of site location; site location; facilities/assets that support activity generatio; and proximity to high-intensity movement activities [2]. These indicators become the baseline of intervention analysis for designers and stakeholders to resolve the residual space issue.

Juxtaposing qualities indicator with Lynch's performance dimensions in The Good City Form, it is stated in Table 1 that the total performance highlighted in residual space is *Fit*; *Access*; and *Sense*. This also proves the perception of the surrounding community which focuses on visual aspects, affordability, and usability. These aspects are considered contradictory to the vision of the impacted city. Apart from these dimensions, other aspects also take a role in keeping the residual space intervention under control. Meanwhile, the *vitality* aspect is an additional performance that is the output of the other such as *control* from stakeholders and access to areas that will create a sense of security for users. In the end, the solution of the residual space as an urban space could be conducted by improving the quality according to the performance preferred to highlight according to the context. So that the interventions taken can be adjusted to the indicators that have been found in the related references.

**Table 1** Physical Qualities of Residual Space by Khalil and Eissa [2] and Lynch [7]

Physical Qualities										
Khalil dan Eissa	Internal Factors							External Factors		
	1	2	3	4	5	6	7	8	9	10
	Accessibility	Security	Visibility	Boundary	Topography	Uniformity	Scale	Site Location	Asset	Access to circulation
	High	High	Exposed	Defined	Flat	Regular	Wide	Edge	Views	Road
Low	Low	Hidden	Undefined	Sloped	Irregular	Narrow	Center	Facilities	Pedestrian Way	
Lynch	Access	Vitality	Access, Sense	Vitality, Control	Fit	Sense	Fit	Sense	Sense	Access, Control
Utilization Qualities										
Khalil dan Eissa	11		12		13		14			
	Current Activities		Users		Time		Late Land-Use			
	Merchant		Local		Morning		Industrial			
	Recreation				Afternoon		Commercial			
	None		External Visitor		Night		Residential			
Etc.		Green Area								
Lynch	<b>Fit</b> , the function suitability with the current activity that is relevant to the time, users, and social activities in it.									

### 3.3 Typology of Residual Space

The typology of residual space is divided into several terms, such as urban voids; leftover space; to residual space. According to Winterbottom [6], residual space

is discovered in the residential context of Seattle and it is classified as non-spaces; leftover space; and dual/multi-purpose space. By this typology, Winterbottom also mentions the solutions of the three typologies, namely Re-adapted; Re-inhabited; and Re-imagined.

Doron in [2] classified residual space based on the affected area, such as *dead zones* and *dead edges*. More detail on the typology mentioned by Villagomez in [8] classified residual space based on the type and location of the affected infrastructure. There is *void space, infrastructure that is not re-used, space under the circulation path*, and so on in Table 2. Different contexts create different types of residual space manifestations. This is reflected in the publication by Khalil M. [2] which has summarized the residual space manifestations based on the existing reference set.

**Table 2** Typology of Residual Space

Author	Year	Category	Typology		
Winterbottom [6]	2000	Forming Factor	<b>Non-Spaces</b> The residual space due to proximity to the movement corridor	<b>Leftover Spaces</b> An improperly programmed space that is separated from its surroundings. Example: odd geometry space adjacent to the intersection, the front of the setback, and the traffic island	<b>Dual Spaces / Multipurpose Spaces</b> Areas with scheduled activities, which become residual space at different time
Doron [2]	2007	Location	<b>Dead Zones</b> Residual space is created due to the absence of relevant functions	<b>Dead Edges</b> Residual space is connected to corridors and is usually located along roads, railroads, riverbanks, and sidewalks.	
Villagomez, Eric [8]	2010	Infrastructure typology	<b>Void Spaces</b> Unused spaces between buildings	<b>Redundant Infrastructure</b> Unfunctional infrastructure	
			<b>Oversized Infrastructures</b> An infrastructure with excessive space for traffic (over-estimated)	<b>Rooftops</b> The unused part of the roof in a building	
			<b>Spaces around</b> A space between new development in an old context (intermediary zone) or between the public street and the interior area of the building.	<b>Spaces Below</b> Spaces under infrastructure such as elevated railroad tracks, motorcycle flyovers	
			<b>Wedges</b> Result of conflicting intersections such as urban grids or infrastructure lines		

Various studies show that there are different manifestations according to the urban spatial context discussed. This difference also makes the residual space a distinctive feature of other cities. Trancik in [2] mentioned several residual spaces related to movement spaces such as areas under bridges and plaza areas that are

far from pedestrian activity. Aside, Rivlin in [2] discussed the manifestation of residual space far from movement space, such as lanes that are in line with the public environment, road medians and junctions, and squares that are intervened by merchant activities. Campbell [9] added parking space as one of the residual spaces related to movement space. This is due to the scheduled use of parking spaces depending on the function it serves, which causes activities at other times. Other manifestations also found in this large-scale public space are closely related to the movement area and visibility to pedestrians. For instance, a park and playground which is fenced and damaged thus create an isolated public space. In addition, open spaces which conflicted between scale and usability are also reasons for abandonment by users [2].

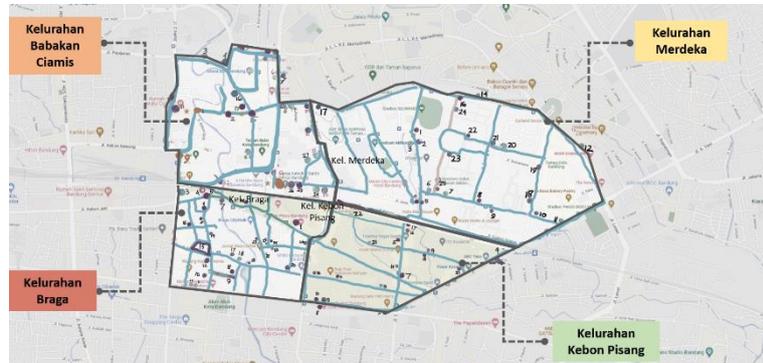
Residual space is also often found in areas that are intentionally vacated by land owners or power holders. This space is usually a buffer space, from conservation activities such as rivers, railroads, and other zones that are eventually intervened by informal activities. This is also related to former industrial zones, ports, and barracks which are not relevant to the needs of existing functions due to reduced land vitality. The essence of this buffer zone will also be disrupted by the intervention of external parties which will end up reducing the effectiveness of this buffer zone. Transitional zones are also intervened by informal activities, such as transitions between districts, buildings, and boundaries between land use. This zone becomes ambiguous due to the vacancy of land which can be a gap for certain elements. In addition, Campbell stated that corridors and alleys that tend to be narrow and invisible are examples of in-between space [9].

There are some studies about residual space in Indonesia, one of them is located in Kebayoran Lama, Jakarta Selatan [10]. Based on the context of urban space, the main typology (location) found in the related context are under the bridge, sidewalk, roadside, and in-between space. These residual spaces are spread out in a linear and clustered pattern. A hypothesis is conducted grounded on this finding in Kebayoran Lama as the similar context found in Sumur Bandung District, Bandung.

### **3.4 Identification of Residual Space in Sumur Bandung District**

According to the literature review of residual space, the hypothesis presented by the author is: There is a possibility of new manifestations of different typologies from both theory and case studies that have been discussed. This hypothesis is conducted based on the contextuality that has been stated in many references before. That context of residual space could be related to the form of residual space. As a discussion of the hypotheses above, the process of analyzing the urban spatial structure of Sumur Bandung District is carried out partially through Google Street Map satellite imagery. Overall, the identification process is conducted by distributing observations based on the village (*kelurahan*), namely Braga, Kebon Pisang, Merdeka, and Babakan Ciamis. Identification is done in

the form of a typology, physical quality, and quality of use according to the theoretical study in the previous chapter.



**Figure 1. Observation Area of Sumur Bandung District**

Land use in Sumur Bandung tends to be mixed with the majority composition of housing/complex, followed by institutions, then stadiums/fields, industry, and the lowest in the form of mixed gardens [11]. As the result, it was found that the dominance of land use in the four *kelurahan* is;

- Braga with a mixture of residential complexes
- Kebon Pisang with a mixture of complexes and settlements
- Merdeka with a mix of institutions
- Babakan Ciamis with a mixture of residential complexes – institutions

Sumur Bandung is also crossed by the Cikapundung River which is one of the regional attractions. The land use around the Cikapundung River is dominated by housing and trading services. The highest intensity of road is located on the streets of Kebon Pisang and the lowest intensity is located in Merdeka. Sumur Bandung sub-district has 12 (twelve) *Rukun Warga* (RW) with a high-density level, 5 (five) of which are located in Kebon Pisang. The highest density is found on roads leading to arterial roads. On the other hand, low density was found in the center of the sub-district in clusters of central government offices. In addition, low intensity is also found in a wider area. The highest road accessibility is found in Braga with tourism activities and its surroundings, as well as Babakan Ciamis with commercial trading activities. [12]

The first observation area is **Braga** with 34 samples of the residual space documented according to the *Google Street Map* shown in Figure 2. Mostly, the typology found in Braga is *non-spaces*, which is a leftover space as a result of proximity to the movement corridor. *Dead edges*, namely the residual space connected to corridors such as river banks, railroads, roads, and sidewalks.



**Figure 2. Samples of Residual Space (A3, A9, & A20)**

Source: Google Street Map, 2022.

The building density in Braga also causes residual space with the typology of *spaces around*. As shown in Figure 2, sample A3 with *space above* the movement corridor is the manifestation of rooftop typology. It is different from sample A9 where the residual space is in the form of a courtyard which is an intermediary room for the old building (BCA KCP Suniaraja) with the residential area of RW 07 Braga. This residual space is often used as a parking lot equipped with semi-permanent buildings as a business area for residents. With high accessibility and visibility, this residual space is very easy for the community to intervene. Another interesting asset of this sample is the riverbank which is often a ‘utility’ area for residents. The impression of disorder is very closely related to this residual space considering the non-uniformity of the surrounding buildings and also the furniture of the facilities that are left in the middle of the residual space. Another manifestation of the residual space found in the context of Braga is the utility box in sample A20 which is usually not covered with pavement materials. This space with dimensions ranging from 1.00 to 1.50 meters is easy for the community to intervene as a motorbike parking or street vendor that fits the dimensions of the related space as in sample A20. These samples from Braga show one of the characteristics of the intervention on the use of the residual space in the city of Bandung to the micro-scale. Overall, there are 3 (three) new manifestations of residual space, such as *space above the alley gate* (A3 & A16), *sidewalks with minimal pedestrian activity* (A9), and *utility boxes* (A20).



**Figure 3. Sample of Residual Space in Babakan Ciamis (B6, B7, and B9)**

Source: Google Street Map, 2022.

In the observation area of **Babakan Ciamis**, 4 (four) new manifestations were found in the type of residual space in urban areas. With the characteristics of Babakan Ciamis, the residual space in this area is mostly in the form of *non-spaces* and *leftover spaces*. Leftover spaces are not properly programmed and separated from their environment. Usually, it is a space with odd geometry adjacent to the intersection, so that is not easy to put it to good use.

In this observation area, 3 (three) contextual manifestations were found. Sample B6 shows the existence of an unlimited transitive space, which is a space between

buildings that is not in the form of a corridor. The boundary of the B6 is blurred as a result of semi-permanent stall activities intervening in the building area. The actor's activity as a form of intervention is the activity of street vendors attached to one wall of the building with the orientation of access to other buildings (Figure 3 left). Meanwhile, sample B7 (figure 3 middle) is a narrow space measuring approximately 1(one) meter below the pedestrian crossing bridge which is one of the spaces intervened by street vendors. Hence, sample **B9** is one of the residual spaces caused by changes in the owner's land requirements. As result, the late entrance route is closed and unused by the land owner. This results in the death of movement activities and makes the space an easy space to be intervened as a car park and street vendor space. In addition, some shades such as trees make this residual space easy for certain elements to intervene if not controlled properly.



**Figure 4. Sample of Residual Space in Kebon Pisang (C9 and C15)**

*Source: Google Street Map, 2022.*

**Kebon Pisang** possesses 22 samples of the residual space with many characteristics and office typologies found. These residual spaces are shown in *non-spaces* and *dead edges* like the samples in Braga. In addition, several samples were found in the form of *redundant infrastructure* that is no longer used. Street vendors as actors who intervene in the residual space are often found in Kebon Pisang. Several materials of the green spaces have been switched into pavements for merchant activities. The characteristics of Kebon Pisang as an observation area also have a tourist attraction at Asia Africa St. In this area, the residual space tends to be a *multi-purpose space*, namely a space with a different use at certain times. These spaces are communal parking spaces (as shown in sample C9) reserved for local office workers. Besides, street vendors are found in the corridor of this road. Street vendors tend to intervene in the narrow alley without interrupting the traffic in this corridor.

The last observation is conducted in **Merdeka** with 25 samples of the residual space. These spaces are dominated by *leftover space* which tends to be unsuitable with the 'background'. In addition, the residual space associated with the high-density road is commonly found in this area. Merdeka is characterized by its military service, namely, Siliwangi Military Regiment Area. Interestingly, the common typology of its residual space is *leftover space*. There are many odd geometries found in this area, for instance, samples D1, D3, D9, and the other ten samples. These spaces are the residual parcels of buildings that are usually developed into green spaces. Moreover, no intervention such as street vendors was found in the area within a radius of 5 km from military parcels. Utility Box is left open by the community thus it could not generate residual space as in the previous areas. Merdeka did not exhibit any new manifestations compared to

those discussed in the literature review. The residual space conditions discussed in Merdeka also tend to be in regular shape. The only weakness of this area is the lacking of regular maintenance such as vegetation and pavement. As a result of the externality of this military area, this area would likely have an effective residual space organization.



**Figure 5.** Sample of Residual Space in Merdeka (D1, D3, and D9)  
 Source: Google Street Map, 2022.

### 3.5 Findings

As the results of the analysis and discussion in the previous chapter, there are 7 (seven) new manifestations of the residual space from the four observation areas. These manifestations will be classified according to the quality assessment of the residual space in the previous literature review. These findings provide insight into the solution of residual space in the city of Bandung and as an answer to the hypothesis stated before.

The first manifestation is *space above alley* with characteristics such as high accessibility and visibility. Samples A3 and A16 are located close to major roads with high vehicle activity. The type of boundary that limits it is the alleyway itself, so it depends on the thickness of the surrounding buildings. The thicker the surrounding buildings, the larger the scale of the residual space above the gate. The shape of the residual space also tends to be a square geometry alongside the boundaries of the building. Its location tends to be in the middle of the city with a high density of buildings. This is due to the factors that form the residual space due to the lack of land that can be utilized.

**Table 3** Quality Assessment of Space Above Alley

Physical Qualities				
Accessibility	Security	Visibility	Boundary	Topography
High	High	High	Defined	Flat
Uniformity	Scale	Location	Assets	Proximity to Circulation
Regular	Narrow	Center	Road, Commercial	Sidewalk, Main Road
Utilization Qualities (Pre-Intervention)				
Land-use	Users	Time	Frequency	
Seating area	Local	All-day	Not routine	

Source: Google Street Map with personal analysis, 2022.

The second manifestation is *pedestrian way without significant activities*. This manifestation is usually located on the sidewalk at a different level from the road.

With this level difference defines the limit of the residual space that can be intervened by street vendors. The scale of the residual space is linear following the existing sidewalk path. However, there are specific characteristics of the sidewalks to be intervened by an informal activity. The residual space characteristics for this manifestation are activity assets, accessibility, and visibility of the sidewalk. Examples of this manifestation are samples A9 and B4. In sample A9, it was found that the access quality is high with asset activities in the form of office and commercial activities. With the lack of pedestrian activity, street vendors can easily appropriate this sidewalk. The forms of appropriation in this manifestation are semi-permanent stalls and street vendors carts lined up along Belakang Factory St.

**Table 4** Quality Assessment of Pedestrian Way Without Significant Activities

Physical Qualities				
Accessibility	Security	Visibility	Boundary	Topography
High	Moderate	High	Defined	1 step rise level
Uniformity	Scale	Location	Assets	Proximity to Circulation
Linear Patterned	Narrow	Center	Commercial, Office	Less Traffic Road
Utilization Qualities (Pre-Intervention)				
Land-use	Users	Time	Frequency	
Seating area	Local	Work Hour	Work Days	

*Source: Google Street Map with personal analysis, 2022.*

Third manifestation found in the observation area is a *utility box infrastructure*. The location of this manifestation is adjacent to pedestrian paths and highways. With the characteristics of utility lines that usually follow the circulation of the path, the scale of this residual space is linear along the way. However, the points usually depend on the activity assets, accessibility and visibility of the location. In samples A20 and B15, residual space was found on the line of utility box. The cover with dimensions of approximately 1 (one) meter can accommodate one street vendor cart so that it is easy for street vendors to intervene.

In this sample, the accessibility of the location is fairly high, with the location of the residual space at the intersection of Markoni St. However, due to the isolated location of the road, the distribution of street vendors is only approximately 100 meters from the entrance of the alley. The furnitures and equipment from these street vendors are often placed at the location of the residual space due to the high intensity of sales activities. In locations that do not have utility covers tend not to be intervened by street vendors.

**Table 5** Quality Assessment of Utility Box Infrastructure

Physical Qualities				
Accessibility	Security	Visibility	Boundary	Topography
High	Low	Low	Undefined	Flat
Uniformity	Scale	Location	Assets	Proximity to Circulation
Linear Patterned	Very Narrow	Center	Commercial, Road	High Traffic Road
Utilization Qualities (Pre-Intervention)				
Land-use	Users	Time	Frequency	
Merchants	Local	Varied	All day	

*Source: Google Street Map with personal analysis, 2022.*



*Transitive area* is a space whose boundaries cannot be defined. The factor that generates this residual space is the intervention of informal commercial activities. The transition in this space tends to be blurred according to the intervention area of the semi-permanent building. Accessibility and visibility of this residual space is quite high with minimal pedestrian activity.

**Table 6** Quality Assessment of Transitive Area

Physical Qualities				
Accessibility	Security	Visibility	Boundary	Topography
High	High	High	Undefined	Flat
Uniformity	Scale	Location	Assets	Proximity to Circulation
Nodal Patterned	Narrow	Center	Commercial, Road	High Traffic & Pedestrian way
Utilization Qualities (Pre-Intervention)				
Land-use	Users	Time	Frequency	
Merchants	Local	Work Hour	Everyday	

*Source: Google Street Map with personal analysis, 2022.*



Another manifestation found is *unused entrance*. Usually building parcel has 2 (two) entrances and exits to create continuous circulation. However, over time and changes in land use, one of both entrances is often unused. The decision to close the door made the allocated space in front of it become the residual space. Alongside the boundaries of building, the definition of scale and the boundaries of the residual space depends on the pavement. In sample B9, this residual space is supported by the presence of shade and low visibility of the location, making it easy to intervene either as a car park or as a stall for street vendors. The activity assets of the B9 location are in the form of government agency facilities on Kebon Sirih St., such as the Sumur Bandung Police Station and Pakuan Building.

**Table 7** Quality Assessment of Unused Entrance

Physical Qualities				
Accessibility	Security	Visibility	Boundary	Topography

High	High	Low	Defined	Sloped	
Uniformity	Scale	Location	Assets	Proximity to Circulation	
Nodal Square	Narrow	Center	Commercial	Less Traffic Road	
<b>Utilization Qualities (Pre-Intervention)</b>					
Land-use	Users	Time	Frequency		
Car Parking, Merchants	Local	Everyday	Everyday		
<i>Source: Google Street Map with personal analysis, 2022.</i>					

*Pedestrian Platform* is the last manifestation found that is formed due to the minimal effectiveness of the sidewalk. Sidewalks with different pavement levels and the dimensions of the sidewalks is relatively small (approximately 1.5 x 1.5 meters) creating the impression of a stage compared to other sidewalks. In sample C15, the quality of accessibility and site visibility is very high with space connection with Sunda St. The intervention of this residual space tends to be nodal or point in accordance with the existing ‘platform’ dimension. The generation from the location that became the asset is Sunda St. itself and the surrounding commercial area. With the availability of shade from trees, possible interventions that can be carried out can be in the form of temporary furniture and stalls from street vendors.

**Table 8** Quality Assessment of Pedestrian Platform

Physical Qualities					
Accessibility	Security	Visibility	Boundary	Topography	
High	Low	High	Defined	1 step rise level	
Uniformity	Scale	Location	Assets	Proximity to Circulation	
Nodal patterned	Narrow	Center	Commercial, Green space	High Traffic Road	
<b>Utilization Qualities (Pre-Intervention)</b>					
Land-use	Users	Time	Frequency		
Merchants, Street Furniture	Local	N/A	Everyday		
<i>Image Source: Google Street Map, 2022.</i>					

#### 4 Conclusion

The tendency of residual space in terms of use is a space that is not used properly nor maintained by stakeholders and shareholders so that it is intervened by informal actors. Residual space is a space that is not well planned so that it generates ambiguity which causes a decrease in the aesthetic value of urban space. In its application in urban areas, the performance dimensions that need to be highlighted are the performance of *Fit*; *Access*; and *Sense*. Another dimensions would be *Vitality* and *Control* as an addition dimensions.

There are several variables of physical quality such as accessibility, security level, visibility, site boundaries, site topography, uniformity of shape, scale of

site location, facility assets, and proximity to circulation. Besides, there are utilization qualities that can be identified with current activities, users, times, and previous land uses. There are various typologies that have been studied by previous authors, that becomes the base theory of this study.

This study learns residual space located in District (*Kecamatan*) Sumur Bandung with 2 (two) limitations of accessibility level and diversity level of land use. The typology of the residual space in Bandung is similar to the previous study, with slight difference in manifestations. There are six new manifestations found in the city of Bandung, namely:

1. Space above alley
2. Pedestrians way without significant activities
3. Utility box infrastructure
4. Transitive area
5. Unused Entrance
6. Pedestrian Platform

This study still has many shortcomings, such as the lack of primary data as data validation to be used in further research. Primary data is needed to provide recommendations for handling residual space in the city of Bandung. This study only targeted in finding contextual residual space in the city of Bandung (Sumur Bandung District). This study requires another variable as limitation other than accessibility and land-use, such as open space and activity assets for 24 hours.

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## How An Ice Breaking Session Supports Cognitive Synchronization in Virtual Design Facilitation: A Case Study

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**Abstract.** The rise of design thinking led to designers' roles expansion, to be a facilitator. In a virtual design facilitation, the facilitator should ensure that all participants shared the same understanding as one of the components of cognitive synchronization despite the limited non-verbal cues. This paper discusses an ice breaking method as the alternative way to establish and enhance the shared understanding. All this time, the ice breaking session has been studied as a method to build trust and familiarity among group members, but in this paper the authors try to elaborate the potential benefit of a different ice breaking method through a case study. The ice breaking aimed to probe participants' financial experiences in the past. Those experiences make them understand other people's financial achievements and difficulties, help to build empathy towards each other, and immerse themselves in the facilitation context. The ice breaking results also can be used as a source of inspiration in discovering product innovation.

**Keywords:** *common referential spaces; cognitive synchronization; design facilitation; ice breaking; shared understanding.*

### 1 Introduction

With the rise of design thinking's popularity, some institutions in some countries provide workshop how to become the facilitator in design thinking facilitation (Napier & Wada, 2016). The main role is to lead non-designers to collaborate in doing design process to discover innovations (Napier & Wada, 2016). The trends lead to the expanding role of designers. Those who aspire to be facilitators should learn and conquer new skills beside designing artefacts.

Design facilitation start to be conducted virtually due to the pandemic. Moreover, as the pandemic begins to subside, some institution such as International Labor Office predicts that the virtual work habit or teleworking and hybrid working trends will still be preferred by some workers (Jon Messenger et al., 2020). Thus, virtual design facilitation would likely to be conducted by some remote workers. The virtual facilitation utilizes some digital applications as the replacement of the offline tools such as sticky notes, whiteboard, and pen. The utilization has some

advantages such as easier documentation because all ideas in every single step will be put in the virtual whiteboard. The written ideas in a board is considered more efficient in yielding more ideas than verbal method (Paulus et al., 2018).

In a group collaboration which consists of diverse individuals, the development of familiarity and trust enhance the feeling of psychological safety and comfortability (Paulus et al., 2018). Thus, the virtual setting is a challenge for the facilitator to present an activity for trust and familiarity development due to the limited non-verbal cues. Ice breaking can be one of the alternative activities to develop the two elements in the online setting. For example, Dixon et al.(2006) conducted a study how ice breaking help the students build collaboration in online environment. They found that ice breaking helps them to establish social strengths such as make connections and encourage the trust relationship development. Pratama et al. (2021) also found that ice breaking session among middle school students increased learning motivation in online setting. In another study by Verma & Anand Pathak (2011), ice breaking is considered can be used on various occasion with diverse purpose such as bringing back the group enthusiasm, tensions reduction in team building session, breaking awkward feelings among participants that are not yet familiar each other, so that it can expand their comfort zones and slowly build relationship based on trust and openness.

Besides that, another important thing to do by a facilitator is to make sure that virtual design facilitation as the manifestation of design collaboration can really facilitate the non-designers to exchange knowledge, to create and explore many ideas, and to select the most suited ideas comfortably. It can be supported by good establishment of the shared understanding among participants due to the different background or cognitive synchronization (Mailles-Viard Metz et al., 2015). However, the virtual setting gives a facilitator another challenge to fulfill this need. In a face-to-face activity, any confusion or misunderstanding can sometimes be spotted through non-verbal cues such as facial expression, but in virtual setting the cues are hardly identified due to the small size face on the screen or there are technical constraints.

Through a study case, the authors explore an ice breaking session which can be utilized to tackle the challenges in the virtual facilitation. This study discusses a method used in an ice breaking and elaborate how it can support cognitive synchronization besides trust and familiarity development. The authors explore additional benefits that an ice breaking could give.

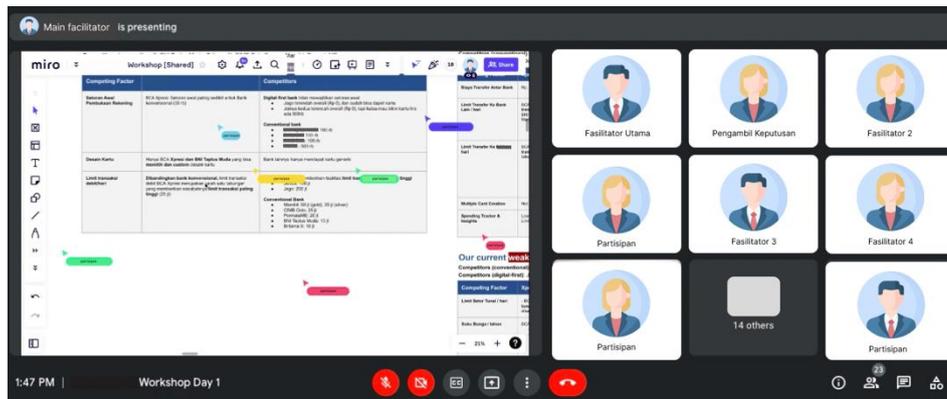
## **2 Cognitive Synchronization in Collaboration**

Design collaboration that can be manifested in design facilitation consists of diverse participant. The diversity of participants' background is required to join the development of solution and to construct the reasoning of the taken decision (Darses, 2009). Darses (2009) argued that in co-design activity, there should be a process called cognitive synchronization which means the cognitive process that make the participants think creatively to explore and agree towards a solution based on the knowledge domain. Cognitive synchronization can be achieved through three main activities: 1) the establishment of common referential spaces, 2) the integration of different point of views, and 3) collective decision making. Quality of the first activity's construction and maintenance determines the success of design process (Darses, 2009).

Common referential spaces can be defined as common point of group references (Mailles-Viard Metz et al., 2015) and functional common representation for designers understandings (Darses, 2009) which can direct the collective activity. In the communication theory, grounding ensures all the participant comprehending the utterances or messages (Clark & Brennan, 1991). Common referential spaces can be considered as the fundamental for the realization of cognitive synchronization. The spaces consist of goals, strategies, procedures, domain knowledge, criteria, and constraints (mental representation). Design artefacts such as sketch, 3D concepts, design documents can also be the spaces or called as external representation. All the representation must be accepted by all participants. In short, common referential spaces provide the discussion context and mutually shared knowledge.

## **3 The Case Study**

The ice breaking session is taking from a case study conducted by a design consultant which provides co-design services through design facilitation. The design facilitation aimed to discover innovative ideas for a banking product to compete with some competitors. There were 18 participants that came from different backgrounds; 1) 9 employees of an Indonesian private bank and their supervisor which consists of different division such as business development, product development, and marketing communication, 2) 9 employees of a creative agency who will in charge of the marketing strategy in the next phase. The design facilitation is conducted to identify the grand ideas related to product development and marketing. This facilitation was led by a facilitator who direct participants in doing some activities, including the ice breaking session. It was held virtually using Google Meet as video call tool and Miro as online collaboration tool. Miro provides facilitation tools such as digital sticky notes.



**Figure 1** The screenshot of Google Meet

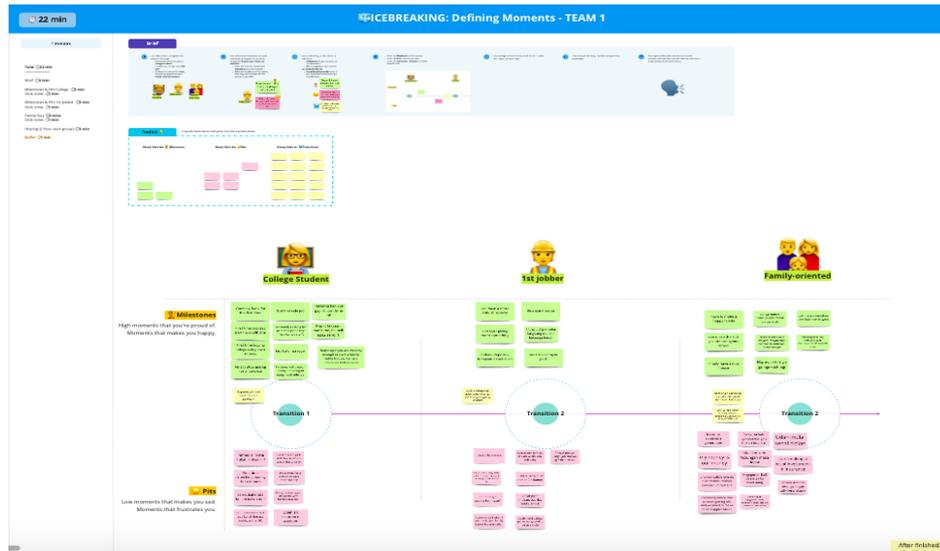
## 4 Methodology

This research uses qualitative study by providing triangulation to develop comprehensive understanding of the ice breaking function. The data were taken from the screen recording of the virtual design facilitation, the facilitation results which have been documented in the digital application, and interview with the facilitator. The screen recording was used to collect participants' utterances in the ice breaking session. The document in the digital application was used to check the potential relation of ice breaking session results and other design process activities. The interview was conducted to elaborate the facilitator's perspective about ice breaking session.

