

Proceeding

14th INTERNATIONAL **CONFERENCE**

ON GREEN TECHNOLOGY

p-ISSN: 2580-7080 | e-ISSN: 2580-7099

Preface of 14th International Conference on Green Technology 2024 (ICGT 2024)

The 14th International Conference on Green Technology (ICGT 2024) was held at the Atria Hotel and Convention Center in Malang, East Java, Indonesia, from October 1 to 2, 2024. ICGT is an esteemed annual multidisciplinary conference that serves as a platform for fostering collaboration and promoting intellectual exchange among educators, researchers, engineers, and industry professionals engaged in the advancement of science, technology, and related fields. In recent years, there has been increasing attention among scholars and practitioners regarding the need for green technologies to transition towards more integrated and sustainable approaches to environmental challenges. Existing frameworks, however, often fall short in addressing the region's diverse climatic, cultural, and environmental contexts. In response to these pressing issues, the theme of the 14th ICGT 2024 was “Emerging Green Technology: A Path Towards a Resilient and Sustainable Built Environment.”

The conference's scientific program included keynote speeches, plenary sessions, and invited lectures, alongside parallel sessions covering a wide range of topics across the STEM disciplines. The event attracted a diverse audience comprising professors, PhD students, early-career researchers, academic supervisors, scientists, master's students, and undergraduates from fields including earth sciences, environmental studies, engineering, natural sciences, technology, and innovation. The primary objective of the conference was to introduce students to the dynamic and evolving STEM landscape, keep experts abreast of the latest developments in their respective fields, and facilitate the exchange of knowledge and research insights across a broad spectrum of scientific and technological domains. Notably, the 14th ICGT 2024 emphasized the development of both accessible and advanced technologies to foster sustainability in diverse environmental and cultural settings.

In light of the global disruptions in recent years, the 14th ICGT 2024 adopted a hybrid format. Although virtual participation was limited, this model enabled all attendees to engage with the conference either in person in Malang or virtually via Zoom. The conference agenda began with keynote speaker presentations and discussions, followed by parallel sessions for all presenters. Each presenter was allotted 20 minutes, including 15 minutes for their oral presentation and 5 minutes for discussion. These sessions were moderated, with all keynote speakers serving as reviewers for the presentations, both in the plenary room onsite and virtually. Additionally, all events were live-streamed on the university's YouTube channel. We would like to express our gratitude to the organizing and scientific committees, as well as to all presenters and participants, for their unwavering support and contributions. Finally, we extend our sincere appreciation to the Faculty of Science and Technology at the Islamic State University of Maulana Malik Ibrahim Malang for their generous financial support and assistance in ensuring the success of this event.

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Ubiquitously Continuous on Seminorm

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Abstract- The term ubiquitously continuous is defined with the purpose of investigating the continuity of a linear operator based on the presence of normed spaces infinite dimensional linear subspaces. Norms and seminorms are parts of the study of normed spaces and obviously are both able to be continuous or discontinuous with respect to their spaces. Hence, this paper aims to explore how ubiquitously continuity of norms and seminorms with respect to infinite dimensional vector spaces. By using available theorems and lemmas, norms and seminorms are generally ubiquitously continuous unless the norms and seminorms themselves are discontinuous at a certain point.

Keywords— Norm, Seminorm, Ubiquitously Continuous

I. INTRODUCTION

Vectors and their operations are fundamental to vector spaces. Any vector space that satisfies the four norm properties can be termed a normed space. On the other hand, when a vector space lacks the positive definite property of a norm, it becomes a seminormed space.

On the other hand, mathematical analysis is closely associated with the term continuity which was discovered by nineteenth-century mathematician Karl Weierstrass. Shortly, the concept of continuity can be explained as how a function behaves normally and there are no sudden unusual changes within that function [1]. The concept of continuity can be developed into the concept of ubiquitously continuous which investigates the implication of how the continuity of a small fraction of a domain causes the domain itself to be continuous or not. Thus, this study seeks to find an answer to how ubiquitously continuity can be applied in any given normed or semi normed space.

A. Vector Spaces

A vector space also a known as a linear space is a nonempty set X defined over a field $\mathbb{F}$ ($\mathbb{R}$ or $\mathbb{C}$) that is equipped by two operations, that is vector addition and vector multiplication with scalar [2]. A vector space can also be described as follows:

Definition 1. A vector space over a field $\mathbb{F}$ ($\mathbb{R}$ or $\mathbb{C}$) is a nonempty set V that is equipped with two functions that are vector addition from $V \times V$ to V and vector multiplication with scalar $\mathbb{F} \times V$ to V that can be notated by $x + y$ and αx ,

for all $x, y \in V$, and $\alpha \in \mathbb{F}$, which mean for every $\alpha, \beta \in \mathbb{F}$ and $x, y, z \in V$.

- (V1) $x + y = y + x$,
- (V2) $x + (y + z) = (x + y) + z$
- (V3) There is $0 \in V$ such that $x + 0 = x$
- (V4) There is $-x \in V$ such that $x + (-x) = 0$
- (V5) $1x = x$
- (V6) $\alpha(\beta x) = (\alpha\beta)x$
- (V7) $\alpha(x + y) = \alpha x + \alpha y$
- (V8) $(\alpha + \beta)x = \alpha x + \beta x$

Example 1. Consider $\mathbb{R}^3$ as a vector space. Let $h, i, j \in \mathbb{R}^n$ and $p, q \in \mathbb{R}^n$ with $h = (h_1, h_2, \dots, h_n)$, $i = (i_1, i_2, \dots, i_n)$ and $j = (j_1, j_2, \dots, j_n)$.

Proof. Now using the properties of the vector spaces, we can get the following:

- (V1) $h + i = i + h$,
- (V2) $h + (i + j) = (h + i) + j$
- (V3) There is $0 \in V$ such that $h + 0 = h$
- (V4) There is $-h \in V$ such that $h + (-h) = 0$
- (V5) $1h = h$
- (V6) $\alpha(\beta h) = (\alpha\beta)h$
- (V7) $\alpha(h + i) = \alpha h + \alpha i$
- (V8) $(\alpha + \beta)h = \alpha h + \beta h$

Thus, $\mathbb{R}^n$ qualifies as a vector space, because it satisfies all the required properties [3].

B. Normed Spaces

A normed space is a vector space that is provided with a norm. the presence of this norm allows the space to satisfy certain conditions, which define its structure as a normed space [4].

Definition 2. Let X be a vector space over a field $\mathbb{F}$. The norm of X , denoted by $\|\cdot\|: X \rightarrow \mathbb{R}$ is a function that associates a real number with each element of X , ensuring the following conditions are satisfied for all $l, m \in X$, and $\alpha \in \mathbb{F}$:

1. $\|l\| \geq 0$
2. $\|l\| = 0$ if and only if $l = 0$
3. $\|\alpha l\| = |\alpha| \|l\|$

$$4. \quad \|l + m\| \leq \|l\| + \|m\|$$

Normed space is a vector spaces X that is provided with a norm.

In a normed space, there is also a concept known as the equivalent norm.

Definition 3. [5] A norm $\|\cdot\|$ on a vector space X is considered equivalent to another norm $\|\cdot\|_0$ on X for all $b \in X$ if there exist constants m and n so that

$$m\|b\|_0 \leq \|b\| \leq n\|b\|_0$$

Because of this, the equivalent norms also determine the same topology in the vector space.

Theorem 4. [5] Equivalent norms in X determine the same topology in X .

Example 2. Suppose L is a linear space over field $\mathbb{R}$ by defining $\|l\| = |l_1| + |l_2| + |l_3|$ it will be proved that $\|l\| = |l_1| + |l_2| + |l_3|$, is a norm with $l = (l_1, l_2, l_3)$ where $l \in L$.

Proof. Based on the conditions of the normed space, we check:

$$(V1) \quad \|l\| \geq 0$$

$$(V2) \quad \|l\| = 0 \text{ if only if } l = 0$$

$$(V3) \quad \|\alpha l\| = |\alpha| \|l\|$$

$$(V4) \quad \|l + m\| \leq \|l\| + \|m\|$$

Thus, it can be concluded that $(\mathbb{R}, \|\cdot\|)$ is a normed space.

C. Seminorm

A seminorm is a function that maps a vector space to the real numbers, satisfying certain properties [6]. It can be defined as follows:

Definition 5. Let X be a vector space over a field $\mathbb{F}$, a mapping $m: X \rightarrow \mathbb{R}$ is named seminorm if

1. $m(x) \geq 0$, for all $x \in X$,
2. $m(x + y) \leq m(x) + m(y)$, for all $x, y \in X$
3. $m(\lambda x) = |\lambda| m(x)$, for all $x \in X$ and all $\lambda \in \mathbb{F}$

The function m is always positive, and then m becomes a norm, if $m(x) = 0$ only when $x = 0$.

Example 3. Suppose $x \in \mathbb{R}, m: \mathbb{R} \rightarrow \mathbb{R}$ is a function defined by:

$$m(x) = x^2$$

Prove that m is not a seminorm on $\mathbb{R}^2$.

Proof. Based on the conditions of the normed space we get:

$$(V2) \quad m(x + y) \leq m(x) + m(y), \text{ for all } x, y \in X$$

The second condition is not stratified because $m(x + y) \leq m(x) + m(y) + 2xy$

$$(V3) \quad m(\lambda x) = |\lambda| m(x), \text{ for all } x \in X \text{ and all } \lambda \in \mathbb{F}$$

$$m(\lambda x) = (\lambda x)^2 = \lambda^2 x^2$$

The third condition is not satisfied because of the value of $m(\lambda x) \neq |\lambda| m(x)$.

Since both conditions (V2) and (V3) are not satisfied, so m is not a seminorm.

D. Continuous on Normed Spaces

In normed space, the concept of continuity is explored through equivalent conditions based on Lemma 4 and Definition 5 [7] which state:

Lemma 6. Suppose X and Y are normed spaces, $a \in A \subset X$, and $f: A \rightarrow Y$ is a function. Then following statements are equivalent:

1. For every $\varepsilon > 0$, there exists $\delta > 0$ such that if $\|x - a\| < \delta$ then $\|f(x) - f(a)\| < \varepsilon$ where $a \in A$ and $x \in A$.
2. If x_n is a sequence in A and if $x_n \rightarrow a$ in X , then $f(x_n) \rightarrow f(a)$ in Y .

Definition 7. Suppose X and Y are two normed spaces, $a \in A \subset X$, and a function $f: A \rightarrow Y$, then f is considered continuous on A and if f satisfies one of the equivalent conditions based on Lemma 6 If f is continuous on every $a \in A$, then f is said to be continuous on A .

E. Continuous on Seminorms

Definition 8. [9] Let X be vector spaces and m is a seminorm on X . If seminorm m is continuous in one point on X , then seminorm m is continuous everywhere. If X is a normed space accordingly m is continuous on X if only if for all constant number L

$$m(x) \leq L\|x\| \quad \text{for all } x \in X$$

Then, continuous seminorm on finite dimensional vector spaces can be explained below [10]:

Theorem 9. Let M is a seminorm defined on finite dimensional vector spaces X over the field $\mathbb{F}$, accordingly M is continuous concerning to the distinct topology on X .

F. Ubiquitously Continuous

The term ubiquitously continuous was coined by [11]. Inspired by his work, the term ubiquitously continuous can be defined as below:

Definition 10. Let X and Y is a normed spaces and $L(X, Y)$ represent linear transformation or operator T with $D(T)$ as

the linear subspace of the domain, that is X , and $R(T)$ as the range or image, that is Y . For a given linear subspace E define $\mathcal{J}(E)$ as the family of infinite dimensional subspaces of E . An operator T is said to be ubiquitously continuous if for every $E \in \mathcal{J}(X)$ contains an $F \in \mathcal{J}(E)$ for which $T|F$ is continuous.

II. RESULT

A. Ubiquitously Continuous on Seminorms

The existence of the origin vector can be used as a tool in order to understand the concept of ubiquitously continuity on norms and seminorms [16].

Lemma 11. Suppose X is an infinite-dimensional vector space over a field $\mathbb{F}$, provided with both a seminorm M and a norm P , accordingly:

- Continuity of M at $x = 0$ implies ubiquitous continuity concerning to the topology determined by P .
- Discontinuity of M at $x = 0$ implies ubiquitous continuity concerning to the topology determined by P .

Proof. a) Assume that M is continuous at $x = 0$ concerning to the topology given by the norm P . Therefore, if $(x_n)_{n=1}^{\infty}$ is any sequence in X , so

$$P(x_n) \rightarrow 0 \text{ implies } M(x_n) \rightarrow 0 \text{ as } n \rightarrow \infty.$$

Choosing $x \in X$, and taking an arbitrary sequence $(y_n)_{n=1}^{\infty}$ for which

$$x_n = x - y_n \text{ and } P(x - y_n) \rightarrow 0,$$

then (1) implies that

$$M(x - y_n) \rightarrow 0 \text{ as } n \rightarrow \infty.$$

Where for every $x, y \in X$

$$M(x) - M(y) \leq M(x - y) \quad (1)$$

$$M(y) - M(x) \leq M(y - x) \quad (2)$$

So based on (1) and (2) it is obtained that

$$\begin{aligned} M(y - x) &\leq M(x) - M(y) \leq M(x - y). \\ |M(x) - M(y)| &\leq M(x - y), \quad x, y \in X \\ |M(x) - M(y_n)| &\rightarrow 0. \end{aligned} \quad (3)$$

Based on the inequality (3)

$$|M(x) - M(y_n)| \leq M(x - y_n) \rightarrow 0.$$

Since $M(x - y_n) \rightarrow 0$, it can be concluded that

$$|M(x) - M(y_n)| \rightarrow 0, n \rightarrow \infty.$$

Thus, proving that M is continuous at $x = 0$ means that M is ubiquitously continuous concerning to the topology determined by P .

- Assuming that M is discontinuous at $x = 0$. There exists a sequence $(x_n)_{n=1}^{\infty}$ in X where $P(x_n) \rightarrow 0$ but $M(x_n) \not\rightarrow 0$ as $n \rightarrow \infty$.

Now that $M(x_n) \not\rightarrow 0$ and assume S is a positive, there exists a constant $k > 0$ provided that

$$M(x_n) \geq k, n = 1, 2, 3, \dots$$

Since $P(x_n) \rightarrow 0$, assume that $P(x_n) \leq \frac{1}{n^2}$, $n = 1, 2, 3, \dots$

$$y_n = nx_n, n = 1, 2, 3, \dots$$

$$P(y_n) = P(nx_n) = nP(x_n) \leq n \left(\frac{1}{n^2} \right) \leq \frac{1}{n}$$

And

$$M(y_n) = M(nx_n) = nM(x_n) \geq nk$$

Then $P(x_n) \rightarrow 0$ but $P(x_n) \rightarrow \infty$ as $n \rightarrow \infty$.

Therefore, at any point $x \in X$, the sequence $(z_n)_{n=1}^{\infty}$ is defined as

$$z_n = x + y_n, n = 1, 2, 3, \dots$$

which satisfies

$$P(x - z_n) = P(y_n) \rightarrow 0.$$

However

$$M(x - z_n) = M(y_n) \rightarrow \infty$$

which means M is discontinuous at x .

So, it is proved that M is discontinuous at the origin which means it is ubiquitously discontinuous concerning to the topology determined by P .

Theorem 12. Suppose X is an infinite-dimensional vector space over a field $\mathbb{F}$, provided with a seminorm M and a norm P , accordingly:

- M is ubiquitously continuous in X concerning to the topology determined by P if and only if there exists an arbitrary point in X where M is continuous.
- Similarly, M is ubiquitously discontinuity in X concerning to the topology determined by P if and only if there exists an arbitrary point in X where M is discontinuous

Proof. a) If there is a point in X for which M is continuous then M is ubiquitously continuous in X concerning to the topology determined by P .

Since there is a point in X for which M is continuous then set the point that is the origin of X . Thus, by the previous Lemma it is clear that M is ubiquitously continuous in X concerning to the topology determined by P .

On the other hand, if M is ubiquitously continuous in X concerning to the topology determined by P then there exists a point in X where M is continuous;

By definition, since M is continuous, then for every E contains F such that $M|F$ is continuous. Consequently, for any chosen E , it is guaranteed that E is continuous. Because E is any subspace of X there exists an E that contains F which is the origin of X . Therefore, by previous proof M is continuous.

Thus, it is proved that M is ubiquitously continuous in X concerning to the topology determined by P if and only if there exists any point in X where M is continuous.

- If there is a point in X for which M is discontinuous then M is ubiquitously discontinuous;

The definition of ubiquitously continuous states that for every $E \in X$ there is an F contained in E which causes $M|F$ to be continuous. Therefore, it is clear that M must be continuous for every E . However, since there is a point in X where M is discontinuous, such as the existence of the origin vector explained in Lemma, therefore M ubiquitously discontinuous.

If M is ubiquitously discontinuous then there exists a point in X where M is discontinuous;

Similarly, if M is ubiquitously discontinuous then it is implied that $M|F$ is discontinuous. Then, since $F \in E \in X$, clearly that $F \in X$. Therefore, it is true that if M ubiquitously discontinuous then there exists a point in X , precisely F , where M is discontinuous.

Thus, it is proved that M is ubiquitously discontinuous if and only if there exists a point in X for which M is discontinuous.

B. Ubiquitously Continuous on Complete Seminorms

Based on [12], a seminorm M is said to be complete [14] if M has positive (non-zero) values and $M(x) = 0$ for some $x \neq 0$ or namely

$$\ker S = \{x \in X \mid M(x) = 0\}$$

Theorem 13. Suppose P is a norm on an infinite-dimensional vector space X over a field $\mathbb{F}$, accordingly there exists a complete seminorm M that is ubiquitously continuous on X concerning to P .

Proof. Suppose V is a nontrivial finite-dimensional subspace of X and U is also a subspace of X provided that $X = U \oplus V$.

Suppose $P': U \rightarrow \mathbb{R}$ is a real valued function measurable concerning to P . The distance from a member in U to a subspace of V is

$$P'(u) = \text{dist}_N(u, V) = P(v \in V)P(u - v), \quad u \in U$$

Since V is infinite-dimensional, the infimum of $P'(u)$ is

$$P'(u) = \min_{v \in V} P(u - v), \quad u \in U$$

Next, it will be proved that $P'(u)$ is a norm on U with the following conditions:

$$(N1) \ P'(u) = \min_{v \in V} P(u - v) \geq 0$$

$$(N2) \ P'(u) = 0 \text{ if and only if } u = 0.$$

$$(N3) \ P'(\lambda u) = |\lambda|P'(u)$$

$$(N4) \ P'(u_1 + u_2) = P'(u_1) + P'(u_2)$$

Thus, it is proved that $P'(u)$ is a norm on U .

Next, for $x \in X$ with decomposition $x = u + v$ where $u \in U$ and $v \in V$, we define

$$M(x) = P'(u)$$

Since M' is a seminorm on U , the mapping $M: X \rightarrow \mathbb{R}$ is a seminorm on X . Then, since $\ker M = V$ and V is a complete nontrivial subspace of X , M is a complete seminorm on X . Furthermore, for any $x = u + v$ in X with $u \in U$ and $v \in V$ we get

$$M(x) = P'(u) = \min_{v' \in V} P(u - v') \leq P(u + v) = P(x)$$

Therefore, for every $x \in X$

$$M(x) \leq P(x)$$

Based on Theorem 7 and Lemma 11 when $M(x) \leq P(x)$ then M is continuous at the origin or $x = 0$ which means M is ubiquitously continuous.

C. Ubiquitously Continuous on Complete and equivalent seminorms

Based on [12], seminorms M_1 and M_2 are equivalent on vector spaces X if there is a constant number $\beta \leq \gamma$ provided that for all $x \in X$.

$$\beta M_1(x) \leq M_2(x) \leq \gamma M_1(x)$$

Corollary 14. [13] For normed spaces X , if $\|\cdot\|$ and $\|\cdot\|'$ is a norm such that both of them a complete normed space and there is $L > 0$ so

$$\|x\| \leq L\|x\|' \text{ for all } x \in X$$

Then, $\|\cdot\|$ and $\|\cdot\|'$ is an equivalent norm on normed spaces X .

Proof. Based on identity mapping $\mathcal{I}: (X, \|\cdot\|') \rightarrow (X, \|\cdot\|)$.

$$\|x\| \leq L\|x\|' \text{ for all } x \in X$$

Implies that the $\mathcal{I}$ is continuous. If $\|\cdot\|$ and $\|\cdot\|'$ are complete norms or are called Banach spaces then in Banach space [12] a one-to-one linear continuous mapping from Banach space $(X, \|\cdot\|)$ on Banach space $(Y, \|\cdot\|')$ is a topological isomorphism such that there exists $C > 0$ where the mapping $\mathcal{I}^{-1}$ is also continuous which results in

$$\|x\|' \leq C\|x\| \text{ for all } x \in X$$

This shows that $\|\cdot\|$ and $\|\cdot\|'$ are equivalent norms in X because they determine the same topology in X .

Based on that Corollary 14 has been proven by Chmielinski and Goldberg (2020) on [12]:

Theorem 15. [12] Let P be a norm on infinite dimensional vector spaces X with a field $\mathbb{F}$ if P ubiquitously continuous to two complete norms P_1 and P_2 then P_1 and P_2 are equivalent.

So based on that Theorem we can give a counter example about ubiquitously continuous on complete and equivalent seminorms. where perhaps the seminorms are not equivalent as below:

Example 4. We are going to prove that if M is a seminorm on an infinite-dimensional vector space X over $\mathbb{F}$, so M is ubiquitously continuous concerning to two complete seminorms M_1 and M_2 . Then M_1 and M_2 maybe not equivalent.

Choose a square n -dimensional linear matrix vector space X that converges to the matrix

$$\bar{X} = \begin{bmatrix} 0 & \dots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & 0 \end{bmatrix}$$

whose equipped with these seminorms; $M_1(A) = \det(A)$, $M_2(A) = \det(A^T)$, and

$$M'(A) := \max \{M_1(A), M_2(A)\}, A \in X.$$

Then, choose matrix A and B which are

$$A = \begin{bmatrix} 0 & \dots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & \frac{1}{2} \end{bmatrix} \text{ and } B = \begin{bmatrix} 0 & \dots & \frac{1}{3} \\ \vdots & \ddots & \vdots \\ 0 & \dots & 0 \end{bmatrix}$$

where obviously $A, B \in X$.

Notice that $M_1(A)$, $M_2(A)$, $M_1(B)$, $M_2(B)$, $M_1(A - B)$, and $M_2(A - B)$ are all equal to zero. But, since seminorms are not positive-definite, then, even though

$$M_1(A) = 0 = M_2(A)$$

and

$$M_1(A - B) = 0 = M_2(A - B),$$

it can be concluded that

$$M_1(A) \neq M_2(A).$$

Thus, it has been proven that if M is a seminorm on an infinite-dimensional vector space X over $\mathbb{F}$, so M is ubiquitously continuous concerning to two complete seminorms M_1 and M_2 . Then M_1 and M_2 may not be equivalent.

III. CONCLUSION

The presence of an origin vector can be used in order to check the continuity of norms and seminorms. Consequently, if said norms or seminorms are continuous, then obviously their respective vector spaces can be categorized as vector spaces equipped with ubiquitously continuous norms and seminorms.

Additionally, unlike norms which are definitely equivalent if two complete norms P_1 and P_2 are ubiquitously continuous, the implication may differ if it was done on seminorms. It can be concluded that if M is a seminorm in an infinite dimensional vector space X over field $\mathbb{F}$, if M ubiquitously continuous with concerning two complete seminorms M_1 and M_2 , then M_1 and M_2 may or may not be equivalent.

ACKNOWLEDGMENT

Gratefully thanks to UIN Maulana Malik Ibrahim Malang for their kind financial assistance. Their assistance was crucial to the accomplishment of my research endeavor. The financial support has helped the research process for the project's success. This research project has been made possible by their persistent support.

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Predicting Inflation in Indonesia Using Bi-predictors Semiparametric Model Based on Local Polynomial Estimator

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Abstract- Inflation is a condition of general and continuous increases in the prices of goods and services over a certain period of time. High and fluctuating inflation rates are a sign of economic instability. This fluctuating nature is due to factors that influence it, causing the relationship patterns in the data to not form a certain pattern and are also used for predictions. This research applies a semiparametric regression model, which combines parametric and nonparametric model, using a local polynomial estimator for inflation data with 2 factors that influence inflation, namely the Bank Indonesia (BI) interest rate in one previous month and the change rate of Money Supply (JUB) in one previous month. The local polynomial method estimates nonparametric functions by considering the local polynomial order and the optimum bandwidth value based on the lowest GCV value. In this research, a semiparametric regression model was obtained with an optimum bandwidth value of order 1, with high accuracy (MAPE 9.61%). The inflation predictions for September 2024, where the value is not yet known, with the BI interest rate and the change rate of JUB values in one previous month, using the model resulted in this research, the predicted value is 2.12%.

Keywords—BI rate, inflation, JUB, local polynomial, semiparametric

I. INTRODUCTION

Many studies and research have been carried out on parametric regression for time series data. In particular, the ARIMA (Autoregressive Integrated Moving Average) model developed by [1], [2], [3], [4], [5], [6]. The ARIMA Box-Jenkins and ARIMAX (Autoregressive Integrated Moving Average with Exogenous Variables) models were also carried out by [7]. The ARIMA model can be used for further data forecasting. Forecasting is the process of predicting future variables based on consideration of past data. Predictions Don't have to be able to provide exact answers certain about an event, but try to find an answer that is as close to the event as possible. The ARIMA model is applied for time series analysis, forecasting, and control. This

technique is a projection technique that combines smoothing, regression and decomposition techniques. Because the ARIMA model is a combination of the AR and MA models, in this model the independent variables are the previous value (lag) of the dependent variable and the residual value of the previous period. Time series regression requires error assumptions to validate the model. A good error is the smallest possible error that is normally distributed and satisfies the properties of randomness. The ARIMA model is a parametric regression that takes into account error assumptions. Nonparametric regression is regression that does not use assumptions and rules like parametric regression. So, it can be said that nonparametric regression is more flexible than parametric regression.

Nonparametric regression has been widely used by several researchers with various estimator methods. Among them are [8], [9], [10], [11], [12], [13], [14] which use a single response nonparametric model with a local polynomial estimator. A more complex regression model, namely semiparametric, which combines parametric and non-parametric models, has been carried out by several researchers. Among them are [23], [24], and [25] using local polynomial estimators in a single response semiparametric model. Local polynomials have several advantages, such as reducing asymptotic bias and producing good estimates [18]. Local polynomial estimators can be utilized by minimizing Weighted Least Squares (WLS). In local polynomial regression, the bandwidth determines how smooth the function is. The Generalized Cross Validation (GCV) method can be used to determine optimum bandwidth, which can be determined from the minimum GCV value. This can be seen from the work of [19].

2. MATERIAL AND METHODS

The bi-predictor semiparametric regression model, namely inflation as a response variable with two predictor

variables, namely change rate of BI interest rate in the previous period as a parametric component with a linear function and change rate of JUB in the previous period as a nonparametric component, can be modeled with a semiparametric model as follows:

$$y_t = \beta_1 z_{t-1} + f(x_{t-1}) + \varepsilon_t \quad (1)$$

Bi-predictor semiparametric regression estimation cannot be carried out simultaneously, but one by one continuously. Starting from estimating parametric component parameters, then nonparametric functions based on local polynomial estimators which are solved using WLS with kernel function weighting. The function on the nonparametric component can be approximated via a Taylor series of order k, assuming the parameter values (β) on the parametric component are known:

$$\begin{aligned} f(x_{t-1}) &= \sum_{j=0}^k \frac{f^{(j)}(x_0)}{j!} (x_{t-1} - x_0)^j \\ &= \sum_{j=0}^k \lambda_j (x_{t-1} - x_0)^j \end{aligned} \quad (2)$$

So the equation (1) for all t can be written in the matrix equation form, namely,

$$Y = Z\beta + X\lambda + \varepsilon \quad (3)$$

The parameter λ in equation (3) depends on a point called a local point which is the data value for each observation sequentially, so that the first starting point will eliminate the first data, and so on. Assuming the estimator parameter β is known, parameter λ is estimated using Weighted Least Square (WLS) with a weighting kernel function K as diagonal matrix of Gaussian kernel function with bandwidth h,

$$K_h(x_{t-1} - x_0) = \frac{1}{h\sqrt{2\pi}} \exp\left(-\frac{1}{2} \left(\frac{x_{t-1} - x_0}{h}\right)^2\right) \quad (4)$$

by minimizing the weighted sum of squared error function,

$$\begin{aligned} S &= (Y^* - X\lambda)^T K (Y^* - X\lambda) \\ &= (Y^*)^T K Y^* - 2\lambda^T X^T K Y^* + \lambda^T X^T K X \lambda \end{aligned} \quad (5)$$

with

$$Y^* = Y - Z\beta = Y - Z(Z^T Z)^{-1} Z^T Y = Y - BY \quad (6)$$

and

$$B = Z(Z^T Z)^{-1} Z^T \quad (7)$$

which is the hat matrix in the parametric regression approach to Y.

The solution of equation (5) is,

$$\lambda = (X^T K X)^{-1} X^T K Y^* \quad (8)$$

So we get a function approach to nonparametric components,

$$f(X) = X\lambda = X(X^T K X)^{-1} X^T K Y^* = A^* Y^* \quad (9)$$

with,

$$A^* = X(X^T K X)^{-1} X^T K \quad (10)$$

which is the hat matrix in the nonparametric regression approach to Y^* . Suppose I_y is a diagonal matrix of size (n-1) x (n-1), so by substituting equation (6) to equation (9) the final form of nonparametric component parameter estimation is obtained:

$$\begin{aligned} \lambda &= (X^T K X)^{-1} X^T K (Y - BY) \\ &= (X^T K X)^{-1} X^T K (I_Y - B) Y \end{aligned} \quad (11)$$

So we get a function approach to nonparametric components,

$$f(X) = X\lambda = AY \quad (12)$$

with,

$$A = X(X^T K X)^{-1} X^T K (I_Y - B) \quad (13)$$

which is the hat matrix in the nonparametric regression approach to Y.

From obtaining the form of estimation of the two parameters above, (7) and (15), a semiparametric model regression estimation form is obtained,

$$Y = Z\beta + X\lambda = BY + AY = CY \quad (14)$$

with,

$$C = A + B \quad (15)$$

which is the hat matrix in the semiparametric regression approach to Y.

In the local polynomial estimator, the initial value (x_0) will be used as an estimation point which will create a local polynomial regression for surrounding data values with a bandwidth h. So the row value x_0 in matrix C will become the hat matrix for a local polynomial around x_0 . This means that there will be as many local polynomials as the initial values used by matrix C which will become elements of each row in matrix C as a hat matrix for all local polynomials formed, namely M.

Apart from depending on the bandwidth value h, the parameter λ also depends on the polynomial order k. So that many estimated values of the parameter λ are obtained from repetition for a combination of the two (polynomial order k and bandwidth h). Therefore, to determine the optimum bandwidth value with a certain polynomial order, cross validation criteria are needed by selecting the minimum GCV value,

$$GCV(h) = \frac{1}{n-1} \sum_{t=2}^n \left[\frac{y_t - \sum_{j=0}^k \lambda_j (x_{t-1} - x_0)^j}{1 - (n-1)^{-1} tr(M)} \right]^2 \quad (16)$$

Furthermore, by obtaining the predicted Y values from equation (16) the GCV and MAPE values can be calculated for each repetition process of the combination above. So that an optimum combination (polynomial order and bandwidth value) can be obtained based on the smallest MAPE value. In this optimum combination, estimated parameter values are obtained which will form a semiparametric regression model.

III. RESULT

A. Correlation Analysis

Implementation of a semiparametric regression model based on a local polynomial estimator to Inflation data, BI interest rate in previous period (lag-1), and change rate of JUB in previous period (lag-1), require the help of statistical program applications. In this research, tools in the form of Open-Source Software R (OSS-R) were used. The following is a scatter plot image of the correlation matrix to determine the relationship pattern along with the correlation coefficient values between the three variables, namely:

Y : Observation data (factual) of Inflation
X1t-1 : Observation data (factual) of BI rate (lag-1)
dX2t-1 : Transformation data (differencing) of JUB (lag-1)

with

$$dX2_{t-1} = \frac{X2_{t-1} - X2_{t-2}}{X2_{t-2}} \quad (17)$$



Figure 1. Scatter Plot of the correlation matrix for paired data on inflation, previous BI rate and previous change rate of JUB.

From Figure 1 it can be seen that the correlation coefficient value between the inflation variable in a period (Y) and the BI interest rate in the previous period (X1t-1) is 0.71 which is significant with an alpha of 0.1% (signed with thress stars) so that it can be said that there is a positive and quite strong relationship with an ascending linear relationship pattern. Meanwhile, the correlation coefficient value between the inflation variable in one period (Y) and

change rate of JUB in the previous period (dX2t-1) is 0.075 which is not significant, so it can be said that there is no linear relationship. Meanwhile, the correlation coefficient value between BI interest rate in the previous period (X1t-1) and change rate of JUB in the previous period (dX2t-1) is 0.039 which is also not significant, so it can be said that there is no linear relationship between both variables. From the results of this correlation analysis, because two variables that is inflation and BI interest rate in previous period (Y and X1t-1) have a significant linear relationship and the two variables and two variables that is inflation and change rate of JUB in the previous period (Y and dX2t-1) do not have a linear relationship, they can be modeled semiparametrically, with Y is the response variable, X1t-1 is the predictor variable in the parametric component (here in after symbolized as Z), and dX2t-1 is the predictor variable in the nonparametric component (here in after symbolized as X). And there is no significant multicollinearity in both predictor variables (Z and X).

B. Implementation of Local Polynomial

Estimator Implementation of local polynomial estimator of polynomial order 1, 2, and 3 with many simulations bandwidth values on 100 training data (March 2013 to June 2021), produce bandwidth value 0.0001 with the smallest GCV 7.915212 on polynomial order 1. The parametric parameter estimator (β) that resulted is 0.75144 and every local point (x_0) on data has nonpametric parameter estimator (λ) resulted. Take any period of data namely with $X = -0.01453$ as local point, nonpametric parameter estimator (λ) that resulted by local polynomial order 1 estimator is -0.75634 and 0.00003. So the semiparametric model with the local point of local polynomial order 1 estimator can be written as:

$$\begin{aligned} y_t &= 0.75144 z_{t-1} - 0.75634 + 0.00003 (x_{t-1} - (-0.01453)) \\ &= 0.75144 z_{t-1} - 0.75634 + 0.00003 (x_{t-1} + 0.01453) \quad (18) \\ &= 0.75144 z_{t-1} - 0.75634 + 0.00003 x_{t-1} + 0.000004359 \\ &= -0.7563404359 + 0.75144 z_{t-1} + 0.00003 x_{t-1} \end{aligned}$$

If resigned to the observation data and substitute equation (17), equation (18) become:

$$\begin{aligned} y_t &= -0.7563404359 + 0.75144 x1_{t-1} + 0.00003 dx2_{t-1} \\ &= -0.7563404359 + 0.75144 x1_{t-1} + 0.00003 \left(\frac{x2_{t-1} - x2_{t-2}}{x2_{t-2}} \right) \quad (19) \end{aligned}$$

The results of nonparametric and semiparametric regression on local polynomial time-ordered data of order 1 with each data value as local point are shown in Figure 2 and 3.

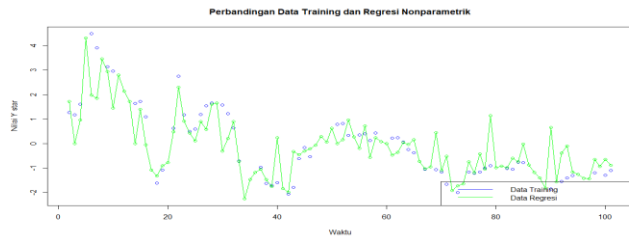


Figure 2. Comparison of time-ordered data with nonparametric regression.



Figure 3. Comparison of time-ordered data with semiparametric regression.

C. Prediction of inflation

The optimum bandwidth value obtained from estimating semiparametric regression parameters can be used to estimate semiparametric model to the testing data (July 2021 to August 2024). With the bandwidth optimum value 0.0001 on polynomial order 1 on the testing data, the MAPE value resulted 9.61%, so it can be said that the model is high accuracy because less than 10%. The parametric parameter estimator (β) that resulted is 0.64853 and every local point (x_0) on data has nonparametric parameter estimator (λ) resulted. Take the last period of data (August 2024) with $X = -0.00614$ as local point, nonparametric parameter estimator (λ) that resulted by local polynomial order 1 estimator is -1.93242 and 0. So the semiparametric model with the local point of local polynomial order 1 estimator can be written as:

$$y_t = 0.64853 z_{t-1} - 1.93242 + 0(x_{t-1} - (-0.00614)) \quad (20)$$

$$= 0.64853 z_{t-1} - 1.93242$$

The results of nonparametric and semiparametric regression on local polynomial time-ordered data of order 1 with each data as local point are shown in Figure 4 and 5.