## 5 The Ice Breaking Session

The ice breaking session was started before any activities in the design facilitation. Ice breaking intended to recall participants' experiences about financial achievements and difficulties during three life stages, that are college, early career and when start a family. The facilitator considered this session could unfreeze the awkwardness among participants that never met face-to-face before (mainly for employees from the agency and the bank) and to diminish skepticism and prejudice about their insignificancies in the idea development. The prejudice usually comes from the participants' employment status as just ordinary staffs. This ice breaking session was designed by the facilitator to be align with the context of design facilitation, not only to 'break the ice'. The facilitator also wanted to make participants could immerse themselves in the context of facilitation.

Participants were asked to write their own experiences and put it on digital sticky notes in Miro. For each life stage, participants were given 4 minutes to write their experiences. They did not need any knowledge based on their education or occupations, but just need to recall their happy and sad memories. After they finished, they were asked to share their written experiences verbally. There were 1 person from the creative agency and 2 people from the bank who shared their experiences excitedly.



**Figure 2** The screenshot of written experiences written by the participants.

## 6 Findings and Discussion

The three participants shared and elaborated their experiences more detail than that written in the digital sticky notes. They talked casually as if usual conversations and reacted spontaneously towards unusual experiences. The shared experiences contained personal stories either achievements or difficulties which created openness among them. They also did not hesitate to share their lowest points in life as well as their weaknesses (see Table 1). By knowing each other's stories, the level of trust can be increased. Trust can be developed through comfortable open sharing and meaningful interaction such as personal conversation, caring talk that can encourage self-disclosure (Holton, 2001).

**Table 1** Highlighted participants' utterances during the ice breaking session

No	Utterance	Analysis
1	A casual reaction from a participant from bank after seeing an experience written by a participant from agency. "Wow, being able to buy a car since early career, seems like a director. Wonderful!" (laugh)	This spontaneous utterance marks the intimacy between participants from different company.
2	"When I was a college student, for the first time I got a part time freelance job, and I could pay tuition fee by myself and buy anything I want. And my parent passed away, so I have to pay the college fee by myself."	The participant shared his proud financial-related-moment and heartbreaking moment. The vulnerability creates openness.
3	"In college, I thought of how I would manage my financial even though I just received it from my parents. How to manage spending including renting a room monthly, fulfilling basic and social needs etc."	The participant shared her concern of managing financial in the past.
4	"In the early career, circle of friends increased, from high school mates until coworkers, so that I feel so many social pressures. Moreover, when they are getting married, having babies or so on, I have to allocate special fund for them."	The participants shared difficulties she felt when facing early adulthood. It creates openness.
5	"When I got my first salary, I became impulsive by treating parents or friends. It made me proud, but the dilemma between saving and please other people haunted me. It is kind of difficult to manage my salary in the early career.	The participants shared his personal feeling (pride) and its consequences. It creates openness.
6	"When already have a family, I cannot buy stuffs related to my hobbies, because now I have to get permission from my spouse and have to predict what spending happen in the near future."	The participants told his financial adaptation towards building a new family. It creates openness.

After the sharing session, participants were asked to explore product opportunities through How Might We questions scheme. The HMW questions were used to identify product opportunities and product ideation in the next session. The facilitator allowed the participants to use the ice breaking experiences as one of the idea sources. The authors find there are some HMW questions that relate to experiences shared in the ice breaking session. It indicates that the ice breaking results are understood by participants and considered very relevant for the design process. Still, not all questions related to the experiences shared. Here are some examples of HMW questions that reflect the experiences.

**Table 2** Examples of HMW questions related to the ice breaking session

Utterance Number	HMW Questions	Original Questions
2, 3	“How might we help college students to manage their spending?”	HMW Bantu college student manage spending
	“How might we help college students to learn managing their financial and make financial plan?”	HMW kita bisa bantu college student untuk bisa belajar manage keuangan/ buat financial plan
5	“How might we help them to have self-control for their financial things?”	HMW help them to have a self-control for their financial things
6	“How might we help those who already build families could use a portion of their income for self-rewarding wisely?”	HMW saat sudah berkeluarga, yg biasanya adalah family oriented, gmn tetep bisa gunain hasil kerjanya untuk self reward dengan bijak

Besides the ice breaking’s effects to group bonding, which already studied by the former researchers, the ice breaking in this case study also contributes to the construction of common referential space. Table 2 shows that the ice breaking sessions results were considered as source of inspiration to write ideas in the next activities (HMW questions). The ice breaking results improve the participants’ understanding about the financial problems that faced in the three life stages, so that it creates the mental representation. The participants were stimulated to develop empathy to other participants in the sharing session which helped them in identifying opportunities for product development. The ice breaking session results also become form of digital documentation which can be referred anytime as the product inspiration.

## 7 Conclusion and Limitation

Beside the operational function of ice breaking to build trust and familiarity among participants who never meet before, an ice breaking session can be utilized to support the collaboration. In the design collaboration, the facilitators should ensure the occurrence of cognitive synchronization where participants shared the same understanding to explore ideas and agree towards certain ideas regardless

the different background. The ice breaking session in this case study can support the cognitive synchronization by establishing common referential spaces that make the participant immerse themselves in the facilitation context. The common referential spaces are manifested in sharing experiences about financial problems and digital documents which can be referred as source of inspiration. Moreover, in the virtual design facilitation where non-verbal cues are limited, the ice breaking session might become the facilitator's endeavor to improve the level of shared understanding.

Ice breaking session can be manifested in different method depend on the objectives. The ice breaking method used in this case study aimed to immerse participants in the certain context, not only to build trust and familiarity. Even this study only uses one study case, so that the result highly depends on the case context, this kind of ice breaking method is potential to be an alternative option which give more benefits for the group creativity in the design facilitation context, moreover in virtual setting. Despite, more than one or two cases in future studies is highly encouraged to give more accurate elaboration.

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## Cultural Expression of Traditional Balinese Architecture at the Retreat in Sanur, Bali

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**Abstract.** This study examines the interior design of a retreat in Bali regarding holistic health services and interior design with a cultural perspective on local wisdom. Human needs encourage the existence of self-actualization, one of which is spiritual tourism. Bali is one of the provinces that contributes to the most spiritual tourism in Indonesia. Sanur is one of the thriving retreat centers in Bali. The attraction of foreign tourists to choose spiritual tourism in Bali is caused by several things such as culture, environment, and ethnicity. This supports the rapidly growing product of retreats in Bali. The presence of regional culture provides a different point of view to finally create a new space. The study was conducted to identify the place of retreat that is expressed through cultural values and healing spaces. This research approach uses field studies with descriptive analysis. The significance of this research is to provide new understanding and scientific development about human-oriented retreats and interior design. The result is that the cultural point of view is expressed by the layout, facilities, and methods of the healing process at a retreat in Bali. The concept of Tri Hita Karana provides a spiritual value that prioritizes nature as the existence of a retreat.

**Keywords:** *spiritual tourism; interior design; retreats; traditional balinese architecture; holistic healing space.*

### 1 Introduction

The existence of tourism provides a human experience to increase self-actualization, for example, spiritual tourism. Tourism encourages health tourism to become spiritual tourism as a package of physical and spiritual health services (Mueller, 2001). Spiritual tourism began to develop because of the promotion of the novel 'Eat Pray Love' by Elizabeth Gilbert in 2006 (Williams, 2014). A total of 33.97% of Bali Tourism statistical data in 2018 contributed to foreign tourist visits. This is because foreign tourists have an attraction to the environment, culture, and ethnicity in spiritual tourism in Bali (Sutarya, 2019). Therefore, the need for tourism in the Bali area has experienced an increase and product diversification in facilities and infrastructure that can trigger visits.

Holistic health space acts as a healing space with an evidence-based design based on a holistic approach. A holistic healing room is a space that has public facilities, therapeutic facilities, and supporting facilities to assist the healing process (Sabar, 2020). Holistic healing rooms have the advantage of treatments that can be performed by anyone and are grounded in tradition and culture. This results in a unique health service. The value of the human body is represented in architectural space which is reflected in the vertical axis where the most important buildings are at a higher elevation (Tuan, 1977). The experience of space and place that is

obtained by humans through form, activity, to value can be an aspect that is considered in the design.

Regional culture is represented in the design based on local, and national styles and cultural traces in history. To know the relationship between traditional and modern design creations to cultural heritage, there is a design approach called traditional regional cultural expressions in interior design architecture (Liang, 2014). This approach is divided into three main indicators, namely the extraction of 'form', the application and extension of 'meaning', and the inheritance of the 'soul' (Liang, 2014). Balinese people have a social system that affects the layout and types of their buildings. Balinese people have a belief that something can be meaningful and charismatic because it has a soul power called 'Taksu' (Sitinjak et al, 2020). Several beliefs developed in Bali as cultural heritage such as the *Tri Hita Karana* concept, the *Bhuana Agung* and *Bhuana Alit* concept, the *Asta Kosala Kosali* system, the *Hulu-Teben* concept, the *Tri Mandala* concept, the *Tri Angga* concept, the *Sanga Mandala* concept, and the *Tapak Dara* and *Swastika* concept. Traditional Balinese architecture has also experienced a shift in meaning from cosmic to modern which is shown in spatial planning, orientation, architectural appearance, interior furnishings, and local regulations (Sitinjak et al, 2020). This also creates a new characteristic of the existing retreats in Bali.

Sanur is one of the centers for the development of spiritual tourism in Bali. The presence of retreats around Sanur Beach is also influenced by the history of Sanur Village. The significance of space, culture, and belief in the place of retreat explores behavioral responses and user experiences in enhancing human interaction with their environment. Therefore, there is a need for a study of cultural expression in facilitating a holistic healing space in a retreat with a traditional Balinese architecture approach. Through field studies, this research seeks to answer the following questions: 1) What are the characteristics of cultural expressions at a retreat in Sanur, Bali? 2) What is the meaning of a retreat in Sanur in the context of Balinese Traditional Architecture? This research is a reference for the implications of culturally minded interior design as a holistic healing space in modern life. As well as knowing the role of culture in a holistic healing space.

## **2 Literature Review**

### **2.1 Space and Place**

Tuan (1977) in his book entitled *Space and Place: The Perspective of Experience* defines space as a complex set of ideas created into two basic spatial principles, namely 1) relationships between humans and 2) posture and structure of the human body. Space is described as an axis of axis that can move in various directions with coordinates at a position (Tuan, 1977). The human body positions a small portion of the axis space on the front-back or left-right. And the vestibule is referred to as the visual space. The experience of time towards space gives a different perception of the atmosphere and thoughts about space to him. Humans are formed by three periods of time, namely the past, present, and future (Tuan, 1977). The place is the result of space, so that place has a smaller projection than space (Tuan, 1977).

## **2.2 The Application of Healing Space Concept in Holistic Care Facilities: A Brief Guideline for Design**

Sabar (2020) explains the three types of facilities that build health services, namely public facilities, supporting facilities, and supporting facilities. Public facilities are used as a place to wait so that the designs created are comfortable and provide designs based on the natural environment. Supporting facilities are the main function used as therapy facilities consisting of holistic therapy rooms. Supporting facilities consist of management offices, service areas, and management rooms used by managers to improve their work.

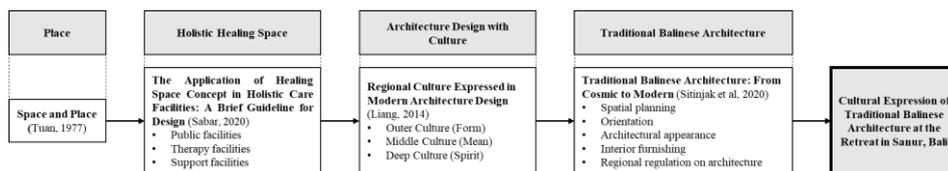
## **2.3 Regional Culture Expressed in Modern Architecture Design**

The expression of the cultural level in interior architecture is divided into three aspects, namely the outer layer, the middle layer, and the inner layer (Liang, 2014). Regional culture can be reflected in architectural interior design which refers to local, national, and cultural styles in history. The outer layer is the surface layer which refers to the shape (Liang, 2014). Forms are represented by traditional architectural structures, facility floor plans, exposed ceilings, paintings, calligraphy, decorations, and decorative patterns on the facades of the space. The middle layer combines culture with thoughts and feelings in the organizational space (Liang, 2014). The middle layer is concerned with operation, use of space, function, and security so that it refers to meaning through the essence of traditional ways of thinking. The application of meaning is implemented through new materials and technologies such as revitalizing. The inner layer focuses on the spiritual principles of traditional culture including aesthetics, ways of thinking, moral sentiments, religious emotions, and national character (Liang, 2014). The soul in space is represented by meanings and ideas that are strong, brave, spacious, sincere, and honest with the forces of nature that make up a respectable personality (Liang, 2014). Traditional meanings in architecture can be reflected by extracting shapes and symbols from traditional elements that represent the original traditional cultural atmosphere in interior architecture.

## **2.4 Traditional Balinese Architecture: From Cosmic to Modern**

The orientation of Balinese people's lives began to shift to modern life so that it affected cultural values and elements. Several things have changed such as spatial planning, orientation, architectural appearance, interior furnishings, and the Regional Regulation on Architecture (Sitinjak et al, 2020). The layout of the Balinese Traditional Architecture space is divided into two types, namely macro and micro with the application of the *Catus Patha* concept in the macro space, while *Sanga Mandala* in the micro room. The orientation of the building has shifted to the potential for planning contemporary Balinese architecture (Sitinjak et al, 2020). The architectural appearance produces a display with simple color, texture, and artificial colors that are in harmony with the natural environment that is preserved in modern buildings using the bale form (Sitinjak et al, 2020). Interior furniture began to be influenced by globalization with the use of modern furniture. Bali Regional Regulations must display regional identity on building functions that are currently fading (Sitinjak et al, 2020).

Based on the theory used in this study, can be described in the scheme below. Place Theory as a theoretical basis was later devoted to the Space Theory of Holistic Healing. This theory has several criteria that are used as guidelines for analyzing the distribution of facilities. Architectural Design Theory with Culture is a theory development that has three parts. It is used in analyzing cultural expressions in the object of research. Traditional Balinese Architecture Theory is used to analyze the building to find out its meaning and value.



**Figure 1** Theoretical framework (Author's analysis, 2022).

### 3 Method

This study used a qualitative method with a field study approach which was analyzed descriptively. Primary data comes from observations and interviews, while secondary data comes from the library. Primary data collection is done in two ways, namely existing observations, and interviews with respondents. The literature used comes from several previous studies related to research topics and theoretical studies about space and place, holistic healing space, Regional Culture Expressed in Modern Architectural Design, and Traditional Balinese Architecture from Cosmic to Modern. The object of this research is in the Sanur area, namely the Power of Now Oasis Teacher Training and Retreat. This place provides various cultural-based retreat programs and the largest yoga teacher training on the island of Bali.

### 4 Results and Discussion

Power of Now Oasis Teacher Training and Retreat is located on Sanur Beach. The north part is Mercure Resort Sanur, the South part is Sanur Beach, the East part is Villas and Clubs, and the West part is Mercure Resort Sanur. There are several temples around this retreat, such as in the east there are Kesumajati Temple and Ulam Agung Temple, in the west, there are Luhur Dalem Mertasari Temple and Tirta Empul Mertasari Temple, and in the north, there are Dalem Lontar Sakti Temple and Blanjong Temple. In major spatial planning with the *Catus Patha* pattern, this retreat is located on the shoreline, namely in the southern part. However, there is a Dalem Lontar Sakti Temple located in the north of this retreat with a distance of  $\pm 90$ m. Pura Dalem is a place of worship of Lord Shiva and Goddess Durga as a representation of the melting pot. This is related to the meaning and value of the sea in the perspective of Balinese Hinduism, namely as a place of purification and melting of all impurities. The sea is used as a place to carry out a sacred bathing tradition called *Melukat*. This tradition has become a cultural heritage that is carried out at sea, one of which is Sanur.



**Figure 2** Map of Retreat Locations (Author's illustration, 2022).

In minor terms, the layout of the Power of Now Oasis Teacher Training and Retreats building is divided into three parts, namely the main building, supporting buildings, and supporting buildings. The main building consists of a lobby, receptionist, waiting room, therapy room, office, and yoga shala A. The supporting building consists of yoga shala B. And the supporting building consists of a rest room. The main functions of the Power of Now Oasis Teacher Training and Retreats are yoga shala and therapy rooms as holistic health services. Based on the concept of Tri Mandala, the main is located in the main, middle in the supporting building, and the disgrace in the supporting building. The main facility functions as a public area to register and wait for class changes. The therapy facilities are used for Ayurvedic therapy, Acupuncture therapy, and yoga. Supporting facilities are used to operate the management of the retreat.

**Table 1** Facilities on *Power of Now Oasis Teacher Training and Retreats* (Author Analysis, 2022)

Facilities	Room	Location on Spatial Planning	Notes
Public	Lobby	1 <sup>st</sup> floor	Lobby and reception as visitor information and administration center.
	Receptionist	1 <sup>st</sup> floor	
	Waiting Room	1 <sup>st</sup> floor	A place to wait for the class shift.

<b>Therapy</b>	Treatment Room	1 <sup>st</sup> floor	A place to practice holistic therapies such as Ayurveda and Acupuncture.
	<i>Yoga Shala A</i>	2 <sup>nd</sup> floor	A place to learn and practice
	<i>Yoga Shala B</i>	1 <sup>st</sup> floor	yoga, meditation, and kirtan.
<b>Support</b>	Office	1 <sup>st</sup> floor	Management room.
	Rest Room	1 <sup>st</sup> floor	As a dressing room or toilet.
	Cage	1 <sup>st</sup> floor	Cow dwelling.

The orientation of the Power of Now Oasis Teacher Training and Retreats building is towards the south, namely Sanur Beach. Based on the results of interviews, managers and therapists agree that the natural scenery of the potential environment of Sanur has several roles. First, as a medium that stimulates therapeutic activities. The second is a positive affirmation given by the spirit of the sea. The third provides a visual experience that affects the sensory. Fourth, it gives the atmosphere of space such as serenity. Fifth increase self-awareness in the meditation process.

*“First to focus on an energy that is believed. Second, the view is directed to the beach so that all of the beach vibrations will be absorbed later, and we believe that is the case.” – (Interview with DS as Resource Person on Sunday, 24 April 2022, Personal Document)*

Power of Now Oasis Teacher Training and Retreats in implementing the *Hulu-Teben* Concept from *Tri Mandala*. This concept is used as the axis of the participant's head position when in the Yoga Shala or the therapy room. As well as the position of the altar in the Yoga Shala. Power of Now Oasis Teacher Training and Retreats is located in a coastal area so that Hulu is in the ocean, namely South and East so that the position of the head and altar is in the South while the position of the head in the therapy room is in the East. Hulu is represented by the ocean which reflects *Tirtha Segara* from the story of Ananta Boga. Thus, the concept of Hulu-Teben in the Sanur area has a different understanding.

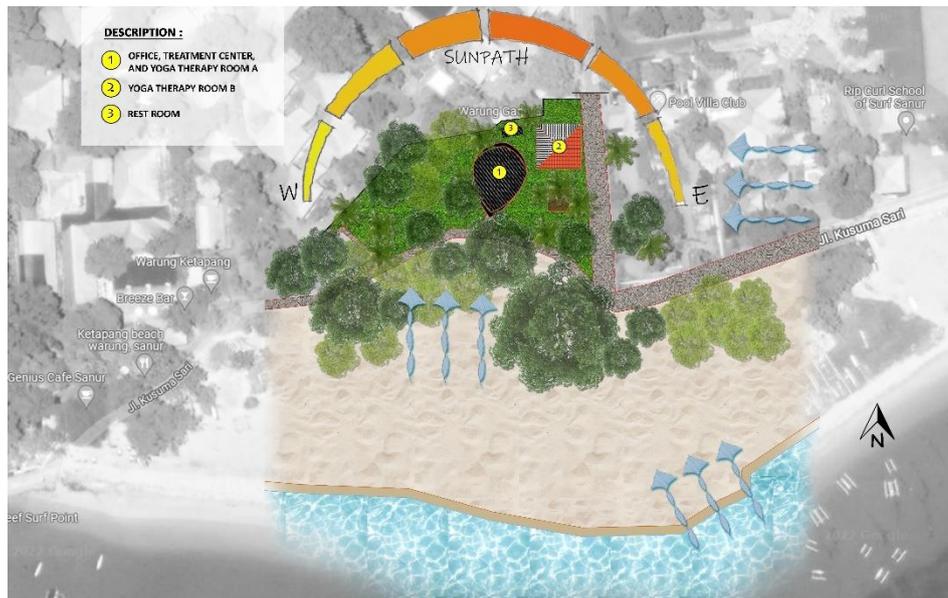


Figure 3 Directional Orientation of the Retreat Building (Author's illustration, 2022).

The architectural appearance of this retreat uses natural materials in all elements that make up the space. The natural materials used are bamboo, wood, and thatch. The Power of Now Oasis Teacher Training and Retreats building has a tropical appearance that adapts to its geographical location. The main building represents a bamboo building with a natural pattern. The supporting building represents the form of *Wantilan* which was adapted as Yoga Shala B. Cultural forms are found in the elements that make up this space, such as the use of *Saka* on the pillars of Yoga Shala B and foundations in the main building and supporting buildings. The entire building on this site uses a knock-down construction system and exposed ceilings. It aims to create a sustainable building. The walls in Yoga Shala A and Yoga Shala B serve as barriers to external and internal security. Externally protects physical disturbances from the natural environment. Internally serves to maintain the spiritual energy of participants in the room.

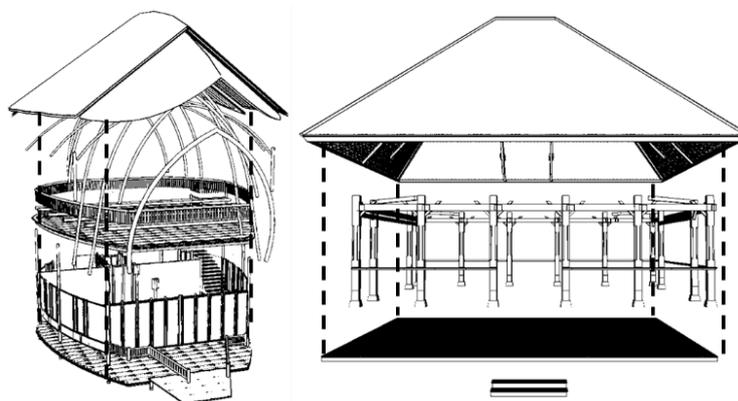


Figure 4 Retreat Axonometry (Author's illustration, 2022).

Vertically Tuan (1997) and Sitinjak et al (2020) state that the most important buildings are at the top. Figure 3 explains the division of buildings in the Power of Now Oasis Teacher Training and Retreats with the *Tri Angga* Concept. The foot consists of a foundation and joints made of concrete and stone. The body of the building in the main building consists of a room on the first floor, the supporting building is made up of Saka, and the service building is made up of a rest room wall. The head is represented by a ceiling and roof but in the main building, the head consists of a Yoga Shala and a roof. Yoga Shala is a place used for spiritual activities such as yoga, meditation, and kirtan so this is following the anatomical division of the building on its priority.



**Gambar 5** Konsep Tri Angga pada Tempat Retret (Ilustrasi penulis, 2022).

The interior furniture in the Power of Now Oasis Teacher Training and Retreats use wood materials and natural shapes. Decorative patterns and decorations are elements that reflect Balinese cultures, such as the use of room name descriptions with carved patterns of Patra Ulanda and Chinese Patra made of wood. Calligraphic elements were applied to the Rerajahan found at the main entrance and therapy room. This calligraphy forms Sanskrit writing and uses colored cloth material, consisting of red, green, blue, yellow, and white. As well as the use of statues of Gods and Goddess as a puja area using a statue of Lord Shiva. Yoga is the union of oneself with nature whose movements are born by Lord Shiva. Spiritually the meaning and soul of Lord Shiva are reflected in the visual media in the puja area, yoga postures, and Pura Dalem Lontar Sakti.

## 5 Conclusion

The Power of Now Oasis Teacher Training and Retreats retreat reflects cultural expression on three layers. The outer layer of Balinese Traditional Architecture is represented by the appearance of the main building with natural construction, the appearance of the Yoga Shala building that adapts the *Wantilan*, and decoration with Balinese carvings. The middle layer is represented by the meaning of Power of Now Oasis Teacher Training and Retreats as a retreat place that is maintained by prioritizing the function of the building into several parts, such as positioning the Yoga Shala as a sacred area. And interpret the retreat with an open concept to maintain the harmony of nature. The inner layer refers to the expression of strong ideas such as the belief that buildings have energy and vibration for their users, this is by the concept of '*Taksu*'. The cultural atmosphere is represented by the Balinese belief in the *Tri Hita Karana* concept which influences the considerations of layout, practice methods, and user behavior

patterns which then results in a new understanding that nature has the highest existence as something honorable. For example, the layout of the participant's head position when doing yoga and doing therapy. Retreats in Bali have a spiritual meaning, a healing meaning, and a security meaning. And have a sincere, strong soul, and respect for nature.

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## Emphasis on Emotional Branding to Increase Awareness and Customer Satisfaction of Norche Women's Bag Store

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**Abstract.** Bags are one of the most sought-after commodities by women when they are in central shopping. Bags are a fascinating accessory for fashion, women buyers intent Local bags accounted for 70% of online surveys. The survey was conducted and 90% of 20 women aged 18-25 in Bandung and Jakarta preferred local bags based on design, function, brand, price, and mood. Nowadays, consumers are more interested in getting emotional pleasures from their shopping experiences than they are in getting high-quality items at reduced prices. Norche is a fashion brand located in Indonesia that provides women's bags with special durable materials. This research was conducted using qualitative data to determine the behavior of Norche customers when making a purchase. Preliminary research based on internal and external conditions using Porter's Five Forces and knowing the satisfaction score using CSAT. The study discovered that Norche lacked an emotional approach to clients since its social media material lacked an emotional connection. The author used Customer Journey Mapping and Emotional Branding Driven to determine how emotional buyers are. The plan must improve the marketing, social media content, cooperation, and assured member cards.

**Keywords:** *customer journey mapping; eco-friendly bags; emotions branding; local brand development; porter's five forces.*

### 1 Introduction

Customers' emotional connections and enduring impressions are sparked through experiences, making branding initiatives successful. As more customers prefer omnichannel purchasing, which involves using numerous channels for a single purchase, such as physical stores, the internet, social media platforms, and mobile applications [1]. One of the local bag brands in Indonesia that implement sensory marketing through social media is Norche. Norche started in January 2022, under these conditions there are still many customers who make online purchases due to changes in customer characteristics from offline shopping to online shopping during the pandemic. Selling fashion products through social media does have many challenges because many products that customers will purchase cannot be touched or seen directly.

The value of Norche Brand as a friendly ecological bag brand from Indonesia that produces bags using durable materials and brings the hype to Millennials about awareness for protecting the environment. The bags are disposed of by various bag trends using the main material as a canvas. "The stylish way to be eco-conscious" gives a message that using our bags will keep you stylish and in fact, you can be one who can reduce the risk of environmental discoloration. The comfortable material can be used frequently, and the dense material keeps the item's welfare in the bag. This research discusses and defined the marketing strategies through emotional branding. this study was conducted utilizing in qualitative method, it investigates how individuals make meaning of their own tangible, real-world experiences in their ideas and thoughts [2].

### **1.1 Changes in Customer Behavior**

Changes in people's behavior and habits that are more aware of the environment have an impact on several businesses, business people must be able to adapt to this attitude. By having the same goals as the community, business people need to take an emotional approach. In this case, Emotional Intelligence Marketing is needed in building awareness and attracting buyer loyalty. The problem is, some of them will doubt whether the goods that will be received are as expected or not, so to convince customers of this, a statement is needed that can convince customers of the goods they are going to buy. Online shopping has one drawback because the product to be purchased cannot be felt directly, this provides new experiences for customers to determine and convince themselves when buying products. In this case, it is necessary to provide an attractive product display and a detailed description of the related product. From the preliminary survey of 20 respondents, 75% of them favor internet shopping, while 25% said they only purchase online at specific times and for particular requirements. Most favor well-known e-commerce platforms, while the remainder uses social media and websites.

### **1.2 Buying Local Brands**

A local brand shows uniqueness and originality, becoming a source of local pride. To assert and maintain that, local brands must have a specific quality, image, and personality to build a good relationship with customers. According to [3], Customers are more likely to appreciate local brands because they understand the process, in other cases, many segmented customers are more likely to buy other familiar luxury brands. Customers are ready to pay more for recognizable brands and are more likely to form favorable associations with such brands through advertising [4]. The brand image that local brands show is another factor that can acknowledge customers about the product, it is also linked with customers' ability to recognize or recall a brand based on associated images [5], as well as the extent to which they are accepted by consumers and reflect their feelings. The brand image relates to customers' recollections of brand perceptions [6].

## 2 Analysis

This study utilizes qualitative methods, starts by looking at the Brand Awareness of local brands in the fashion sector, especially the community's Brand Awareness of Brand Norche. These are conducted because we see Norche as a new local brand participating in the fashion business, which is situated in the red ocean; thus, it is vital to determine the level of brand awareness among current and prospective customers. Furthermore, externally and internally analyze Norche's brand equity with porter's Five Forces. The Customer Journey is done to recognize the behavior of the customer buying process, validate it using a Face-to-Face Depth Interview and look at the accumulated results of the Customer Satisfaction Satisfaction Score to identify how satisfied the customer is, the customer fills out the questionnaire survey to fulfill the Customer Satisfaction Score data. Norche uses Emotional Branding after closing numerous branding strategy gaps. Sensory Branding, Storytelling, Cause Branding, and Empowerment will develop a Noche branding approach.

### 2.1 Porter's Five Forces

According to Hole and Pawar [7], the five forces are intended to improve firm performance, resolve numerous critical situations, assess the competitive character of an industry, and build suitable corporate strategies. The five forces approach acknowledges that suppliers may become a firm's rivals.