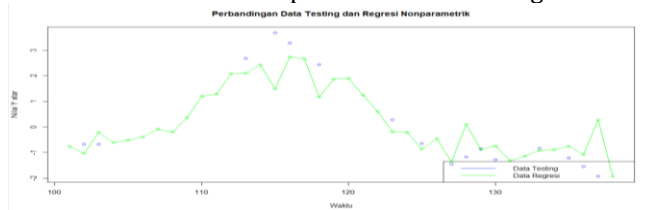


Figure 4. Comparison of time-ordered data with nonparametric regression.

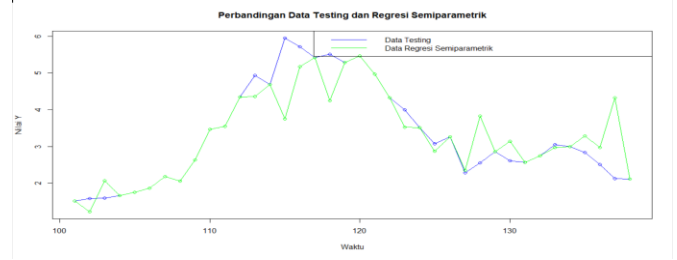


Figure 5. Comparison of time-ordered data with semiparametric regression.

The prediction for inflation value on September 2024, where the inflation value data is not yet known, the BI rate for August 2024 is 6.25%. Using the semiparametric regression model in equation (20) the inflation prediction value is obtained in July 2024:

$$y_t = 0.64853(6.25) - 1.93242 = 2.12 \quad (21)$$

IV. CONCLUSION

Implementation of the bi-predictor semiparametric model using a local polynomial estimator approach to the inflation rate in Indonesia with two predictors, BI interest rate in previous period and change rate of JUB in previous period month, resulted in a semiparametric regression model with an optimum bandwidth value is 0.00001 of polynomial order 1 with high accuracy. Predictions for September 2024, where the inflation value data is not yet known, using semiparametric based on local polynomial order 1 estimator, the obtained value is 2.12%.

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Development of Smart Live Edu-Multimedia Multilingual Adaptive for Digital Quran to Children and Parents Utilize meta-Deep Lightweight SORA Algorithm

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Abstract-. This research related to collaboration Islamic religious education methods in the family home is urgent and important, particularly for children and parents, especially regarding the introduction of the Quran as the word of Allah SWT delivered by the Prophet Muhammad SAW through the angel Gabriel. To improve education ways, the approach, if only conducted conventionally, such as only monotonous with static books, of course, is not enough to attract interest in reading to memorization. Based on these constraints, this study carried out an adaptive approach by utilizing technology from the meta-Deep lightweight SORA algorithm as a tool to create a smart digital Quran that is able to display live adaptive multilingual multimedia, including textual, audio, and video content. We propose Cooperative Agents Meta-Learning (CAML) algorithm as its contribution in supporting greater convenience for early childhood education and parents. The results of this study are expected to be able to provide a treasure trove of Islamic education with a blended method while maintaining methods such as in Islamic boarding schools with the latest Artificial Intelligence (AI) technology.

Keywords; *CAML algorithm, Development of Smart Digital Quran, Edu-Multimedia Multilingual, Meta-Deep Lightweight SORA Algorithm*

I. INTRODUCTION

The advancement of digital technology has dramatically reshaped the educational landscape, including religious education. The Digital Quran is an essential tool for children and parents, offering a more interactive approach to learning. Yet, many of these platforms fall short in terms of multilingual support and adaptive learning capabilities, limiting their effectiveness for a diverse audience. This paper introduces the Smart Live Edu-Multimedia Multilingual Adaptive platform, leveraging the meta-Deep Lightweight SORA algorithm to address these limitations, delivering a more personalized and efficient Quranic education system [1–3].

Given the global distribution of the Muslim population, the importance of multilingual support in digital Quran platforms cannot be overstated. Existing systems often cater to a limited range of languages, making it difficult for non-native speakers to engage meaningfully with the content [4,5]. This system addresses these challenges by offering real-time adaptive learning in multiple languages, enhancing both accessibility and the user experience [6]. The platform is designed to accommodate both children and parents, offering age-appropriate, culturally relevant content to foster better understanding [7,8].

This research is related to the urgent need for collaboration in Islamic religious education methods within the family, especially regarding the introduction of the Quran, revealed by Allah SWT to the Prophet Muhammad SAW through the angel Gabriel. Conventional methods, such as relying solely on static books, fail to capture children's attention or foster deeper learning. To overcome this, the study adopts an adaptive approach by utilizing the meta-Deep Lightweight SORA algorithm, which enables the development of a smart digital Quran with live adaptive multilingual multimedia. This system includes textual, audio, and video content, making it more engaging for early childhood education and parents alike. It combines traditional methods with the latest Artificial Intelligence (AI) technology, akin to practices found in Islamic boarding schools [9,10].

The meta-Deep Lightweight SORA algorithm offers several key advantages. It is lightweight and designed for low-resource environments, making it ideal for mobile and remote learning applications. The algorithm's meta-learning framework allows the platform to rapidly adapt to new users and learning environments with minimal data input [11,12]. This adaptability ensures that the platform delivers personalized learning experiences tailored to each user's progress and needs. Moreover, its low computational requirements enable the platform to function in areas with

limited internet connectivity, extending its reach to underserved communities [13,14]. However, despite its capabilities, the SORA algorithm does face challenges in handling more complex multimedia content and larger language datasets, requiring further refinement [15]. The use of multimedia in Quranic education significantly enhances learning outcomes, particularly among younger learners. Research has shown that interactive features such as audio recitations, visual verse representations, and translations improve engagement and retention [16,17]. By integrating the SORA algorithm, the platform adapts content in real-time to the learner's progress, offering a personalized and dynamic learning experience. This adaptive system is crucial for maintaining interest and fostering a deeper connection with the Quran [6]. Furthermore, the platform encourages parental involvement, allowing families to learn together, thereby creating a supportive educational environment.

AI-powered educational platforms are revolutionizing how religious education is delivered. Traditional methods, while effective, often lack the flexibility to cater to diverse learning styles and paces, particularly in multicultural and multilingual contexts. By leveraging AI, platforms like Smart Live Edu-Multimedia offer real-time feedback, multilingual support, and personalized learning paths, making them ideal for Quranic education. The system's ability to scale and adapt ensures continuous engagement, making it a valuable tool for both formal and informal educational settings. The Smart Live Edu-Multimedia Multilingual Adaptive platform, utilizing the meta-Deep Lightweight SORA algorithm, represents a transformative approach to Quranic education. By combining multilingual support with adaptive learning features and lightweight AI models, it offers a more accessible and engaging learning experience for children and parents. Its low-resource design ensures usability across a wide range of environments, making it a significant contribution to the future of Islamic education.

II. METHODS

Digital Quran

Combining the Quran in high end technology also with Artificial Intelligence (AI) based on Fig. 1 significantly improves the development of adaptive educational content for children and parents. AI-powered systems adjust learning content based on user engagement, creating more personalized and efficient learning experiences. Techniques like Deep Learning assess individual learning styles to tailor Quranic lessons, addressing various age group needs [18][19].

Additionally, adaptive videos enhance interactive learning by leveraging AI algorithms that recommend the best instructional approaches based on past user interactions [20][21]. These tools simplify Quran recitation

and interpretation materials, enriching children's spiritual education while assisting parents with a structured yet flexible learning environment [22][23].

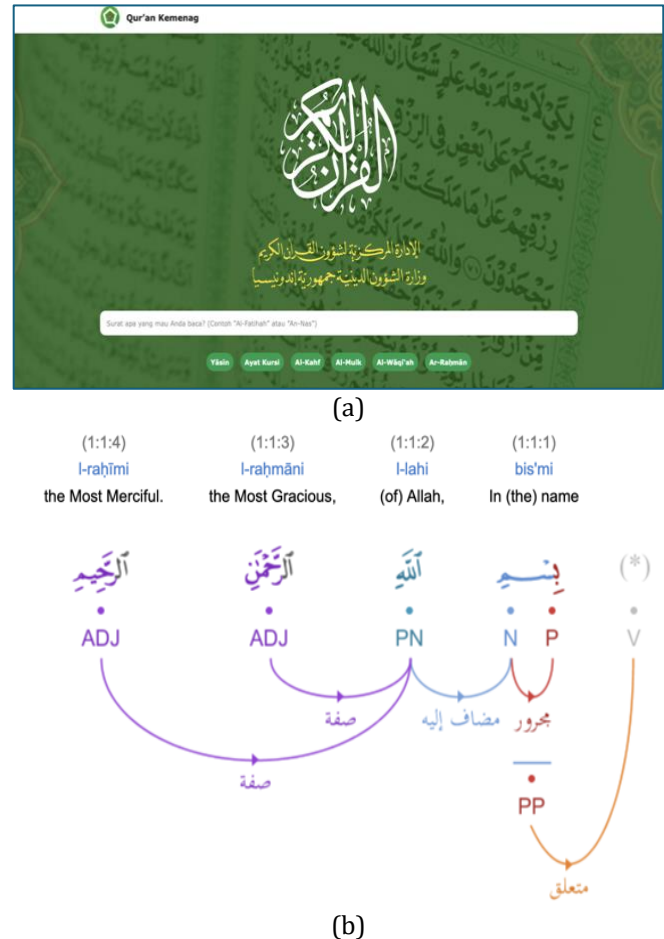


Figure 1. (a) Qur'an Kemenag online [24], (b) sūrat l-fātiḥah (The Opening) verse 1 [25]

Smart Live Edu-Multimedia of Quran

To develop a highly effective Smart Live Edu-Multimedia platform, incorporating advanced technology like OpenAI's SORA is essential. SORA enables the creation of interactive, visually appealing educational content that adapts in real-time to user needs, enhancing engagement for both children and adults [26]. This technology offers tailored video content that brings Quranic lessons to life, making them more accessible and immersive for local audiences [27].

Moreover, integrating high-quality audio that captures the spiritual depth of the Quran is crucial for user satisfaction. Leveraging AI tools like SORA allows the production of localized audio content with clear pronunciation and appropriate cultural nuances [28,29]. Combining adaptive video and accurate audio delivery enhances the overall Quranic educational experience [30].

Propose of meta-Deep Lightweight SORA Algorithm

The SORA algorithm employs a basic approach for processing Quranic materials, achieving moderate levels of accuracy and efficiency. While it allows for fundamental feature extraction and model training, its adaptability and scalability are limited. Additionally, the video generation process can be slower, and the user experience is fairly standard. In the meta-Deep Lightweight SORA algorithm significantly boosts performance. It features enhanced efficiency, leveraging advanced techniques for feature extraction and offering better adaptability. This algorithm facilitates faster video production and delivers a more engaging experience for users, making it a superior option for multimedia Quranic education.

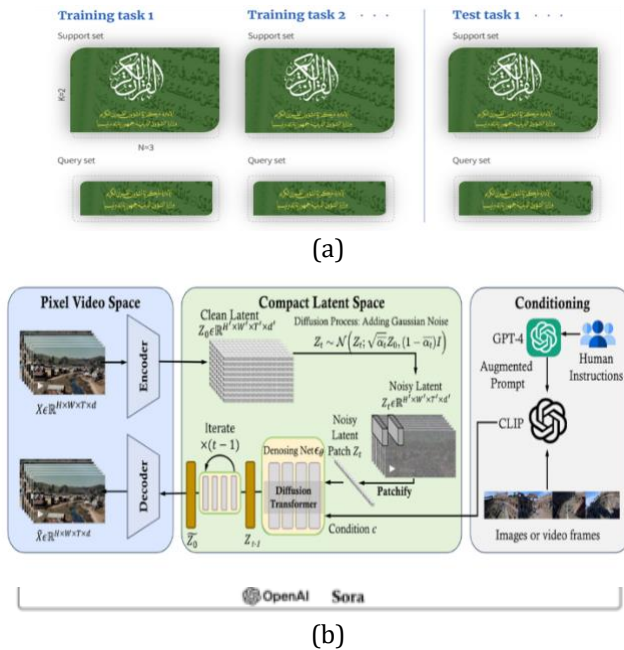


Figure 2. (a) Few-Shot Learning [24], (b) SORA algorithm

We propose Cooperative Agents Meta-Learning (CAML) algorithm 🐶 as "meta-Deep Lightweight" mechanism for SORA Algorithm [29] that enables few-shot meta-learning [31], enhanced by mixed (a) and (b) based on Fig. 2 based on pairs few "task" sets for Train and Test e.g. ([support_set_1, query_set_1],..., [support_set_n, query_set_n]) with "and/or" flexible combination of each task included Model 1 utilize surah makkiyah, Model 2 utilize surah madaniyah, Model 3 utilize surah 'makiyah_and_madaniyah' + 'between_makiyah_and_madaniyah', and Model 4 As Baseline or Growth Truth utilize all surah.

- The concept of "[support_set_i-th, query_set_i-th]" in the prediction results, referred to as a "Test task," always matches the true value in terms of accuracy if this CAML algorithm for classification

or always zero error rate if for regression, applying fault tolerance across the model. In this research using regression approach manages resource distribution or resource sharing together between surahs, reflecting connections based on the provided input features (it's can use 5-term features, 10-term features, or 15-term features from the {id_surah}.json file, specifically from ["id_surah"].["translations"].["id"].["text"] with Indonesian terms for feature extraction and build dataset to modeling 1 until 4.

- Input of generate video of smart live edu-multimedia:
 - Quran text, for example from one of the translations in Indonesian using top_k = [5, 10, 15]
 - Multilingual *.srt file (Arabic, Indonesia, Java, and English)
 - Audio
 - Gen video resource (input: features value of surah, output: background_options, transition_types, and choose existing or generate temporary file in the image_paths (*.jpg, *.png, *.gif, *.webp, *.mp4, or etc) after with or without applying style transfer learning, easyAnim or others) using training and testing as part of initialization pre-process by The CAML algorithm, which is capable of using diverse models, including those from deep learning or other types.
- Training:
 - set params:
 - n_input = 475
 - n_hidden1 = int(n_input * 2.0)
 - n_hidden2 = int(n_hidden1 * 0.75)
 - n_output = 114
 - epochs = 500
 - feature extraction and build dataset to regression modeling
 - top_k = [5, 10, 15]
 - ["id_surah"].["text"] with arabic terms, ["id_surah"].["translations"].["id"].["text"] or ["id_surah"].["tafsir"].["id"].["k_emenag"].["text"] with Indonesian terms
 - save model and loss (model_{id_model}.json and loss_{id_model}.json)
- Testing:
 - load all model (1 until 4)

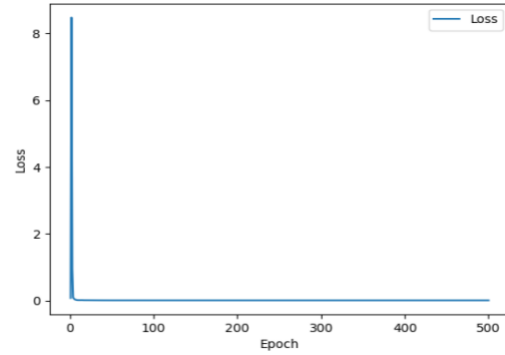
- call function `get_bg_resource(id_surah, time_intervals)` to generate video resource, based on input features of `id_surah` using regression approach to resource-sharing by combination all output model 1 until 4, with limited only `n_top` using `argmax` from each model prediction result together between all surahs for resource sharing in a collection bank of images or videos in the local directory (`dataset/bg_object`)
- Metadata
 - Output:
 - video Smart Live Edu-Multimedia of Quran
 - File *.srt with combine all language
 - In the CAML algorithm, the input process is more flexible to meet specific needs, allowing for elements like a fun tone or a particular theme. For example, it can incorporate results from various animations, images, videos, or other media, with or without applying style transfer learning, Variational Autoencoder (VAE), Generative Adversarial Network (GAN), mini SORA and others.

III. RESULT AND DISCUSSION

Evaluation of performance across different surah Tests, for very short surahs such as Al-Kautsar (3 ayahs), the time is around 13.81 seconds. Similar surahs like Al-Ikhlash, Al-Falaq, and An-Nas have slightly longer times, between 13.34, 19.87 and 25.99 seconds. The algorithm efficiently processes shorter surahs, allowing for rapid video generation while maintaining quality. This computation time is greatly influenced by the length of the surah as well as the type of data resources, background type, and translation type. Additionally, the consistency in HD/360p output quality indicates that the model is running effectively.

Table 1. Video Generation Time of 4 Surah

Scenario	Number of Ayahs	Video Generation Time (s)
Surah (Al-Kautsar)	3	13.81
Surah (Al-Ikhlash)	4	13.34
Surah (Al-Falaq)	5	19.87
Surah (An-Nas)	6	25.99



(a)



(b.1)



(b.2)

Figure 3. (a) Training Loss per Epoch for list_model_comb_all_unique model, (b) Gen Video of Surah Al-Kautsar and Al-Ikhlash [360p/ HD]

Based on Table 1 and Fig. 3 as the number of ayahs increases, so does the time for video creation, but the algorithm continues to perform consistently, scaling well across different surah lengths. This makes it highly suitable for generating quick and engaging educational content, whether for short or long surahs. All complete code can be checked at the following link "<https://github.com/imamcs19/Digital-Quran-Ai---Al-Imamain-Utilize-meta-Deep-Lightweight-SORA-Algorithm>" in the GitHub repository.

IV. CONCLUSION

The development of the Smart Live Edu-Multimedia platform, utilizing the meta-Deep Lightweight SORA algorithm for multilingual adaptive Quran learning, has yielded encouraging outcomes. The system achieved an average performance time of approximately 18.25 seconds. With the model proved highly effective in generating accurate multilingual content while maintaining optimal computing efficiency. This technology acts solely as a supplementary tool for children's Quran learning at home with parents. However, it remains essential for children to continue their Quranic studies with teachers who have an authenticated chain of transmission (sanad) that traces back to the Prophet Muhammad (PBUH). To further enhance educational content performance, expanding dialect coverage using smart Deep Lipsync technology can improve children's reading methods. Continuous updates to the AI model will help improve content by utilizing extensive datasets that include not just each surah but also each ayah for resource-sharing within a local directory collection bank of images or videos (dataset/bg_object), improve feature extraction through one-hot encoding with recurrent feature vectors, enable automatic tajwid detection by recognizing patterns in Arabic subtitles (written right-to-left (RTL)) with multi-color formatting, an additional feature offering stories for children also feature truth sign (according to abjadun, natural phenomena and others), inspired by themes from the surahs, and support the auto-generation of *.pdf files with ergonomic layout design for the Digital Quran, covering all 30 juz, also level up relevance, ensuring that the educational experience remains engaging and effective for users across various learning environments.

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Enhanced Virtual First Aid Box to Prevent and Rescue in Body Health Using Deep Extreme Genetic Model-Agnostic Meta-Learning (EG-MAML) Algorithm

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Abstract- This study is focus to Enhanced Virtual First Aid Box (EVFAB) leverages advanced technologies to provide health monitoring and preventive measures, integrating the Deep Extreme Genetic Model-Agnostic Meta-Learning (EG-MAML) algorithm for robust and adaptive solutions. EG-MAML enables the system to rapidly learn from minimal data, optimizing medical decision-making and preventive actions in dynamic health scenarios. The model integrates genetic algorithms with deep learning to enhance the adaptability of first aid protocols, tailoring responses to individual health conditions and real-time physiological data. This innovation not only aids in timely interventions during emergencies but also proactively identifies potential health risks, ensuring early detection and personalized prevention strategies. By utilizing an intelligent system like EG-MAML, the virtual first aid box becomes a versatile tool, contributing to public health resilience and improving individual well-being through cutting-edge machine learning techniques.

Keywords; Body Health, Deep Extreme Genetic Model-Agnostic Meta-Learning Algorithm, Prevent and Rescue

I. INTRODUCTION

In the digital era, healthcare technology continues to evolve, enhancing the capacity to monitor, prevent, and respond to health emergencies. One such innovation is the Enhanced Virtual First Aid Box (EVFAB), a cutting-edge system designed to revolutionize personal health management. Traditional first aid kits are limited to physical tools and supplies, providing immediate yet basic care during emergencies. While they are essential, their scope remains restricted to passive medical aid, relying on the knowledge and preparedness of individuals [1]. With the integration of artificial intelligence (AI) and machine learning (ML) algorithms, the concept of a first aid box has taken a significant leap forward, offering proactive and intelligent solutions that adapt to real-time health conditions [2]. This paper explores the development of EVFAB using the Deep Extreme Genetic Model-Agnostic

Meta-Learning (EG-MAML) algorithm, a powerful approach that enables real-time health prevention and rescue.

EVFAB represents a shift from reactive to preventive healthcare, offering personalized health monitoring and guidance [3]. By utilizing sensors, data analytics, and AI-driven decision-making, the virtual first aid box can detect physiological anomalies, predict potential health risks, and recommend preventive measures before an emergency arises [4,5]. Furthermore, in critical situations, EVFAB provides immediate, customized instructions tailored to the individual's health condition, significantly improving response time and accuracy [6]. The core of this system lies in the EG-MAML algorithm, which allows the model to adapt quickly to new health data, making it a versatile tool for a wide range of users and medical conditions [7,8].

The EG-MAML algorithm is a hybrid approach that combines deep extreme learning machine with genetic algorithms, and model-agnostic meta-learning [9,10]. Deep learning provides the system with the ability to analyze complex, high-dimensional data such as heart rate, oxygen levels, and other physiological signals [11]. Genetic algorithms introduce optimization techniques that evolve the model over time, enhancing its ability to make precise predictions and recommendations [12]. Model-agnostic meta-learning (MAML), a framework designed to enable quick learning from limited data, is crucial for real-time health applications, where data may be sparse or unpredictable [13,14]. By combining these elements, EG-MAML empowers EVFAB with the capability to generalize across diverse health scenarios and user profiles, while continuously improving its performance based on new data [15]. The integration of EG-MAML in the EVFAB system offers several key advantages. First, it ensures that the first aid box is not merely a passive tool but an intelligent, dynamic system that evolves with the user's health needs [16]. For example, if the system detects recurring patterns in a user's health data, it can adjust its predictions and

preventive measures accordingly [17]. Second, the EG-MAML algorithm allows the system to learn quickly from minimal data, making it especially useful in urgent situations where time is critical, and large datasets are unavailable [18,19]. The Enhanced Virtual First Aid Box, powered by the EG-MAML algorithm, represents a significant advancement in personal healthcare technology, from pre-emergency response to proactive prevention especially at home and in general when traveling outside the home.

II. METHODS

Virtual First Aid Box

Virtual First Aid Box in the cloud based on Fig. 1 is a digital solution that integrates advanced technologies to provide quick and easy access to first aid information utilize AI [20][21].

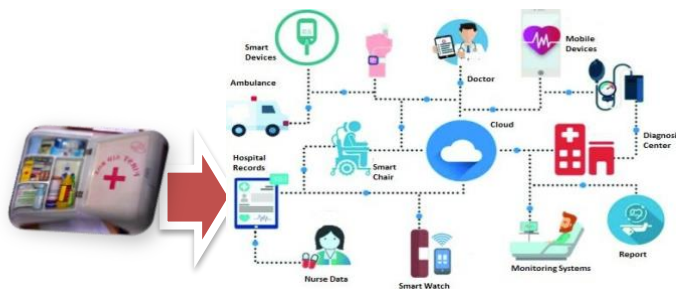


Figure 1. Illustration of First Aid Box to Virtualization (Pre-Hospital Emergency) [22–24]

As an prototype open microservice development for hospitals in Indonesia based on API, the system can also be integrated with real-time patient health data [25]. With AI features that offer recommendations tailored to the user's condition, the Virtual First Aid Box can support faster and more accurate emergency care [26][27]. The Virtualization of FAB like a IoT technology that connected to health devices enables the system to provide early diagnoses or alert users to signs of danger [28]. The use of API ensures that this system is flexible and can be integrated with various healthcare services in hospitals to support more responsive emergency care [29].

Body Health in the Green Technology of Islamic Medicine

Body health based on Fig. 2 using the intelligence system of VFAB to assist users in handling health emergencies by offering step-by-step instructions accessible as data information of human body [30]. The information provided covers how to manage wounds, injuries, and emergency actions such as heart rate suddenly beats fast after eating certain foods (heart palpitations) that may your body have food allergies or sensitivities so can trigger them.

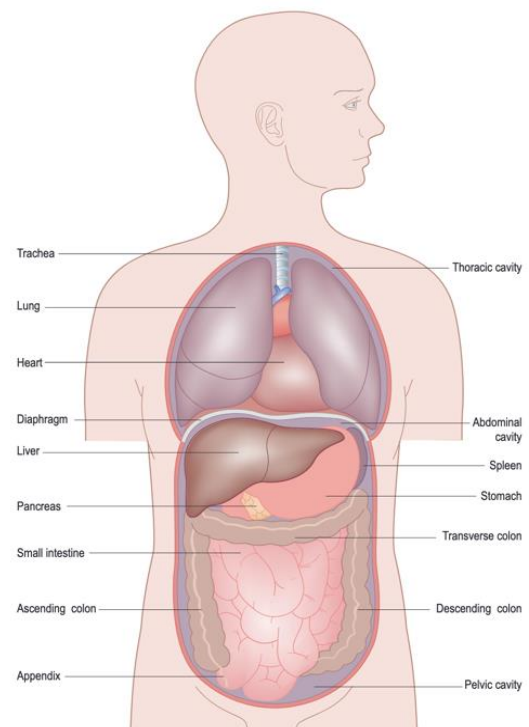


Figure 2. Human Anatomy [31]

The paradigm of *the green technology of Islamic medicine* is not merely a traditional approach; it represents a comprehensive health management approach that remains highly relevant in the context of both modern and postmodern developments, which can be studied through the Quran and Hadith. The following points emphasize the importance of health preservation through dietary practices and their implementation as part of the *green technology of Islamic medicine* framework.

- The urgency and importance of choosing halal, wholesome, and healthy food are based on Surah Al-Baqarah, verses 168-169 [32], which emphasizes consuming what is lawful and good, and on Surah Al-A'raf, verse 31, which advises eating and drinking without excess.
 - Select types of food and drink that are halal, wholesome, and healthy, such as those verified through halal blockchain, natural, fresh, and not overly cooked. This type of food, *Insha'Allah*, promotes better health and acts as a preventive measure, akin to medicine, as prevention (pre-emergency care) is better than cure.
 - Moderation: Individual preferences may vary based on personal experience and conditions.
- Every Muslim is also permitted to seek medical treatment, as per Hadith [33], since every illness has a cure.

- Treatment options can include visits to medical laboratories, hospitals (general practitioners or specialists), clinics, and equivalent health institutions for consultations. Muslims can request referrals for blood tests, Mean Arterial Pressure (MAP) checks, Caesarean sections, endoscopies, colonoscopies, vaccinations, or other advanced technology procedures.
- Moderation: Adjust treatments according to recommended dosage preferences, as individual needs may vary depending on specific circumstances.

Deep Extreme Genetic Model-Agnostic Meta-Learning (EG-MAML) Algorithm

The Deep Extreme Genetic Model-Agnostic Meta-Learning (EG-MAML) method is introduced as an innovative approach that merges meta-learning techniques with genetic algorithm-based optimization to improve a model's capacity to learn effectively from limited data. The primary aim is to enable models to adapt to new tasks more swiftly. EG-MAML also incorporates the concept of Extreme Genetics by combining the Extreme Learning Machine (ELM) algorithm with a genetic algorithm (GA) based on Geometric Time Variants (GTV) [34]. This integration promotes a well-balanced, efficient process of exploring and exploiting across generations.

Require: $p(\mathcal{T})$: distribution over tasks

Require: α, β : step size hyperparameters

- 1: randomly initialize θ
- 2: **while** not done **do**
- 3: Sample batch of tasks $\mathcal{T}_i \sim p(\mathcal{T})$
- 4: **for all** $\mathcal{T}_i$ **do**
- 5: Evaluate $\nabla_{\theta} \mathcal{L}_{\mathcal{T}_i}(f_{\theta})$ with respect to K examples
- 6: Compute adapted parameters with gradient descent: $\theta'_i = \theta - \alpha \nabla_{\theta} \mathcal{L}_{\mathcal{T}_i}(f_{\theta})$
- 7: **end for**
- 8: Update $\theta \leftarrow \theta - \beta \nabla_{\theta} \sum_{\mathcal{T}_i \sim p(\mathcal{T})} \mathcal{L}_{\mathcal{T}_i}(f_{\theta'_i})$
- 9: **end while**

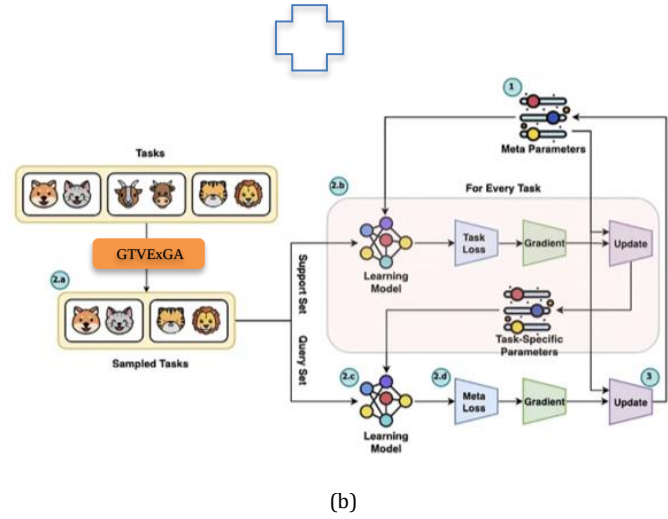
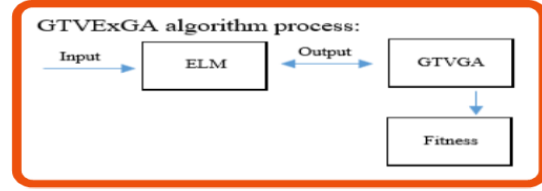
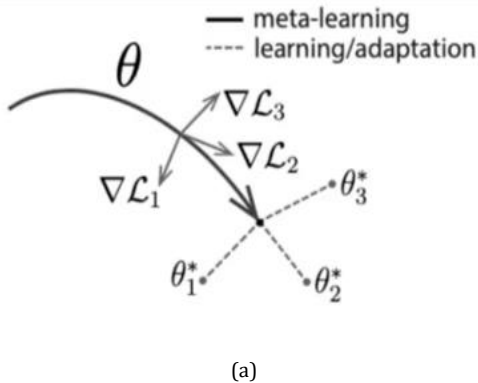


Figure 3. (a) Model-Agnostic Meta-Learning (MAML) Algorithm, (b) Deep Extreme Genetic Model-Agnostic Meta-Learning (EG-MAML) Algorithm

This algorithm integrates in Fig 3, the gradient-based update approach from MAML with evolutionary strategies from genetic algorithms. Through this combination, the model's initial parameters (meta-parameters) are refined using mutation, crossover, and natural selection mechanisms. Meanwhile, MAML's gradient updates speed up the search for optimal solutions within complex parameter spaces, making the algorithm more robust and better suited for nonlinear problems. EG-MAML Process Steps:

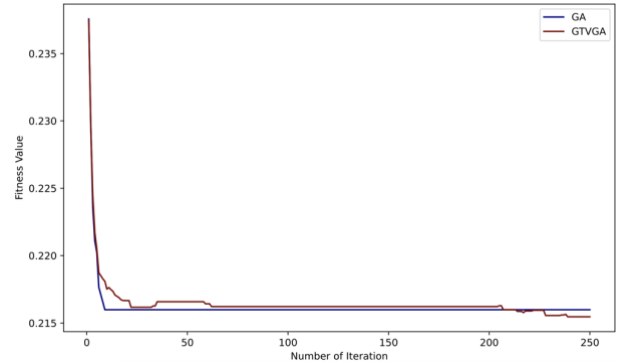
1. Population Initialization: Begin by generating a population of individuals, where each one represents a set of initial model parameters. This population is then evolved using genetic algorithm processes.
2. Selecting Meta-Learning Tasks: Choose several tasks from the available task distribution. These tasks are used to update model parameters during training.
3. Updating via MAML: Apply Model-Agnostic Meta-Learning (MAML) updates to improve each individual's parameters, enhancing the model's ability to tackle new tasks effectively.
4. Mutation and Crossover: After MAML updates, mutation and crossover are applied to adjust and combine individual parameters. Mutation alters a small subset of parameters, while crossover merges

parameters from two individuals to generate new offspring.

5. Evaluation and Elitism Selection: Each individual is assessed based on performance on the meta-learning tasks. The top-performing individuals are retained, while those with lower performance are modified or removed through natural selection.
6. Cycle Repetition: Repeat these steps until the model achieves optimal or near-optimal performance over multiple cycles.
7. Generalization and Prediction: After training, the model is tested on unseen tasks, aiming to allow rapid adaptation to new data and demonstrate strong generalization abilities.

III. RESULT AND DISCUSSION

During evaluation, the system uses the "Open Dataset Health" from hospital websites or other official sources. The results indicate that the GTVGA-based EG-MAML outperforms in terms of fitness values across all tested function scenarios. For instance, the search boundary format for the fitness function in the second scenario, `fitness_ind_eg_maml_tp_2`, is defined as: `bounds_tp_2 = [(0, 8), # for seed; (0.001, 0.2), # for inner_step_size; (1, 14), # for inner_epochs; (0.001, 0.4), # for outer_stepsize_reptile; (0.0001, 0.1), # for outer_stepsize_maml; (1, 20), # for n_iterations; (0, 1) # for run type]`.



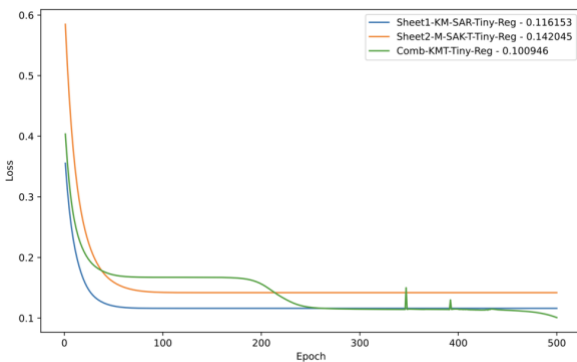
(c)

Figure 4. (a) Training Loss per Epoch for All Task, (b) Convergence of Mean Fitness Value for `fitness_ind_eg_maml_tp_1`, (c) Convergence of Mean Fitness Value for `fitness_ind_eg_maml_tp_2`

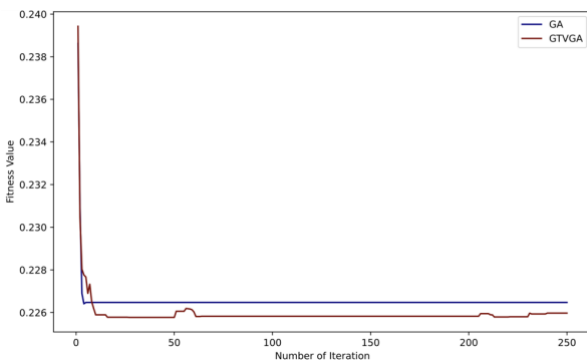
Based on Fig. 4, the GTV EG-MAML achieved a fitness score of 0.21484125, while the non-GTV version scored 0.21573043, showcasing the algorithm's effectiveness in handling health-related issues with enhanced precision. This algorithm's food recommendations offer users valuable guidance for maintaining health and preventing illness. The full code is accessible at <https://github.com/imamcs19/Virtual-First-Aid-Box-Prevent-n-Rescue-Body-Health-Using-Deep-Extreme-Genetic-MAML-Algorithm> in the public repository.

IV. CONCLUSION

The Enhanced Virtual First Aid Box, created using the Deep Extreme Genetic Model-Agnostic Meta-Learning (EG-MAML) algorithm, has introduced notable advancements in identifying health conditions and delivering first aid support. The system processes each detection in approximately 1 to 3 seconds, achieving a strong fitness score of 0.21484125. Its ability to adapt to changing medical data makes the EG-MAML model a reliable solution for healthcare needs, enabling rapid responses in pre-emergency situations. While the system performs well, optimizing real-time monitoring with cloud-based medical sensors in hospitals could broaden its applicability across more health scenarios. Furthermore, working with larger datasets, set many optimizer method like Adam Annealling and many define model option (`n_hidden_layers` and custom activation) or others inside to MAML as additional chromosome gen in GTVGA would more enhance the system's metrics and reliability. The system could also be improved for greater flexibility by integrating a combination of multivariate treatment methods grounded in the green technology of Islamic Medicine, employing evolutionary strategies for contemporary practices that address both physical and non-physical aspects, such as



(a)



(b)

engaging in acts of charity, reciting the Quran, performing prayers, salawat, and practicing dhikr and others.