**Table 1** Porter Five Forces Analysis of Norche.

No	Forces	Key Points	Degree of Forces
1	Competitive Rivalry	Currently, many fashion brands, especially in the field of women's bags, have started producing bags made of canvas material. However, most of them also don't have the same value or campaign as Norche, besides that the type of canvas material used and the color choices are chosen are very different from Norche.	Intermediate
2	Threat of New Entrants	There is quite a few fashion brands in the city of Bandung, some of which are always following trends. There are plenty of local bag brands, especially in the city of Bandung, so as a new brand in the red ocean, it requires a bigger branding effort	High
3	Bargaining Power of Suppliers	Suppliers of Norche products is quite easy to reach, but the norche tailors sometimes experience several obstacles, such as delayed progress.	Intermediate
4	Bargaining Power of Buyers	The customer has a very big right to be able to determine which product to buy, but some of them	High

		will be very considerate of the design, and function of the bag he is going to buy.	
5	Threat of Substitute Product	Comparing one product with another is very possible, especially with Norche products because some have already used canvas for women's bags.	High

## 2.2 Brand Awareness

Norche has reached several customers from various regions. Based on insights from Norche's Instagram account, including Bandung, Jakarta, Majalengka, and Banjaran. In addition, 96.6% of Norche reach accounts in Indonesia and 3.3% from Pakistan. Norche's target market, in particular, is women aged 18 - 35 years, from Norche's Instagram insights, the dominant gender that has succeeded in reaching Norche is women with 62% and 37.9% by men. The age range that Norche has been able to reach to date is 66.6% by 18 - 24 years old, 30% 25-34 years old, and 3.3% 35 - 44 years old. To increase the awareness of the brand name "Norche" among Local Brands in Bandung, Norche conducted a Soft Opening which also collaborated with Pa.Ma Coffee.

Five of the key survey respondents indicated that they frequently observed Norche Brand advertisements on social media platforms and Instagram. Recently, they reported receiving information about Brand Norche two to four times per day, seven days per week. Most stated that they are familiar with Norche goods due to their basic bag designs, durable and eco-friendly materials, multifunction and fashionable bags, and affordable costs. The average recommendation score for Norche goods and brands is 8.4 out of 10. Three of the five important responders have not purchased the product, but they have shown interest in it, showing that this unconscious emotional connection has not been established with prospective buyers.

## 2.3 Emotional Driven of the Brand Experience

Experience-centric approach to branding [8], proposes Brand Experience Proposition as a concept for expressing the brand in an experiential way, thus providing the basis for further exploration of the experiential nature of brands. In stages from Emotional Branding Driven, there are several factors that form the basis of the data, namely, their feelings and opinions about the brand personally, their feelings and income on the appearance of products and brands on the online platform, their sensitivity to products and a brand, and also encourages them to buy a product from a brand. Here are the brand experiences related to Norche:

**Table 2** Emotional Driven by Personal Experience of Norche Respondents.

<b>Personal Experience (Emotionally Driven)</b>		
Screening the social needs	From Instagram/Facebook/eCommerce ads	64.9%
Target consumers' extraction	Interest in eco-friendly bag products	68.4%
Branding Story Development	The appearance of the platform is very influential because it provides knowledge about the brand and product	68.4%

Based on these results, it is known that respondents as Norche customers and potential customers feel the impact of advertisements that are directly directed at them as the target audience of Norche, while Influencer posts are not a big enough factor to determine respondents to follow a brand on social media.

**Table 3** Emotional Driven by Appealing Experience of Norche Respondents.

<b>Appealing Experience (Emotionally Driven)</b>		
Mood fitting	See the overall appearance of content when first assessing interest in a brand or product	84.2%
Visualize	The products displayed by Norche give a modern and simple impression	85%
	The impression of the appearance of the Norche product display on the website or Instagram attracts the attention of customers and potential customers	91.2%
	The appearance of the Norche logo is attractive	73.7%
Systematize	The services provided by Norche when customers are going to buy products online can be easily accessed	75.4%

**Table 4** Emotional Driven by Sensory Experience of Norche Respondents.

<b>Sensory Experience (Emotionally Driven)</b>		
User experience and interaction map	Customers and potential customers buy bag products based on the function (size) of the bag	87.7%
Material allocation	Monochrome is the most dominant choice when customers and potential customers buy bag products	68.5%

	Canvas material is the most widely known material as a durable and eco-friendly bag material	84.2%
Prototype Testing	Of the 3 latest designs of Norche products, 'Berdine Bag' is the most dominant choice	54.4%
User feedback	<ol style="list-style-type: none"> <li>1. Models and colors are considered to be a trend</li> <li>2. The shape is simpler because of its size</li> <li>3. More varied designs and the right color combinations</li> <li>4. Keep it simple, but with a more trendy impression</li> <li>5. The model is unique, provides interesting elements, suitable for everyday use</li> <li>6. Can be more color pop if you want to match the color of the rope</li> <li>7. The color is neutral so you can wear it anywhere, the strap color is contemporary and cute</li> <li>8. The design is not market and the color is good</li> <li>9. The previous bag design was simple but cute, but the new design is more interesting</li> <li>10. Interesting, more interesting if given a finishing touch such as accessories or sewing motifs that make it more beautiful, still elegant, simple but not boring</li> <li>11. Products are fresher and in demand by millennials</li> <li>12. The bag model looks more comfortable to use and suitable for college</li> <li>13. Simple and compact but still up-to-date, hopefully, the straps can be sold separately and have more colors</li> </ol>	

The percentage result shows the positive value given by the respondent to the emotional experience when making a purchase or at the stage of purchasing Norche products. Of the several Emotional Branding Driven indicators, the indicators above have the greatest influence and effect that can affect the emotional development process of the Norche brand. The results of the feedback provided are also considered and materials for strategy implementation will later be applied using the Emotional Branding approach.

**Table 5** Emotional Driven by Navigation Experience of Norche Respondents.

Navigation Experience (Emotionally Driven)		
Media and communication	Product reviews are the highest driving force when buying bag products	80.7%
Message and Communication path	More interested in Instagram ads in the form of videos (via the reels feature or Instagram stories)	70.2%
Branding Story Development	The highest attraction when viewing a message or content on social media is when you can pay attention to moving images or videos with background sound (music, reviews, storytelling).	70.2%
	The media that has a high influence in deciding product purchases is Instagram Platforms	89.5%
Message distribution	Most respondents have not seen the ad that has previously been distributed through the Instagram platform @norche__	50.9%
	Advertisements in the form of Product Videos (via the Instagram story feature or reels) are received in approximately 1 week by respondents	61.4%

## 2.4 Customer Journey Mapping

Customer journey mapping is a method for discovering about the experiences and emotions of customers as well as how they react to goods and services during the course of their journey. This strategy requires mapping out all the steps a customer takes to try to complete a transaction [9]. [10] Crosier concludes by using Customer Journey Mapping as a method to examine how people feel about products, services, and other things. The Customer Journey Map is carried out to complete the required data from Emotional Branding Driven, the required data is based on Execution and Identity Management from appeal-driven, customer interaction map from sensory experience.

The customer's persona is separated into five major personas, all of whom reside in Bandung. This supports the factors of emotional branding driven towards Brand Norche in accordance with the customer buying process. The following is a Customer Journey Mapping from Loyal Customer Norche, the researcher uses keywords to analyze the Customer Journey based on what the customer said in the depth interview. Each persona's profession is Working in startups, High School students, College students, or Hangout, and their average income is between IDR 3,000,000 and IDR 5,000,000. The following are the results of deep interviews with 5 loyal customers who have made purchases and often interact with the Norche brand

The buying process from Norche customers is influenced by their knowledge and awareness of local brands that sell women's bags. Customers are familiar with the Norche brand from the Instagram platform, Instagram advertisements, e-commerce profiles, and e-commerce advertisements, as well as referrals from family members. At the consideration stage, the client evaluates the advantages of purchasing Norche items, such as an easy-to-access platform, excellent service, good product quality, pricing, and product design, as well as the company's closeness to the consumer influence purchases. The buyer can purchase via E-commerce or the Official Website Store once interested, after reading reviews on each platform. Consumers expressed pleasure with Norche's goods and services in the e-commerce feedback column or Website Store. Customers gave comments on Instagram stories.

**Table 6** Customer Journey Mapping of Norche Brand.

Customer Journey Map					
Timeline	P1	P2	P3	P4	P5
<b>Awareness</b>	<i>Online Approaches:</i> Instagram Ads	<i>Online Approaches:</i> Instagram Profile <i>Offline Approaches:</i> Word of mouth	<i>Online Approaches:</i> E-commerce profile <i>Offline Approaches:</i> Word of mouth	<i>Online Approaches:</i> Instagram Profile <i>Offline Approaches:</i> Word of mouth	<i>Offline Approaches:</i> Word of mouth
<b>Consideration</b>	Easy to access, nearby, appealing	Appealing, affordable	Easy to access, appealing	Price, appealing, size	Nearby, size, appealing
<b>Research</b>	Review, detail product	Touches product, trust seller, price	Appealing, difference	Touches product, difference	Touches product, trust seller
<b>Purchase</b>	<i>Online purchase:</i> Website Store	<i>Offline purchases:</i> In Person <i>Online Purchases:</i> E-commerce	<i>Offline purchase:</i> In Person	<i>Online purchase:</i> E-commerce	<i>Offline purchase:</i> In Person

Emotion					
	Excited, happy	Interest, curious, happy	Interest, excited	Interest, confused	Interest, happy, satisfied
<b>Review</b>	Feedback on Website: Love the product, good quality, on-time delivery	Feedback in person: Satisfied with the product, good quality, functional	Feedback in person: Love the product, good quality, daily used	Feedback on E-commerce: Love the product, on-time delivery	Feedback in person: Satisfied with the product, functional, daily used

### 2.5 Customer Satisfaction Score

In accordance with the American Customer Satisfaction Index [11], the global average CSAT score for the fashion industry is 75%, while the average score for all industries is 80%. Following are the customer satisfaction results from a yes to each question based on that calculation:

$$CSAT = \frac{\text{Total Positive Responses}}{\text{Total Response}} \times 100\%$$

In accordance with the American Customer Satisfaction Index [12], the global average CSAT score for the fashion industry is 75%, while the average score for all industries is 80%. Following are the customer satisfaction results from a yes to each question based on that calculation:

**Table 7** Customer Satisfaction Score of Positive Responses.

Total Positive Responses						
Social Media	Accessibility	Product	Quality	Service	Packaging	Shipping
39 of 60	50 of 60	56 of 60	58 of 60	57 of 60	58 of 60	59 of 60
<b>65%</b>	<b>83.3%</b>	<b>93.3%</b>	<b>96.7%</b>	<b>95%</b>	<b>96.7%</b>	<b>98.3%</b>

Based on the results of the customer survey, it indicates that social media accounts have a customer satisfaction rating of 65%, with Instagram account

Norche being identified as having somewhat lower satisfaction due to insufficient information about the product or brand's worth. In this case, the primary focus is on maintaining social media content and providing information that is easily consumable by customers.



Figure 1 Customer Experience.

## 2.6 Result and Discussion

In this study, companies adopted the Emotional Branding Framework from the beginning to understand the market trends, including their experience, true self, warm glow, and co-creation. As a result, the company may suggest utilizing or implementing tactics to enhance branding efforts. The graphic for emotional branding is shown below.

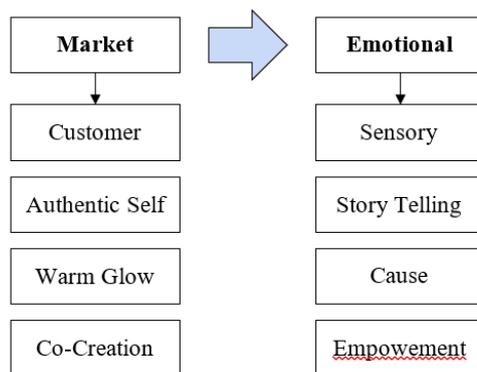


Figure 2 Emotional Branding Strategies  
(Source: Kim & Sullivan, 2019) [13]

### 3.1.1 Sensory Branding

Based on the feedback received by Norche based on the results of Prototype testing, customers and potential customers like products with simpler designs and also made of canvas or leather. Among them stated that *“The model is unique, provides interesting elements, suitable for everyday use”* – Dwi Kartika (R1), besides that in terms of color, there is also the statement *“The color is neutral so you can wear it anywhere, the strap color is contemporary and cute”* – Benyta (R2) and also that the product meets market expectations and needs *“Products are fresher and in demand by millennials”* – Fadhila (R3).

### 3.1.2 Story Telling

The results of the analysis state that the audience likes content with the concept of “Product review”, so that they can understand more in detail from someone's story about Norche products. So far, Norche has not carried out this strategy to increase trust or increase the presentation of converts to purchase of Norche products. The Target Customer Extraction that has been implemented by Norche is enough to show how big the Norche audience.

### 3.1.3 Cause Branding

Based on the results of the previous analysis, the biggest reason the audience buys the product is because of the function of the bag, Norche can apply the size of each bag and also provide a review of the details of Norche products. Price is the next factor that is the reason for buying bag products. Norche bags have an average price of above Rp. 150,000, Norche only contains pricing information on the internet shop and e-commerce, not on social media displays, so the company may show price information and further information on social media as information fulfillment and to convince the audience to purchase the goods instantly.

### 3.1.4 Empowerment

Empowerment marketing transcends traditional marketing strategies by recasting consumers as heroes with the capacity to make their lives better. Customers' self-efficacy and self-esteem can benefit from empowerment marketing [14]. In collaboration with various of fashion businesses or influencers, Norche may make a number of innovative strides to develop a genuine trend style. Influencers may also have a significant impact on enhancing delivery to consumers; this might take the shape of decreased worry or influencers with a strong image of women's empowerment or environmental concerns.

### 3 Conclusion

Based on a strategy that has been designed using an emotional branding approach, it was found that Norche will implement based on four important elements of emotional branding, examination sensory branding, storytelling, and cause branding, and empowerment. Furthermore, the strategy will be implemented into several strategic implementation focuses which will be explained as follows.

1. Optimizing content on the Instagram Platform: This is because the content displayed on Instagram Norche is still less attractive, and has a lack of information and stories about the brand and the product itself.
2. Optimizing content on the Official Website Store This is because the product catalog displayed is still too basic, and information about product details is still not displayed in detail. This needs to be developed because the website platform is one that provides convert sales of Norche products.
3. Creating campaigns and collaborations with other brands and influencers: This is necessary to increase the level of the audience for the spread of the Norche Brand identity to a wider audience of brands and other influencers.
4. Develop the products provided by Norche: This is necessary to increase the sensory-driven customers towards Norche products that have consistently provided the best quality.

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## **Utilizing TikTok for Broadcasting Educational Content During a Pandemic**

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**Abstract.** According to a 2020 study in the United States, TikTok is the most downloaded virtual communication app. It is particularly popular among teenagers, ages 13—the minimum age requirement for TikTok users—up to 24 years (Sehl, 2020). In the same year, according to the 2020 population census, Indonesia experienced a demographic bonus, where the productive age population was at a high percentage, namely at 70.72%. The slice of this productive age are those who are classified as teenagers.

In the meantime, finding an appropriate learning process during this COVID-19 pandemic is necessary. Based on a literature review, TikTok is currently considered highly potential in the online content broadcasting process (Dilon, Cell. 2020). However, in-depth research to explore the potential of this application is still very much needed.

This study aims to explore potential of TikTok as a a medium to deliver computer-based educational content, and to find appropriate ways of communicating digitally to today's youth. The qualitative descriptive method was carried out by comparing three educational contents broadcast through TikTok. The results of this study are educational publication concept content strategic recommendations for teenagers, during the pandemic.

**Keywords:** *covid-19; pandemic; online; education; platforms; potential; TikTok; teenager, visual, communication.*

### **1 Introduction**

March 2020 was the start of the lockdown in Indonesia and globally. The situation resulted in schools across the country having to close. Since the pandemic, education has undergone a radical change in the process. According to previous research, the world is experiencing technological, pedagogical and social challenges. (Ferri, F., Grifoni, P., & Guzzo, T., 2020). Another study found that teenagers were stressed and fatigued due to the many tasks assigned daily. (Literates, I., 2021). In the world of education, one of the biggest challenges is

how to make students interested and stimulated to learn. (Chomsky, 1992). In a time of pandemics like now, the use of digital platforms can be suitable and considered strategic because this media is the most used by teenagers. Aligned to the current situation, where changes occur rapidly, radical adjustments need to be made, including the world of education. As stated above, helping students become interested in learning is the responsibility of teachers and stakeholders. A new approach is needed in delivering materials that will support the educational process, such as educational materials that can bridge the process of delivering educational materials contained in the educational curriculum, which is delivered with a more conventional procedure. This research will explore the features of the TikTok platform as one of the most popular platforms among teenagers today. According to a 2020 study in the United States, TikTok is the most downloaded virtual communication app. Research findings also suggest that the app is popular among teenagers, ages 13—the minimum age requirement for TikTok users—up to 24 years (Sehl, 2020). This research is limited to TikTok content published during the fourth quarter of 2020 to the third quarter of 2021, where online education is being carried out evenly in schools globally. This research intends to find a strategy for publishing content that would be valuable to educate teenagers during the pandemic so that teachers can achieve students' engagement and become interested in the teaching material. In concern to digital communication as a subject of discipline, this research aims to recommend a digital communication concept and strategy that is more suitable for teenagers.

## **2 Theoretical Background**

The foundation of this research is based on the things that underlie the theories in communication and visual communication theory, such as how a message can be clearly received by the target recipient. For that we need a special strategy for each targeted recipient, which then really depends on the function of cognition in communication, which can be divided by verbal function where articulation skills, and communication style, is used in communicating with certain communication targets, and visual function, whereas the use of images can help develop and boost understanding.

Another theory says that in attempt to maximize the precision of the communication process in terms of emotional connection, adolescents often use emoticon symbols or emoji icons, to convey emotional messages or verbal emphasis on texts that are not interpreted by simple punctuation marks (Moss, 2013).

Aside to that, in communicating, teenagers have uniqueness. Their communication lies in the value of transactional or instrumental communication, namely for developmental power and social capital (Haslet & Bowen, 1989).

Then, it was clarified by M. Bucholtz, that based on research for adolescents there is the use and function of slang as a group marker, as well as to distinguish the identity of one teenager from another. These theories on how teenagers communicate are the background of this study, specifically on how to find the unique communication style in TikTok, and how they can be applied in communicating digital educational content effectively.

In addition to the youth communication styles above, in TikTok, the media is displayed in video format, so the theory related to visual composition is also highlighted as the background for this research. According to Zetti (2016), in motion pictures, conventional methods of composition are no longer sufficient. Knowledge of how to structure a dynamic visual between one image sequence and another is required.

### **3 Methodology**

This is a qualitative descriptive-analytic, the data are collected from TikTok and will be analysed by comparing the narrative structure of three TikTok content, with the same topic, regarding basic mathematics, assuming the three contents targeted the youth since the topic is a topic that is discussed at the youth education level. Another qualification is the three contents obtain significant viewing achievement. In addition, this study will identify the particularities of what communication style is used in each content narrative. The time span of the content studied is content published between December 2021 to December 2022.

### **4 Result and Discussion**

From the results of this study, TikTok as a social media platform favoured by teenagers (Sehl, 2020), has the main feature as a video maker application. In this application, the manufacturing process is very simple because it only requires one device, such as a smartphone that is connected to the internet network.

The limited duration on TikTok may be an advantage because the shorter the content the less effort it takes for the content creator to fill the content while for the audience, the short duration of TikTok content becomes light, not time-consuming and not tiring. The duration of TikTok segment is fifteen seconds, with a maximum length of up to three minutes. Apart from that, the process of operating TikTok is quite easy, in fact all supporting media equipment such as sound generating features, adding background music features, text generators, to adding visual elements and effects, which are needed to produce a video have been integrated into one user interface

In Table 1 and the two graphs below, you can see a comparison of the level of engagement of the three contents with the topic of mathematics lessons which have a fairly high level of audience involvement.

In Table 2 there is a comparative analysis between the three contents mentioned above, with a description of the treatment given to each of the elements that make up the observed content, including:

1. **Visual**, based on the theory of composition and elements in a composition (Zetti, 2016) and regarding the use of helpful visual symbols (Moss, 2013)
2. **Sound**, based on how sound can affect the audience's perception and emotions (Zetti, 2016)
3. **Communication style**. Based on the theory of adolescent language style, which tends to use slang/slang in daily life. (Bucholtz, M. 2000)
4. **Narrative structure**. Speaking techniques have various structures (Gitner, 2016). This element is important to be investigated, in order to find the most appropriate structure for today's youth.

Based on the findings in Table 1, the content entitled Trik MTK, Decimal Mix by Lianna Nathania received a fairly significant high level of engagement; it was liked by 1,400,000 viewers and up to the time this journal was written, the video had been played 12,000,000 times, this is a stark contrast when compared to two other content that have a close values of engagement rates. Jerome Polin's video, How to Calculate Leaf Area is liked by 162,700 views and has been viewed 1,900,000 times, while slightly below it. Video  $1+1=?!$ , by Falya Aqila was liked by 150,900 viewers and has been played 1,500,000 times. The Shared factor though is not in the millions metric range, but is directly proportional to the Liked and Played factor. On the other hand, the level of audience engagement, the Comments factor, is higher than the first video.

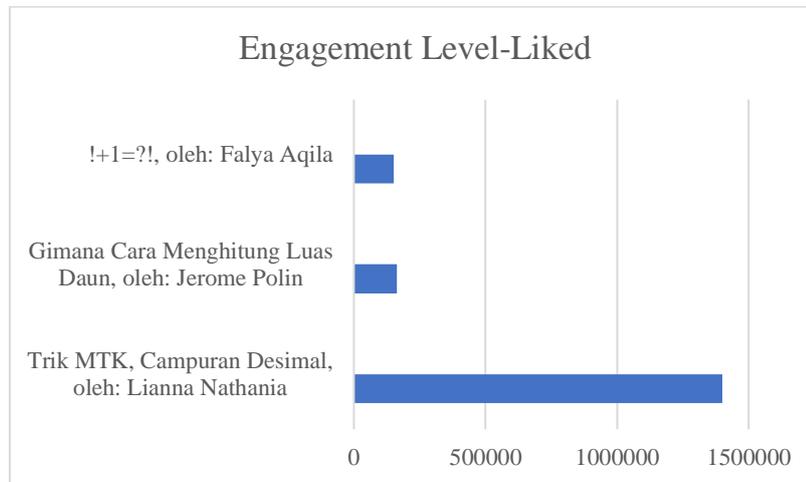


**Figure 1** Screenshots from TikTok accounts, @LiannaNathania, @Jerome Polin and @Falya

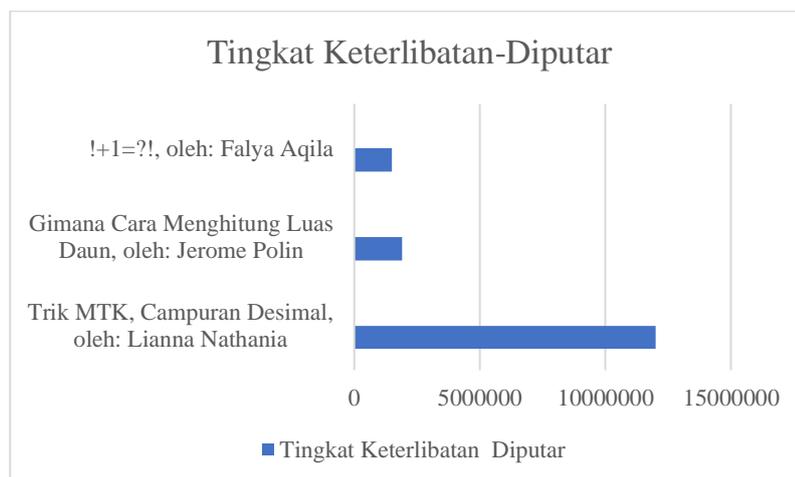
**Table 1** Educational contents and their level of engagements, December 2021-December 202.

Title	Engagement Level			
	Liked	Played	Comments	Shared
<i>Gimana Cara Menghitung Luas Daun, oleh: Jerome Polin</i>	162700	1900000	4680	1766
<i>Trik MTK, Campuran Desimal, oleh: Lianna Nathania</i>	1400000	12000000	63200	45200
<i>1+1=?!, oleh: Falya Aqila</i>	150900	1500000	11400	1696

Source: compiled from **TikTok**



**Figure 2** Graphic of engagement level-liked



**Figure 3** Graphic of engagement level-played

Based on the findings in Table 1 and the theories that form the basis of this research, the following are the results of the analysis description given to each content element in the three contents as mentioned above, in Table 2:

**Table 2** Analysis.

Observed elements in content	Educational Content with Math Topics		
	<i>Trik MTK, Campuran Desimal, oleh: Lianna Nathania</i>	<i>Gimana Cara Menghitung Luas Daun, oleh: Jerome Polin</i>	<i>1+1=?!-Gampang Banget, oleh: Falya Aqila</i>
Visual	Using visual aid pop up text that serves to support verbal communication.	Using digital illustration graphics.	In the title scene, there is a comment sticker from the account's followers.
	The presenter's face is friendly, and he often smiles.	Presenters are shown, along with video compositions within the video.	Video is recorded in simple manner, there is a change in shooting angle, Using simple props, no cropping.
	Presenter wear casual and polite everyday clothes.	Presenter wear casual and polite everyday clothes.	
	Video direkam sederhana, satu sudut pengambilan, menggunakan alat bantu peraga yang sederhana, tanpa dipotong.	Video is recorded in simple manner, one angle shot, using simple props, without cropping.	
Sound	There is background music that is not too loud, there is a narrative that is spoken quickly, clear articulation, dynamic intonation, with a high but cheerful tone of voice.	There is background music that is not too loud, there is a fast spoken narration, clear articulation, and dynamic intonation.	There is background music that is not too loud, there is a narrative that is spoken quickly, clear articulation, dynamic intonation, with a high but cheerful tone.
Communication Style	Friendly communication style.	Communication style is like storytelling.	The communication style is straightforward, friendly and relaxed.
	There are persuasive invitations, for example "It doesn't take five seconds to finish", "Easy, right?"	Using non-standard Indonesian, with a mixture of slang in the form of English which is commonly used by young people in Indonesia, for example, "Hi Guys!"	Menggunakan bahasa Indonesia yang tidak baku, dengan campuran slang yang lazim digunakan anak muda, contohnya, "Cekidot!"

		Contains elements of comedy.	Contains elements of sarcasm.
Narrative Structure	Very clear step-by-step instructions for counting.	Background-instructions-conclusion	Instructions for counting steps.
	There are three examples of questions and give the audience a chance to practice.		The narrative structure contains a tragedy phase, where the audience is led to confusion about content that is contradictory to the message in the title.

## 5 Conclusions

Through point of views in this research, the use of TikTok as a digital medium for educational material in the current pandemic era, which enable an emergency online learning process to take place can be seen as very promising process and has high potential to be explored. An interesting finding in this study is that the three videos compared above have similarities in the production process. All three videos are made with simple devices and in a simple way, where the presenters use the existing settings, using polite and simple clothes, without any artistic assistance. excessive light, or any particular props. The TikTok platform allows for minimalistic processes as mentioned above, yet still resulting a content that can still meet the level of audience satisfaction, that can be proven by the relatively high level of “likes” factor engagement in the three videos compared. MTK Trick Video, Decimal Mix, by: Lianna Nathania, which achieved bombastic numbers compared to the other two videos, in the results of the description of visual elements, still accommodating the audience's needs, to still be able to understand the content of the video, in situations where sound may not be accessible by the audience by reading while still being able to enjoy the images on the existing videos. The other two videos don't really apply what was done to this highest-engagement-winning video. However, the three videos above are examples of three content with math topics, which are rated well by the audience of TikTok users who are assumed to be teenagers.

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## Winged Bean Seed (*Psophocarpus Tetragonolobus* L) as a Natural Coagulant and Natural Zeolite as a Simultaneous Adsorbent for Tofu Waste Treatment

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**Abstract.** Winged bean seeds are known as waste that is rarely used, so it needs to be developed for wastewater treatment, which is more economical and environmentally friendly. One of the methods used to reduce the amount of organic matter in the winged bean tofu wastewater is as a natural coagulant and natural zeolite as an adsorbent. Winged bean seeds and natural zeolite have a reactive ionic charge so that they can bind and absorb other components that oppose the charge. Parameters of turbidity test, DO, TSS and pH in industrial wastewater using coagulation-flocculation method tofu followed by adsorption method. The research variables of the coagulation method were pH 6, pH of tofu liquid waste (4, 6, 8 and 10), winged bean seed dosage (500, 750, 1000 and 1250 mg/L), and flocculation time (10, 20 and 30 minutes). Analyze data with graphics. The results showed that the optimum dose of pH 6 treatment was 750 mg/L. The optimum pH at pH 4 with a dose of 750 mg/L, and the optimum flocculation time at 20 minutes was able to control the turbidity of 54.34%. Furthermore, the adsorption method using natural zeolite adsorbent is able to utilize the turbidity value of 94.51%, the DO value from 1.67 to 6.61, the TSS value of 92.96%, the zeolite dose of 1.5 g. The initial pH value of tofu liquid waste was 4.7, which could be improved with a pH value of 6.6. The final values of turbidity, DO, TSS and pH obtained meet the quality standards stated in the Regulation of the Peraturan Menteri Lingkungan Hidup RI Nomor 5 tahun 2014 tentang Baku Mutu Air Limbah.

**Keywords:** *adsorption; coagulation; DO; natural zeolite; Tofu waste, winged bean seed; turbidity; TSS; pH.*

### 1 Introduction

Agroindustry not only provides positive benefits but also has negative consequences due to the waste generated from its production process. Agroindustry usually uses water for manufacturing processes in large quantities so as a consequence large quantities of wastewater will also be generated. In general, agroindustrial wastewater has a fairly high organic matter, this can be seen from

the high values of DO and COD. Water treatment in industrial waste can be carried out by various methods such as precipitation, adsorption, and coagulation. The method of coagulation and adsorption is one of the most widely applied methods in water treatment because it does not require a large budget compared to other water treatment methods. Industry produces waste in the form of liquid waste. This waste can have negative consequences for the area and the health of residents. One example of an industry that contributes waste is the tapioca flour industry.

Most of the liquid waste of the food industry can be handled easily with biological or chemical systems, because the main pollutants are organic materials such as carbohydrates, fats, proteins, and vitamins. (Direktorat Jendral Industri Kecil Menengah, Departemen Perindustrian, 2007). The production of tapioca flour will produce liquid waste containing organic materials. Organic material contained in the waste is biodegradable, which means that the material can be naturally decomposed or easily broken down by microbes. (Sholikhah et al., 2015).