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Effectiveness of Mensiang Plants (*Actinoscirpus grossus*) in Absorbing Linear Alkylbenzene Sulfonates (LAS), Copper (Cu), Nitrate and Phosphate

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Abstract- Water is essential for all living creatures, but population growth is decreasing its availability. This is due to increased pollution from human activities, including domestic waste (like detergents), industrial waste (such as copper), and agricultural runoff (nitrates and phosphates). Various ways can be done to overcome water pollution, including phytoremediation techniques. One of the aquatic plants that has the potential as a phytoremediation agent is the *Actinoscirpus grossus* plants. This study aims to assess the ability of *Actinoscirpus grossus* plants to absorb LAS, Cu metal, nitrate and phosphate with several variations in concentration and determine the response of exposure to LAS, Cu metal, nitrate and phosphate to the growth of *Actinoscirpus grossus* plants. The method used is an experimental method using a completely randomized design (RAL) with 12 treatments and 3 replications (plant control; LAS 80 mg/L without plants; Cu 5 mg/L without plants; LAS 80 mg/L; Cu 5 mg/L; LAS 80 mg/L + Cu 5 mg/L) and (plant control; nitrate 30 mg/L without plants; phosphate 30 mg/L without plants; nitrate 30 mg/L; phosphate 5 mg/L; and nitrate 30 mg/L + phosphate 5 mg/L) with a detention time of 15 days. The results showed that mensiang plants proved effective in absorbing LAS and Cu contaminants as evidenced by the value of LAS removal power decreased by 74.52% in treatment LAS 80 mg/L + Cu 5 mg/L and Cu metal decreased by 83.40% in treatment Cu 5 mg/L. The effectiveness value of absorption by mensiang plants is most optimal in treatment Cu 5 mg/L which is 62.2%. Meanwhile, the results of the plant's absorption of nitrate 50-92% and 58-84% of nitrate in the combined contamination treatment. Phosphate was able to reduce up to 71-81% and 4-41% of phosphate in the combined contamination treatment. *Actinoscirpus grossus* plant weight was not significantly affected by nitrate and phosphate contamination. However, *Actinoscirpus grossus* experienced slight changes in leaf color due to nitrate and phosphate, these changes include leaves turning dark green in phosphate contamination, yellowish green in combination contamination and brown spots in some treatments.

Keywords; *Actinoscirpus grossus*, copper, Linear Alkylbenzene Sulfonates, nitrate, phosphate, and phytoremediation.

I. INTRODUCTION

Water is one of the most important elements for all living things in the process of life on earth [Desti and Ula, 2021]. Clean water is becoming important as the population increases. However, clean water quality is currently difficult to obtain [Putriarti *et al.*, 2021]. One of the causes is the large amount of water polluted by various types of waste produced by human activities [Harmayani and Konsukartha, 2007]. Aquatic resources have an important role in life. However, the increasing intensity of human activities that utilize aquatic ecosystems such as agricultural and plantation activities contribute to a decline in water quality [Putri *et al.*, 2019]. A total of 25 rivers in Indonesia have a heavily polluted status and this increased to 38 rivers with a heavily polluted status in 2019 [Firmansyah *et al.*, 2021]. In addition, agricultural areas require sufficient water availability. Irrigation systems are used to ensure the availability of water for plants so that aquatic ecosystems such as reservoirs, lakes or rivers are often found as sources of irrigation water around agricultural land [Retnaningdyah & Arisoesilaningih, 2018].

Increased detergent use has an impact on waste and the environment, including disturbed water aesthetics, decreased dissolved oxygen levels, changes in the physical and chemical properties of water, and eutrophication [Handayani, 2020]. High phosphate from detergents can cause the growth of water weeds [Yuliani and Purwanti, 2015]. This pollution is caused by surfactants in detergents [Suastuti *et al.*, 2015], active substances in organic chemicals which are divided into anionic, cationic, nonionic and amphoteric categories [Oppusunggu *et al.*, 2015]. Anionic surfactants are generally used for households, while nonionic, cationic and amphoteric surfactants are more often used in industry [Wibisono, 2018]. Apart from

detergent waste, heavy metals also often pollute the aquatic environment (Andriarna *et al.*, 2022). Heavy metals are difficult to degrade and easily accumulate (Budianta and Pambayun, 2015). They are toxic, potentially causing poisoning, metabolic disorders, and decreased physiological function in organisms (Yalcin *et al.*, 2008). Levels that exceed the maximum limit and accumulate over a long time can cause death (Putranto, 2011).

Eutrophication is water pollution due to excess nutrients, especially nitrogen (N) and phosphorus (P), which results in excessive growth of phytoplankton and aquatic plants. This can damage the balance of aquatic ecosystems, cause fish deaths, and hinder water flows (Mustika & Utomo, 2023; Darmono, 2001). Phytoremediation is an environmental cleaning method using plants to remove pollutants. This technology, which is environmentally friendly and driven by solar energy, harnesses the ability of plants to clean pollutants in-situ (Wang *et al.*, 2020; Sukono *et al.*, 2020). Plants that are effective for phytoremediation have fast growth, high water absorption capacity, and high tolerance to pollutants (Fatmawati, 2013).

The mensiang plant (*Actinoscirpus grossus*) has the potential for phytoremediation because of its ability to absorb pollutants in liquid waste thanks to its hollow stems and branched roots. Research shows that this plant, together with *Limnocharis flava*, is effective in reducing nitrate and phosphate concentrations (Sundari, 2013). Therefore, this study aims to test the effectiveness of *Actinoscirpus grossus* in reducing concentrations of Linear Alkylbenzene Sulfonates (LAS), copper (Cu), nitrate and phosphate, as well as morphological changes in plants due to these pollutants.

II. METHODS

This study uses a quantitative descriptive research type with an experimental approach. This research used a Completely Randomized Design consisting of 6 treatments and 3 replications. Observations were carried out for 15 days where these observations included measurements of physicochemical factors such as temperature, pH, TDS, LAS concentration, copper (Cu), nitrate and phosphate in the water media, as well as measuring the concentration of copper (Cu) in plants. Plant weight measurements were carried out on the 0th day before treatment and the 15th day after treatment to determine the plant's response to pollutants. The experimental design of this research is as follows (Table .1)

Concentrati onVariation s	LAS and Cu Treatment	Nitrate and Phosphate Treatment	Detentio n Time
S ₀	Plant Control (Without LAS and Cu metal)	Plant control (without nitrates and phosphates)	15 Days
S ₁	LAS 80 mg/L Without plant	Nitrate 30 mg/L Without plant	
S ₂	Cu metal 5 mg/L Without plant	Phosphate 5 mg/L Without plant	
S ₃	LAS 80 mg/L + plant	Nitrate 30 mg/L + plant	
S ₄	Cu metal 5 mg/L + plant	Phosphate5 mg/L + plant	
S ₅	LAS 80 mg/L + Cu metal 5 mg/L + plant	Nitrate 30 mg/L + phosphate 5 mg/L + plant	

The research stage begins with the process of plant acclimatization. During this process, a working solution is also made. After acclimatization is complete, with Range Finding Test (RFT) treatment.

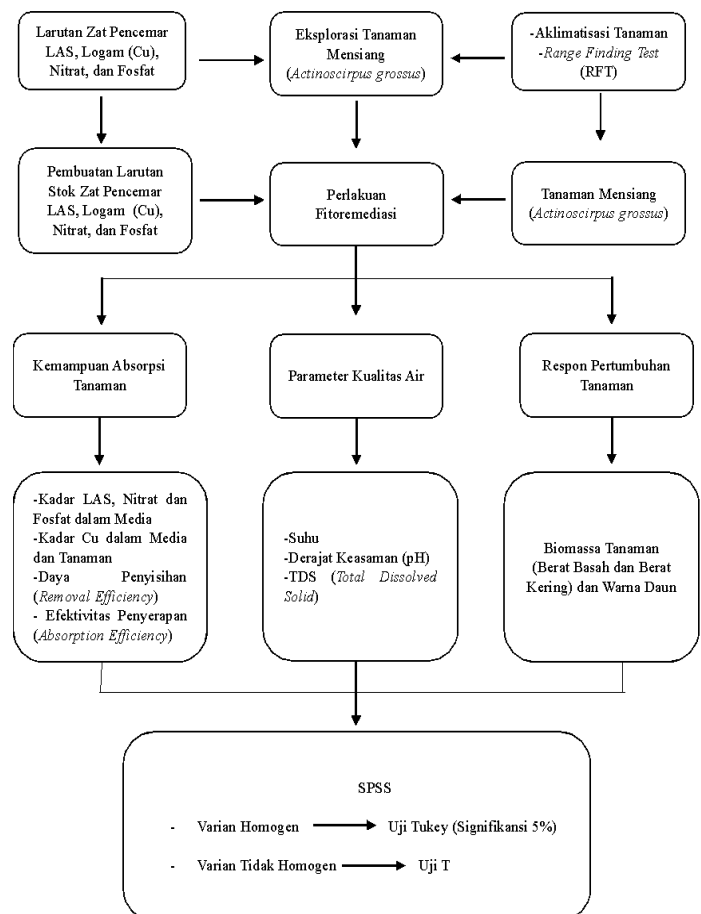


Figure 1. Research Outline

III. RESULT AND DISCUSSION

A. Removal Efficiency

Removal Efficiency LAS

The research results in Figure 1 show that the removal power of LAS varies depending on concentration. The LAS 80 mg/L + Cu 5 mg/L treatment showed optimal removal of 74.52%. *Actinoscirpus grossus* plays a role in decomposing organic compounds and increasing absorption by plants, thanks to synergy with rhizospheric microbes that absorb organic waste (Rukmi *et al.*, 2013; Ni'ma *et al.*, 2014). The combination of LAS and Cu accelerated the decrease in LAS, with LAS 80 mg/L + Cu 5 mg/L lagging behind by 20.38 mg/L on day 15, while LAS 80 mg/L lagged behind by 26.03 mg/L. The interaction of LAS and Cu metal causes structural changes in LAS, facilitating absorption by plants (Yong *et al.*, 2008; Andriarna *et al.*, 2022). The statistical test showed a significance of 0.01 ($p < 0.05$), indicating a real difference in the reduction of LAS levels with variations in treatment concentration. The most optimal value of excluded LAS levels in the LAS 80 mg/L + Cu 5 mg/L treatment was 59.62 mg/L.

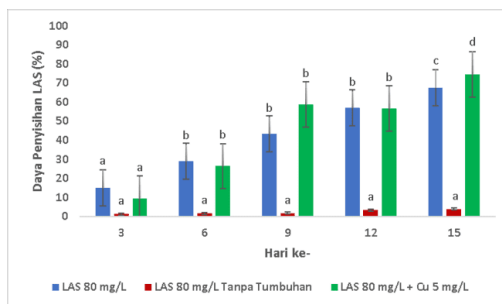


Figure 2. LAS removal efficiency value (%). The same letters above the bars indicate significant differences based on the t test $\alpha = 0.05$.

Removal Efficiency Copper Metal (Cu)

The research results in Figure 2 show variations in the removal power of copper metal (Cu) in various treatments. The optimal decrease in Cu levels occurred until day 15 in the 5 mg/L Cu treatment, with remaining Cu levels of 0.83 mg/L and removal power of 5.21%. In controls, Cu levels are considered 0 mg/L, while the normal range is 0.05–0.5 mg/L (Ed Bloodnick, 2021). The decrease in Cu levels is influenced by the absorption of *Actinoscirpus grossus* and phytochelatin compounds which reduce metal toxicity (Santosa *et al.*, 2013; Wulandari *et al.*, 2018). Absorption is also assisted by microorganisms around the roots (Widyawati and Sunu, 2021). Without plants, 5 mg/L Cu treatment showed a decrease in Cu levels of 0.45% to 4.64 mg/L, caused by evapotranspiration and metal deposition (Syranidou *et al.*, 2017; Novita *et al.*, 2012). The statistical test shows a significance value of 0.01, which

means that variations in concentration have a significant effect on reducing Cu levels. Cu treatment of 5 mg/L with plants showed the most optimal Cu content removed, namely 4.17 mg/L, with the highest average difference of 2.42400*.

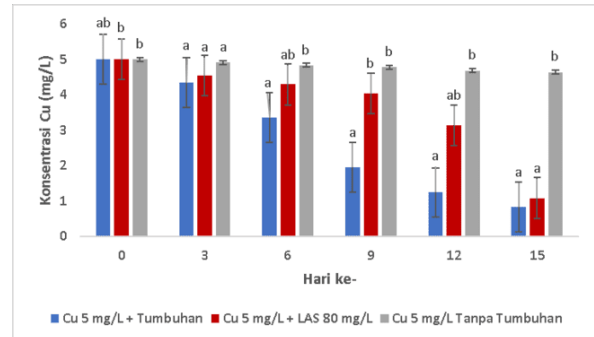


Figure 3. Copper Metal (Cu) Content in Media (mg/L). The same letters above the bars indicate significant differences based on the t test $\alpha = 0.05$.

Removal Efficiency Nitrate

The research results which can be seen in the diagram in Figure 3 show a significant reduction in nitrate concentration from 30 mg/L to 2.47 mg/L in 15 days, with a reduction of 92%. This decrease was caused by absorption by *Actinoscirpus grossus*, adsorption by the substrate (Rachmawati and Rinawati, 2020), and the activity of nitrate-reducing microorganisms (Prahardika *et al.*, 2013). In media with a combination of nitrate and phosphate, the nitrate concentration decreased from 6.47 mg/L to 4.83 mg/L on day 15, with a reduction of 84%. This decrease was lower compared to nitrate media alone, possibly due to N-P bonds which inhibit nitrogen absorption (Suasti *et al.*, 2017). In the control treatment without plants, the nitrate concentration fell from 30 mg/L to 9.90 mg/L in 15 days, with a reduction of 67%. Fluctuations in nitrate concentration are thought to be influenced by substrate adsorption and desorption processes (Vymazal, 2007), as well as nitrate-reducing microorganisms (Prahardika *et al.*, 2013).

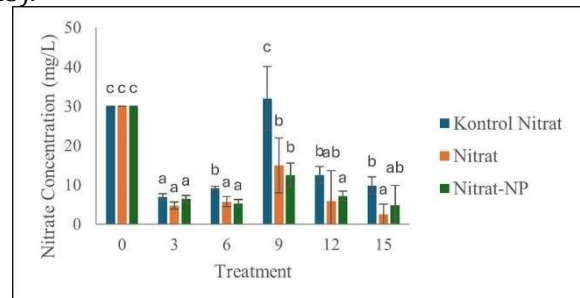


Figure 4. Comparison of Nitrate Concentrations Between Observation Times. The same letters above the blocks indicate significant differences based on the paired samples t-test $\alpha = 0.05$.

Removal Efficiency Phosphate

The research results in Figure 4 show that the initial phosphate concentration of 5 mg/L decreased significantly to 0.87 mg/L on the sixth day, with a decrease of 81%. This decrease was caused by phytoremediation by *Actinoscirpus grossus*, adsorption by the substrate (Maulini *et al.*, 2018), and possibly phosphate-reducing microorganisms (Prahardika *et al.*, 2013). Phosphate increased insignificantly on the ninth and 12th days, then fell again to 0.95 mg/L on the 15th day. In water media containing nitrate and phosphate, phosphate decreased significantly to 1.63 mg/L on the third day, then increased insignificantly to 2.00 mg/L on the sixth day and increased significantly to 4.80 mg/L on the second day. ninth. A further decrease to 2.97 mg/L on day 15 showed a 41% lower reduction compared to the single phosphate treatment, possibly due to the interaction of phosphate with nitrate.

In the control without plants, phosphate decreased significantly to 1.63 mg/L on the third day, then increased significantly to 7.10 mg/L on the ninth day before decreasing again to 5.57 mg/L on the 15th day. This fluctuation is thought to be due to substrate adsorption and desorption processes (Maslukah *et al.*, 2020; Vymazal, 2007) as well as phosphate-reducing microorganisms (Prahardika *et al.*, 2013), with the final decrease not being significant compared to the initial day, and a decrease of -11% compared to 12th day.

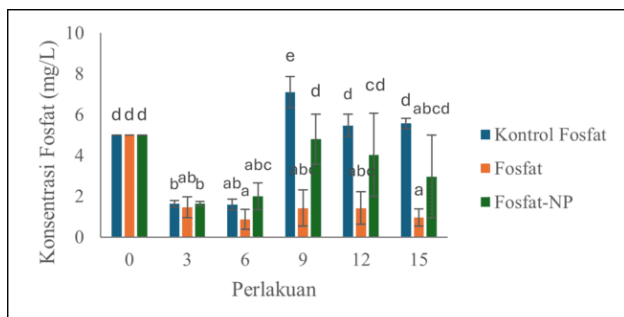


Figure 5. Comparison of Phosphate Concentrations Between Observation Times. The same letters above the blocks indicate significant differences based on the paired samples t-test= 0.05.

B. Effectiveness of Heavy Metal Cu Absorption by Plants

The results of the study in figure 5 show the effectiveness of copper metal (Cu) absorption by different plants at various concentrations. The highest Cu level was found in roots with Cu treatment of 5 mg/L, which was 3.11 mg/L, while the lowest level was in the crown with LAS treatment of 80

mg/L + Cu 5 mg/L, which was 0.84 mg/L. Hyperaccumulator plants, such as *Actinoscirpus grossus*, effectively absorb heavy metals with optimal absorption at roots (62.2% for Cu 5 mg/L) and crowns (58% for LAS 80 mg/L + Cu 5 mg/L). The absorption effectiveness is considered high if it is more than 50% (Djo *et al.*, 2017). The statistical test showed a significance of 0.04 (sig. < 0.05), indicating a significant effect of concentration on the decrease in Cu and LAS levels in plants. Treatment of Cu 5 mg/L on the roots showed the highest absorption effectiveness with an average difference of 51.26033*.

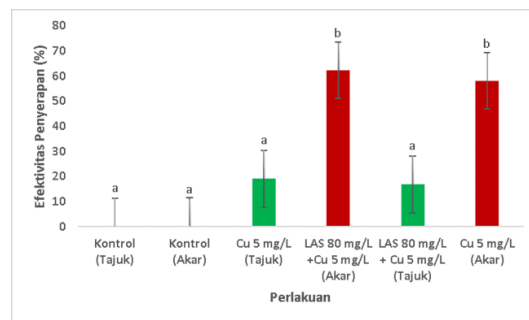


Figure 6. Effectiveness Value of Copper Metal (Cu) Absorption by *Actinoscirpus grossus* Day 15. The same letter on the block shows a noticeable difference based on the t-test $\alpha = 0.05$

C. Plant Growth Response

The observation of the observed plant growth response is the wet weight of the plant. Observations of the wet weight of the plant showed that *Actinoscirpus grossus* underwent significant changes after exposure to pollutants. On the 15th day, the highest wet weight of the plant was found in the LAS treatment of 80 mg/L + Cu 5 mg/L with an increase from 26.45 grams to 49.7 grams (Figure 6). This increase is due to the synergistic effects of LAS and Cu that stimulate growth by increasing plant metabolism and photosynthesis (Liu *et al.*, 2022). Statistical tests showed a significance of 0.03 for the wet weight of the plants, indicating a significant difference between the treatments. LAS treatment of 80 mg/L + Cu 5 mg/L showed optimal results.