Sumiyati's research (2009) states that tapioca waste can cause aquatic environmental communities in rivers to be threatened with extinction, because tapioca liquid waste contains very high toxic compounds CN- or HCN. Disposal of waste into the river environment does not undergo treatment first. The negative impact of liquid waste results in environmental pollution, including unpleasant odors and some residents' wells that are not suitable for consumption. Tapioca liquid waste contains organic matter including glucose 21.067%, carbohydrates 18.900% and vitamin C 51.040%. Liquid waste is discharged directly into the environment before processing it will cause water pollution and cause a foul odor. The results of the tapioca flour industrial wastewater contain organic materials in the form of starch or fiber, both dissolved and suspended particles. If this industrial liquid waste is discharged into the environment without prior treatment, the wastewater will turn blackish brown in color and smell bad (Said and Handajani, 2005).

There are several parameters that are commonly used as indicators of wastewater quality including COD (Chemical Oxygen Demand), BOD (Biochemical Oxygen Demand) (Alaerts and Santika, Sumetri Sri 1987) and turbidity (turbidity). The poor water quality can be seen from the results of the large COD, BOD and turbidity tests. Large COD and BOD numbers indicate the amount of oxygen needed to decompose organic substances in water and the amount of dissolved oxygen or DO (Dissolved Oxygen) is small. Meanwhile, turbidity is a measure that uses the effect of light as a basis for measuring the state of raw water. The method used is the method of coagulation and adsorption.

Winged bean (*Psophocarpus tetragonolobus* L) protein has a high range of protein (27.8-36.6%) and fat (14.8-17.9%), which is similar to soybean. Extraction with NaCl extract showed the highest protein concentration range (60.2-77.6%).

(Fumio, et al., 1983). According to Dobrynin and Michael (2005), polyelectrolytes are polymers that carry a positive or negative charge from ionized groups. In a polar solvent such as water, these groups can dissociate, leaving a charge on the polymer chain and releasing the opposite ion in solution. Winged bean is expected to be an alternative biocoagulant (natural coagulant) because this plant is easy to cultivate, grows fast, and can be rejuvenated.

The results of research conducted by Thamzil Las and Husen Zamroni (2002) showed that Indonesian natural zeolites contain amorphous alumina-silica, modernite crystals and klipnoptilolite crystals. If this natural zeolite is activated and modified, Indonesian natural zeolite will have good quality to be used as a catalyst, absorber and ion exchanger. Zeolites are minerals consisting of hydrated alumino silicate crystals containing alkaline or alkaline earth cations in a 3-dimensional framework. These metal ions can be replaced by other cations without destroying the zeolite structure and can absorb water reversibly. Zeolite structure is very open consisting of cavities and pores, filled with water and cations that can be exchanged and have a certain pore size. Therefore, zeolites can be used as molecular filters, ion exchangers, absorbent materials, and catalysts. (Syoufian, 2001).

Therefore, on this basis, a research was conducted on the use of natural coagulants and adsorbents in tapioca flour wastewater which did not meet the quality standards for disposal into the waters. The coagulant used in this liquid waste is winged bean seed coagulant which is then subjected to additional treatment with an adsorption process with an adsorbent, namely natural zeolite. So it is expected to meet the quality standards with parameters including: pH, Turbidity, and DO (Dissolve Oxygen).

## **2 Experimental Section**

### **2.1 Materials**

The materials used in this study were tofu waste, old winged bean seeds, natural zeolite, Aquades, 0.1M NaOH, 2M NaOH, and filter paper. All the chemicals used were of analytical grade, purchased from Merck Chemical Company (Merck, Germany). The tools used in this research are digital balance, blender, ayakan 140 mesh, measuring flask, 45 cm diameter glass bowl, magnetic stirrer, hot plate, oven, glass beaker, turbidity meter, DO meter and pH meter.

### **2.2 Preparation Phase**

Preliminary Preparation of Winged bean (*Psophocarpus tetragonolobus* L)

Winged bean seeds used in making the suspension are old and dry winged bean seeds. Winged bean seeds soaked in water for  $\pm$  12 hours then peeled and dried. The dried winged bean seeds are then mashed with a blender and then sieved to obtain a fine powder menggunakan ayakan 140 mesh. Winged bean powder was

made into a 2% (w/v) suspension by dissolving 2 grams of fine powder with distilled water until the volume was 100 mL. The suspension was then filtered through filter paper. The manufacture of winged bean seed suspension according to the desired concentration is carried out by dilution (Hendrawati, et al, 2013)

### **2.2.1 Initial Preparation and Activation of Zeolite**

Zeolite granules were soaked in distilled water for 24 hours at room temperature, then filtered and dried using an oven at 110°C. The dried powdered zeolite was soaked with 0.1M NaOH, filtered and washed with distilled water repeatedly and dried in an oven at 130°C (Suyanta, 2009)

## **2.3 Coagulation Stage**

### **2.3.1 Determination of optimum pH by coagulation method**

Tofu waste collection. The effluent collected from the factory is filtered to remove large impurities. Turbidity, DO, TSS and initial pH of tofu wastewater were measured as controls (Sholikhah, et al, 2015). The sample of tofu wastewater was 200 mL with the degree of acidity (pH) of the sample set to 6 by adding NaOH. Winged bean powder is added in variations of 500; 750; 1000 and 1250 mg/L of tapioca flour industrial wastewater. After each addition, the sample was stirred rapidly (100 rpm) for 1 (one) minute then followed by slow stirring (40 rpm) for 3 (three) minutes. The dose of coagulant that produces the highest turbidity removal is used. The sample was 200 mL and the pH was adjusted by adding NaOH and H<sub>2</sub>SO<sub>4</sub> for 4, 6, 8 and 10. The sample was then stirred rapidly for 3 minutes (coagulation process) and followed by slow stirring for 12 minutes (flocculation process) then allowed to settle for 60 minutes. The supernatant turbidity of each sample was measured (Enrico, et al, 2008)

### **2.3.2 Determination of the optimum dose by the coagulation method**

The beaker was filled again with 200 ml tofu wastewater sample and the pH was adjusted according to the pH which resulted in the optimum turbidity of the supernatant sample. The natural coagulant of winged bean (*Psophocarpus tetragonolobus* L) was added with a dose of 500; 750; 1000 and 1250 mg/L samples were then stirred rapidly for 3 minutes (coagulation process) and followed by slow stirring for 12 minutes (flocculation process) and then allowed to settle for 60 minutes. The supernatant turbidity of each sample was measured (Enrico, et al, 2008).

### **2.3.3 Determination of optimum time by coagulation method**

The beaker glass was refilled with 200 ml of tapioca flour industrial wastewater sample and the pH was adjusted according to the dose and pH which resulted in the optimum sample supernatant turbidity in the above section. Stirring at a speed of 10 rpm with various times (10; 20 and 30 minutes). The purpose of this stirring

is to combine the flocs so that they become larger in size. Samples that have gone through the coagulation stage will be left for 60 minutes to precipitate the floc. At this stage the floc which has sufficient weight will settle to the bottom of the glass beaker. The waste is separated from the formed flocs using a filter, and the waste will then be analyzed for the Turbidity value (Enrico, et al, 2008).

## 2.4 Adsorption Stage

0.5 each; 1.0; 1.5; and 2.0 g of zeolite plus 10 mL of wastewater (water industry waste tofu) which has been through the coagulation method with the optimum dose, pH and time. The mixture was shaken for 150 minutes at 300C then centrifuged. Separated between the filtrate and residue, then the filtrate was measured the value of Turbidity, DO, TSS and pH. (Trisnadewi, et al, 2017)

## 2.5 Statistical Analysis

Determination of the turbidity value of the tofu liquid waste before and after being treated with a coagulation system and followed by adsorption with the test parameters Turbidity, DO, TSS and pH. Each parameter was analyzed according to the analytical method. Measurements were carried out in triples. Determination of the percentage reduction in levels of each parameter:

$$\% \text{ drop} = \frac{C_0 - C_1}{C_0} \times 100\% \quad (1)$$

Where :

$C_0$  = initial concentration parameter

$C_1$  = final concentration parameter

### 2.5.1 Determination of Suspended Solids Content (TSS)

The filter paper was heated in an oven at 105°C for 1 hour, then cooled in a desiccator and weighed to a constant weight (B grams). A total of 10 ml was filtered. The filter paper and residue were heated in an oven at 105°C for 1 hour, cooled in a desiccator and weighed to a constant weight (A gram). The suspended solids content can be calculated in the following equation:

$$\text{TSS (mg/L)} = \frac{A - B \times 1000}{C} \quad (2)$$

Where :

A = Filter weight and residue after heating 105°C (mg)

B = Dry filter weight after heating 105°C (mg)

C = Sample volume (ml)

Data analysis was carried out using a comparative descriptive method, where the quality of the tofu liquid waste that had been processed was compared with the quality of the tofu liquid waste before processing to obtain the effectiveness value presented in tabular form. Data analysis was carried out using the Microsoft Excel program. The method used in analyzing the relationship between variables is to create a scatter diagram. Data analysis was carried out by analyzing the data that had been obtained from sampling activities, namely turbidity data for the coagulation method, and turbidity Turbidity, DO, TSS and pH for the adsorption method.

### **3 Results and Discussion**

#### **3.1 Winged Bean Seed**

The coagulant used in this study is a natural coagulant of winged bean seeds in powder form. Winged bean seed powder is obtained by soaking old winged bean seeds in water for 12 hours which aims to make the winged bean seeds softer so that later it is easy to separate the skin, then separate the seeds and skin, after that it is heated in the sun so that it can dry. then grinded. After grinding, the powder was sieved using a flour sieve to homogenize and so that the surface area of the coagulant was the same.

Winged bean seeds can be used as a coagulant in the coagulation process due to the consideration of the protein content in the seeds and natural polymers such as starch which function as flocculants. The ability of winged bean as a biocoagulant is due to its high protein content which can act as a polyelectrolyte. According to Dobrynin and Michael (2005), polyelectrolytes are polymers that carry a positive or negative charge from ionized groups. In a polar solvent such as water, these groups can dissociate, leaving a charge on the polymer chain and releasing the opposite ion in solution.

In this preliminary study, the tofu industrial wastewater was first measured for turbidity, pH, and DO initially. The most important physical characteristic of wastewater is its solid content, because it affects the aesthetics, clarity and color of the water. Liquid waste that has a high suspended content should not be discharged directly into water bodies because in addition to causing siltation, it can also block sunlight from entering the bottom of the water so that the photosynthesis process of microorganisms cannot take place (Alaerts and Sumetri Sri Santika, 1987).

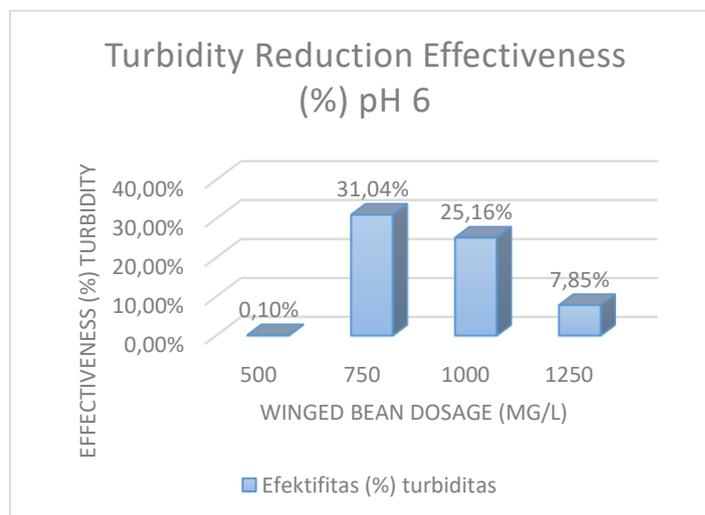


**Figure 1.** Dried and old winged bean pods (left), young winged winged seeds (middle) and old winged winged pods (right).

Tri Handayani, Kelompok Peneliti Pemuliaan dan Plasma Nutfah  
Balai Penelitian Tanaman Sayuran, 2013)

### 3.1.1 Effect of Coagulants pH Variations on Turbidity

The initial step was taken by measuring the initial turbidity value of tofu waste obtained at 680 FNU. The initial stage of the coagulation method with dose variations obtained data that the turbidity value decreased. The sample of tofu waste used was 200 ml. This waste is put into a glass beaker which is then adjusted to pH 6 by using the addition of NaOH. This pH 6 setting is due to the fact that at pH 6-7 the use of coagulants can work with optimal capabilities. Then the sample was stirred with fast stirring (100 rpm) for 1 minute and then stirred at a slow speed (40 rpm) for 3 minutes. The doses of natural coagulant of winged bean used are 500; 750; 1000 and 1250 mg/L of tofu industrial wastewater. From the data obtained, the optimum dose of winged bean seed coagulant is at a dose of 750 mg/L of tofu industrial wastewater.

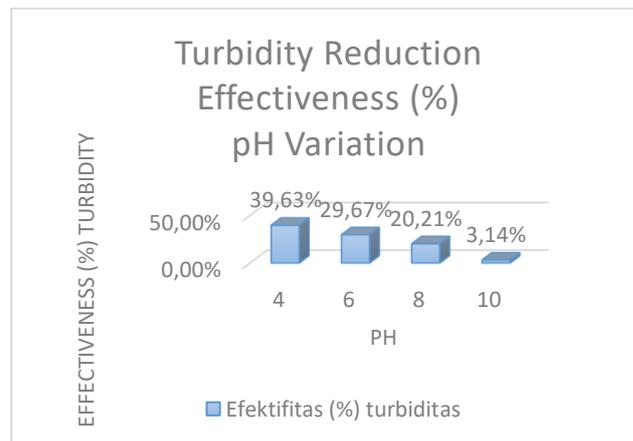


**Figure 2.** Effect of pH 6 Coagulants on Turbidity.

In Figure 2, it can be observed that the initial turbidity of the tofu waste can be removed with an effectiveness of 31.04% with a turbidity value of 469 FNU with

the optimum dose of winged bean seed coagulant used at a dose of 750 mg/L of tofu industrial wastewater. Turbidity will increase along with the addition of winged bean seed coagulant dose, this is due to too much winged bean seed coagulant dose so that the ability to purify liquid waste from the tofu industry becomes saturated. Meanwhile, at lower doses, the coagulation-flocculation process has not occurred.

The next step, after obtaining the optimum dose with pH 6 treatment, is carried out by varying the pH of the tofu liquid waste to pH 4, 6, 8 and 10. Liquid waste from the tofu industry with an initial turbidity of 680 FNU and an initial pH of 4.7 is put into a glass beaker. as much as 200 ml then adjusted the pH by adding NaOH to raise the pH and 15% concentrated H<sub>2</sub>SO<sub>4</sub> to lower the pH. Tofu liquid waste whose pH has been adjusted is added winged bean seed coagulant with the optimum dose obtained from the previous step of 750 mg/L of tofu industrial wastewater, fast stirring (100 rpm) for 3 minutes and slow stirring (40 rpm) for 12 minutes.



**Figure 3.** Effect of Coagulants pH Variations on Turbidity.

The final turbidity allowance of the sample for the use of coagulants with different pH is shown in Figure 3. Winged bean coagulant has an optimum pH of waste with pH 4, the effectiveness of decreasing turbidity is 39.63%. The coagulation process is strongly influenced by pH. Coagulants have a certain pH range to achieve optimum coagulation. Therefore, the liquid waste to be treated must have an adequate pH to be able to react with the coagulant to produce floc. Winged bean seed biocoagulants can work more optimally at acidic pH (Hendrawati, *et al*, 2013).

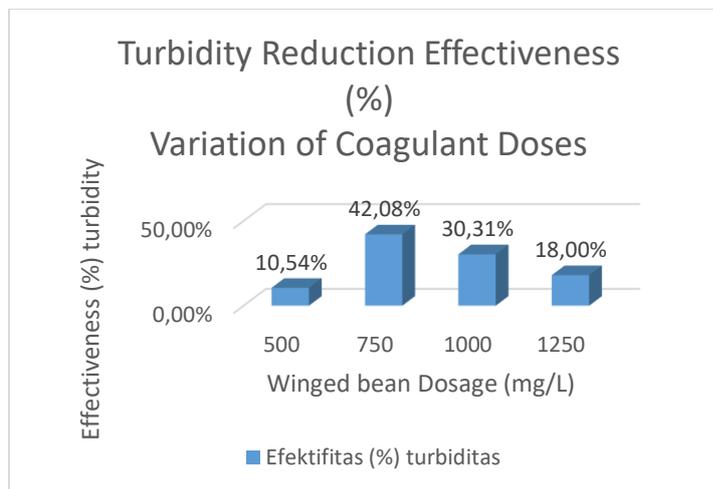
Winged bean coagulant works effectively at pH 4 due to the glutamic acid content in the seeds, so that the H<sup>+</sup> ions in the glutamic acid bind to negative ions in the colloidal particles of the tofu industrial wastewater to form a layer that will gradually enlarge, called floc. At acidic pH protonation occurs in the amino group

(NH<sub>2</sub>) of the dissolved protein from winged bean seeds so that the amino group interacts with H<sup>+</sup> from the solution to become -NH<sub>3</sub><sup>+</sup>. The -NH<sub>3</sub><sup>+</sup> group supports the bonding between winged bean protein and negatively charged colloidal particles.

Winged bean seeds contain a type of low molecular weight water soluble protein which when dissolved will produce a large number of positive charges. So that the cationic protein is distributed throughout the waste liquid and then interacts with negatively charged particles that cause turbidity which are dispersed in the liquid waste. Due to the glutamic acid content contained in winged bean seeds, the H ions in the glutamic acid bind to negative ions in the colloidal particles of the tapioca flour industrial wastewater to form a layer which over time will enlarge which is called floc. Tofu industrial wastewater treatment uses winged bean seed as a coagulant, the optimum pH is at pH 4 with a final turbidity of 410 FNU. So that pH 4 can be used for the next step.

### 3.1.2 The Effect of Variations in Coagulant Doses on Turbidity

The dose of coagulant can have an effect on decreasing the turbidity of tofu industrial waste because by giving the right dose, the removal of sample turbidity will be more significant. At pH 4 this tofu industrial wastewater is the optimum pH, the dose required for the coagulation-flocculation process is not too large, namely 750 mg/L of tofu industrial wastewater which shows a decrease of 42.08%, so that if the dose is further increased it becomes 1000 and 1250 mg/L of liquid waste from the tofu industry will cause contamination due to excessive doses and the solution will become saturated. Meanwhile, at a dose of 500 mg/L, the coagulation-flocculation process has not occurred. As shown in Figure 4 below:



**Figure 4.** The Effect of Variations in Coagulant Doses on Turbidity.

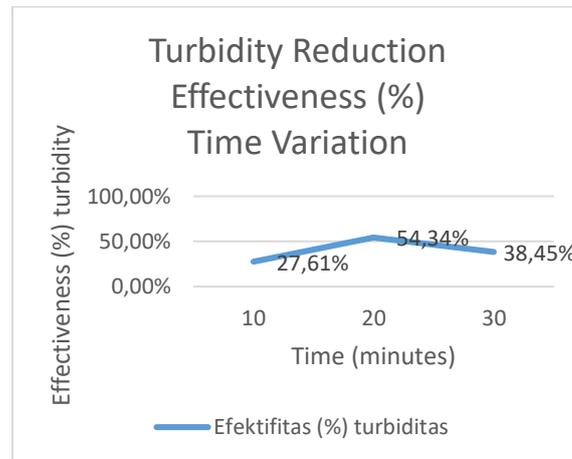
The coagulant dose of winged bean seed does not exceed the coagulant concentration determined according to Wagner (2001) which is between 0.5 percent and less than 1.0 percent, if it is assumed in weight percent per volume (w/v) where 1% w/v 1 grams of coagulant in 100mL of waste. The effectiveness of decreasing turbidity again decreased due to the addition of excessive biocoagulants resulting in an increase in the tendency of the floc to float and not settle. Excess coagulant that does not interact with colloidal particles will also cause turbidity so that the turbidity again increases above the optimum dose. The addition of the right polyelectrolyte concentration will result in reduced colloid stability and will reduce the repulsive force between the particles so as to support the deposition process.

In general, all colloidal particles have the same charge. Due to similar charges, there is a repulsion between colloidal particles. This causes the colloidal particles to not be able to combine so as to provide stability to the colloidal system. Dissolved protein from winged bean contains  $-NH_3^+$  groups which can bind negatively charged particles so that these particles are destabilized to form larger particle sizes which can eventually be deposited.

The ongoing stirring process must also be considered to support the success of the coagulation process. Rapid mixing plays an important role in coagulant mixing and particle destabilization. The purpose of rapid stirring is to produce water turbulence so that it can disperse the coagulant in water. The rapid stirring that takes place helps the fine particles in the water collide with each other to form microflocs. Meanwhile, slow mixing plays a role in floc merging efforts. These microflocs that have been formed through slow stirring will combine to form macroflocs which can be separated through sedimentation. At doses of 1000 and 1250 mg/L there was saturation in the tapioca flour industrial wastewater due to excessive doses so that the reduced floc was exhausted and the coagulant acted as an impurity which caused the turbidity level to increase. Coagulation/flocculation is required to remove suspended or colloidal waste material. Colloids are particles with a diameter of about 1 nm (10<sup>-7</sup>cm) to 0.1 nm (10<sup>-8</sup>cm). These particles cannot settle for a certain period of time and cannot be removed by ordinary physical treatment processes.

### **3.1.3 Effect of Flocculant Time Variations on Turbidity**

Based on the results of the analysis with time variations, the efficiency of decreasing the turbidity value is 54.34% from the initial turbidity value of 680 FNU to 310 FNU. This value was obtained by adding the winged bean seed coagulant dose of 750 mg/L tofu industrial waste with a flocculation time of 20 minutes. According to Wiley (1955) if a coagulant is able to reduce the turbidity value by 50% then the coagulant is effectively used so that the winged bean particle coagulant is an effective coagulant to reduce the turbidity of the tofu industrial wastewater. As seen in Figure 5 below :



**Figure 5.** The Effect of Flocculant Time Variations on Turbidity.

In addition to the dose of winged bean seeds, the duration of stirring is one of the basics that plays an important role in the formation and development of flocs during the flocculation process. Long stirring or short stirring will affect the effectiveness of winged bean seed coagulant. At all optimum doses of winged bean seed coagulant flocculation time of 10 minutes gave a smaller percentage reduction compared to the percentage at 20 minutes of stirring. This is related to the ability of winged bean seeds as a coagulant in the role of binding and linking (Mohd Arifin et al, 2007).

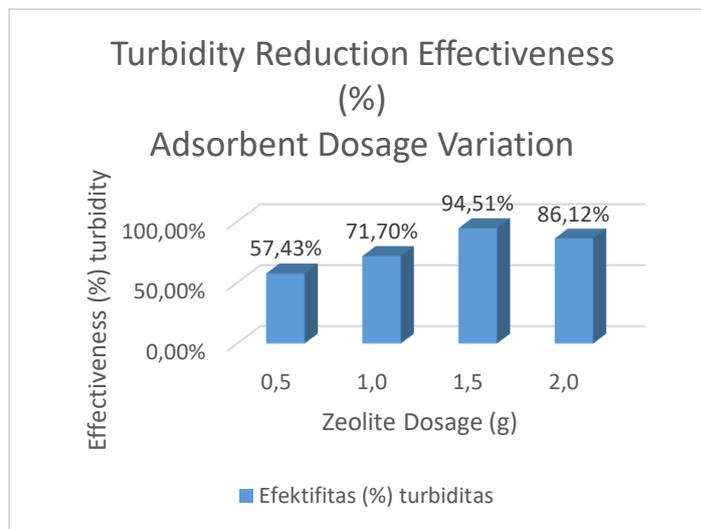
At short agitation (10 min), the collision between the coagulant and suspended solids is low and reduces the flocculation rate. Longer flocculation time will affect the distribution of coagulant so that collisions occur between particles for the neutralization process to be perfect, but if the stirring time is too long it will cause the floc to break and cause its size to be small. Bouhg (1976) also stated that coagulants added to wastewater with slow stirring speed produced better coagulation results compared to processes that used faster agitation. This stirring speed will cause an imperfect distribution of coagulation because the particles of organic matter and winged bean will only rotate together, besides that fast stirring will also damage the flocs that have formed during the coagulation process.

### 3.1.4 Natural Zeolite Adsorbent

The initial treatment for natural zeolite is to activate the natural zeolite with an alkaline process using NaOH. Activated zeolite is dehydrated and will have open pores. The wider the zeolite pores, the more adsorbate will be adsorbed (Azamia, 2012).

### 3.1.5 The Effect of Variation of Adsorbent Doses on Turbidity

The optimum dose of adsorbent with the addition of activated natural zeolite is 1.5 g. At a mass of 2.0 g the turbidity rises again. This is due to the greater the ratio of activated natural zeolite in the same volume of waste, the greater the possibility of interaction between organic substances in the waste and activated natural zeolite. The decrease in optimum turbidity occurred at the interaction of 1.5 g of activated natural zeolite with a decrease in turbidity of up to 94.51%. Meanwhile, at a dose of 1.0 g natural zeolite, the coagulation-flocculation process has not occurred so that the decrease in turbidity cannot be optimal. Seen the results shown in Figure 6 below :



**Figure 6.** The Effect of Variation of Adsorbent Doses on Turbidity.

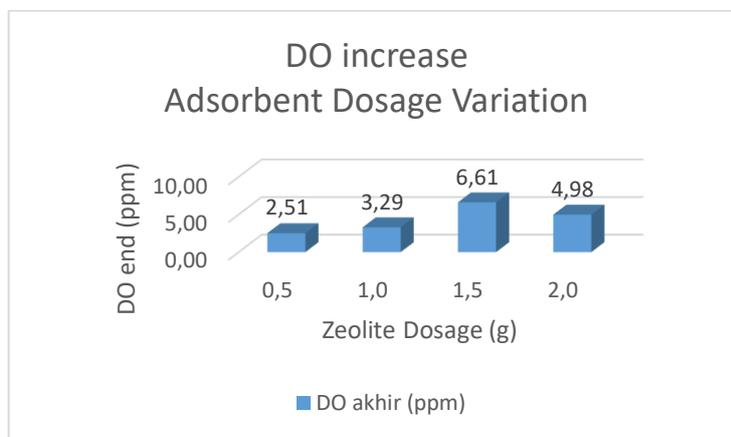
Determination of the optimum dose in this adsorption method, tofu waste added with natural zeolite is a factor that affects the decrease in organic matter. The optimum dose provides contact time for the system to maximally adsorb the waste components, in addition to providing the opportunity for bacteria or microorganisms to grow (Huang, et al, 2010). The flow of liquid waste that enters the zeolite system must also be evenly distributed, so that the waste can be distributed perfectly. Zeolites function to absorb dyes, anions, cations, and organic substances that are not bound by anion or cation exchange resins (Kim, et al, 2013).

### 3.1.6 The Effect of Variation of Adsorbent Doses on DO

In figure 7, the DO parameter test in the waste carried out at the beginning was found to be 1.67 ppm. The low DO range is a strong indication that the tofu waste can cause pollution. Poor water quality can be seen from the DO test results stating that the amount of oxygen needed to decompose organic substances in

water is large and the amount of dissolved oxygen or DO (Dissolved Oxygen) is small so that it can be stated that high COD and BOD and vice versa (Mollema & Antonellini , 2016).

At a dose of 1.5g the adsorbent has a high DO value of 6.61 ppm, because the layer can experience gas exchange between CO<sub>2</sub> and O<sub>2</sub>. Determination of the optimum dose in the waste added with natural zeolite is a factor that affects the decrease in organic matter. The optimum dose provides contact time for the system to maximally adsorb the waste components, in addition to providing the opportunity for bacteria or microorganisms to grow. Zeolites function to absorb dyes, anions, cations, and organic anions and cations that are not bound in the coagulation method.



**Figure 7.** The Effect of Variation of Adsorbent Doses on DO

Measurement of low initial oxygen levels because the waste contains a lot of bacteria that undergo a degradation process of organic material and causes the water to become anaerobic or without air. Chemical compounds are in reduced form, so they can form deposits at the bottom of the layer due to the low oxygen content. (J. G. Speight, 2020). Polluted water causes its oxygen content to be very low, the more organic waste material in the water, the less residual dissolved oxygen content in the water, this is based on research conducted by Wardhana (2004) in Ali, et al. (2013).

Dissolved Oxygen (DO) is the total amount of oxygen present (dissolved) in the water. DO is needed by all living organisms for respiration, metabolic processes or the exchange of substances which then produce energy for growth and reproduction. In addition, oxygen is also needed for the oxidation of organic and inorganic materials in aerobic processes. Salmin (2005) that the main source of oxygen in waters comes from the photosynthesis of organisms that live in these waters, apart from the diffusion process from the free air. DO content in a waters is closely related to the level of pollution, the type of waste and the amount of

organic matter in the waters. Therefore, based on the obtained DO concentration, it can be concluded that the DO value of the marine waters of Depapre belongs to the category of low pollution level with DO value  $> 5$  mg/l (Wirosarjono, 1974 in Salmin, 2005).

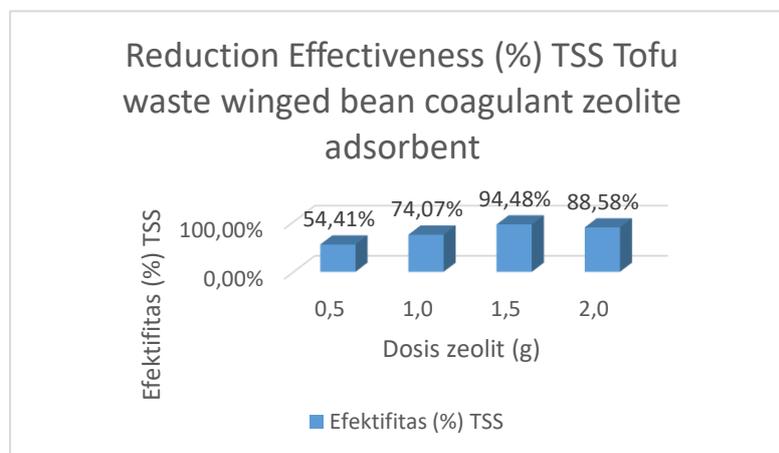
**Table 1** Water pollution levels based on DO and BOD values

Pollution level	Parameter	
	DO (ppm)	BOD
Low	$>5$	0 – 10
Currently	0 – 5	10 – 20
High	0	25

Wirosarjono (1974)

### 3.1.7 Effect of Variation of Adsorbent Doses on TSS (Total Suspended Solid)

Turbidity in water is closely related to the TSS value because turbidity in water is caused by the presence of suspended solids. Suspended substances in water consist of various substances, such as fine sand, clay, and natural mud which are inorganic materials or can also be organic materials floating in the water (Alaerts and Santika, 1987).