Observation of the wet weight of plants in the nitrate and phosphate contamination treatment in figure 7 is known that the control treatment increased from 25 grams to 48 grams, but it was not significant due to the lack of nitrates and phosphate (153% productivity). Nitrate treatment increased wet weight from 26 grams to 54 grams, with the highest productivity value (189%). Phosphate treatment also increased from 20 grams to 46 grams significantly. The nitrate and phosphate mixture showed an increase from 13 grams to 39 grams, but it was not

significant. This result is in line with previous research which shows that nitrates and phosphates affect plant growth, playing an important role in increasing wet weight because nutrients are chemicals needed by organisms as raw materials for their survival (Soedarsono *et al.*, 2013).

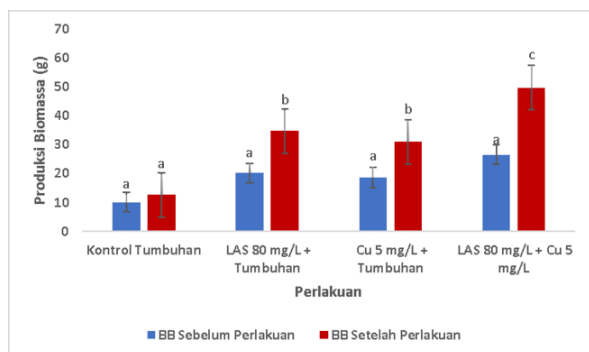


Figure 7. Wet weight of plants in LAS and Cu contamination treatment. The same letter shows no real difference based on the anova test at the level of 5%

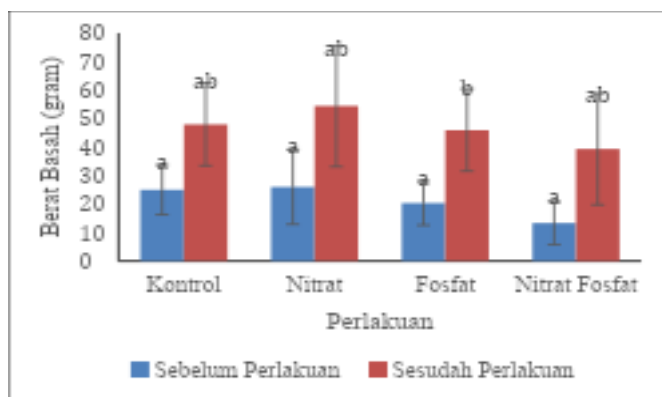


Figure 8. Wet weight of plants in nitrate and phosphate contamination treatment. The same letter shows no real difference based on the anova test at the level of 5%

D. Water Quality Parameters

The study also evaluated the effectiveness of *Actinoscirpus grossus* in addressing pollutants such as LAS, Cu metals, nitrates, and phosphates and their impact on water quality. The parameters measured were temperature, pH, and Total Dissolved Solids (TDS). The results of temperature measurements in the LAS and Cu treatments in table 1 showed fluctuations between 25-32°C. Meanwhile, in the nitrate and phosphate contamination treatment in Figure 8, the room temperature during the observation ranged from 26.5-32.1 °C, while the water temperature during the observation ranged from 25.3-27.2 °C, which was affected by the weather and sunlight intensity. This temperature range corresponds to the tolerance of *Actinoscirpus grossus*. *Actinoscirpus grossus* is

able to live in the temperature range of 32-25°C (Govaerts, 2007).

Table 2. Temperature Data on LAS and Cu Treatment (°C)

No.	Concentration Variations	Day					
		0	3	6	9	12	15
1.	Plant Control	25,1	25,4	26,6	28,5	28,7	28,8
2.	LAS 80 mg/L Without Plant	25,1	25	26,6	29,2	29,3	30,1
3.	Cu 5 mg/L Without Plant	25,1	25,1	26,6	28,8	29	29,3
4.	LAS 80 mg/L + Plant	25,4	24,9	26,6	28,4	28,7	28,9
5.	Cu 5 mg/L + Plant	25,2	25,1	26,6	28,3	28,7	28,9
6.	LAS 80 mg/L + Cu 5 mg/L	25,2	25,9	26,4	26,7	27,7	28,3

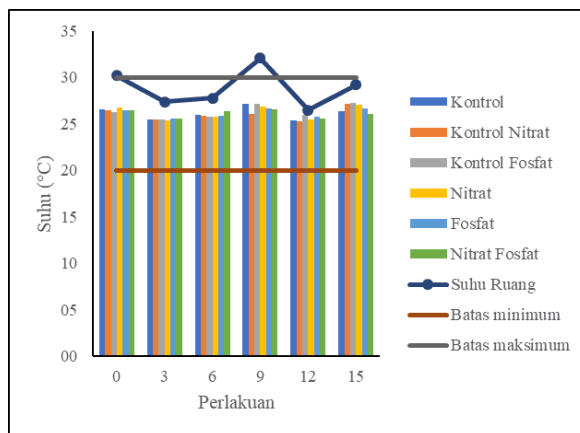


Figure 9. Temperature Data on Nitrate and Phosphate Treatment

The initial pH value of LAS and Cu treatment in table 2 ranged from 7.3-8.2, increasing to 7.7-8.6 after 15 days. Meanwhile, the pH value in nitrate and phosphate treatment at the first observation until the 15th day has a value in the range of 6.85-7.88 (Figure 9), still within the national water quality standard limit in the Minister of Environment and Forestry Number 22 of 2021 attachment VI, which is 6-9. Changes in pH are influenced by photosynthesis, respiration, and chemical reactions with pollutants (Suryadi *et al.*, 2017; Widya *et al.*, 2015).

Table 3. pH Data on LAS and Cu Treatment

No.	Concentration Variations	Day					
		0	3	6	9	12	15
1.	Plant Control	7,3	7,5	7,6	7,7	7,7	7,8
2.	LAS 80 mg/L Without Plant	8,5	8,2	8,1	8,2	8,2	8,2

3.	Cu 5 mg/L	7,	7,	7,	7,	8	8,
	Without Plant	4	8	9	9	8	2
4.	LAS 80 mg/L +	8,	7,	7	7,	7,	7,
	Plant	2	4	1	1	2	
5.	Cu 5 mg/L +	7,	7,	7,	7,	7,	7,
	Plant	4	0	2	1	2	3
6.	LAS 80 mg/L +	8,	8,	8,	8,	8,	8,
	Cu 5 mg/L	2	3	4	4	5	7

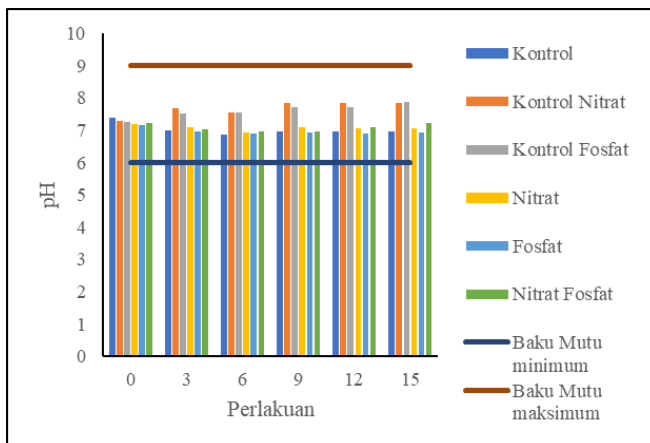


Figure 10. pH Data on Nitrate and Phosphate Treatment

The TDS value fluctuated between 139-225 mg/L in the LAS and Cu treatments (Table 3) while the TDS in the nitrate and phosphate treatments in figure 10 ranged from 139-225 mg/L, remaining below the national water quality standard limit in the Minister of Environment and Forestry of the Republic of Indonesia Number 22 of 2021 attachment VI, which is 1000 mg/L. The increase in TDS was caused by the accumulation of organic and inorganic solutes (Efendi, 2003), as well as the rest of plant tissue (Kustiyaningsih and Irawanto, 2020).

Tabel 3. TDS data on LAS and Cu treatment.

No	Concentration Variations	Day					
		0	3	6	9	12	15
1.	Plant Control	150	196,3	218,7	196,7	231,7	242,3
2.	LAS 80 mg/L Without Plant	269,3	256,7	349,7	362,3	363	374,7
3.	Cu 5 mg/L Without Plant	183,3	189,7	220	202	259	268
4.	LAS 80 mg/L + Plant	252,7	257,7	346,3	396,3	398	420,7
5.	Cu 5 mg/L + Plant	173,3	208,7	219,7	225,3	248	255,7
6.	LAS 80 mg/L + Cu 5 mg/L	265,7	268,0	297,3	285,3	284,7	312,3

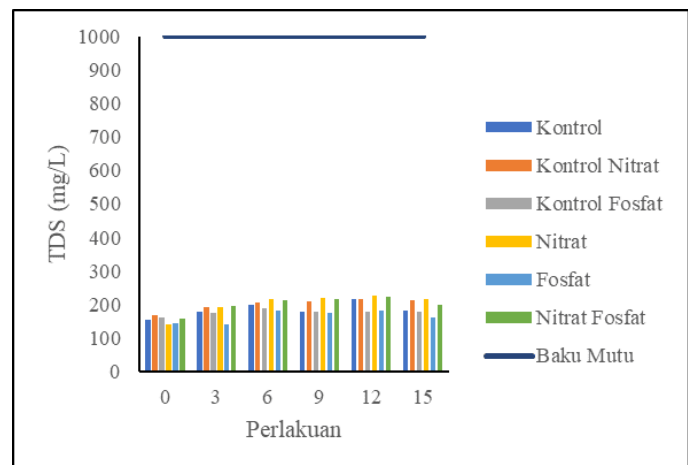


Figure 11. TDS Data on Nitrate and Phosphate Treatment

IV. CONCLUSION

Actinoscirpus grossus significantly decreases the concentration of nitrate and phosphate pollutants. In nitrate contamination, the decrease reached 92% in single treatment and 84% in combination treatment. In phosphate contamination, the decrease in phosphate was 81% in single treatment and 41% in combination treatment. In addition, LAS, Cu, nitrate, and phosphate contamination significantly affected the wet weight of *Actinoscirpus grossus*.

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Effect of boiling temperature and time on total flavonoids, total phenols, and radical scavenging activity of decoction water fresh gotu kola (*Centella asiatica* (L.) Urb.)

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Abstract. Gotu kola (*Centella asiatica* (L.) Urb.) possesses significant pharmacological effects as a versatile herb, particularly in wound healing, neuroprotection, and cardiovascular health. Some people derive the benefits of medicinal plants by boiling and consuming them. The boiling process significantly impacts the biochemical composition, including total phenols, total flavonoids, and antioxidant activity. This study aims to investigate the impact of temperature and time on total flavonoids, total phenols, and radical scavenging activity during the boiling process of fresh *C. asiatica*. Three different temperature treatments (75°C, 85°C, 95°C) and four different boiling time treatments (5, 10, 15, and 20 minutes) were used to assess the total flavonoid content, total phenolics, and radical scavenging activity using the DPPH method. Quantitative data analysis employed DMRT and PCA techniques to ascertain the impact and correlation among factors. The results showed that temperature and boiling time significantly influenced total flavonoids, total phenols, and radical scavenging activity. Maximum levels of total flavonoids, total phenols, and radical scavenging activity were achieved in *C. asiatica* boiling water after boiling at 95 °C for 20 minutes. Temperature, total flavonoids, and total phenols have a strong correlation, where total flavonoids and total phenols increase as the boiling temperature increases.

Keywords; Boiling Process, *Centella asiatica* (L.) Urb., Total Flavonoid Content, Total Phenol

I. INTRODUCTION

Centella asiatica (L.) Urb., also known as Gotu Kola and Pegagan in Indonesia, is a perennial of the Apiaceae family with a remarkable therapeutic application as an herb [1]. The activity of this agent can be explained in a way that the bioactive constituents contribute substantially to the therapeutic effects, including triterpenes like asiaticoside,

madecassoside, and their acid forms, which possess antioxidant, anti-inflammatory, and neuroprotective properties [2–4]. Significantly, these compounds significantly augment the plant's capacity to scavenge free radicals, leading to reduced oxidative damage and raised levels of cellular protective mechanisms [5–7].

The use of medicinal has been orthodox for ages in most of the societies of the earth's surface, for instance, in Wawo District Bima Regency, where it has been used together with the land boiled plant, which is then taken orally by the people [8,9]. Furthermore, the Dayak Kanayatn people residing in Tonang Village, Sengah Temila District, Landak Regency, West Kalimantan, have relied on traditional medicine, primarily mostly by ingesting manufactured herbal mixtures[10]. These long-standing customs have been transmitted over generations, offering crucial insight into how the local population has been harnessing the medicinal resources of nature to fulfil their healthcare requirements [11,12].

Optimization of total phenols, total flavonoids, and radical scavenging activity based on boiling temperature and time has been the subject of numerous investigations leading to complicated conclusions considering numerous factors, such as the type of plant material and specific boiling parameters [13,14]. Apart from this, the boiling general effects on total phenolics and more so on flavonoid contents in different plant extracts, who reported that after boiling bamboo shoots for thirty minutes, the total phenolics and flavonoids concentrations decreased together with the radical scavenging activity, thereby suggesting that extreme temperature for a long duration can cause breakdown of these bioactive substances [15]. In about the same "state," boiling celery roots resulted in a significant reduction in total phenolic content and

antioxidant activity, which is related to the loss of water-soluble phenolics in boiling water [16]. This phenomenon is explained that oxygen may still reach the reactant even during heat treatment by heat-induced boiling and leaching and, therefore, phenolic acids and flavonoids may be reduced [17].

Some studies indicate that boiling can also enhance the extraction of certain phenolic compounds, where a 3% rise in the overall phenolic acid content was observed in white beetroot after boiling for 60 minutes, suggesting that the boiling process can sometimes facilitate the release of phytochemicals from plant matrices [18]. Previous studies have demonstrated that longer boiling times typically result in a decline in antioxidant capacity and reported a significant reduction in antioxidant activity of sweet potato leaves after boiling, with a decrease of 63.82% observed [19]. Similarly, a 50-60% reduction in quercetin levels in onions after 60 minutes of boiling is documented, which directly correlates with diminished antioxidant activity [20]. Alternatively, several studies propose specific cooking methods, leading new antioxidant compounds, where boiling chestnuts resulted in a total phenolic content comparable to that of baked chestnuts, suggesting the possibility of improved antioxidant properties under certain circumstances [21].

Principal Component Analysis (PCA) is a robust multivariate statistical method that clarifies the correlations among total phenols, total flavonoids, and radical scavenging capacity in various plant extracts [22]. Research highlights the utility of PCA in differentiating phenolic compounds and antioxidant activity across various tea types, demonstrating that PCA can effectively capture the variance in phenolic content and its relationship with antioxidant capacity [23]. Similarly, there is a strong correlation between total phenolic and flavonoid contents and radical scavenging activities, indicating that these compounds significantly contribute to the antioxidant potential of plant extracts [24]. This relationship is reinforced by research indicating that more significant amounts of phenolic compounds are linked to enhanced antioxidant activity, as demonstrated by the positive regression coefficients documented in several analyses [25,26].

An analysis of intricate datasets related to medicinal herbs and spices supports the idea that Principal Component Analysis (PCA) may accurately summarize the connections between several variables, including total phenols, flavonoids, and antioxidant activity [27]. There was a high linear correlation between anthocyanins and antioxidant capacity, suggesting that phenolic compounds are crucial in determining antioxidant activity [28]. This comprehensive understanding can guide future research and applications in natural antioxidants to determine the effect and relationship between total flavonoids, total

phenols, and radical scavenging activity parameters in studying the effect of temperature and boiling time of fresh *C. asiatica*.

II. MATERIAL AND METHODS

Sample preparation

The materials used were *C. asiatica* planted in the Medicinal Plant Garden of UPF Dr Sardjito in Karangpandan District, Karanganyar Regency, Central Java Province. The tools used were analytical scales (Adam PWZ 14), a Sonicator (Elma S40H), and a Spectrophotometer (Thermo Scientific Multiskansky).

Heat 1000 ml of water on a hot plate. Add 100 grams of fresh *C. asiatica* sample to the pot until it can be consumed while stirring. Turn off the hot plate. The sample is then filtered, and 25 mL of water is taken. The experimental design used was completely randomized, with three levels of temperature treatments, namely T1 (75 °C), T2 (85 °C), and T3 (95 °C), and four levels of boiling time treatment (D1 (5 minutes), D2 (10 minutes), D3 (15 minutes), and D4 (20 minutes). The samples were then tested for total flavonoids, total phenols, and radical scavenging activity using a spectrophotometer.

Total flavonoid content (TFC)

Analysis of total flavonoid content was conducted using the Widodo technique. In methanol, the extract was dissolved at a concentration of 1,250 µg/mL. The experimental mixture comprised 500 µL of the sample, 150 µL of a 0.1 M AlCl₃ solution (in a control group without AlCl₃ and substituted with 150 µL of methanol), 350 µL methanol, 250 µL of acetate buffer (pH 3.8), and methanol to a total volume of 1250 µL. A 30-minute incubation at 37 °C was conducted on the reaction mixture. A 150 microlitre test solution was placed into the microplate and the absorbance was quantified using a spectrophotometer at a wavelength of 398 nanometres. Quercetin is employed as a standard by constructing a standard curve. The compound Quercetin was dissolved in a constant volume of methanol at concentrations of 0, 50, 100, 300, 400, and 500 µg/mL. The quantification of flavonoids is expressed in µg of Quercetin Equivalents (RE) per gramme of extract [29].

Total phenol content (TPC)

Quantification of total phenol content was conducted using the Widodo method with certain adjustments [30]. In its final state, the reaction mixture comprises 40 mg of extract, 4% methanol, 10% FCR, and 5% NaCO₃. A 40 µL sample of extract (1 mg/mL: 1 mg dissolved in 1 mL methanol using a sonicator for 15 minutes) was combined with 360 µL of deionised water and 100 mL of fresh distilled water. After homogenising the solution, it was let to stand for 2 minutes. Neutralisation of the reaction was achieved by adding 500 mL of sodium carbonate (10% w/v)

thoroughly mixed and then incubated at 37 °C for 35 minutes. The test solution, measuring 150 µL, was prepared and placed onto the microplate. The absorbance of gallic acid was measured using a spectrophotometer at a wavelength of 732 nm, which corresponds to the highest achievable absorbance. Gallic acid was employed as a standard with concentration series ranging from 0 to 32 µg/mL. Expression of total phenol content is in µg Gallic Acid Equivalent (GAE) per gramme of extract.