**Figure 8.** The Effect of Variation of Adsorbent Doses on TSS

The decrease in TSS value can be shown in Figure 8 above, the optimum TSS value occurs at the addition of a dose of natural zeolite as an adsorbent with a TSS reduction value of 1.5 g, from a TSS value of 536.20 to 29.60. This is because the larger the dose added and accompanied by homogeneous stirring, the

suspended particles and organic compounds will be bound by alum molecules to form a precipitate. This is what causes the TSS value to drop. Meanwhile, with the increasing dose of natural zeolite added, it will cause the solution to be more saturated so that the remaining coagulant will contaminate the existing solution.

### **3.1.8 Effect of Variation of Adsorbent Doses on pH**

Parameters The degree of acidity (pH) determined with a pH meter showed that the pH of the sample was 4.7. Meanwhile, according to the Peraturan Menteri Lingkungan Hidup RI No. 5 tahun 2014 tentang Baku Mutu Air Limbah states that the tolerable pH for tapioca waste is in the range of 6.0 - 9.0. Prayitno (2008) said that the low pH value indicates that in the waste sample there is microorganism activity so that it can degrade organic matter that easily decomposes into acid. The pH value of the liquid waste can indicate whether or not it is necessary to pre-treat the waste to prevent interference with the conventional wastewater treatment process. From the results of the treatment, the pH value of 6.6 was obtained which was in accordance with the standard value of wastewater quality.

## **4 Conclusion**

Tofu liquid waste that does not meet the quality standards according to the Peraturan Menteri Lingkungan Hidup RI No. 5 tahun 2014 tentang Baku Mutu Air Limbah, the quality was improved by using the coagulation - flocculation method using winged bean seeds as a coagulant and continued with the adsorption method using natural zeolite as an adsorbent. Winged bean seeds and natural zeolite have a reactive ionic charge so that they can bind and absorb other components that are opposite in charge so as to reduce DO, pH, TSS and turbidity values. Winged bean seeds were able to reduce the initial turbidity value of 680 FNU to 310 FNU, so the effectiveness of the reduction was 54.34%. Then continued with the adsorption method using activated natural zeolite adsorbent, able to reduce the initial turbidity value of 680 FNU to 37 FNU, so that the effectiveness of the reduction was 94.51%. The initial DO value is 1.67 ppm and can be improved with a value of 6.61 ppm. The initial TSS value of 536.20 ppm was improved to 29.60 ppm. The initial pH value of tofu liquid waste was 4.7 from the treatment results obtained with a pH value of 6.6. The final values of the measured parameters, namely turbidity, DO, TSS and pH, have met the quality standards stated in the Peraturan Menteri Lingkungan Hidup RI No. 5 tahun 2014 tentang Baku Mutu Air Limbah. From these results, it was concluded that in the coagulation process with variations in pH, the dose of winged bean and flocculation time which was effective to reduce the turbidity value was at pH 4, the addition of winged bean seed dose was 750 mg/L with a flocculation time of 20 minutes. In the further adsorption process with natural zeolite adsorbent, the optimum dose of natural zeolite used is 1.5 g.

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## Flexibility Hosting Capacity Calculation in Bantul Distribution System

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**Abstract.** Maximum integration of PLTS penetration into the system without violation and reliability is very important. This research looks at the impact of maximum penetration due to the PV integration of dynamic systems. The impact of maximum penetration is important to consider because of the massive target of the NRE mix in the system for the next few years. This research uses direct measurement point data so that the output accuracy of the solar power plant installation points in each feeder can be seen. The Digsilent Programming Language (DPL) method helps in processing data to extract the results processed into excel. The results of the research that with the maximum value of PLTS integration, it is still within the limits of both voltage, thermal, and flexibility index based on zoning, which is still below 1. These results are relevant to be implemented into a distribution system based on real cases.

**Keywords:** *plts; dynamic system; flexibility index; distribution system; DPL.*

### 1 Introduction

The effect of the signing of the Paris Agreement applying all countries to increase the share of renewable energy as a source of electricity supply, and one of them is Indonesia. Based on RUPTL [1], Indonesia's renewable energy mix until 2030 will reach a total of 4680 MWp, where the installed portion is 78.5 MWp or around 0.04% of total capacity. In addition, based on the RUPTL that there is a potential for PLTB in the Samas Bantul area of around 50 MW. This is the basis for seeing the potential for PV mini-grid integration in the Bantul Distribution System.

Based on the website <http://indonesiasolarmap.com/>, PLTS potential measurement points have been launched on 17 June 2022. A measurement point, one of which is in the province of Yogyakarta, strengthens the potential of the PLTS. Reference[2], Renewable energy penetration limits without causing violation and network operating limitations such as voltage, losses, protection failure, and harmonics. Reference[3], hosting capacity is a challenge for network operations, management, and planning. Reference[4], hosting capacity is a

probability study due to the uncertainty of renewable energy and load dynamics. Reference[5], hosting capacity aims to ensure system security and reliability to distribution system operators(DSOs) when interconnecting renewable energy. Reference[6] hosting capacity can be caused by the impact of individual renewable energy, housing, and small industries connected to the system. So, the effect of maximum penetration on the distribution system with the presence of renewable energy is very dynamic, this study looks at the system flexibility index. Reference[7], flexibility is a network that can accommodate related energy consumption and resource availability. Reference[8], Flexibility is the study of maintaining the balance of the power system due to increased uncertainty and diversity of renewable energy. Reference[9], Flexibility requires an assessment matrix to improve planning and operations. Reference[10], flexibility due to maximum penetration of renewable energy. So, adequacy matrix modeling, assessment, and detailed data-intensive for modeling are needed. The purpose of this research is to provide a maximum limit of PV-grid penetration in the distribution system without causing interference and reliability of the system. The parameters used are referring to the Indonesian standard regulation no 20 of 2020 regarding interconnection to the Grid System. Besides that, this research also consideration of the dynamic system model side due to intermittent solar PV penetration

## **2 Bantul Distribution System**

The Bantul distribution system is a type of radial system with 4 sub-feeders. Where is the length of each feeder as shown in **Figure 1**. In **Figure 1** there are 4 feeders, where the red color is the Bangunharjo feeder, the yellow color is the South Brontokusuman feeder, and the green color is the Mantrijeron feeder, and the blue color is the Panggungharjo feeder.

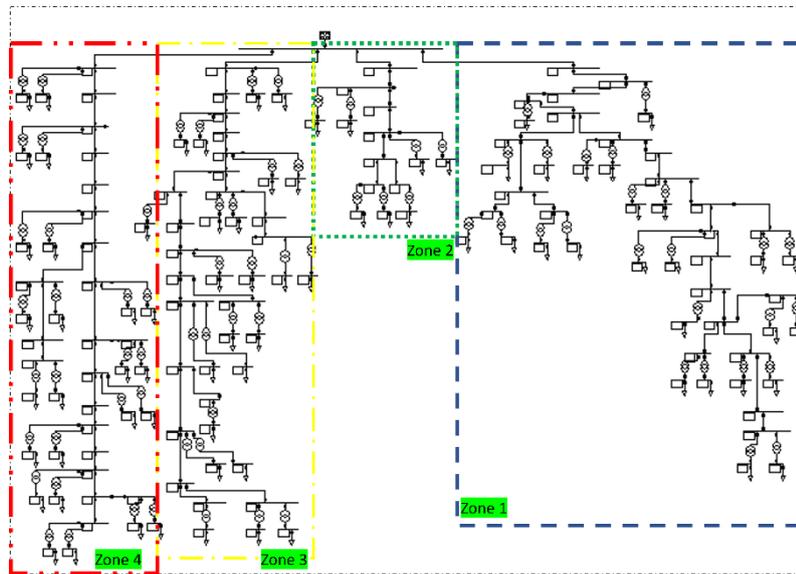


Figure 1 Bantul Distribution System

### 2.1 Sun Irradiation in Yogyakarta

According to data from Indonesiasolarmap.com, where it can be seen for the best radiation in June on the 1<sup>st</sup>. The irradiation curve ( $w/m^2$ ) on June 7 is shown in **Figure 2**, where the amount of power at the peak is  $633 w/m^2$  at 12:25 WIB Indonesian time.

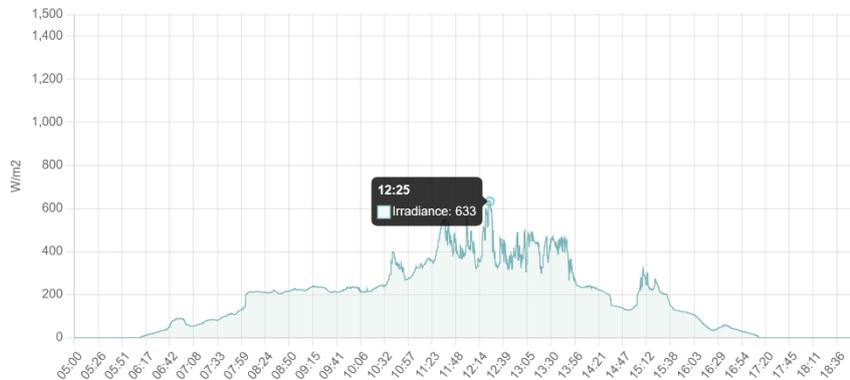


Figure 2 Sun Irradiation in Yogyakarta

Based on the data that has been taken from the AESI solar radiation in one week, can be seen in **Figure 3**. During one day of measurement, the radiation value is very fluctuating. This is because the solar PLTS taken is a type of solar utility. For this reason, in this research, the best data is taken for fluctuations to input data on the digsilent in **Figure 3** which is circled in red.

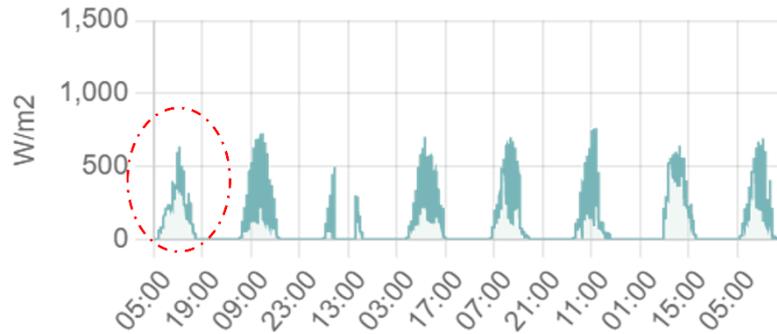


Figure 3 radiation in 1 week

## 2.2 Voltage Increase due to PV-Grid injection

From **Figure 4**, we know that the increase in voltage due to the addition of DG is formulated in Eq. (1) below. Where  $(\Delta V)$  is the voltage difference between the slack bus and the grid bus.  $V_G$  is the voltage on the slack bus, assuming that it is constant, and with a power angle of  $0^\circ$ .  $Z$  represents the network impedance, the combination of the series resistance  $R$  and the series reactance  $X$ , and the voltage improvement  $(\Delta V)$  is defined

$$\Delta V \equiv U_G - U_n \quad (1)$$

In a 2-bus system,  $S$  is defined as the total amount of power injected into the system from the bus load shown in Eq. (2). Where  $P_G$  and  $Q_G$  represents the active power and reactive power generated by the PV inverter,  $P_L$  and  $Q_L$  represents the active power and reactive power consumed on the bus.

$$S \equiv (P_G - P_L) + j(Q_G - Q_L) = P + jQ \quad (2)$$

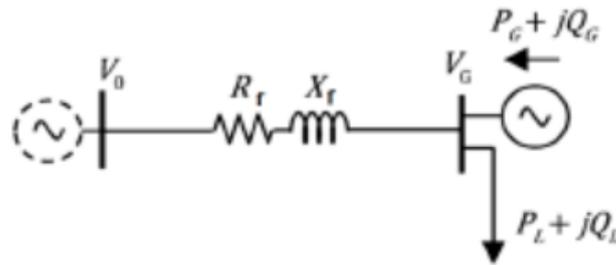


Figure 4 Bus Injected PV[11]

Where the value of  $\Delta V$  is determined using Eq.(3):

$$\Delta V = I \cdot Z = I \cdot (R + jX) \quad (3)$$

Here,  $I$  is the current flowing from the PV Source to the Slack bus. Neglecting the power losses through the conductors, then  $I$  can be formulated as:

$$I = \left( \frac{S}{|U_n|} \right)^* = \frac{P-jQ}{|U_n|} \quad (4)$$

By combining Eq. (3) and Eq. (4), it becomes:

$$\begin{aligned} \Delta V &= \left( \frac{P-jQ}{|U_n|} \right) \cdot (R + jX) = \frac{P.R+QX}{|U_n|} + j \left( \frac{P.X-Q.R}{|U_n|} \right) \\ &= \Delta U_d + j\Delta U_q \end{aligned} \quad (5)$$

We use the Hosting Capacity calculation[12], and Kirchoff Voltage Law (KVL) calculations can be applied to find the voltage solution on PCC. By representing resistance and reactance in the form of  $R_G$  and  $X_G$ , considering  $U_{grid} \angle 0^\circ$  or as a slack bus. Eq. (5) can also be rewritten to get a simplification so that the maximum hosting capacity calculation is the equation that can be written in Eq. (6).

$$P_g^{max,1} = \frac{V_n^{max,1}(V_n^{max,1}-V_g^1)}{R_f+X_f \tan(\varphi)} \quad (6)$$

If you haven't gotten the optimal solution capacity of VRE value from Eq. (6), then the hosting capacity method is digsilent[13]. Then the iteration is carried out based on the initial value that we input on digsilent. The initial value in this study uses Eq. (6) which is then entered into the iteration into the calculation, as formulated in Eq. (7)

$$P_{new} = P_{ini} \times \left( 1 + \frac{step_{ini}}{100\%} \right) = 1MW * \left( \frac{101\%}{100\%} \right) = 1,01 \quad (7)$$

### 2.2.1 Constraint Grid Code Indonesian Utility

Constraints are used to calculate the hosting capacity value obtained from reactive power injection. This constraint is to measure the time of the entry of PV into the grid. Here, we can use the constraints as in Eq. (8), Eq. (9), and Eq. (10).

$$Vmin \leq |Vi| \leq Vmax \quad (8)$$

$$\theta \min \leq \theta_{ik} \leq \theta_{max} \quad (9)$$

Thermal Line Limit:

$$|Sn| \leq Smax \quad (10)$$

**Table 1** Grid Code Regulation[14]

Item	Tolerance
Frequency	$\pm 0,2$ Hz

Voltage	1.05 p.u & 0.9 p.u
Thermal	< 100%

### 2.3 Flexibility Index

This flexibility index is needed to ensure the long-term stability and security of the supply of high penetration maximum renewable energy to the grid. Based on paper[15], In the dynamic system model, there is an assessment of the frequency response index, transient, and inertia.

#### 2.3.1 Indeks FLeXibilitas Jaringan pada zona jaringan

The grid flexibility index is based on the number of N branches with the highest load ratio in the network at the time (t) and the average weight ratio used for the flexibility index at the time (t). This can be formulated by Eq. (11). Eq. (11) is used to determine the flexibility of each zone based on the total load capacity in each zone.

$$\text{Flex\_net}(t) = \sum_{i=1}^N \mu_i L_i(t) \quad (11)$$

Where flex\_net(t) is the network flexibility at a time (t), N is the number of selected branches,  $\mu_i$  is the weight factor for the flexibility of the branch (i),  $L_i(t)$  is the load ratio of the branch (i) at a time(t), load ratio ( $L_i$ ) formulated with the Eq. (12):

$$L_i(t) = \frac{S_i(t)}{S_{i\max}} \quad (12)$$

where  $S_i(t)$  is the line capacity of the branch (i),  $S_{i\max}$  is the maximum line capacity of the branch I, While the flexibility factor of the network per zone is obtained by the Eq. (13):

$$\mu_i = \frac{\sigma_i^2}{\sum_{i=1}^N \sigma_i^2} = \frac{\sum_{t=1}^T (L_i(t) - \bar{L}_i)^2}{\sum_{i=1}^N \sum_{t=1}^T (L_i(t) - \bar{L}_i)^2} \quad (13)$$

where  $\sigma_i^2$  is the variance of the load ratio in-branch i,  $\bar{L}_i$  is the average load ratio i at all times, N and T are the maximum number of branches and the maximum number at each time.

## 3 Methodology

The methodology used in this study is represented in the form of a flowchart as shown in **Figure 5**. We know the network structure in the distribution system by analyzing the Resistance and Reactance data with line lengths extracted using DPL. The process of extracting data from digsilent to excel is shown in **Table 2**.

**Table 2** Digsilent Extract Data

```

set arrayLoad, arrayLine; object load, line, comldf
    comldf=GetCaseCommand('ComLdf')
    comldf.Execute()
xlNewWorkbook()
xlSetWorksheetName(1, 'Load')
    xlSetValue(1, 1, 'No')
    xlSetValue(2, 1, 'Nama Beban')
i = 2;
arrayLoad = AllRelevant('*.ElmLod')
for (load = arrayLoad.First(); load; load = arrayLoad.Next()) {
    xlSetValue(1, i, i-1)
    xlSetValue(2, i, load:loc_name)
    xlSetValue(3, i, load:m:P:bus1)
    xlSetValue(4, i, load:m:Q:bus1)
    xlSetValue(5, i, load:m:U11:bus1)
    i = i + 1}
saveFile = 'D:\tes1.xlsx';
    
```

The data obtained from the DPL is then calculated using Eq. (6) to get the hosting capacity value for PLTS integration. Then, the capacity of plts was implemented into the system by connecting PLTS to each bus node point. If it reaches fitness, then a flexibility analysis is carried out from the maximum integration of PLTS to bus points in the system.

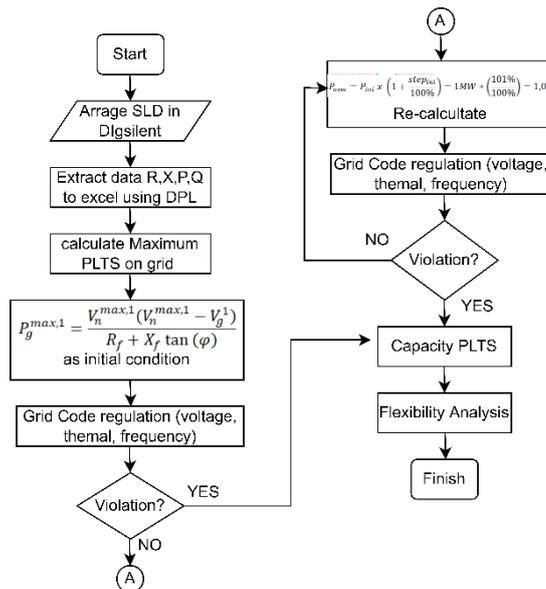
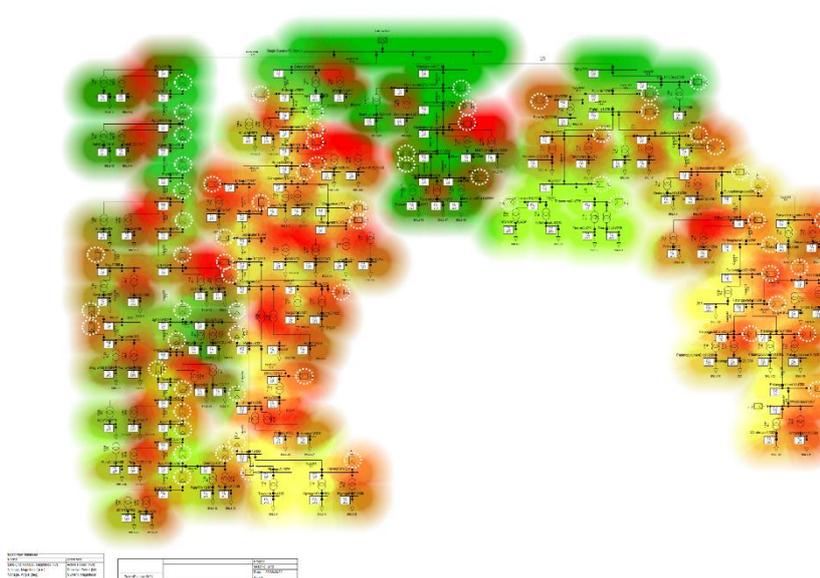


Figure 5 Flowchart of Research

#### 4 Result and Discussion

The integration of renewable energy is very massive because the renewable energy mix target from the government is specifically stated in the RUPTL 2021-2030. So, the calculations that have been done, see the amount of PLTS capacity that can enter the system without causing interference or violation in terms of the voltage profile, and loading. The penetration of renewable energy that is directly connected to the grid, allows for bidirectional load flow from the utility to the PLN grid. So, the constraints are entered as in Table 1 above according to the Indonesian Utility grid code regulation.

The implementation model for installing PLTS on each bus looks as in **Figure 6**. The color temperature when load-flow, the thermal line with 80°C capacity is orange, and the maximum thermal loading is 100°C red. While the highest voltage profile value with 1.05 p.u is green, the voltage value of 1 p.u is light blue.



**Figure 6** Implementation Distributed of PLTS

The calculation of hosting capacity has been carried out, so the maximum penetration capacity value of PLTS that can enter the system without causing violation is obtained. From these results, the PLTS capacity entered into the system can be run with the result that the voltage profile value is still below 1.05 p.u in the distribution system. So, from the calculation do not use the Eq. (7), because it has got its fitness value. The value of the capacity that is hosting the PLTS capacity obtained is shown in **Table 3** below.

**Table 3** Candidate of PLTS

Bus	Capacity (kW)	Bus	Capacity (kW)	Bus	Capacity (kW)	Bus	Capacity (kW)
2809	248,09	2875	215,73	338	5513,17	411	198,47
3202	248,09	2884	215,73	335	551,31	408	198,47
3206	1033,72	3260	708,83	332	551,31	407	206,74
281	1033,72	3262	708,83	326	248,09	404	275,65
280	597,81	3278	248,09	331	636,13		
277	597,81	3268	826,97	3012	240,86		
211	439,10	2920	175,95	3018	318,06		
276	390,69	2926	620,23	3020-1	248,09		
284	2067,44	3038	620,23	3020-2	318,06		
285	2067,44	3050	1984,74	430	248,09		
288	576,96	432	1984,74	427	248,09		
292	576,96	320	661,58	426	370,28		
298	698,85	317	661,58	390	1908,4		
296	698,85	316	661,58	387	1908,4		
298	1016,77	347	5513,17	386	1908,4		
309	1107,55	345	5513,17	423	370,28		
312	1029,43	344	463,72	393	107,86		
301	1064,77	341	463,72	422	261,15		
308	683,45	340	223,50	415	689,147		
305	683,45	323	527,85	419	261,15		
304	436,78	337	223,50	418	689,147		

#### 4.1 Characteristic Supply and Demand

These supply and demand characteristics are very important to know the characteristics of the distribution system. Based on **Figure 6**, we know that the Single Line Diagram in the distribution system supplies electrical energy from the substation and supplies it to each final load. This operation scenario follows from the Distributed System Operator (DSO), so in **Figure 7**, there is a maximum generation that can be injected into the system without causing quality and reliability. So, the penetration due to injected of PLTS is not to reduce the generation supply, but here it is more to add mode power from the maximum penetration of PLTS that can enter. It can be seen in **Figure 6**, the yellow curve of the amount of supply from DSO and the addition of PLTS that is allowed to enter the supply system.

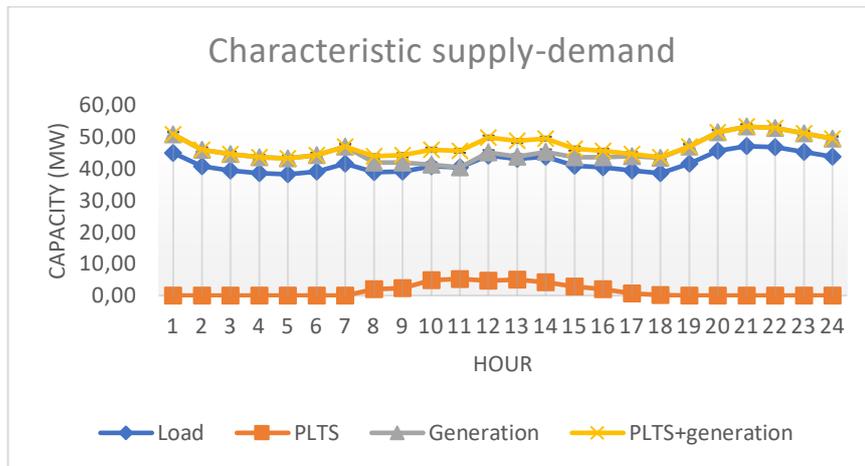


Figure 7 Characteristic Supply and Demand

### 4.2 Voltage Profile

This voltage profile is one of the flexibility indexes in this study. The effect of this PLTS maximum penetration, the value of the voltage profile does not cause a violation in the system. It can be seen in **Figure 8**, where the maximum limit value is close to 21kV or 1.05p.u at point 298.301. In addition, the limit of the lowest voltage value without solar power penetration is 18.5 kV at bus 387. The standard value of this voltage refers to SPLN 1-1995[16], related to the Voltage limit at the medium voltage level. Where the standard limit value for the distribution voltage is at least 0.9 p.u and 1.05 p.u. The time for this simulation is 13:28:15 WIB. Based on **Figure 2**, the potential for PLTS at 13:28:15 WIB is 300W/M2.

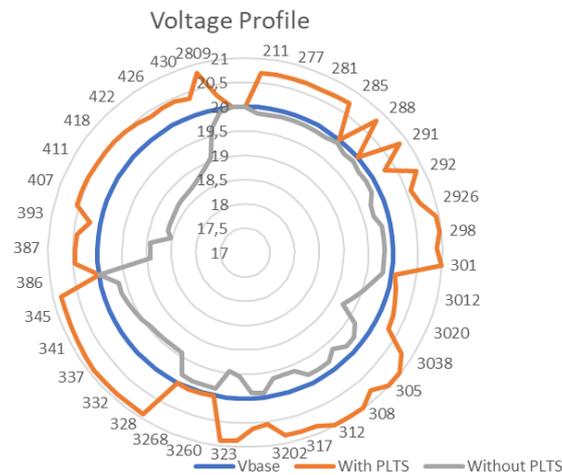


Figure 8 Voltage Profile

This dynamic voltage profile allows DSOs to control and predict network operator or load characteristics. We can see in Figure 9, that with the maximum penetration affecting the peak voltage on each bus per end customer, it is still within the maximum standard range with the input PV capacity. Meanwhile, at night because it is intermittent, the voltage fluctuation will decrease but it is still within a tolerance of 0.9 p.u. so that this maximum penetration is safe and reliable when applied to the distribution system.

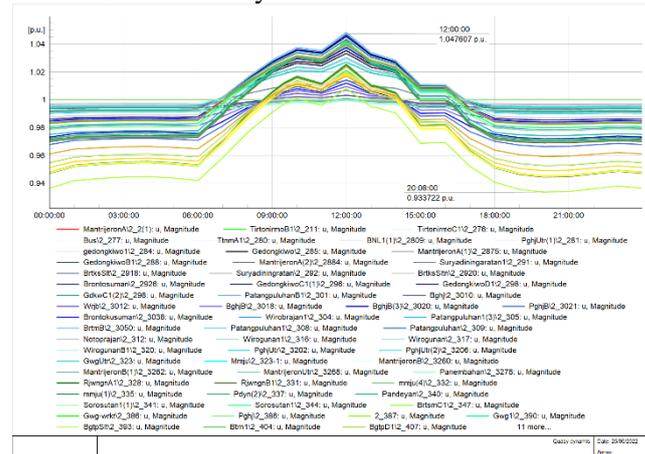
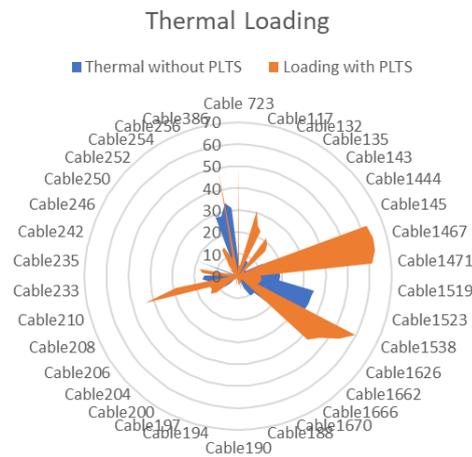


Figure 9 Voltage Profile in 24 hours

### 4.3 Line Loading

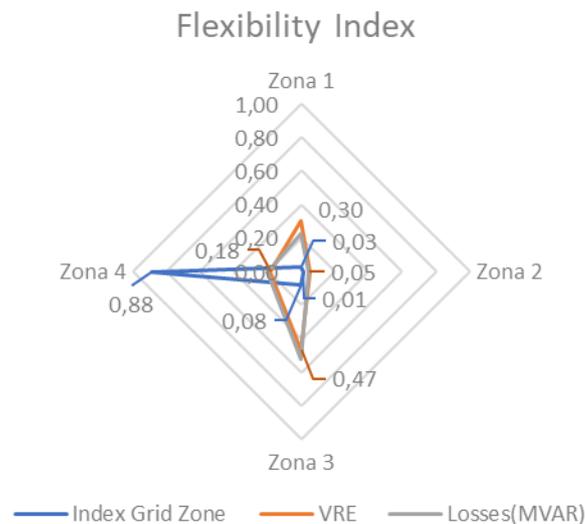
This line loading is one of the references observed by this research from the high penetration of PLTS so that the network is still in normal condition and has good constraints. Paper[17] and standard Indonesian grid code[14], where the safety standard is the thermal limit on the distribution channel, the limit is 80% and the maximum limit is 100%. In **Figure 9**, it can be seen that at the time of the maximum penetration of PLTS thermal, the largest is at cable1467. It is still in a safe condition because the value is still below 70%.



#### 4.4 Flexibility index

The flexibility index is the flexibility of the network due to the dynamics of high penetration of renewable energy with intermittent nature and dynamic load changes. **Figure 10** is the result of the grid flexibility index based on the divided zones as shown in **Figure 1**. To calculate the zone grid flexibility index, we used Eq. 11, Eq. 12, and Eq. 13. This index value is obtained by using a combination of load per zoning, maximum integration of renewable energy, and network losses.