Radical scavenging activity (RSA)

The assay employs the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method with several modifications [29]. The DPPH were prepared in methanol p.a. at 350 µM, respectively. Samples were prepared in a 1500 µL tube by combining 40 µL of the sample, 760 µL of methanol, and 200 µL of DPPH. The control comprised 40 µL of the sample and 960 µL of methanol. The tube underwent vortexing for 10 seconds and was subsequently incubated at 37 °C for 35 minutes in a dark incubator, with inversion occurring every 10 minutes. Absorbance was measured using a spectrophotometer at a wavelength of 515 nm. The DPPH radical scavenging assay was conducted on three separate occasions.

The calculation of radical inhibitory activity was performed using the following formula (1):

$$(1) \quad \% \text{ Inhibition} = \frac{[(\text{Abs control} - \text{Abs blank}) - (\text{Abs sampel} - \text{Abs control sample})]}{(\text{Abs control} - \text{Abs blank})} \times 100\%$$

Data analyst

The data obtained in the previous stage were analyzed statistically with DMRT at the 5% level to determine the effect of treatment on parameters. The correlation between parameters was tested using the Principal Component Analysis (PCA) method. Data processing in this study used the help of Past4.13.exe software.

III. RESULT AND DISCUSSION

Total flavonoid content at the level of temperature and time in fresh *C. asiatica* boiled water (Figure 1) shows that the higher the temperature and the longer the boiling time, the higher the total flavonoid content. Boiling at 75 °C for 5 minutes has the lowest flavonoid content compared to other treatments which is 0.17 ± 0.05 µg QEq/mL. At 95 °C boiling for 20 minutes, the highest flavonoid content was obtained at 1.00 ± 0.09 µg QEq/mL. Total flavonoid content increased by over 40% at 95 °C, boiling for 5 to 20 minutes. Similar research on *Muntingia calabura* leaves where total flavonoid levels increased up to a boiling time of 20 minutes but decreased at boiling for 30 minutes. Because of density,

temperature can impact a compound's solubility. This is most likely because a prolonged boiling time damages the flavonoid components in the heat-sensitive water extract of *M. calabura* leaves, resulting in a drop in overall flavonoid concentration [31].

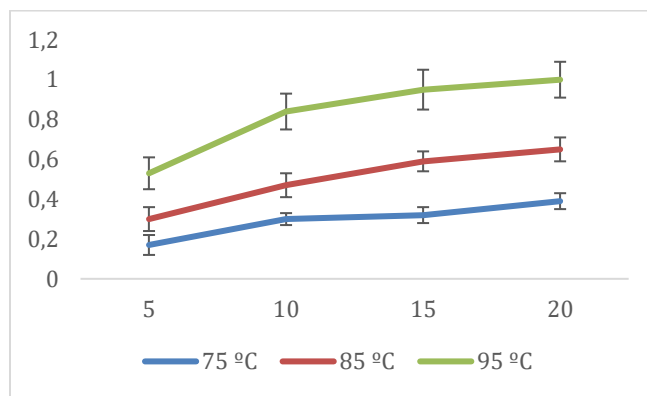


Figure 1. Total flavonoid content of *Centella asiatica* (L.) Urb. decoction water.

The highest total phenol content in *C. asiatica* leaf cooking water was obtained at 95 °C. Figure 2 shows that the higher the boiling temperature, the higher the total phenol content. The total phenol content also increases with the longer the boiling time. Figure 2 illustrates that the total phenol content at a boiling temperature of 75 °C did not increase significantly. Boiling *C. asiatica* for 15 minutes to 20 minutes, there is no significant difference. There was an increase in total phenol content in the boiled water of *C. asiatica* leaves, reaching three times the boiling water with a temperature of 95 °C. Extending the heating time of black tea has yielded similar results in terms of an increase in total phenolic content. This is due to the possibility that the boiling procedure destroyed the effects of the cell wall structure on the solvent's ability to extract more phenolic chemicals [14,32].

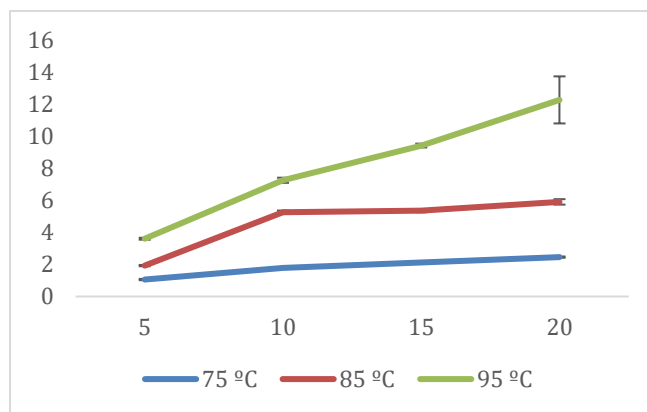


Figure 2. Total phenol content of *Centella asiatica* (L.) Urb. decoction water

Figure 3 shows the radical scavenging activity of *C. asiatica* decoction water at a concentration of 2000 µg/mL using the DPPH method. The highest activity of *C. asiatica* leaf cooking water was also obtained at a temperature of 95 °C with a duration of 20 minutes (µg/ml). Figure 3 shows that the higher the boiling temperature, the higher the radical scavenging activity. The radical scavenging activity also increases with the length of boiling time. Figure 3 illustrates that the total phenol content at boiling temperatures of 85 and 95 °C has reached more than 50% inhibition. At 85 °C boiling time of 10 to 20 minutes, there was a sharp increase of 412% from the original inhibition. The radical scavenging activity remained at 15 to 20 minutes of boiling. The results differ from research on turmeric, where the longer the boiling time, the more antioxidant activity decreases due to temperature damage [33].

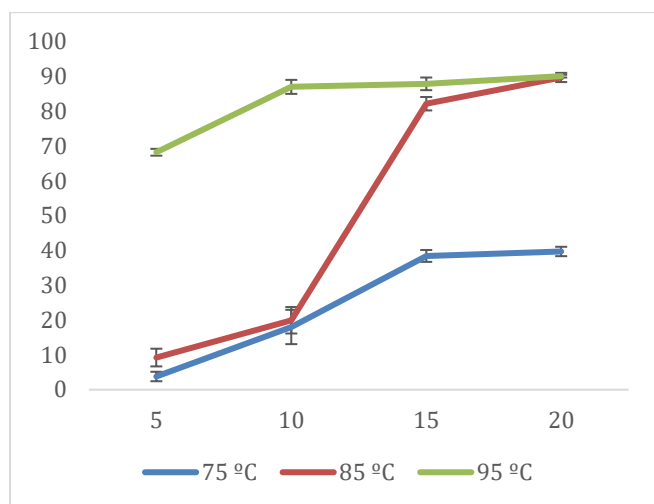


Figure 3. Radical scavenging activity of *Centella asiatica* (L.) Urb. decoction water.

Table 1 shows the results of DMRT analysis on the parameters of total flavonoid content, total phenolics and radical scavenging activity of fresh *C. asiatica* boiling process at specific temperatures and time levels. The analysis showed that the temperature and boiling time significantly influenced the total flavonoids, total phenols and radical scavenging activity of fresh *C. asiatica*. The higher the temperature and the longer the boiling time, the higher the total flavonoids, total phenols and radical scavenging activity levels. However, the levels of total phenols in boiling for 15 minutes and 20 minutes did not differ significantly. Increase in total phenol content after heating because cooking inactivates the enzyme polyphenol oxidase, inhibiting the degradation of polyphenols [34].

Table 1. Total phenol content, total flavonoids, and radical scavenging activity of *Centella asiatica* (L.) Urb. decoction water

Sample Code	TPC (mg GAE/g)	TFC (µg QEq/mL)	RSA (µg/ml)
T1D1	1.06 ± 0.04 a	0.17 ± 0.05 a	3.78 ± 1.36 a
T1D2	1.78 ± 0.02 ab	0.3 ± 0.03 b	18.00 ± 4.93 c
T1D3	2.12 ± 0.02 b	0.32 ± 0.04 b	38.41 ± 1.71 d
T1D4	2.46 ± 0.04 b	0.39 ± 0.04 bc	39.69 ± 1.35 d
T2D1	1.93 ± 0.04 b	0.30 ± 0.06 b	9.22 ± 2.54 b
T2D2	5.27 ± 0.10 d	0.47 ± 0.06 cd	19.93 ± 3.80 c
T2D3	5.36 ± 0.10 d	0.59 ± 0.05 ef	82.13 ± 1.93 f
T2D4	5.91 ± 0.17 d	0.65 ± 0.06 f	89.67 ± 1.32 g
T3D1	3.61 ± 0.06 c	0.53 ± 0.08 de	68.19 ± 0.98 e
T3D2	7.26 ± 0.16 e	0.84 ± 0.09 g	86.97 ± 2.01 g
T3D3	9.43 ± 0.12 f	0.95 ± 0.10 gh	87.84 ± 1.82 g
T3D4	12.28 ± 1.47 g	1.00 ± 0.09 h	90.05 ± 0.40 g

Remarks : The value is average value ± deviation standar; n=3. The same abjad on the same column shows no significant difference at 5%.

Table 2. Principal Component Analysis extraction result of *Centella asiatica* (L.) Urb. decoction water

PC	Eigenvalue	% variance
1	0.366335	85.818
2	0.0364748	8.5446
3	0.0234268	5.488
4	0.00060634	0.14204
5	3.11621E-05	0.0073001

Table 2 shows that the 5 variables extracted with 2 components already represent 94.3626% of the overall parameters. For example, there are 85.818% in component 1 and 8.5446% in component 2. In addition, there is a graph that explains the results of determining the number of factors, the graph can be seen in Figure 4 Scree Plot. In this study, 2 PC were taken because 2 PC had reached 90% of the overall parameters.

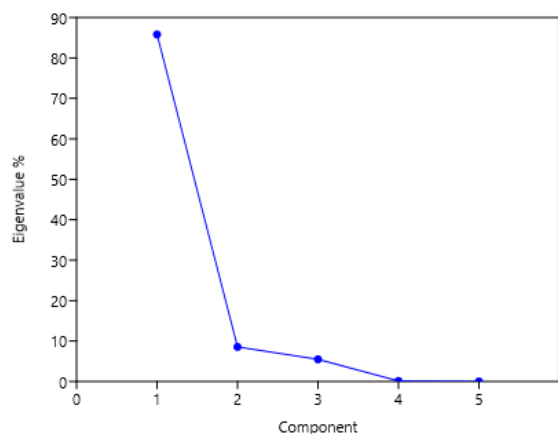


Figure 4. Scree plot Principal Component Analysis of *Centella asiatica* (L.) Urb. decoction water

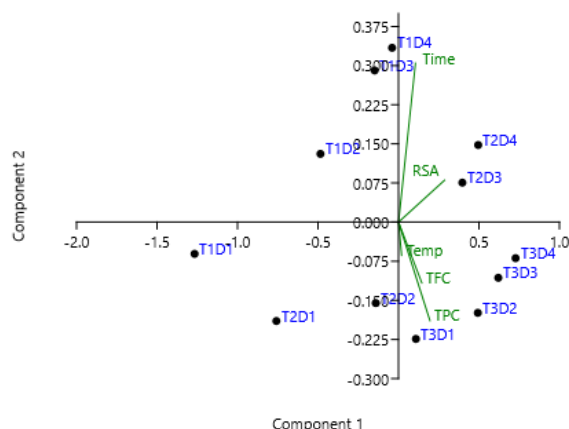


Figure 5. Biplot Principal Component Analysis of *Centella asiatica* (L.) Urb. decoction water

The PCA Biplot graph shows the relationship of the main components of all variables that can make a difference (Figure 5). Samples T1D1 and T1D2 had the most different properties from the other samples based on the variables of temperature and boiling time. TFC and TPC parameters have a positive correlation characterized by the angle formed between with the angle formed between the two parameters is very small less than 45°. TFC and TPC parameters also have a positive correlation relationship to the boiling temperature variable. Research in 2016 had similar results where TFC and TPC had a positive correlation in boiling Egyptian sweet and chilli pepper [35]. Sample T3D1 has similar properties to the TPC parameter

so that it can be concluded that sample T3D1 is dominant to the TPC parameter. Meanwhile, samples T2D4 and T2D3 have a tendency with RSA parameters. Samples T1D4 and T1D3 have the same tendency with the variable boiling time.

IV. CONCLUSION

The amount of total flavonoids, total phenols, and radical scavenging activity were all highly impacted by the boiling temperature and duration. Boiling at 95°C for 20 minutes produced the maximum levels of total flavonoids, total phenols, and radical scavenging activity in *C. asiatica* heated water. There was a substantial relationship between temperature, total flavonoids, and total phenols, with total flavonoids and total phenols rising with rising boiling temperatures. The metrics of total flavonoids content and total phenols content correlated positively. The time parameter, on the other hand, correlated positively with radical scavenging activity.

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Exploring Riparian Vegetation Dynamics and Water Quality Assessment of Welang River – East Java

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Abstract- The Welang watershed is a river that authority of East Java Province, located in three administration (Malang Regency, Pasuruan Regency and Pasuruan City). Welang catchment area from upstream to downstream is 511.60 km², with main river length 40.09 km. The Welang river basin accommodates surface water (57 tributaries) and ground water (79 springs) in the area of Mount Arjuna (3.200 m) and Mount Bromo (2.400 m). Welang river from upstream to downstream have environmental problems. Riparian vegetation is plants that are found growing and on river banks and function as a transitional ecosystem between aquatic and terrestrial habitats. The main target in Global Strategic Plant Conservation (GSPC) is the study of plant diversity, especially in priority threatened habitats. So an initial study of riparian vegetation diversity in the Welang watershed is very important. Riparian areas are useful for maintaining river water quality and potential for environmental phytoremediation. Result this study, diversity of riparian vegetation are 171 species (upstream), 67 species (mid-stream), 37 species (downstream) and 25 species of aquatic (ex-situ) with 40 species of forest terrestrial (in-situ). The Welang water quality at upstream contained organic. The middle part has the same content, no an-organic found. Meanwhile, the downstream contained an-organic.

Keywords; Plant; Riparian; Aquatic; Terrestrial; Watershad

I. INTRODUCTION

Water plays a vital role in life, and one of its main sources is river. River not only provide water for daily needs, but also support the surrounding ecosystem. In addition, rivers also play an important role in the hydrological cycle, flowing rainwater from land to the ocean [1]. A land area that is a unity with rivers and tributaries is called a river basin or commonly abbreviated as DAS [2]. The main function of DAS based on Government Regulation

No. 37 Year 2012 concerning River Basin Management is to accommodate, store, and flow water from rainfall to the sea or lake naturally.

One of the strategic watersheds and its management under the authority of the East Java province is the Welang River Basin. Welang watershed is one of the rivers that passes through three administrative areas in East Java Province. The total area of the Welang river basin that passes through Malang Regency, Pasuruan Regency, and Pasuruan City from upstream to downstream is 511.60 km² with the main river having a length of 40.09 km [3]. The Welang watershed accommodates surface water in 57 tributaries and groundwater in 79 springs located in the Mount Arjuna area (+3,200 m) and Mount Bromo (+2,400 m) [2]. The Welang river in its upstream part is a strategic conservation area. The Mount Arjuna area is included in the TAHURA R. Soerjo Forest Park while the Mount Bromo area is included in the TN Bromo-Tengger-Semeru National Park. Then before entering the middle / main stream of the Welang river, there are two ecosystems, namely: a conservation forest ecosystem, TWA Gunung Baung Nature Tourism Park as an in-situ conservation area, and a conserved vegetation ecosystem in the Purwodadi Botanic Garden as an ex-situ conservation area.

The challenge for the Welang river which is located in a strategic area and a divider between in-situ and ex-situ conservation ecosystems is its location which is also close to residential areas, agriculture and industry. So that it becomes a factor that can cause pollution in the Welang watershed, in addition to erosion and sedimentation from the upstream area. According to the research results, the carrying capacity of each part of Welang watershed has moderate to poor quality [4]. In addition, vegetation cover in the middle to downstream of Welang watershed is in very

poor condition. Whereas vegetation on the banks of the river has a very important role in supporting the surrounding ecosystem.

Vegetation on riverbanks is a transition area between aquatic ecosystems and terrestrial ecosystems that have important value and function to protect living things around the river. Vegetation in the transitional ecosystem is well known as riparian vegetation. Riparian is a wetland ecosystem with a high water level because it is directly related to aquatic or river ecosystems [5],[6]. Vegetation in riparian ecosystems is a buffer zone for water management and functions as a river embankment, which is located on the right and left of the river body. Riparian vegetation provides ecological functions as a filter for runoff water, retaining nutrients and sediment, and also being a habitat for wildlife.

The function of riparian vegetation to maintain river water quality and the existence of organisms living in rivers makes riparian ecosystems have great potential for environmental phytoremediation. Phytoremediation comes from the word phyto which means plants (Greek: phyton), and the word remediation which means repairing or cleaning something (Latin: remediare). The concept of phytoremediation is quite simple, economical, effective, and environmentally friendly, because it takes into ecological aspects in ecosystem [7], [8]. The concept of water recovery using plant technology is not yet widely known to the public, even though the phytoremediation process is relatively easy to implement, has low operational costs and abundant availability of plant vegetation. The public does not yet know much about the ecological benefits of these plants [9]. The lack of knowledge regarding information on plant potential is due to the lack of distribution of educational media that is easily accessible online [10].

In addition to its potential as a phytoremediator, riparian vegetation in the Welang river is also a supporting vegetation for conservation areas. So that vegetation along the Welang river must be well known and maintained in balance in the ecosystem. This is also in line with the objectives of the GSPC (Global Strategic Plant Conservation) to document important specific habitats and stop the loss of plant diversity. Therefore, it is necessary to conduct a comprehensive inventory of the diversity of riparian vegetation species from upstream, middle and downstream as well as in existing conservation areas and to measure water quality in Welang river - East Java. This research is very important as a form of monitoring water quality and transitional ecosystems that support conservation areas and play an important role in environmental remediation.

II. MATERIALS AND METHOD

This research used descriptive methods, which were conducted for three years, from 2021 to 2023. There were

three stages of research, namely: 1. Collecting data and information from relevant agencies and literature studies. 2. Conducting a field survey and determining the location of plant diversity research, and 3. Sampling water quality along Welang river from upstream, midstream and downstream, Welang watershed map and distribution of water sampling points, can be seen in Figure 1. Monitoring of river water quality using test kits consisting of 14 parameters, and measurements for environmental quality. Data obtained from the results of literature studies and direct vegetation observations and measurements of water quality in the Welang river are presented in the results and discussions with carried out by processing and rearranging the data obtained and then presenting them in tables form or figures and in text description.