Based on the results in **Figure 1**, the highest load index is in zone 4, while the highest VRE capacity is in zone 3. The value of VRE depends on the value of resistance and reactance due to the value of the distance of the feeder being far based on the voltage drop point. So, it can be seen from the results of the index, the values of network losses that get the maximum penetration index of PLTS injection into the system without causing a violation. So the lowest index value is in zone 2 because it has the least length and load index.



**Figure 10** flexibility index

## 5 Conclusion

The maximum penetration of PLTS in the distribution system is obtained at its maximum capacity without affecting the security and constraints of the system. This can be seen from the value of the voltage profile and thermal loading which are still within the Indonesian utility standard grid code limits. The results of dynamic simulations carried out due to the maximum penetration of PLTS, it can be seen that the results of the highest and lowest voltage profiles are still in the range of limitations.

The value of this PLTS capacity range can be used as a recommendation. The network flexibility index is based on zones, it is seen that the largest index is in zone 3 based on many loads and feeder lengths. The zone view of the strength index in the grid zone of the distribution system.

## Acknowledgement

If necessary you can type your acknowledgement here

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## **The Effect of Physical Environment on Mother's Anxiety in Dealing with Labour (Case Study: Hj. Ade Markonah S. ST Independent Practice Midwife, Cirebon Regency)**

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**Abstract.** Woman always expect the birth of their baby to be normal, safe and full of positive experiences. Giving birth is complex and crucial, not just reproductive health and the physical environment, but furthermore a woman's psychophysiological and their family's feeling. This research aims to identify the influence of many environmental physical elements in the birthing place to reduce labour anxiety. In this study, researchers compared a literature review and the results of observations at Hj. Ade Independent Practice Midwife, be equipped with the results of interviews of 30 patient perceptions about the physical arrangement of the inpatient room, afterward analyzed using descriptive and comparative analysis. Based upon the opinion by Sarwono [24] regarding Environmental Psychology, to wit the interaction of humans and the environment that form each other. The results showed that (1) Temperature, (2) Nature, (3) Cleanliness, (4) Room Size, (5) Sound and (6) Scent most influence mother's comfort before giving birth. In conclusion, the greater the application of favorable design features, the more benefits for mothers and babies. This research is important to complement evidence on influence of the physical birthing environment on maternal labor outcomes and expected can be the latest reference to design the birthing environment.

**Keywords:** *birthing place; environmental design; independent practice midwife; labour anxiety; physical birthing environment; qualitative research.*

### **1 Introduction**

Pregnancy and childbirth are extraordinary events that woman experienced as well bringing great changes in their lives. Various emotions, physical and psychological changes to the need for new adjustments that woman have go through to get the best results for the baby and herself. The birth story is a very important and special personal narrative of a woman's life experience by Callister in [3]. Childbirth is like a peak momentum that is both exhausting and risky.

Psychological changes are complexly elevated in the run-up to labor. This is because mothers are increasingly aware of the presence of their fetuses as well as a number of fears and anxieties about the state of the baby and herself (Janiwarty, 2013). The maternity mother requires a special approach, both physically, socially, especially psychologically. Generally, the closer the time of delivery, the mother gets more anxious by Muzayyana and Saleh in [16]. This anxiety is mostly focused on the process of labor towards birth by Handayani (2015). If this anxiety is allowed it can be a bad risk for childbirth and birth outcomes (Chabbert *et al.*, in [5]).

In addition to the medical approach, the environment also acts as a non-medical approach. Childbirth facilities play an important role, especially during the delivery process until they are ready to give birth, for mothers to assess their childbirth experience even the assessment is multidimensional formed through the accumulation of various factors as well as attributes associated with the experience of maternity care by *World Health Organization*. That assessment can influence future pregnancy decisions by Berg, *et al.*, in [1]. This provides an understanding of the role of the built environment in terms of supporting patients with anxiety, sensitivity, and stress by Sadek and Willis, in [23]. Together, place and space are concepts that have an important relationship for childbirth by England, Fannin and Hazen in Carlsson, *et al.* in [4] Both the physiological and psychological conditions of the patient support each other in the success of childbirth.

The environment of the delivery facility is very influential on the childbirth process, but it tends to be ignored and instead provides fear, anxiety, boredom to stress that can result in neurohormonal disruption to encourage intervention during labor and birth by Cahyati in [2] In general, the managers of labor facilities have not paid much attention to the arrangement of the delivery environment, tend to only optimize the quality of medical treatment and services. According to Utomo (1999), Indonesia health facilities in general look simple and as they are, so they tend to ignore the psychological factors of patients and their comfort. The built environment focuses only on economic aspects and functions, regardless of the psychological aspects of the user, especially as long as the patient is preparing for her delivery by Susanto *et al.*, (2016) and Cahyo *et al.*, (2008). Whereas some experts emphasize the importance of the patient's environment for their health outcomes and empirical evidence supports these benefits by Jamshidi, *et al.* in [9].

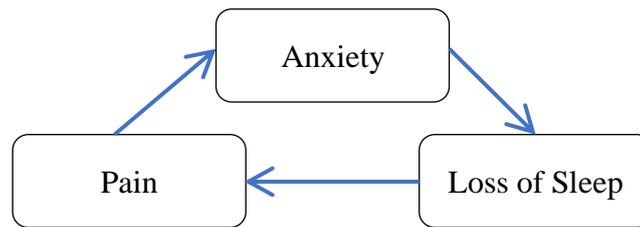
In general, the built environment of childbirth facilities is built only for the fulfillment of building standards, but have these standards been able to meet the physical and psychological needs of their patients? This review attempt to answer

the question, how does the arrangement of the physical environment of the birthing place affect and what are the elements of the physical environment that are able to suppress maternal childbirth anxiety? This study aims to identify the influence of structuring and various elements of the physical environment that can suppress maternal childbirth anxiety. Research focuses on the maternal childbirth experience in Hj. Ade Markonah S.ST Independent Practice Midwife in Cirebon related to the study of the arrangement of the physical environment of childbirth to the psychology of the maternity mother. Based on research Nilsson, *et al.* in [17] that there is still incomplete evidence of the influence of the maternity environment on the outcome of childbirth and birth, then if by conducting this research will be able to contribute a little new knowledge related to environmental influences, particularly with regard to maternal childbirth anxiety. It is hoped that this research can be the latest reference for designers in making design decisions as well as being an input for the managers of midwifery health facilities, especially the Independent Practice Midwife in Cirebon Regency.

## **2 Literatur Review**

### **2.1 Labour**

The experience of childbirth is complex things, multidimensional and subjective and has the potential to affect women and their families physically and emotionally by Li *et al.*, in [12]. Childbirth is more than just a study of reproductive health, nursing metaconceptions, and the environment (England, Fannin, and Hazen in Carlsson, *et al.* in [4]. On the eve of childbirth, often women experience pain, haunted by various worries and negative images of the labor, to the anxiety that is no less great than the pain of childbirth by Musbikin in (Cahyati in [2] . Depicted a various psychological symptoms of women before childbirth such as feelings of discomfort, anxiety and fear, seeing birth as an ordeal, doubts about whether Labor can proceed normally, doubts about the ability of the helper, the death, various concerns regarding the mother and baby condition until worry about her future ability to take care of the baby because her new role as a mother by Sumarah in (Kumala and Arsandrie in [10] and Abineno, 2018). Therefore, women in labor often want the presence and support of emotional, physical, spiritual, and psychological by midwives and social to increase their confidence in her ability to give a birth by Olza, *et al.* in [18]. Physical, emotional, mental, psychological, and socio-economic readiness is the determining factor behind a woman's readiness to face the labor.



**Figure 1** Vicious cycle of pain, anxiety and sleeplessness, (Source: NHMRC in Swarjana in [27]).

The birth process is closely related to pain. Most women wants a natural delivery without excessive pain, but this depends on the level of anxiety that she experienced. *National Health and Medical Research Council* in Swarjana, in [27], states that anxiety, correlated with pain and sleeplessness, forms a vicious cycle that is affects each other. Maternal anxiety is influenced by several factors, one of them comes from the setting of the physical environment of childbirth, especially her care room where the woman spends most of her time before giving birth by Cahyati in [2].

## 2.2 Childbirth Anxiety

Conditions before delivery are one of the factors that cause anxiety by Muzayyana and Saleh in [16]. In general, this anxiety is experienced by women who have given birth for the first time (primigravida) by Shodiqoh and Syahrul, in [25]. This is because her childbirth experience is special and new for her, also bring big changes in her life but it is often cause stress by Cahyo *et al.*, (2008). Anxiety arises due to helplessness to face the childbirth (Shodiqoh and Syahrul in [25]).

According to Rinata and Andayani in [21]; Adams *et al.*, (2012); Muharyani *et al.*, [15]., The anxiety is displayed through Psychological forms (fear, tension, worry, confusion) and Physiological forms (insomnia, hypertension, pre-eclampsia and eclampsia). This also has a negative impact on the outcome of childbirth such as longer duration of childbirth, preterm childbirth, causing Stage II labor (the phase from complete cervical dilatation of 10 cm until the baby is born), medical complications, unpleasant birthchild experience to trauma that can even extend to other matters such as labor costs, readiness for motherhood, personal appearance, and household problems by Riska *et al.* in [22].

Labor anxiety levels are driven by internal and external factors by Daradjat in Furwasyah, *et al.* In [6], Rinata and Andayani in [21], Muzayyana and Saleh in [16], Shodiqoh and Syahrul in [25]. These internal factors include personality, physical readiness, self development and maturity, psychological (psychiatric)

and mental conditions, balance of thinking, feelings, and belief in labor myths. While external factors include social, economic, political, customs, information from health workers, husband support, and the environment.

### **2.3 Psychological Comfort**

Pheasant (2003) interprets comfort as a psychiatric condition in which an unpleasant feeling, can not be perceived by the body. Comfort is the embodiment of homeostatic conditions with the results of the search for coping techniques and adaptation to the environment. Comfort level is inversely proportional to anxiety. Therefore, it is necessary to increase the comfort of the mother in order to reduce her childbirth anxiety by Hodnett et al., (2009). This theory is in line with Katharine Kolcaba's Theory of Comfort (2003) which explains three forms of comfort: Relief, Ease, and Transcendence with four Contexts of Comfort namely, Physical, Psychospiritual, Environmental, and Sociocultural. The realization of a calm attitude from the mother is very necessary for the smoothness of her childbirth process. This can be done through good breathing control, relaxation, cognitive interventions, religious approaches, avoiding bad stories, assistance by the spouse, the presence of the closest relatives and the selection of an adequate delivery place by Agustinus in Shodiqoh and Syahrul in [25] ; Cahyati in [2]. In addition, having personal belongings next to the bed with an interior design that is more familiar to the home atmosphere can ease the pain by Olausson *et al.*, (2013).

### **2.4 Independent Practice Midwife**

Currently, according to Minister of Health Regulation No. 97 of 2014 in [14], the government requires women to give birth in a health facility, Independent Practice Midwife is one of it. Independent Practice Midwife is a Health Service Facility organized by midwives who are graduates from professional education to provide direct services to clients by Republic of Indonesia act, Number 4 of 2019 concerning Midwifery in [20]. This facility provides midwifery services for pregnant women, childbirth and the physiologic postpartum including family planning and newborn care by Ruskusumastuti, (2008).

Environment is the key to freedom of movement. The ward setting relates to activities the mother can do to prepare for the birth process to reduce her anxiety. According to Permenkes RI Number 97 of 2014, the treatment room is a place or room that serves as a temporary residence for pregnant women and their companions before and after the childbirth period. The TPMB Treatment Room standards have been determined by the government in Building Permit Requirements for the Implementation of Midwife Practice in Regulation of the Minister of Health of the Republic of Indonesia Number 28 of 2017 in [19].

## 2.5 Structuring the Physical Environment of Childbirth

Improving the quality of service can be improved through aspects of the labor room environment. The physical environment has a 94% effect to smoothness the process of labor by Cahyati in [2]. The alignment of the childbirth environment facilitates the patient through non-pharmacological techniques by sorting and arranging stimuli applied to a built delivery environment in order to support optimal childbirth and even to relieve a pain. This embodies two main mechanisms namely 1) Relaxation through a calm and supportive physical environment and 2) Women are able to labor in a relaxed, comfortable manner, their movements are not restricted and their privacy is safeguarded (Gedey, *et al.*, [7]). Improving the physical environment, increasing women's hope and confidence (Newburn and Singh, 2003 in Siagia, *et al.* in [26]).

The childbirth environment can have a major influence on the fear and anxiety the mother experienced, due to routine and lack of privacy, loss of emotional control and can disrupt the physiology of normal labor (Lestari, 2015). The regulatory effect in healthcare environments is particularly important, where people experience relatively high in the levels of uncertainty, fear, and stress by Dijkstra *et al.* (2018). Required Design of birth units, models of care, communication support from staff, health workers, and woman in labor, to ease the stress of the mother ahead of the birth of their babies are needed. In order to minimize labor anxiety, it is important to design health facilities that have a feeling of self-control over the environment, freedom of movement, reduce stress, utilize positive distraction, have a connection to nature and access to social support by Jamshidi *et al.* in [9], The Royal Collage of Midwives in Lestari [10], Ulrich in Iyendo *et al.* in [8].

## 2.6 Human and Environmental Interaction (Environmental Psychology)

A physical of environment has an influence on human thoughts, feelings and behavior by Sarwono in [24]. The labor facility environment is the built environment (*man-made environment*) that humans create based on a specific purpose. Humans form buildings, then buildings will shape humans and this affects each other by Chiras in Sarwono in [24]. Improper environmental arrangement can potentially increase childbirth stress factors. Based on Ulrich's supportive design theory, a supportive environment can enhance recovery and reduce stress. This is because the environment provides a stimulus that is responded by human senses to eventually form a perception that indirectly affects human emotions and behavior. Perception is the basis of every experience gained

by the process of the "sensing-perception-reaction *Stimulus-Organism-Response*" by Sarwono in [24].

The perception of each individual is different in receiving, understanding and responding to stimuli, and always changes depending on their emotional state, personal experience and abilities by Sarwono in [24]. These feelings are closely related to the ability to filter out irrelevant stimuli and may be due to illness causing people to have a lower ability to filter information by Dijkstra *et al.*, (2008). The healthcare environment requires patients adapt to accept a "change" to make them feel more comfortable. The results of adaptation are found in the formation and change of attitudes. According to Murphy in Yetti (2017), there are three approaches in structuring the health facility environment, namely nature, senses, and psychology, so that patients become more relaxed, comfortable and safe.

## **2.7 Various Stimuli in the Environment**

Humans have a set of senses that function to capture stimuli in the form of visual, radio, thermal, touch, smell, and so on. If these various stimuli are transcribed in interior elements, they can include Lighting, Color, Layout, Airing, Furniture Selection and Completion. The variable factors that affect patient outcomes include shape, unit layout, floor materials, room features, visibility of medical equipment, nature, lighting and music by Jamshidi *et al.*, in [9]. According to Ulrich in Fourer *et al.*, (2010), there are various factors that contribute to labor satisfaction including space, light, noise, air quality, natural scenery, privacy, and a single rooms.

## **3 Method**

This research uses Descriptive Qualitative Research Methods with psychometric and Comparative approaches. Data collection begins with a literature review from various sources such as scientific journals, books, theses, data from the government until government regulations. The various data obtained are then used to explain the situation in accordance with the arrangement of the physical environment at TPMB. Followed by Observation at Tempat Praktik Mandiri Bidan Hj. Ade Markonah and interview respondents in order to obtain factors in accordance with the situation based on experience, memory and patient perception. Selection of respondents using purposive sampling technique. Data collection involved 30 respondents with the criteria that the respondents were patients at Tempat Praktik Mandiri Bidan Hj. Ade Markonah who had stayed in the inpatient room before giving birth and when interviewed the mother was not experiencing postpartum blues and was healthy. The data collection period was

taken within the last two months to one year (May 2021 - February 2022) referring to Waldenström's (2003) research.

During the interview process, the interviews were recorded using a mobile phone. The recorded interviews were then transcribed into writing to be read repeatedly to gain a global understanding and ensure the respondents' statements remained the focus of the analysis. The descriptive analysis process is related to the aspect of sensory perception (stimulus filtering of the labor environment) of maternal patients to explore their experiences motivated by physical, social, psychological needs, labor experiences (retrieval of emotional events from memory). After the interview results were transcribed, it was continued by summarizing and grouping the answers based on the group boundaries that had been made from the results of the literature review. This is to get a picture of the patient's perception of their hospital room. The results of the literature review (ideal criteria), the results of observations (size and identification of physical buildings and observing activities and patient flow directly) and the results of patient perceptions will then be compared.

In collecting data from 30 respondents, a guided interview type consisting of open ended questions and closed ended questions (fixed alternatives) was used. The interview consisted of five main questions. Question 1 (Q1), Question 4 (Q4) and Question 5 (Q5) are closed ended questions. Question 2 (Q2) and Question 3 (Q3) were open ended questions. The main questions in the interview were about (Q1) the level of labor anxiety, (Q2) what causes labor anxiety, (Q3) how to reduce labor anxiety, (Q4) the degree of influence of the patient's hospital room on the anxiety of childbirth, and (Q5) the choice of physical environment elements accessible from the hospital room that affect anxiety.

The other questions as additional questions include respondent profile, duration of patient waiting at the clinic until delivery, childbirth companion, noise from the highway, privacy in the inpatient room, busyness, and parity. The element options displayed in Q5 are Lighting, Interior Aesthetics, Room Cleanliness, Natural Elements, Room Size, Furniture, Room Temperature & Air Quality, Room Sounds and Scents. The element options displayed are based on various physical elements of the environment that affect patients based on a literature review, which are then readjusted based on the stimuli groups found at TPMB Bidan Hj Ade Markonah. Sense of Sight - Visual (Lighting, Interior Aesthetics, Room Cleanliness, Natural Elements, Space Area, Furniture); Sense of Hearing - Audio (Sound of Splashing Fish Pond); Sense of Smell - Olfactory (Room Scent); Sense of Touch - Thermal/Tactile (Room Temperature & Air Quality, Furniture, Room Cleanliness).

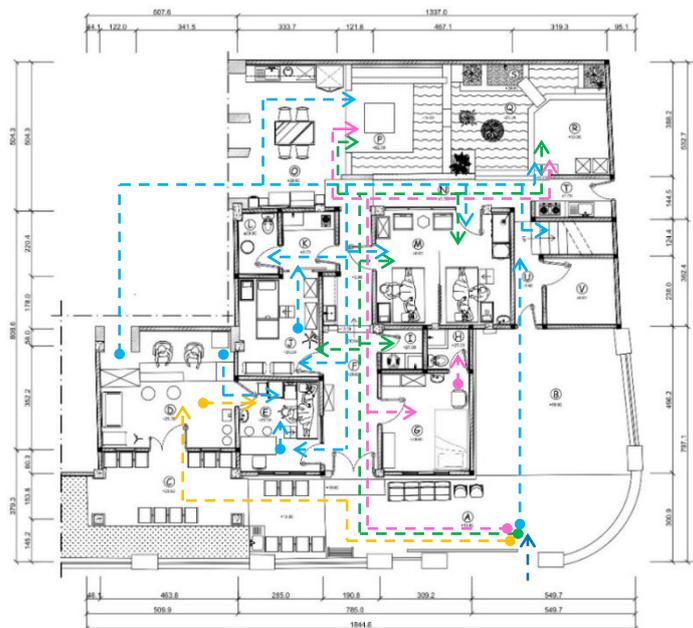
## 4 Finding and Result

### 4.1 Case Study: Hj. Ade Markonah S. ST Independent Practice Midwife



**Figure 2.** Hj. Ade Markonah, S. ST. independent practice midwife (Source: Regita)

Hj. Ade Markonah, S. ST. Independent Practice Midwife is a midwifery facility run by Senior Midwife, Hj. Ade Markonah with three midwives assistant. This TPMB is located in Cirebon Regency and has been labeled as a *Bidan Delima*. This childbirth place was chosen in accordance with the criteria of previous research TPMB by Cahyati in [2] and Lestari in [10]. It is located on the side of the road in the middle of Sumber city, the intersection of highways and housing complexes, so it is easily accessible through many routes and is quite well known in the community. This is in accordance with the Independent Practice Midwife location requirements in Article 30 section (2) in the form of Independent Practice Midwife must be in a location that is easy for referral access and pays attention to environmental health aspects.



**Figure 3.** Layout and circulation in Hj. Ade Markonah, S. ST. independent practice midwife (Source: Regita)

Description:		
A. Outdoor Waiting Area	I. Patient Bathroom I	P. Gazebo
B. Parking Area	J. Delivery Room	Q. Fish Pond
C. Terrace	K. Infection Prevention Room	R. Musholla
D. Lobby	L. Patient Bathroom II	S. Wudhu Area
E. Check-up Room	M. Inpatient Room	T. Dirty Kitchen
F. Corridor	N. Back Corridor	U. Service Room
G. VIP Room	O. Family Kitchen	
H. VIP Bathroom		
<p>---&gt; Circulation of patient giving birth &amp; companions (regular)</p> <p>---&gt; Circulation of patient giving birth &amp; companions (VIP)</p> <p>---&gt; Circulation of patient &amp; companions for check-up and immunization (midwifery)</p> <p>---&gt; Circulation of midwives and assistants</p>		

This study focuses on the patient's room where the patient spends most of her time before giving birth. With an approximate area of 17.38 m<sup>2</sup>, this room is intended for two patients, and it functions as a waiting and recovery area during childbirth. This room is able to facilitate the woman's need to do various activities to prepare for her childbirth, such as playing gymball, taking small walks, resting, getting health care, chatting with family to build a comfortable atmosphere, and doing various other activities as a form of positive distraction. Sometimes this room is also used as a place to give birth when there is an emergency that cannot force the patient to give birth in the delivery room or when the delivery room is filled with other patients.

In this room there are various kinds of furniture such as patient beds, chairs and waiting tables, resuscitation tables, storage cabinets, curtains, baby boxes, and infusion poles. This room is also equipped with various wall decorations, fake plants, air conditioners, sinks, and they also provide drinking water. The room is designed using two doors with only one top vent. The walls are painted in white and orange colors and bordered by List border wallpaper to beautify the room. The floor used is non-slip, light-colored and easy to clean. The ceiling is pink in color with a single point cool white lamp illuminates this room.



**Figure 4.** Inpatient Room in Hj. Ade Markonah, S. ST. independent practice midwife (Source: Regita)

In this room, the researcher measured various furniture, identified the room, and documented observations to complete the data. Researchers identified various stimuli that can be felt when women are in the treatment room. The stimuli that can be identified by adjusting to the research focus, are Lighting, Interior Aesthetics, Room Cleanliness, Natural Elements, Space Area, Furniture, Fish Pond Splashing Sound, Room Scent, Room Temperature & Air Quality, Furniture, Room Cleanliness.



**Figure 5.** 3D modelling axonometric view for inpatient room in Hj. Ade Markonah, S. ST. independent practice midwife (Source: Regita)

## 4.2 Data Analysis

After a process of data collection, the research results were obtained. Of the 30 respondent interviews, only 29 data were included in the assessment. Seen from demographic data, most respondents are in the ideal reproductive age category, 20-34 years with a percentage of 83%. Followed by old reproductive age at 14% and young reproductive age at 3%. Most respondents are housewives with a percentage of 75%, followed by 18% as employees and 7% as entrepreneurs. Half of the respondents had given birth to children once (48%), followed by giving birth twice (28%), the same number of mothers who gave birth three times (10%) and four times (10%), and at least five times giving birth (4%).

**Tabel 1.** Respondent demographic data

No.	Criteria	Respondent Percentage				
		>20 years (%)	20-34 years(%)		35< years (%)	
1.	Age (years)	3%	83%		14%	
2.	Occupation	Housewives	Employees		Entrepreneurs	
		75%	18%		7%	
3.	Parity	1 child	2 kids	3 kids	4 kids	5 kids
		48%	28%	10%	10%	4%

(Source: Regita)

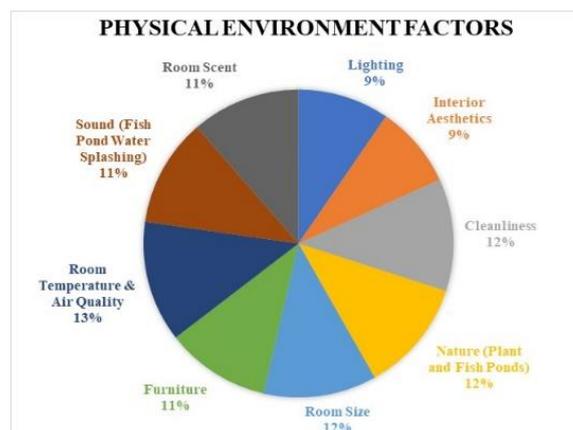
Respondents consisted of 14 primigravida (women who gave birth for the first time) and 15 multigravida (women who have given birth several times). Most experienced childbirth anxiety, only 1 multigravida did not experience childbirth anxiety. 50% of primigravida experienced high childbirth anxiety. While 53% of multigravida experienced low childbirth anxiety. When viewed in general, most mothers experience anxiety that tends to be low (38%), followed by high and moderate anxiety, each of which has a percentage of 28%, closed with anxiety that tends to be high and not anxious with the same percentage of 3%.

From the results of the study, most mothers experience labor anxiety caused by pain, soreness and unbearable heartburn, fear, anxiety, sadness, awkwardness and panic about giving birth. As for other reasons that make mothers anxious about childbirth, they are traumatized by previous childbirth, worried that negative experiences of childbirth will be repeated, have not had childbirth experience (giving birth for the first time), hear stories of other people's unpleasant childbirth experiences or myths, imagine various negative thoughts of childbirth and worry that the conditions are not as expected, doubts and worries about her ability to give birth to her baby, worries about her ability to take care of the baby in the future, worries about the mother's physiological and psychological conditions, worries that if normal delivery will switch to cesarean section, worries because of the long labor and the age of the pregnancy that is not as expected, fear of medical equipment - medical intervention (fear of injections because of fear of needles). Most respondents chose Midwife Services (46%) and Husband/Family Support (46%) to be most effective in reducing their anxiety. Only a few respondents chose Environment (8%) as the main thing to suppress their childbirth anxiety.

However, all patients rated the treatment room at TPMB Bidan Hj Ade as having a role to make them comfortable and able to minimize childbirth anxiety so that they are better prepared to give birth. Most respondents rated the role of the patient room as High (62%) in making them comfortable. Other respondents chose Moderate (21%), Low Tendency (10%) and High Tendency (7%) on the role of the patient room in influencing her. Most Primigravida (79%) and Multigravida (46%) rated the room conditions as highly influential in reducing childbirth anxiety and making them comfortable. This assessment is caused by many factors, one of which is when the room is filled with two patients, some respondents feel uncomfortable because their privacy is disturbed. However, others said they did not have a problem with it, because they had friends to chat with and had comrades in arms who understood each other.

Various ways women try to reduce their childbirth anxiety. Based on the results of the study, most respondents chose support from their husband, family, and social environment as well as maintenance of the TPMB environment (condition

of the inpatient room, the room is close to each other and easily accessible) to make them comfortable and reduce childbirth anxiety. The various other ways are Increase knowledge and information about childbirth and learn from the experiences of yourself and others, Prepare for childbirth by learning and practicing related to labor (processing breath, edenting, etc.), pray a lot (beliefs / psychology). Praying a lot (trust/psychospiritual) and trying, Doing and occupying yourself with various other activities (positive distraction), Reducing activity and increasing rest, Building a comfortable, calm atmosphere and fulfilling the needs of the mother, Listening to the midwife's direction, Getting support and good service from the midwife (the midwife is patient, does not panic and tries to calm and reassure the patient if everything will go smoothly and safely), Building a sense of trust between patients and midwives. Patients believe in the quality, service, performance of labor assistants (midwives and assistant midwives) and the completeness of facilities at TPMB. Calm down, relax, be patient and enjoy the process; Motivate yourself, focus, build mindsets and positive affirmations, increase self-confidence and make the wait to meet a prospective baby a positive encouragement.



**Figure 7.** Physical environment factors in inpatient room (Source: Regita)

From the results of the interviews, it was found that the order of the elements of the physical environment that affect childbirth anxiety included: (1) Room temperature & air quality, (2) Natural elements, room cleanliness and room size, (3) Room sounds and smells, (4) Furniture, (5) Lighting, (6) Interior Aesthetic. Then the top three most influential physical environmental elements were compared with ideal criteria based on government standards and literature reviews, observations and patient perceptions.

The reason respondents chose to give birth at Bidan Ade was based on recommendations from family and friends, had been a frequent patient, because

it was close to home or knew about it by looking for themselves. Behind it all, this is because respondents have trusted the quality of service, the completeness of facilities, and the ability of childbirth helpers (midwives and assistants) so that they can reduce their anxiety. After identifying the most influential elements in reducing childbirth anxiety, a comparative analysis was conducted by comparing standard regulations, observations and perceptions of respondents.

**Table 2.** Standard comparison of ideals, observations and patient perceptions

No.	Environmental Physical Element Type	Ideal Criteria (Standard)	Object Condition	Elemental analysis based on theory		Application of elements according to patient perceptions		The result of comparison of elements based on the theory and patient's perception
				Ideal	Not Ideal	Comfortable	Not Comfortable	
1.	Room Temperature and air quality	Air circulation 15% x Floor area (if 15% is not met, then air circulation regulators can be added such as: air conditioning, fan)	There is air conditioner	✓		✓		The temperature and air quality conditions in the inpatient room are ideal and comfortable
2.	Nature (plants and fish pond)	-	Located in front of the treatment room but there are no windows. Visual access is blocked, requiring the patient to open the door	✓		✓		The availability of natural elements outside the inpatient room is considered comfortable
3.	Room Cleanliness	The room is clean and not dusty.  The walls and floors are made of impermeable and easy-to-clean materials, hard, flat, not slippery.  There is a place to wash hands with running water and soap or antiseptic is available.	The baby crib has a lampshade. It's dusty  The condition of the walls and corners of the floor looks stained		✓	✓		The cleanliness of the inpatient room is not ideal but comfortable

4.	Room Size	Minimum size 2x3 m for 1 bed.	4.5 x 3.9 m for two mattresses	✓		✓		The condition of the room area in inpatient room is ideal and comfortable
5.	Sound (fish pond water splashing)	-	The sound of splashing pool water reached the hospital room. requires the patient to open the door to hear louder and clearer			✓		The sound of spalching fish pond water from the front of the inpatient room is considered comfortable
6.	Room Scent	-	No use of room scent. Only the smell of antiseptic on the floor area that sometimes dominates the room.  No annoying smell			✓		There is no disturbing odor, which is considered comfortable

(Source : Regita)

## 5 Discussion

The study is based on the experience of patients who perceive the inpatient room they live in as influencing prenatal anxiety. Despite the diverse results of the data obtained using the psychometric approach, it is evident that the arrangement of the physical environment of the childbirth facility, especially the inpatient room, can affect the mother's anxiety. This diversity of results is due to differences in experience, beliefs, background, age, parity, knowledge, occupation, self-readiness, maternal needs, and the length of time the mother has been in labor and living in the inpatient room. This result is considered insufficient which is sometimes constrained when respondents find it difficult to express their opinions or share their experiences. The results of the study are in line with the statement by Muzayyana and Saleh in [16], that most respondents feel their anxiety increases when approaching labor time. The majority of respondents chose midwife services and husband/family support as the most effective way to relieve their anxiety. This is in line with the statement by Olza *et al.*, in [18], regarding physical, spiritual, and psychological emotional support and wanting family presence to increase their confidence in their ability to give birth.

Through this research, we found three elements of the physical environment that dominate the influence on the mother's psychology, namely (1) Temperature, (2) Natural elements, Room Cleanliness and Room Size, (3) Room Sounds and

Scents. The temperature setting most influences the mother's anxiety when waiting for her childbirth. Due to the condition of the mother when contractions are draining and often produce a lot of sweat. Not to mention the temperature in Cirebon which is known to be hot (can reach 34 celcius degree) forcing the need for temperature regulation in the hospital room for the comfort of patients. This is in line with the results of research (Meiranny, 2017), that temperature regulation can help increase maternal confidence, but thermal dissatisfaction can actually be associated with physical stress to cause mothers to be anxious and feel pain which will have an impact on the outcome of labor. Often the hospital room is used as a delivery room therefore, this is in line with the statement by Nilsson *et al.*, in [17] to increase the temperature in the delivery room. This is also supported by the explanation (Sarwono, 2016) related to the psychological sensing of temperature (body temperature) which is compound due to temperature receptors in the skin (thermoreceptors) which are sensitive to changes in environmental temperature and therefore subjective. Environmental temperature is also sensed through the senses of touch (air or wind friction) and humidity. Therefore, the results of human sensing of ambient temperature are often different if the ambient temperature is measured using a device.

From the results of the study, visual stimuli (natural elements, cleanliness of the room, spaciousness of the room) ranked second. This is related to the need of the mothers for positive distraction to nature, trust in clean health facilities, and freedom of movement to do an activities to trigger labor and distraction from pain). This study does not prove the results of other research by Sari in Kumala and Arsandrie in [10], which states that of the many types of stimuli on the human body, visual stimuli are the most effective in triggering feelings of pleasure and comfort. The results of the comparison show that standard hygiene is not ideal but comfortable according to the patient. This is because during labor, respondents feel pain, pain, anxiety, various images of their childbirth and focus on the birth of their baby. So that the respondent's attention is distracted and his ability becomes lower to filter existing stimuli. This is in line with Sarwono's in and (Dijkstra *et al.*, 2008) statements related to the ability of each individual to always change depending on their emotional state and abilities. In addition to thermal and visual stimuli, Audio (Sound of Splashing Fish Pond) and Olfactory (Room Scent) stimuli are considered by respondents to make them comfortable. From the results of the comparison, this case study is considered to exceed the standard requirements of the Building for the Implementation of Midwife Practice Set by the government. This place applies various supporting physical elements (natural elements) as environmental therapy to treat the anxiety of its patients. Most of the respondents claimed to be helped and felt comfortable with this.

However, visual access to natural elements (plants and fish ponds) is limited

because the doors and windows are covered by sandblasted glass stickers intended to maintain patient privacy. This is unfortunate because the stimuli cannot be optimally utilized. The sound of the fish pond can still be enjoyed from inside the treatment room, but with a small volume of sound. The visual stimuli in the interior of the treatment room cannot replace the visual needs of nature. Even though these interior stimuli are very close and spend a lot of time with respondents, they actually rank last. This study explains that interior aesthetics cannot shift the mother's psychological need for natural stimuli to help her calm and comfortable.

There are some shortcomings in this study, especially when collecting data with interviews, there are often distractions. The interview environment was not conducive, the recording was not clear, the respondents did not fully understand the purpose and lack of openness of the respondents, and the respondents' focus was distracted because they were interspersed with other activities such as calming their babies. As for the guided interview form with a discussion-like approach, it sometimes led to some questions not being asked to some other respondents. It would be more effective if the question instructions and examples could be simplified using language that is easier to understand.

## **6 Conclusion and Suggestion**

Pregnancy and childbirth are reflected as special and extraordinary events in a woman's life. Various ways are taken to ensure a smooth and good labor outcome. Labor is a peak momentum that is both exhausting and risky. During labor, mothers are described as experiencing a series of worries about the course of childbirth, pain, confusion, a negative vision and anxiety that is no less intense than the pain of childbirth. If left unchecked, this anxiety can negatively affect the childbirth process and outcome. Not only physiological fulfillment, mothers also need a special approach psychologically, one of which is through the arrangement of a good physical labor environment as a non-pharmacological therapy to suppress labor anxiety. Anxiety is inversely proportional to comfort, hence the importance of optimizing the role of the environment to realize the comfort of the mother in childbirth.

Primigravida experienced more anxiety than multigravida. most mothers experience labor anxiety caused by pain, soreness and unbearable heartburn, fear, anxiety, sadness, awkwardness and panic about giving birth. Most Primigravida (79%) and Multigravida (46%) rated the room conditions as highly influential in suppressing childbirth anxiety and making them comfortable. The role of the inpatient room was highly influential (62%) in determining childbirth anxiety. Assessment of hospital room perceptions of childbirth anxiety by Primigravida (79%) and Multigravida (46%). Assessment of hospital room

perceptions of childbirth anxiety depends on its ability against the background of differences in experience, beliefs, background, age, parity, knowledge, occupation, self-readiness, maternal needs, to the length of labor and maternal stay in the hospital room. Various ways women try to reduce their childbirth anxiety. Based on the results of the study, most respondents chose support from their husband, family, and social environment as well as maintenance of the TPMB environment (condition of the hospital room, between rooms close and easily accessible) to make them comfortable and reduce childbirth anxiety. Elements of the physical environment that have the most influence on childbirth anxiety include: (1) temperature, (2) natural elements, (3) room cleanliness (4) room size, (5) sound and (6) room scent.

The researcher concluded that the body's reaction is strongly influenced by the temperature of the environment. There are various other elements to support the fulfillment of the mother's needs for access to nature, self-control, freedom of movement to carry out various activities that trigger labor and positive distraction. For the optimal process and outcome of childbirth, it is necessary to arrange the physical environment of childbirth (inpatient room design), service and quality of assistants, completeness of health facilities, care models, communication and trust between patients and midwives and support from husbands, families and the social environment to relieve anxiety before giving birth to their babies. This study will have implications for people involved in the design process of a childbirth health facility, especially the design of the inpatient room. The results of the study can also be the latest reference for design, consideration of mothers in choosing a place to do her childbirth, as well as input for managers of obstetric health facilities, especially Independent Practice Midwife in Cirebon Regency to balance the physiological and psychological needs of its users. For the sake of the development of this research, it is suggested that further research is expected to be able to find interior standards of the treatment room that can support thermal optimization for patients so that it can be an input regarding the arrangement of the ideal childbirth health environment that is able to ensure the psychological comfort of its patients.

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## Visibility of Electrochemical Behavior of Curcumin in Water-Based Solution: a Preliminary Study

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**Abstract.** Curcumin is a natural compound from *Curcuma longa* that is widely used as traditional medicine, coloring agent, etc. It becomes a hype after there are many researchers who pointed to curcumin as a potential medicine for cancer. However, the researchers found the lack of curcumin, including its solubility in water. Otherwise, the analysis of curcumin commonly uses organic solvents. Curcumin has a high solubility in ethanol and in a basic solution. In this study, the solubility of curcumin was analyzed and the effect of solvent was investigated to obtain a stable solution of curcumin for the analysis of curcumin by voltammetry. The stability was investigated using UV-Visible spectrophotometry while the electrochemical analysis used cyclic voltammetry and normal-pulse voltammetry (NPV). The UV-Visible analysis resulted in a stable solution of curcumin in an ethanol-NaOH solution. Curcumin could be electro-oxidized in Au electrode at around 0.8 V depending on the pH and solvent.

**Keywords:** *basic solution; curcumin; electrooxidizing; voltammetry.*

### 1 Introduction

Curcumin is a phenolic compound that can be obtained from the isolation of rhizomes of the turmeric plant (*Curcuma longa*). Turmeric has been widely used in traditional medicines. Hence, it attracts researchers to find out its activity as medicine [1]. The chemical nature of curcumin plays an important role as antioxidant, anti-bacterial [2], anti-viral [3, 4], anti-protozoa [5], anti-fungal [6, 7], anti-inflammatory [1], and anti-cancer [8]. Curcumin is declared safe for consumption by JECFA (The Joint United Nations and World Health Organization Expert Committee on Food Additives). EFSA (European Food Safety Authority) states that curcumin is safe to consume 0-3 mg/kg per day. The FDA has confirmed curcumin as 'generally recognized as safe' [9]. Meanwhile, Masek *et al.* in [10] added that the safe dose of curcumin consumption is 10 g/day. In fact, a study reported that administration of curcumin up to 12 g/day in patients did not produce toxic symptoms [11]. Meanwhile, a research conducted by Sharma *et al.* in [12] and Bayet-Robert *et al.* in [13], curcumin therapy in patients with colorectal and breast cancer caused symptoms of mild diarrhea and

neutropia when the curcumin dose was increased. Other symptoms that may appear as a result of increasing the dose of curcumin (1-12 g) are headache, rash, and yellow stools [14]. Apart from these reports, many researchers have developed analytical methods for curcumin, either using UV-Vis ([15], FTIR [16], flow-injection chemiluminescence, thin layer chromatography, chromatography high performance liquids [17], mass spectrometry, capillary electrophoresis, and electrochemistry [18].

The electrochemical method is a developed method for analysis by improving sensitivity and selectivity. The sensitivity of this method can be increased by modifications, either modified electrodes, supporting electrolytes, or types of electrochemical method, such as potentiometry, voltammetry, or amperometry. Meanwhile, the most popular method is voltammetry which is based on the properties of the electroactive analyte. The performance of the voltammetric method can be affected by the type of working electrode, reference electrode, and the voltammetric technique used. Nowadays, electrochemical analysis of curcumin has been developed, such as that conducted by [19, 20]. However, the previous studies used organic solvents such as ethanol, methanol, DMSO, and other organic solvents in preparing curcumin solutions [21]. On the other hand, several other studies have also shown that curcumin can dissolve in water under basic conditions [22–24]. Thus, in this research, voltammetric analysis of curcumin will be carried out using water as a solvent. Measurement modifications will be made to maintain the stability of curcumin and increase the sensitivity of the measurement method. Hence, this method can be used for both medical and non-medical fields (daily control).

## **2 Materials and Methods**

### **2.1 Materials**

All chemicals used in this study were analytical grade without further purification, including curcumin (Sigma Aldrich), NaCl (Merck), NaOH (Merck), ethanol (Merck), graphite (Merck), and demineralized water as a solvent. The UV-Visible measurement used UV-Visible spectrophotometer from Agilent 8453 and the electrochemical analysis used PalmSense4 with a software of PStTrace 5.6. The measurement was conducted in three-electrode electrochemical cell in which the working electrode was a gold-disc electrode (Au), the reference electrode was Ag/AgCl (3 M NaCl), and the auxiliary electrode was Pt wire.

## 2.2 Solubility Test of Curcumin

The solubility of curcumin was explored by using UV-Vis spectrophotometry. 40 ppm curcumin was prepared by using ethanol. 1 mL of this solution was then added with 1-9 mL of demineralized water in a total volume of the solution of 10 mL. The measurement was conducted at 215 nm, 258 nm, and 423 nm.

## 2.3 Stability Test of Curcumin

This stability of curcumin in NaOH condition was carried out by solvating 1 mg of curcumin with 1 mL of ethanol and 1 mL of 0.1 M NaOH. This solution was diluted by adding demineralized water until it reached 25 mL. 1 mL of this solution was diluted by the addition of 0.1 M NaOH in various volume (100-900  $\mu$ L) and demineralized water in a 10 mL of volume flask.

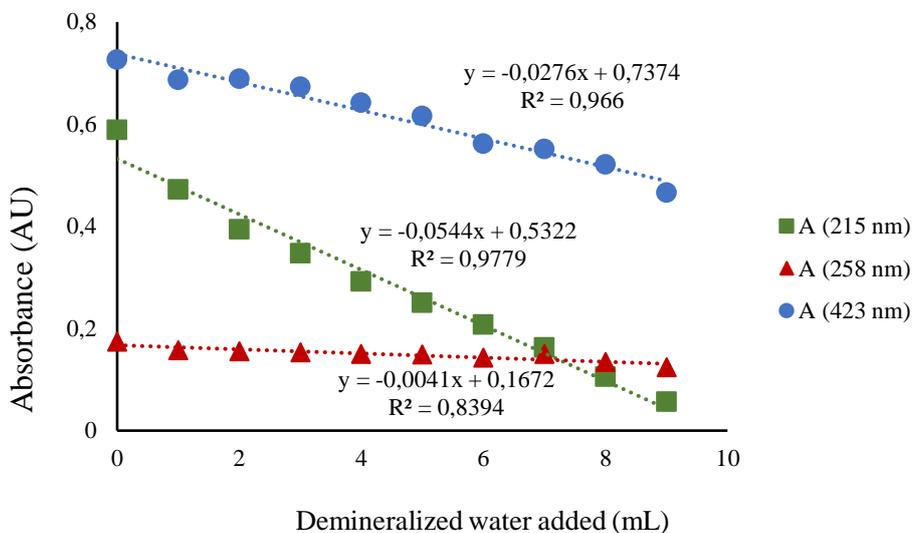
## 2.4 Electrochemical Behavior of Curcumin

The stock solution of 100 ppm curcumin was prepared in 100 mL of the basic solution. 10 mg of curcumin was added with 1 mL of 0.1 M NaOH and demineralized water. The solution was adjusted with  $\text{CH}_3\text{COOH}$  and HCl to set the pH value. For the measurement, 10 ppm curcumin was prepared from the stock solution which was diluted with 0.1 M NaCl as the supporting electrolyte.

# 3 Results and Discussion

## 3.1 Solubility Test of Curcumin

Curcumin is usually dissolved in ethanol. The addition of water in the solution could decrease the solubility since it is insoluble in water. The scanning of UV-Vis spectrophotometry provided 3 peaks of curcumin at 215 nm, 258, and 423 nm. Figure 1 presented the effect of water addition into curcumin stock solution which was dissolved by ethanol. The absorbances were linearly decreased following the addition of demineralized water at about 0.0544 AU/mL, 0.0041 AU/mL, and 0.0276 AU/mL for 215 nm, 258 nm, and 423 nm, respectively.

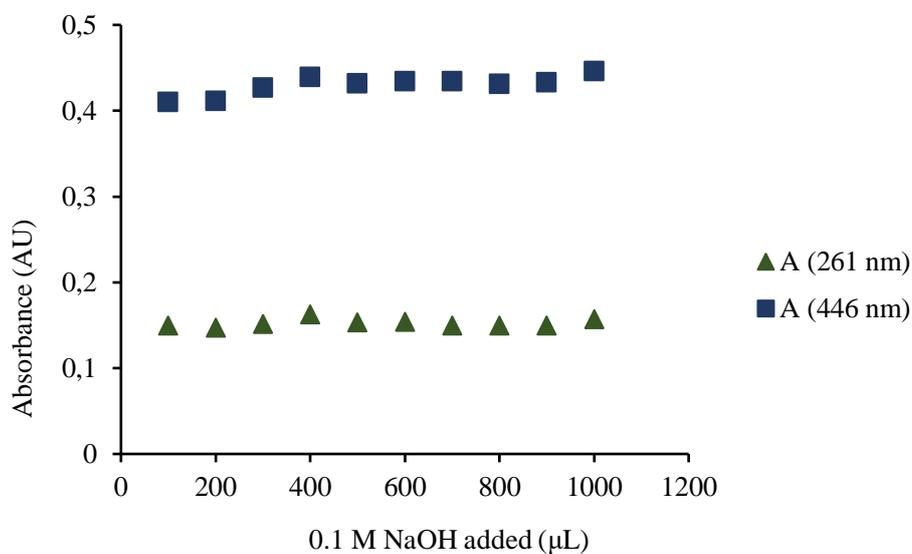


**Figure 1** The dependence of absorbance of curcumin in ethanol on the addition of demineralized water (in a total volume of 10 mL).

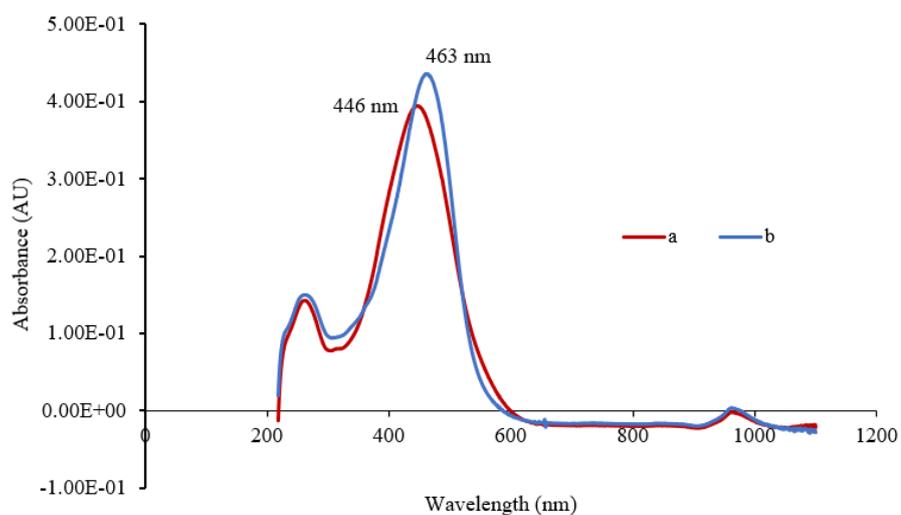
### 3.2 Stability Test of Curcumin

Curcumin can be dissolved either in ethanol or basic condition [25, 26] In basic condition, curcumin is susceptible to degradation. Meanwhile, it is stable in ethanol. In this study, ethanol and 0.1 M NaOH were used to prepare the stock solution of 40 ppm curcumin, and the dilution used demineralized water. From this stock solution, the stability of curcumin was investigated. The result was shown in Figure 2.

In the previous step, curcumin in ethanol was unstable when it was added with demineralized water which showed by the decrease in absorbance. Figure 2 shows that the presence of NaOH could keep the solubility of curcumin. The mixture kept the stability of curcumin although the solution was continuously added with 0.1 M NaOH. However, the addition of 0.1 M NaOH shifted the wavelength of curcumin to about 17 nm.



**Figure 2** The stability of curcumin in EtOH-NaOH solution with the addition of 0.1 M NaOH (in a total volume of 10 mL).



**Figure 3** The UV-Vis spectra of (a) curcumin in ethanol-NaOH stock solution and (b) curcumin in EtOH-NaOH solution with the addition of 0.1 M NaOH (in a total volume of 10 mL).

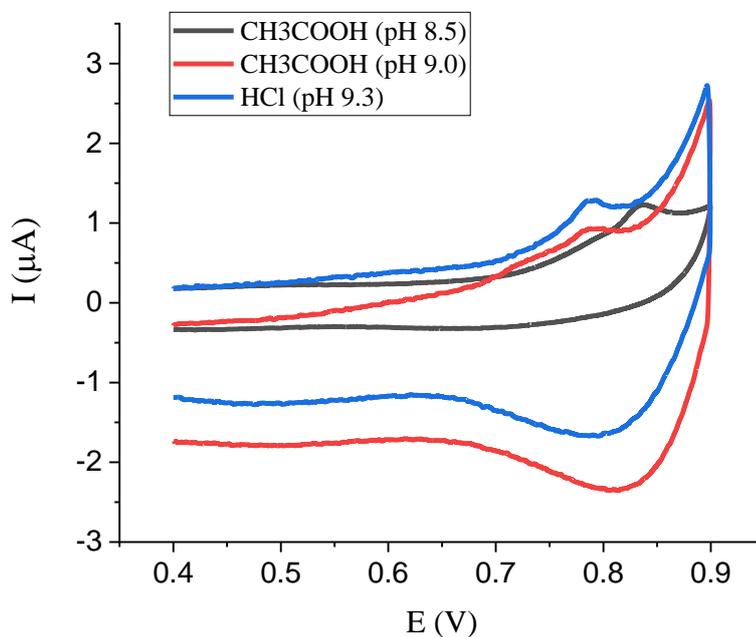
### 3.3 Electrochemical Behavior of Curcumin

Curcumin was reported to have electroactive properties. Several studies found that curcumin experienced oxidation and reduction [18, 20, 27]. Curcumin will be oxidized at a potential of 0.71 V and then reduced at 0.49 V by using bare GCE in a phosphate buffer pH 3.5. This anodic peak would be faded in the successive cycle while the cathodic peak was not altered. In the second cycle, a new anodic peak appeared at 0.49 V [28]. However, those study was different from a study conducted by [29]. The study showed that curcumin could be analyzed in a basic aqueous solution. 5 mM NaOH was used as the solvent to make a stock solution and to adjust the pH value, they used HCl. Curcumin was electrooxidized at 0.29 V and electroreduced at 0.09 V at pH 10.

In this present study, curcumin was prepared by using 1 mL of 0.1 M NaOH and diluted with demineralized water. The pH value was adjusted by using CH<sub>3</sub>OOH to pH 8.5 and 9, and also HCl to pH 9.3. The cyclic voltammogram was displayed in Figure 4. However, in this study, curcumin was only oxidized. The use of Au as the working electrode was suspected of contributing to this result. The different acids and pH values led to the different anodic peak potential and anodic peak current (Table 1).

**Table 1** Anodic peak potential and anodic peak current of 10 ppm curcumin affected by acids

Acids/pH	E <sub>pa</sub> (V)	I <sub>pa</sub> (μA)
CH <sub>3</sub> COOH (pH 8.5)	0.834	0.31
CH <sub>3</sub> COOH (pH 9.0)	0.786	0.21
HCl (pH 9.3)	0.786	0.28



**Figure 4** Cyclic voltammogram of 10 ppm curcumin in various pH and acid adjusters by using Au-disc as working electrode, Ag/AgCl (3 M NaCl) as reference electrode, and Pt wire auxiliary electrode in a scanrate of 100 mV/s.

#### 4 Conclusion

Curcumin has low solubility in water-ethanol. The stability of curcumin can be improved by using ethanol and NaOH for dissolving curcumin. Curcumin could be oxidized in basic solutions at a potential around 0.8 V. The anodic peak potential and anodic peak current depended on the acids used and pH values.

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## LULC Change Simulation using Markov Chain and MODIS data, A Case Study in Citarik Watershed in Upper Citarum River, West Java, Indonesia

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**Abstract.** Markovian matrices have often been used in the land use/land cover (LULC) change model to estimate the rate of change. When transition matrices for different observation periods are compared, the observation intervals often differ because satellite images or photographs of the study area taken at constant time intervals may not be available. In this study, data from the MODIS satellite from 2001-2020 is used to analyze land changes in the Citarik watershed area, which is growing into a peri-urban area due to high urbanization. Markov chain is used to identify land-use changes with an analysis of the yearly transition matrix. We developed a computer program to calculate and calibrate the yearly matrices and estimate the prediction errors. The sudden increase of socio-economic affected the error in land use and land cover changes.

**Keywords:** *markov chain; land use/land cover; citarik watershed; remote sensing; citarum.*

### 1 Introduction

Land use is the term used to describe human uses of the land or immediate actions modifying or converting land cover. It includes such broad categories as human settlements, protected areas, and agriculture [1]. Land cover refers to the surface cover on the ground, whether vegetation, urban infrastructure, water, bare soil, or other. Although the meanings of the terms are distinct, land use and land cover (LULC) are often used interchangeably [2]. Rapid changes in LULC are observed throughout the world, especially in developing countries, due to their heavy reliance on agricultural production [3] and increasing population [4], [5]. The use of LULC is highly acknowledged for water resources management [6], [7] and for estimating ecosystem services for urban sustainability [8]. LULC is something that has long been developed in various places both in Indonesia [2] and in the world [8]–[10] As with other emerging scientific fields, the number of

publications related to land-use change modeling has increased [11]. Nevertheless, LULC maps play a significant and prime role in planning, management, and monitoring programs at local, regional, and national levels. It is necessary to monitor the ongoing process of LULC patterns over some time [12].

Population growth is one of the fundamental things that initiate land change [13]. The term peri-urbanization is used to describe the urbanization in the countryside, creating peri-urban areas, mainly due to the migration of the urban population to rural areas to get a better living environment [14]. The Citarik area, as part of the upstream Citarum water basin, functions as a conservation area [15] is experienced the LULC change as the impact of the growing population in Bandung City [16]. Many methods have been used to simulate land change, including using the Markov chain [17], cellular automata [5], artificial neural network [2], artificial intelligence [8], and machine learning [18]. In addition, modeling using agent-based models in LULC is also of interest because it combines the influence of human decision-making on land use mechanistic, formally, and explicitly spatially by considering social interactions [12], [13], [19].

Remote sensing is critical in estimating and assessing changes in LULC in different years [20]. The extensive archives of satellite data such as LANDSAT, MODIS, and SENTINELs have given researchers unprecedented access to data, allowing them to quantify better and understand local and global land change [21]. The significant limitations of using many of these datasets are their coarser spatial resolution and missing details on LULC at local or sub-basin levels [13]. The other problem is that the photographing interval taken by satellite may not be at a constant time [22]. So, it is crucial to figure out how the Markovian approach can take care of the problem.

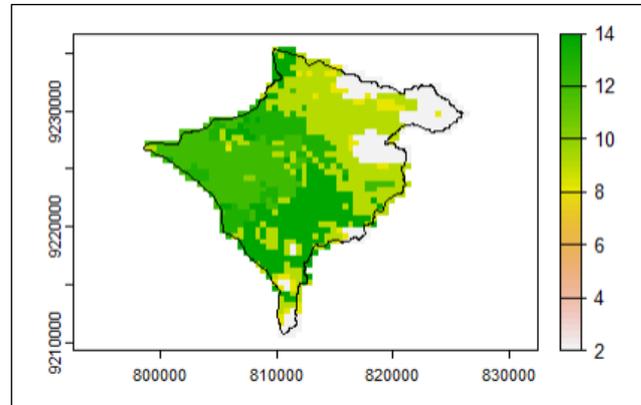
## **2 Study Area and Data**

### **2.1 Study Area**

The study area is located in the Citarik watershed, part of the upper Citarum river basin in West Java, Indonesia. The Citarik watershed is located in the eastern part of the upper Citarum river and is now experiencing sedimentation and pollution due to land-use change [23]. The Citarik watershed, part of the Bandung area, is part of the upstream Citarum river system, with a river length of 43.52 km (BBWS Citarum) with a watershed area of  $\pm 266$  km [24]. The Citarik area is interesting to study because it is planned by the West Java Regional Government to be used as a location that presents the management of the Citarum River and the government's efforts in controlling pollution and damage to the Citarum



map has been correctly loaded in R. The map shows a color-coded land cover, which we will remap/reclassify in the subsequent parts.



**Figure 2** Sample of MODIS file as raster in R.

## 2.3 Data Analysis

### 2.3.1 Image classification

The classification of land change begins by clipping Citarik location data for each raw image containing the Citarik watershed from 2001-2020. Furthermore, the image data is processed using R by plotting each picture pixel. According to [23], [26], the classification can be based on the maximum likelihood into seven classes: building land, primary forest, secondary forest, mixed garden, plantation, wet agriculture land, dryland farming dan waterbody. In this study, the classification is simplified into three classes because most of the human activity in the Citarik watershed is for agriculture, built area (settlement and industries), and forest as a conservation area. Thus, the codification used in this study is built area, agriculture, and forest areas (Table 1). The land use and land cover were classified using supervised classification using the terra package in R that follow the National Land Cover Database 2011 (NLCD 2011) classification scheme [29] for the Citarik watershed area.

**Table 1** Description of the LULC classes.

Class	LULC type	Description
Forest	Primary forest	It consists of natural forests that have not been disrupted by human exploitation and
	Production forest	it consist of forest that under management of land for commercial wood production including the extraction of timber therefrom but does not include the milling or processing of timber.
Agriculture	Wet agriculture	it is a kind of farming which depends generally upon rain like wet paddy rice fields
	Dry agriculture	the cultivation of crops without irrigation in regions of limited moisture,
	Plantation and mixed garden	it is a type of business cultivating where generating profit is a motive by growing crops
Built area	Commercial, industrial, and residential area.	it consists of buildings that has already been constructed.

### 3 Methodology

R software was used to analyze the land-use change dynamics. R is widely used to calculate and monitor land-use change [21], [30]. The data from MODIS land-use product loaded using the library terra and tidyverse libraries in R. R classified the image based on NLCD classes and then reclassified into set the class value for each class. The values chosen were 20, 80, and 40, representing developed, planted/ cultivated forests. Then, set the colors manually; in this case, red is built area, yellow is agriculture, and green is forest. The images from MODIS are already clear from the clouds from the start. It helps increase the classification and analysis process [31]. After obtaining the map of land use and land cover in pixel images from 2001-2020. Statistical analyses were performed to count sampling for every class and put it in the matrix to analyze the dynamics of land changes. These classification change detection methods are based on pixel-to-pixel analysis, which measures the quality and spatial distribution of LULC changes [32].

#### 3.1 Markov Chain Model

In simulations and predictions of land change, it is essential to spatially understand the rate of land change from time to time [22]. The Markov chain model is widely used to calculate spatiotemporal land cover changes [12], [33]. A Markov chain model describes the LULC change to predict the future LULC [12], [34]. The Markov chain process can be expressed as given in Eq. (1) [22]:

$$\mathbf{X}_{t+c} = \mathbf{X}_t \mathbf{A} \quad (1)$$

Where  $\mathbf{X}_t$  is a 1-by- $n$  row vector that gives the proportion of each category at the initial time  $t$  with  $n$  is the number of categories in the land-use classification. The value  $c$  is the number of the years between the initial year  $t$  and the subsequent year of observation. Matrix  $\mathbf{A}$  is an  $n$ -by- $n$  transition matrix. Each  $a_{ij}$  element represents the conditional transition probability of a pixel from category  $i$  at time  $t$  to category  $j$  at time  $t + c$ .

$$A = a_{ij} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \quad (2)$$

But sometimes, the problem arises when comparing transition matrices in different observation periods. The satellite observation intervals may not be at the constant time [22]. Assuming that the transition rule is invariant within one observation interval, i.e.,  $c$  years, as mentioned by Takada [22], we can define:

$$X_{t+c} = X_t A = x_t \underbrace{BBB \cdots BB}_{c \text{ times}} = x_t B^c \quad (3)$$

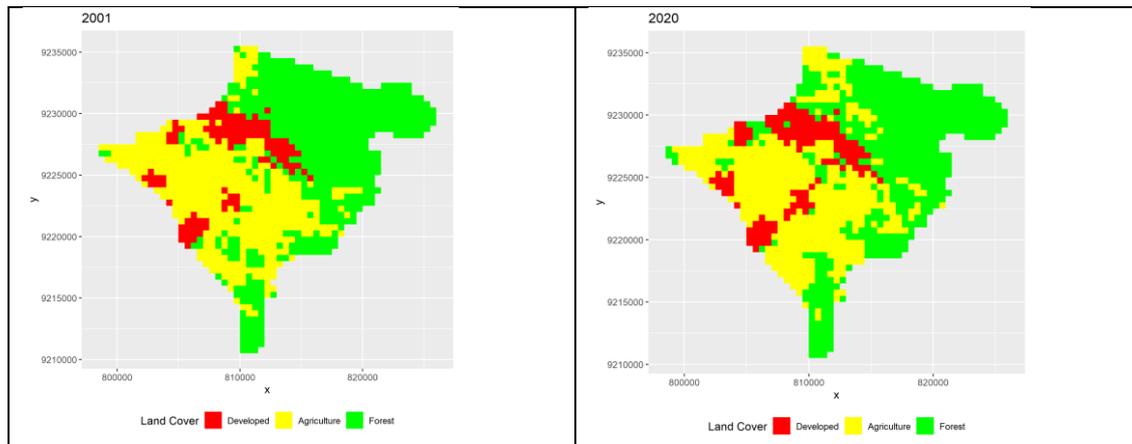
$$B = A^{\frac{1}{c}} = U \begin{pmatrix} (\lambda_1)^{\frac{1}{c}} & & 0 \\ & \ddots & \\ 0 & & (\lambda_n)^{\frac{1}{c}} \end{pmatrix} U^{-1} \quad (4)$$

$$U = (u_1, u_2, \dots, u_n) \quad (5)$$

With  $\mathbf{B}$  is a yearly transition matrix, and  $\mathbf{B}$  is the  $c$ -th power root of an original matrix  $\mathbf{A}$  [22], [35]. The calculation of the  $\mathbf{B}$  matrix in equation 5 follows Jordan decomposition principles [36].

#### 4 Results and Discussion

There are 20 images of the Citarik watershed area from 2001-2020. Every raster image contains 1168 pixels. The resolution of the MODIS product is 500m x 500m [37]. Through the land use and land cover mapping, it was possible to identify three different thematic classes in the study area.



**Figure 3** Land use/ Land cover in Citarik watershed area of 2001 and 2020.

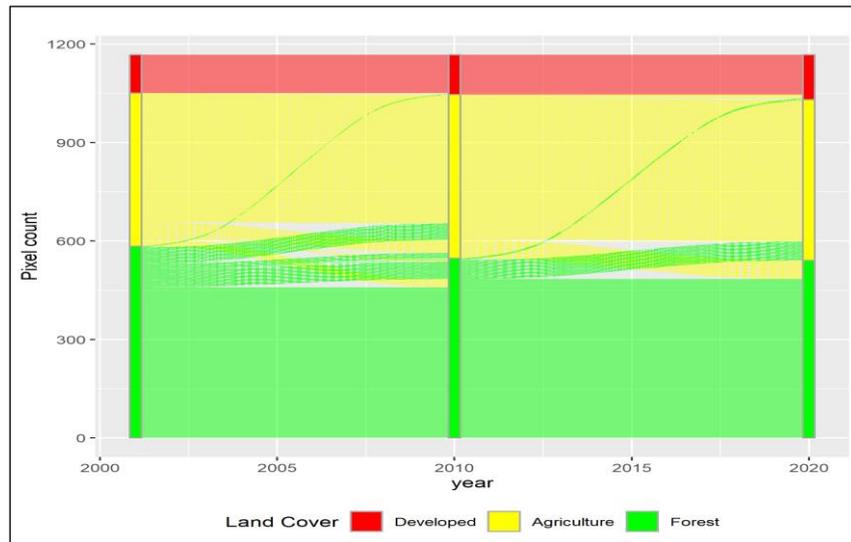
**Table 2** LULC dynamics for the period 2001-2020.

Land use types	2001 Area (ha)	2010 Area (ha)	2015 Area (ha)	2020 Area (ha)	Delta change (2001-2010)	delta change (%) (2001-2010)	delta change (2010-2015)	delta change (%) (2010-2015)	delta change (2001-2020)	delta change (%) (2001-2020)
<b>Developed</b>	29.25	30.3	30.5	34.25	1.00	0.34	0.25	0.09	5.00	1.71
<b>Agriculture</b>	116.5	125	129	122.3	8.25	2.83	4.50	1.54	5.75	1.97
<b>Forest</b>	146.3	137	132	135.5	-9.25	-3.17	-4.75	-1.63	-10.75	-3.68

#### 4.1 Land use land cover dynamic

For 2001-2020, the region under various LULC types was estimated and provided in Table 2. Over the last five years, the developed area has grown dramatically. In 2001, the Citarik watershed had a developed 29.25 ha and only rose to 0.09% in 2015, which is 30.5 ha, but in 2020 it rose to 34.25 ha (1.71%). The delta change in the developed area period 2015-2020 is almost the same as the delta change in the 2001-2015 period. This is due to the accelerated urbanization and infrastructure development as part of the construction process. Agriculture has seen a fluctuation within 20 years. From 2001-2010, the agriculture area grew 8.25 % (table 2) from 116.5 ha to 129 ha. In the 2010-2020 period, the growth got slow with a delta change of 1.54% (129ha) period (2010-2015) and a decrease to 122.3 ha in 2020. Overall, the agriculture area rose 5.75 ha in 2020 from 2001. This happened because the agricultural area was converted into a developed area (Figure 3). Forest has seen a substantial decline over the last 20 years. Between 2001 and 2010, the growth rate was -3.17%, from 146.3 ha to 137 ha, and it keeps declining in 2020 by 3.68% (135.5ha).

From 2001-2015 the land use and cover change focused on converting forests into agriculture. Then, since 2015, the agriculture area has decreased as the study area has experienced a rapid conversion to a developed area. Over 20 years, the forest suffered a slight loss of around 3.68% (10.75 ha) delta transition, transformed into agriculture, and developed (**Figure 4**). But, seeing forests converted straight into the developed area means the possibility of forest land clearing for agriculture and the developed area is even higher.



**Figure 4** The land conversion over time.

The 1168 lines in **Figure 4** show the transformation of the LULC each year. Extreme changes occurred from what was originally a forest directly to a developed area. The abrupt change is an example of clearing forest land to develop sites in the Citarik watershed area. The increasing population also increases the emergence of other agriculture and the increasing needs and human activities in the Citarik watershed. From 2010-2020 the land-use change from forest to agriculture, agriculture to the developed area, and forest to the developed area is still happening. Overall, from 2001-2020 the amount of developed area and agriculture increased, and forests decreased. The increasing development area positively indicates economic growth [36]. Still, the emergence of problems in the Citarik watershed, such as flooding [24], sedimentation [38], [39], and garbage pileup [15] shows a negative value on ecological damage.

## 4.2 Markov model

Next, the Markovian model was used to compare the rate of change in the LULC using yearly Markovian matrices and Markovian matrices with calibration [22]. For example, the transition matrix of 2001-2002:

$$B_1 = \begin{matrix} & \begin{matrix} Developed & Agriculture & Forest \end{matrix} \\ \begin{matrix} Developed \\ Agriculture \\ Forest \end{matrix} & \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0.99356223 & 0.006437768 \\ 0.001709402 & 0.02735043 & 0.97094017 \end{bmatrix} \end{matrix} \quad (6)$$

Transition matrix of 2002-2003

$$B_3 = \begin{matrix} & \begin{matrix} Developed & Agriculture & Forest \end{matrix} \\ \begin{matrix} Developed \\ Agriculture \\ Forest \end{matrix} & \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0.99582463 & 0.004175365 \\ 0 & 0.02276708 & 0.977232925 \end{bmatrix} \end{matrix} \quad (7)$$

All the process repeats until the transition matrix of 2019-2020. After obtaining 19 yearly matrices using our computer program, most diagonal elements of the yearly transition matrices are >90%, which means that the land-use change in all of the observation periods is very slow on a yearly basis [22].

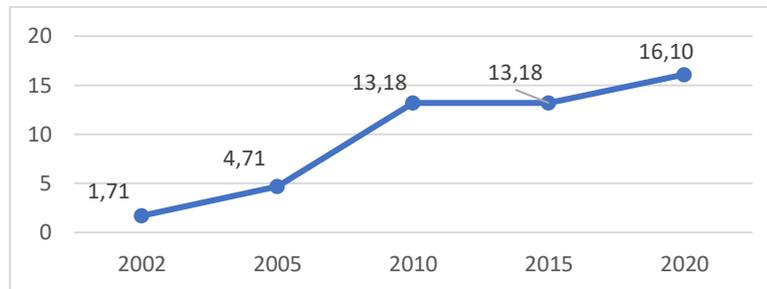
From the yearly Markovian matrix, the transition matrix from 2001-2020 can calculate as follows:

$$A = \begin{bmatrix} 1 & 0 & 0 \\ 0.01934983 & 0.7193385 & 0.2613117 \\ 0.01877433 & 0.2628859 & 0.7183397 \end{bmatrix} \quad (8)$$

$$B = A^{\frac{1}{19}} = \begin{bmatrix} 1 & 0 & 0 \\ 0.8125033 & 0.9828114 & 0.9318031 \\ 0.8112131 & 0.9320977 & 0.9827395 \end{bmatrix} \quad (9)$$

It has been suggested that an acceptable accuracy limit for land cover maps derivated from the classification of satellite data is 85% [40]. **Figure 5** shows that until 2015 the error estimation < 15% (1.71233%, 4.7089%, 13.1849%, 13.1849%), but in 2020 the error is > 15% (16.0959%). This implies that the transition matrix is a good estimator of the area vector in the year before 2015. This could occur because of the extreme changes in human activity[40]. Especially **Table 2** shows that in the study area, there was a sudden increase in the number of developed areas from 2015-2020 (3.75ha). Then, to solve the error > 15%, we try to simulate a new Markovian matrix using data from 2010-2020—

the results show an improvement; the error decreased from 16.09589% to 11.22%.



**Figure 5** Error values between the observed area and estimated area using a calibrated transition matrix.

## 5 Conclusions

Dynamics of land use/land cover changes and their future in the Citarik watershed have been carried out in this paper using the Markov chain process in R programs. The 2001-2020 MODIS satellite imagery was used as the source LULC data. This study reveals calibrated yearly transition matrices showing the rate of land-use change. Analysis shows that the annual rate of change in the forest area is prolonged. It was found that the conversion of agriculture into a development area in 2015-2020 (3.75 ha) is tripled compared to 2001-2015 (1.25 ha). A related study indicates the sudden change happened because of economic reasons. At the same time, the forest conversion got slower. This study has demonstrated the capability of the Markovian approach to model LULC change and serve as a baseline for the upcoming studies, especially concerning the LULC change in Citarik, Upper Citarum, and Bandung Metropolitan Area.

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## Modular Timber Building Assessment

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**Abstract.** Modular construction systems offer an opportunity for the construction industry to have almost all *on-site* building work *off-site* and transform conventional production systems in the field into manufacturing production systems.

The obstacle faced in making construction systems using Modular Wood is the absence of a wood building assessment/testing system with a modular system/components in Indonesia. The modular wood building grading system cannot use the conventional wood building grading system due to the complexity of the modular building system so a grading system using the empiric approach is needed.

The assessment of buildings and modular construction systems is carried out with the approach of empiric. Assessment with an empirical approach is obtained by direct observation of buildings with modular wood construction systems in the field. The buildings that have been built will provide better observation of field conditions, the strength of the modular wood construction system structure, and the durability of the material.

Analysis of the *Sekolah Alam Dago* building shows that (1) The treatment factor given to the wood gives better results on the Visual Inspection Indicators because the *treatment* given to the wood will make the wood life in the building longer and (2) The class of wood used in buildings with modular construction systems affects the efficiency and economic value of the building. The results of the assessment of buildings constructed of modular wood also changed the conventional construction system. Modular Wood Construction System can provide good building quality by not using the highest quality of wood so that it can reduce construction costs and streamline work time.

**Keywords:** *assesment tools; modular timber; knockdown system; construction method; wood architecture.*

## 1 Introduction

In recent years, the construction sector has always lagged behind other sectors in terms of productivity. To catch up, innovations are needed that can increase the productivity of the construction sector, one of which is a modular construction system.

The Modular Construction System is not a new concept, but technological developments, economic needs, and a change in mindset make this system attractive in interest and investment. If this system is developed and continued, it can provide great progress in the productivity of the construction industry sector

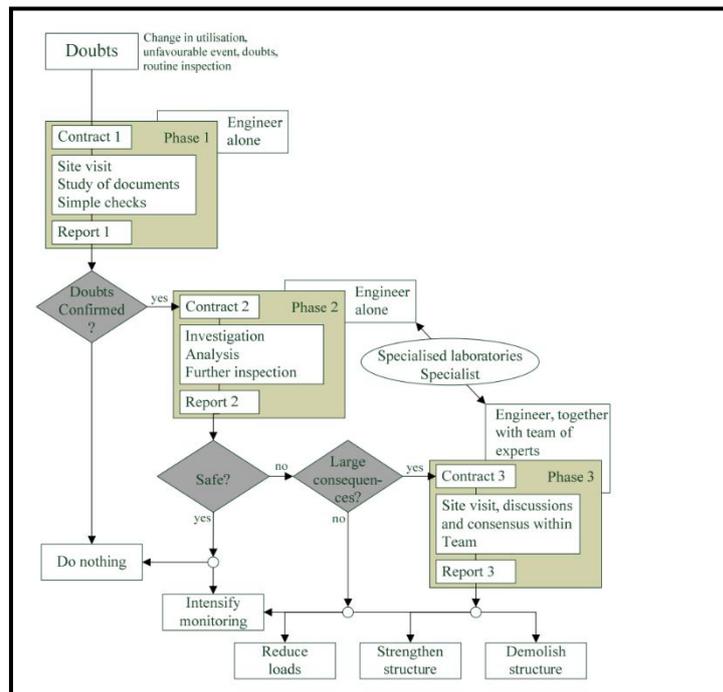
In Indonesia itself, various types of modular construction system elements have begun to be developed. One of these elements is Modular Wood which is the result of innovation from the Building Technology Research Group of SAPPK ITB. This construction system using Modular Wood has been created in various types of buildings that are produced independently.



**Figure 1** Sekolah Alam Bandung which is constructed using Modular Wood

The obstacle faced in making a construction system using Modular Wood is that there is no assessment/testing system for wooden buildings with modular systems/components in Indonesia. Modular wood building grading systems cannot use conventional wood building grading systems.

Conventional scoring systems test the strengths of each architectural element and such testing systems cannot be applied in modular systems because modular systems have a more complex style of channeling that is different from conventional style channeling systems. Testing of modular building systems can be carried out when the building has been built intact.



**Figure 2** Conventional Building Valuation Diagram. Source: Professional Engineers Ontario

As a preliminary step, the assessment of buildings with a modular construction system is carried out with the approach of empiric. Assessment with an empirical approach obtained by means of direct observation of buildings with modular wood construction systems in the field.

The purpose of this empirical assessment is to obtain the condition of modular wooden buildings that have been built so that the assessment carried out is more accurate than the buildings assessed from simulations or laboratory trials. The buildings that have been built will provide better observation of field conditions, the strength of the modular wood construction system structure, and the durability of the material.

## 2 Research Method

The assessment of modular wooden buildings will include 2 main parts, namely the assessment of modular elements of wood and the assessment of the unity of wooden elements as a building system. This assessment of modular elements is used to provide information regarding the nature of the properties of modular

elements. An assessment of the building system is used to give a real picture of the state of the building in the field.

The assessment of wood modular elements consists of 3 main criteria: The Main Characteristics of Modular Elements, Resistance of Modular Elements to Fire and Resistance of Modular Elements to sound/acoustics. This criterion is coupled with the current growing issue, namely the economic, and environmental value of a building.

The Main Characteristic Criteria of modular Elements provides the main information of modular wood elements consisting of 8 indicators, as follows.

1. Defects of modular elements from the plant (*Defect / Feature*)
2. Ratio of Single Wood Eye to Wooden Surface (*Single Knot*)
3. Ratio of Wood Eye Group to Wood Surface (*Knot Cluster*)
4. Wood Grain Slope (*Slope of Grain*)
5. Distance of *Renggat* / Annual Line of Wood (*Ring Width*)
6. Absolute Bending Stress
7. Absolute Pressure Stress
8. Density



**Figure 3** Modular Wooden Building Interior

The Economic and Environmental Value Criteria are taken in part as *the Sustainability Performance Criteria (SPC)* in the journal *Life Cycle Sustainability Performance Assessment Framework For Residential Modular*

*Building: Aggregated Sustainability Indices.* The selection of SPC in this assessment is carried out by considering the assessment carried out in the nature of an initial assessment and regular observation of the building.

The Economic Value Criterion of the Modular Element provides information about the role of buildings in shaping a sustainable economy. This criterion consists of 6 indicators, namely.

1. Reduction in construction duration (*Construction Time*)
2. Reduction in construction costs (*Construction Costs*)
3. Reduction in operating costs (*Operational Costs*)
4. Reduction in maintenance costs (*Maintenance Costs*)
5. Durability of the Building (*Durability of Building*)
6. Flexibility in Building Buildings (*Flexibility of Building*)

The Environmental Value Criteria of modular elements provide information about the role of buildings in shaping a sustainable surrounding environment. This criterion consists of 4 indicators, namely.

1. Construction Waste Management
2. End of Life Waste Management
3. Renewable and Environmentally Preferable Product
4. Regional Material

In assessing a building in the field, there are several methods that can be used to provide an assessment of the building. These methods include acoustic, electromagnetic, thermal and optical methods, and mechanical techniques. In this assessment, the approach was carried out with *the Non-Destructive Technique* (NDT) technique, namely visual inspection in the field. This Visual Inspection can provide a quick overview of the state of the building in the field and can be carried out regularly without the skills or use of complex tools.

*In the Wood and Timber Condition Assessment Manual 2nd Edition* issued by the United States Department of Agriculture, there are 8 indicators in visual inspection in assessing a conventional wooden building.

1. Fruiting Bodies
2. Sunken Faces or Localized
3. Staining or Discoloration
4. Insect Activity
5. Plant or Moss Growth
6. Missing Modular Components (Missing Members)
7. Wood Treatment Examination (Check and Spill)
8. Modified Modular Components (Alteration)

In the assessment of modular wooden buildings, additional indicators are needed that can assess the performance of modular elements. Additional indicators of this assessment are based on the observation of modular elements as a building system, the relationship between modular elements, and the components that make up modular elements. Additional indicators for visual inspection consist of.

1. Structural Deformation
2. Buckling or Torsional Buckling
3. Modular Joint Cracking
4. Destruction of Modular Element Adhesives (Detail Component Deterioration)

Valuing in the assessment is carried out by balancing the valuing of the assessment of modular elements of the building and the assessment of modular elements as a building system. The assessment of Modular Elements of Buildings consists of the **Main Characteristics of Modular Elements, Resistance of Modular Elements to Fire, Resistance of Modular Elements to Sound/Acoustics, Economic Value, and Environmental Value**. The assessment of modular elements as a building system consists of **Visual Inspection** criteria.

**Tabel 1** Building Criteria Table

	<b>Criteria</b>	<b>Value</b>
1	Main Characteristics of Modular Elements	10
2	Product Resistance to Fire	10
3	Product Resistance to Sound/Acoustics	5
4	Economic Value	10
5	Environmental Values	15
6	Visual Inspection	50

Each indicator in the assessment criteria has an equal value. This division is carried out without regard to the magnitude of the influence of each indicator in a criterion because there has not been a literature study that explores these indicators. Each indicator will then be assessed in 3 qualities: **high, medium, and low**. High, medium, and low quality are scored **3, 2, 1**, respectively.

Then, the scores of each indicator are converted into score values so that they correspond to the scores of each indicator. The score values are summed up for each indicator and will result in the final score of the building. The quality of a building as a whole can be seen in the table below.

**Table 1** Building Quality Assessment Table

<b>Final Score</b>	<b>Building Quality</b>
85 – 100	Excellent
70 – 84	Good
50 – 69	Average
30 - 49	Low

### 3 Case Study: Sekolah Alam Bandung, Dago, Kota Bandung

Sekolah Alam Bandung is a school with the first nature-based concept in the city of Bandung. One of the buildings that are a shared classroom is constructed using a modular wood construction system and as a representation of a modular wood prototype developed by SAPPK ITB. The building was built in 2019 with a size of 9m x 9m and has 2 floors. The entire building stands on a concrete roof with a height of 30 cm.



Figure 4 Rear View of Sekolah Alam Bandung, Dago

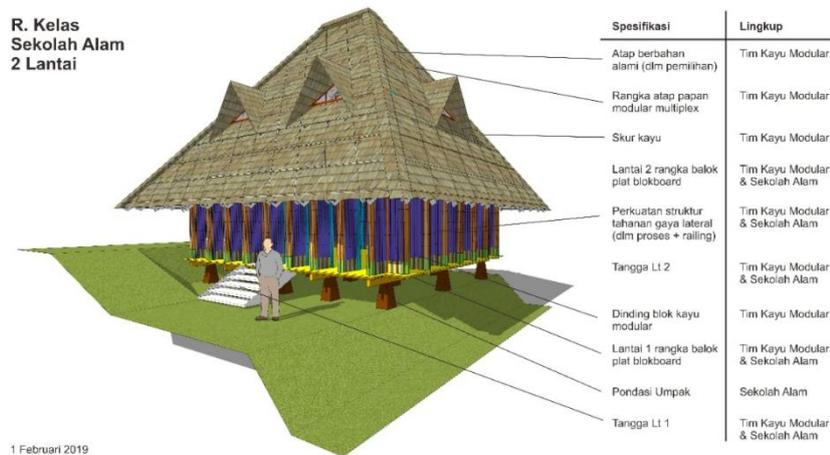


Figure 5 3D Building Model of Sekolah Alam Bandung

### 3.1 Assessment of the Building

The assessment of the building begins with collecting modular element data from laboratory trials. Then, the assessment of the building is continued with a visual inspection of the entire building which is carried out by direct observation in the field. The results of the visual inspection will provide identification of the overall structure of the building, the relationships between modular components, and the details of the modular components.

#### 3.1.1 Criteria: Main Characteristics of Modular Elements

In Sekolah Alam Dago building, there are 2 modular components used in buildings, namely (1) Modular Wood Blocks that make up the building wall plane and (2) Plywood Boards that make up the building roof plane. The Modular Wood Blocks used are the result of class III wood processing while the Plywood Boards used are the result of processing class IV wood. Modular Wood Blocks produced from the factory have defects such as *thermal crack* and *wound* while for Plywood Boards there are no defects whatsoever caused by the factory.

#### 3.1.2 Criteria: Resistance of Modular Elements to Fire



**Figure 6** Fire Resistance Test in the Laboratory

Laboratory Trials conducted on Modular Wood Blocks burned with fire showed that the field components of Modular Wood Blocks and Plywood Boards without *treatment* could last 15 minutes before the Modular Wood Blocks were completely destroyed. The durability of Modular Wood

Blocks and Plywood Boards can be extended by providing fireproof wood treatment so as to increase the durability of the building when a fire occurs.

### 3.1.3 Criteria: Resistance of Modular Elements to Sound



**Figure 7** Scenery surrounding the building

Buildings made of Modular Wood Blocks and Plywood Boards can reduce external noise that enters the building without having to be given additional sound insulation. Factors of land and the surrounding environment will also influence this criterion. Buildings located within the city will receive a higher external sound than buildings located on the outskirts of the city/village.

### 3.1.4 Criteria: Economic Value of the Building

This building constructed using modular elements can significantly reduce the time required to build the building. This reduction in time in construction will also have implications for the operational cost of building buildings so that buildings constructed using modular wood will be cheaper than buildings constructed with conventional systems.

The modular elements used in buildings come from class III and IV wood which have a cheaper price but can provide building quality that is suitable for use. The use of class III and IV wood can help reduce building construction costs which are largely influenced by the price of the building materials used.

Observations in the field also show that buildings that have been built for 3 years have never been given significant maintenance. Buildings built with a combination of class III and IV wood are expected to last a minimum of 10 years without special maintenance and protection.

Building construction can be carried out without requiring special training because modular elements only need to be included between one another so that workers without special skills can also be involved in construction work. This ease of construction provides high flexibility in modular construction systems, increases worker productivity, reduces the time required in construction as well as reduces the operational costs required to finance workers.

### **3.1.5 Criteria: Environmental Values**

The production process of modular wood blocks can use new wood or wood so that it does not leave any remaining raw materials while Plywood Boards are produced from sawdust which is the result of processing residues. When this building is no longer in use or about to be demolished, most of the modular elements can still be reused so that the waste generated at the end of the building's life becomes small and does not cause environmental damage.

The raw materials used in the production of Modular Wood Blocks and Plywood Boards come from class III and IV wood which are very abundant in quantity and can be produced in a short time. The raw materials used also come from forests within West Java Province so that carbon emissions that occur due to material transportation are low.

### **3.1.6 Criteria: Visual Inspection**

Direct observation of the building in the field shows that there is deformation in the building but does not harm the structure of the building. This can be seen from the slight slope of the wood on the wall and also the door leaf frame that is buckling. On the exterior of the building, there are several parts of the wall that are overgrown with fungi and moss in small

quantities. The growth of these fungi and lichens shows that there are some parts of the building that are being exposed to water and also undergo discolorization.

In the building, no insect activity was found in the building casing which was indicated by the absence of insect movement, no holes, and no wood residue due to gnawing from the inside. In the building, there is also no part of the modular wood that has undergone partial destruction which shows that fungi and moss on modular wood only grow on the outermost part of the wood.

Modular Elements in the building do not undergo human-caused deformation and also no missing modular elements are found. At the joints between the modular element / interlocking parts there is no fracture found that can cause failures in the building structure as well as the adhesive elements between the modular elements nothing is missing/loose.



**Figure 8** (left). There are some parts of the building exteriors that are overgrown with mushrooms. (middle). Deformation of the structure on the 2<sup>nd</sup> floor of the building. (right). There are parts of the building overgrown with moss.

#### 4 Discussion and Result

Assessment of modular wood construction system buildings through an empirical approach requires a large number of appraisers to obtain more accurate data. The assessment carried out by the field tends to be the subjective assessment of each assessor even though there are already parameters of each indicator quality. The results obtained from the direct observation of the *building of Sekolah Alam Bandung* include.

1. *Sekolah Alam Bandung* got a score of **81.77** and was in the **good** category (70-84).
2. Direct observations in the field provide the fact that *the treatment* factor has a major effect on the results of **visual inspection** of buildings. The low quality of the visual inspection criteria indicates the lack of *treatment* given to the wood so that the building is easily overgrown by plants, fungi, and eaten by insects which have implications for the strength of the building structure.
3. The class of wood used in modular elements has no effect on the quality of the building. The building of *Sekolah Alam Bandung* uses wood from classes III and IV, but the quality of the building obtained is still in good condition. The quality of the building can still be improved by providing additional treatment to wood such as fire and water insulation which can increase the durability of the building but increase the cost and construction time in the field.
4. Construction using modular wood has more advantages in the criteria of economic and environmental value. The Modular wood construction can reduce financings in the construction phase and also when the building is used. These cost reductions can increase consumers' purchasing power toward modular wood buildings. In the environmental value criteria, modular elements can be made from raw materials that are abundantly available in a place to reduce carbon emissions due to material transportation. When the building is deprecated, these modular elements can still be reused because the modular elements are hooked between the modules without the use of permanent adhesives.

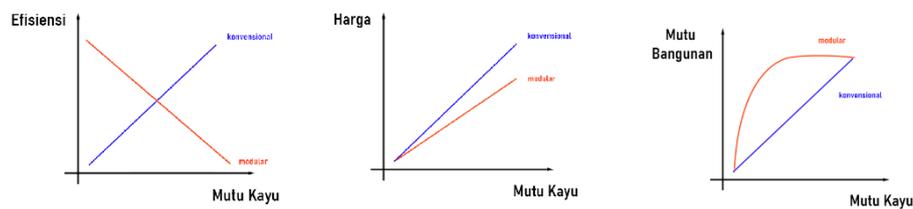
#### 4.1 Research Limitation

As with other studies, there will be many factors and challenges related to direct analysis and observation in the field that can affect the results of building assessments. These limitations include limitations in the number of people involved in building assessment and in the world, the unavailability of a standard modular construction grading system so that further study of modular wood construction systems is needed.

### 5 Conclusion

Construction using Modular Wood provides many advantages, such as speed in construction, reduction in construction costs, reduction in waste generated from buildings, flexibility in buildings, and much more. But, this system is still faced with various challenges such as the lack of modular elements that have been manufactured, the unavailability of an assessment system or standards that can be used to assess buildings with modular construction systems, and the mindset/stigma of people who still doubt the ability of modular wood construction and others.

The comparison between conventional wood systems and modular wood systems can be illustrated in the chart below.



The graph between Wood Quality and Efficiency shows that in conventional construction systems, the higher the quality of the wood used, the higher the efficiency, but in buildings with modular construction systems, high wood quality does not provide high efficiency to wood. This is due to the increasing difficulty of processing high-grade wood.

The graph between Wood Quality and Price shows that modular construction systems have a lower cost compared to conventional construction. Modular elements can be produced in factories so as to minimize work in the field and reduce the duration of building construction which has an impact on reducing operational costs in buildings.

The graph between Wood and Building Quality shows that in conventional construction systems, the higher the quality of the wood used, the higher the quality of the building produced. This provides information that getting a building of good quality also requires a high cost to obtain anything with good quality. However, this is different from construction with modular wood where the quality of the wood is already able to provide good building quality.

The assessment system created is an initial instrument to assess the performance and capabilities of modular wooden buildings. This assessment system still needs to be developed again so that the assessment system carried out is not only an initial instrument but can be carried out to check for damage to buildings, provide a comparison of the performance and capabilities of buildings every year, to become a standard that can be used in any modular construction.

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