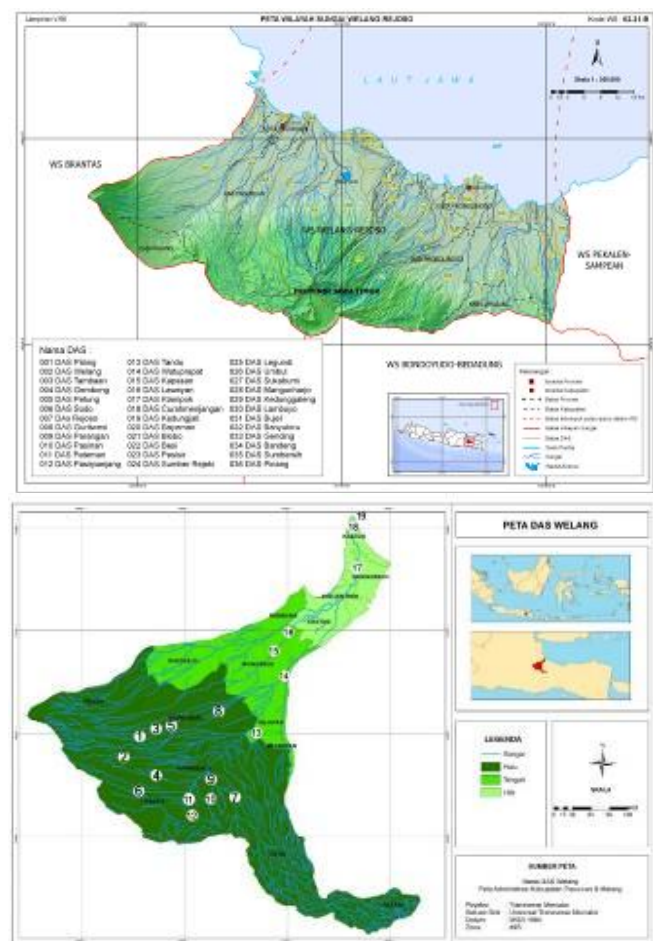


Fig. 1 Map of the Welang-Rejoso River Basin (WS) (a) and Map of the Welang Watershed (DAS) with 19 points of water quality sampling (b).

III. RESULT AND DISCUSSION

The Welang watershed has environmental degradation in the form of critical land, low land fertility, soil damage is light to moderate, and the main priority is

erosion factors [11]. The decline in land quality is in line with the decline in water quality in Welang river, due to waste disposal, domestic, agricultural and industrial waste. So that all activities communities along the Welang river affect the quality of the river water [12]. In addition, the frequent flooding problems in the Welang Watershed [13], this is certainly inseparable from the hydrological cycle that has changed due to human activities that change the landscape. Human factors that are less aware of the function of the river so that they carry out destruction, deforestation and changes in border land into settlements in river areas cause water absorption to disappear and result in flooding during the rainy season. The results study of the Erosion Hazard Level (TBE) in the Welang river [14] from very light TBE (20.88%), light TBE (38.51%), moderate TBE (17.69%), heavy TBE (15.04%) and very heavy TBE (7.88%). The occurrence of this erosion is determined by climate factors (rainfall), topography, vegetation cover and land use. So that the composition of land use in the upper Welang watershed should be managed as much as 50% of the total watershed area and plan land use according to its function.

The environmental problems and damage that occur above, such as erosion, flooding, sedimentation, soil degradation, and decreased water quality, can be overcome with natural plant-based technology, or what is known as phytotechnology. This technology can be applied by starting with baseline data on the existence of riparian vegetation along the Welang river. Riparian plants can maintain river water quality, through phytoremediation mechanisms so that river ecosystems can be naturally purified and the existence of living things in the river (river biota) makes the riparian ecosystem have great potential to be protected and maintained sustainably. The results of vegetation observations along the Welang river from upstream, middle and downstream obtained a list of the diversity of riparian vegetation species in the Welang river, as can be seen in table 1.

Table 1. List of Riparian Vegetation in Welang River.

No.	Species	Family	U	M	D
1	<i>Abelmoschus moschatus</i>	Malvaceae	✓		
2	<i>Achyranthes aspera</i>	Amaranthaceae	✓		
3	<i>Adenanthera pavonine</i>	Fabaceae	✓		
4	<i>Adiantum philippense</i>	Pteridaceae	✓		
5	<i>Aeschynomene elegans</i>	Fabaceae	✓		
6	<i>Ageratum conyzoides</i>	Asteraceae	✓		
7	<i>Albizia chinensis</i>	Fabaceae	✓		✓
8	<i>Albizia falcata</i>	Fabaceae	✓	✓	✓
9	<i>Albizia lebbekoides</i>	Fabaceae	✓	✓	
10	<i>Albizia procera</i>	Fabaceae	✓	✓	
11	<i>Albizia saman</i>	Fabaceae			✓
12	<i>Alstonia scholaris</i>	Apocynaceae	✓		
13	<i>Alternanthera sessilis</i>	Amaranthaceae	✓		
14	<i>Amorphophallus variabilis</i>	Araceae	✓		
15	<i>Ampelocissus thyrsoflora</i>	Vitaceae	✓		
16	<i>Annona muricata</i>	Annonaceae	✓		

No.	Species	Family	U	M	D
17	<i>Annona squamosa</i>	Annonaceae		✓	
18	<i>Antiaris toxicaria</i>	Moraceae	✓		
19	<i>Arcypteris irregularis</i>	Aspidiaceae	✓		
20	<i>Arenga pinnata</i>	Arecaceae	✓		✓
21	<i>Artocarpus altilis</i>	Moraceae	✓		
22	<i>Artocarpus elasticus</i>	Moraceae	✓		✓
23	<i>Artocarpus heterophyllus</i>	Moraceae	✓		✓
24	<i>Artocarpus sericarpus</i>	Moraceae	✓		
25	<i>Asystasia gangetica</i>	Acanthaceae	✓		
26	<i>Athyrium esculentum</i>	Athyriaceae	✓		
27	<i>Averrhoa bilimbi</i>	Oxalidaceae	✓	✓	
28	<i>Avicennia marina</i>	Verbenaceae			✓
29	<i>Axonopus compressus</i>	Poaceae	✓		
30	<i>Azadirachta indica</i>	Meliaceae			✓
31	<i>Balakata baccata</i>	Euphorbiaceae	✓		
32	<i>Bambusa arundinacea</i>	Poaceae			✓
33	<i>Bambusa blumea</i>	Poaceae		✓	
34	<i>Bambusa vulgaris</i>	Poaceae		✓	
35	<i>Barleria prionitis</i>	Acanthaceae		✓	
36	<i>Barringtonia acutangula</i>	Lecythidaceae	✓	✓	
37	<i>Belgia capensis</i>	Meliaceae	✓		
38	<i>Bidens biternate</i>	Asteraceae	✓		
39	<i>Bidens Pilosa</i>	Asteraceae	✓		
40	<i>Bischofia javanica</i>	Euphorbiaceae	✓		
41	<i>Blumea lacera</i>	Asteraceae	✓		
42	<i>Bombax ceiba</i>	Bombacaceae			✓
43	<i>Calliandra houstoniana</i>	Fabaceae	✓		
44	<i>Calopogonium mucunoides</i>	Fabaceae	✓	✓	
45	<i>Calotropis gigantea</i>	Asclepiadaceae	✓		
46	<i>Cananga odorata</i>	Annonaceae	✓		
47	<i>Canarium vulgare</i>	Burseraceae	✓		
48	<i>Capparis micrantha</i>	Capparaceae	✓		
49	<i>Carica papaya</i>	Caricaceae	✓	✓	
50	<i>Cascabela pinifolia</i>	Apocynaceae	✓		
51	<i>Cascabella thevetia</i>	Apocynaceae		✓	
52	<i>Cassia fistula</i>	Fabaceae		✓	
53	<i>Cayratia trifolia</i>	Vitaceae	✓		
54	<i>Ceiba pentandra</i>	Bombacaceae	✓	✓	✓
55	<i>Centrosema pubescens</i>	Fabaceae	✓		
56	<i>Cerbera floribunda</i>	Apocynaceae	✓		
57	<i>Cerbera odollam</i>	Apocynaceae	✓		
58	<i>Christella arida</i>	Thelypteridaceae	✓		
59	<i>Chromolaena odorata</i>	Asteraceae	✓		
60	<i>Cleome viscosa</i>	Capparaceae		✓	
61	<i>Clinacanthus nutans</i>	Acanthaceae	✓		
62	<i>Coix lacryma-Jobi</i>	Poaceae	✓		
63	<i>Commelina benghalensis</i>	Commelinaceae	✓		
64	<i>Corchorus aestuans</i>	Tiliaceae	✓		
65	<i>Cordia bantamensis</i>	Boraginaceae		✓	✓
66	<i>Corypha utan</i>	Arecaceae			✓
67	<i>Crotalaria pallida</i>	Fabaceae	✓		
68	<i>Cyathula prostrata</i>	Amaranthaceae	✓		
69	<i>Cymbopogon citratus</i>	Poaceae		✓	
70	<i>Dehaasia caesia</i>	Lauraceae	✓		
71	<i>Delonix regia</i>	Fabaceae	✓		
72	<i>Dendrocalamus giganteus</i>	Poaceae			✓
73	<i>Dendrocnide stimulans</i>	Urticaceae	✓		
74	<i>Derris elliptica</i>	Fabaceae		✓	
75	<i>Desmodium triflorum</i>	Fabaceae	✓		
76	<i>Dimocarpus longans</i>	Sapindaceae		✓	
77	<i>Diospyros cauliflora</i>	Ebenaceae	✓		
78	<i>Diospyros macrophylla</i>	Ebenaceae	✓		
79	<i>Dracontomelon dao</i>	Anacardiaceae	✓		
80	<i>Durio zibethinus</i>	Malvaceae	✓		

No.	Species	Family	U	M	D
81	<i>Dysoxylum gaudicaudium</i>	Meliaceae	✓	✓	
82	<i>Elephantopus scaber</i>	Asteraceae	✓		
83	<i>Eleusine indica</i>	Poaceae	✓		
84	<i>Eranthemum pulchellum</i>	Acanthaceae	✓		
85	<i>Eucalyptus platyphylla</i>	Myrtaceae	✓		
86	<i>Euphorbia hirta</i>	Euphorbiaceae	✓		
87	<i>Excoecaria agallocha</i>	Euphorbiaceae			✓
88	<i>Ficus copiosa</i>	Moraceae	✓		
89	<i>Ficus hispida</i>	Moraceae		✓	
90	<i>Ficus racemosa</i>	Moraceae	✓	✓	✓
91	<i>Ficus septica</i>	Moraceae	✓		
92	<i>Ficus variegata</i>	Moraceae	✓		✓
93	<i>Ficus virens</i>	Moraceae	✓	✓	
94	<i>Galinosa quadriradiata</i>	Asteraceae	✓		
95	<i>Gigantochloa apus</i>	Poaceae		✓	✓
96	<i>Gigantochloa aster</i>	Poaceae		✓	
97	<i>Gliricidia sepium</i>	Fabaceae	✓		
98	<i>Gmelina arborea</i>	Verbenaceae	✓	✓	✓
99	<i>Hedyotis corymbosa</i>	Rubiaceae	✓		
100	<i>Hibiscus tiliaceus</i>	Malvaceae			✓
101	<i>Hiptage benghalensis</i>	Malpighiaceae	✓		
102	<i>Homalomena pendula</i>	Araceae	✓		
103	<i>Hopea sangal</i>	Dipterocarpaceae	✓		
104	<i>Hypobatrachium peutilicum</i>	Liliaceae		✓	
105	<i>Imperata cylindrica</i>	Poaceae	✓		
106	<i>Ipomea asiatica</i>	Convolvulaceae		✓	
107	<i>Ipomoea fistulosa</i>	Convolvulaceae	✓		
108	<i>Jasminum multiflorum</i>	Oleaceae	✓		
109	<i>Jatropha multifida</i>	Euphorbiaceae	✓		
110	<i>Kigelia Africana</i>	Bignoniaceae	✓		
111	<i>Kleinhovia hospital</i>	Sterculiaceae	✓	✓	
112	<i>Kyllinga monocephala</i>	Cyperaceae	✓		
113	<i>Lagerstroemia thorelii</i>	Lytracheae	✓		
114	<i>Lansea coromandelica</i>	Anacardiaceae	✓	✓	
115	<i>Laportea aetuous</i>	Urticaceae	✓		
116	<i>Leea indica</i>	Leeaceae	✓		
117	<i>Leucaena leucocephala</i>	Fabaceae	✓	✓	✓
118	<i>Litsea glutinosa</i>	Lauraceae	✓		
119	<i>Ludwigia octovalvis</i>	Onagraceae	✓		
120	<i>Magnolia candolii</i>	Magnoliaceae	✓		
121	<i>Mangifera indica</i>	Anacardiaceae	✓	✓	✓
122	<i>Manilkara akra</i>	Sapotaceae	✓	✓	
123	<i>Maranta arundinacea</i>	Marantaceae	✓		
124	<i>Melanolepis multiglandulosa</i>	Euphorbiaceae	✓		
125	<i>Melicoccus bijugatus</i>	Sapindaceae			✓
126	<i>Melochia umbellata</i>	Sterculiaceae	✓	✓	
127	<i>Meremia emerginata</i>	Convolvulaceae	✓	✓	
128	<i>Microcos tomentosa</i>	Euphorbiaceae	✓		
129	<i>Microlepia speluncae</i>	Dennstaedtiaceae	✓		
130	<i>Mikania cordata</i>	Asteraceae	✓		
131	<i>Mimosa borealis</i>	Fabaceae		✓	
132	<i>Mimosa pudica</i>	Leeaceae	✓		
133	<i>Moghania strobilifera</i>	Fabaceae	✓		
134	<i>Moringa oleifera</i>	Moringaceae	✓		✓
135	<i>Mucuna propraena</i>	Fabaceae		✓	
136	<i>Muntingia calabura</i>	Elaeocarpaceae	✓	✓	✓
137	<i>Murdannia nudiflora</i>	Commelinaceae	✓		
138	<i>Musa paradisiaca</i>	Musaceae		✓	
139	<i>Naucllea orientalis</i>	Rubiaceae	✓	✓	
140	<i>Nephrolepis radikal</i>	Dryopteridaceae	✓		
141	<i>Octomeles sumatrana</i>	Datiscaceae	✓		
142	<i>Oplismenus burmanni</i>	Poaceae	✓		
143	<i>Oplismenus compositus</i>	Poaceae	✓		
144	<i>Orophea enneandra</i>	Annonaceae	✓		

No.	Species	Family	U	M	D
145	<i>Oxalis barrelieri</i>	Oxalidaceae	✓		
146	<i>Paederia scandens</i>	Rubiaceae	✓		
147	<i>Parkia speciosa</i>	Fabaceae	✓	✓	
148	<i>Parkia timoriana</i>	Fabaceae	✓		
149	<i>Paspalum conjugatum</i>	Poaceae	✓		
150	<i>Passiflora foetida</i>	Passifloraceae	✓	✓	
151	<i>Pennisetum purpureum</i>	Poaceae	✓	✓	
152	<i>Peperomia pellucida</i>	Piperaceae	✓		
153	<i>Persea americana</i>	Lauraceae	✓	✓	
154	<i>Phyllanthus niruri</i>	Euphorbiaceae	✓		
155	<i>Phyllanthus reticulatus</i>	Euphorbiaceae	✓		
156	<i>Pinus merkusii</i>	Pinaceae	✓		✓
157	<i>Piper cubeba</i>	Piperaceae	✓		
158	<i>Pisonia aculeata</i>	Nyctaginaceae	✓		
159	<i>Pisonia umbellata</i>	Nyctaginaceae	✓		
160	<i>Pogonanthera paniceum</i>	Polytrichaceae		✓	
161	<i>Pogonatherum marceum</i>	Poaceae	✓		
162	<i>Polyalthia littoralis</i>	Annonaceae	✓		
163	<i>Polyalthia longifolia</i>	Polytrichaceae		✓	
164	<i>Pometia pinnata var. javanica</i>	Sapindaceae	✓		
165	<i>Pragmites orca</i>	Poaceae		✓	
166	<i>Protium javanicum</i>	Burseraceae	✓		
167	<i>Pseudelephantopus spicatus</i>	Asteraceae	✓		
168	<i>Psidium guajava</i>	Myrtaceae	✓		
169	<i>Psydrax dicoccos</i>	Rubiaceae	✓		
170	<i>Pteris cretica</i>	Pteridaceae	✓		
171	<i>Pteris ensiformis</i>	Pteridaceae	✓		
172	<i>Pterocarpus indicus</i>	Fabaceae		✓	
173	<i>Pterospermum diversifolium</i>	Sterculiaceae	✓		
174	<i>Rhizophora mucronata</i>	Rhizophoraceae			✓
175	<i>Ricinus communis</i>	Euphorbiaceae		✓	✓
176	<i>Rivina humilis</i>	Phytolaccaceae	✓		
177	<i>Roystonea regia</i>	Arecaceae	✓		
178	<i>Schizostachyum tiaminsi</i>	Poaceae		✓	
179	<i>Schleichera oleosa</i>	Sapindaceae	✓	✓	
180	<i>Scoparia dulcis</i>	Plantaginaceae	✓		
181	<i>Semecarpus heterophylla</i>	Anacardiaceae	✓		
182	<i>Senna spectabilis</i>	Fabaceae	✓	✓	
183	<i>Sida acuta</i>	Malvaceae	✓		
184	<i>Sonneratia alba</i>	Lythraceae			✓
185	<i>Spathodea campanulate</i>	Bignoniaceae			✓
186	<i>Spermacoce articularis</i>	Rubiaceae	✓		
187	<i>Spigelia anthelmia</i>	Loganiaceae	✓		
188	<i>Sporobolus diander</i>	Poaceae	✓		
189	<i>Stenochlaena palustris</i>	Blechnaceae	✓		
190	<i>Sterculia coccinea</i>	Sterculiaceae	✓		
191	<i>Sterculia foetida</i>	Sterculiaceae	✓		✓
192	<i>Swietenia macrophylla</i>	Meliaceae	✓		✓
193	<i>Synedrella nodiflora</i>	Asteraceae	✓		
194	<i>Syzygium cumini</i>	Myrtaceae	✓		
195	<i>Syzygium formosum</i>	Myrtaceae	✓		
196	<i>Syzygium littorale</i>	Myrtaceae	✓	✓	✓
197	<i>Syzygium pycnanthum</i>	Myrtaceae	✓		
198	<i>Tabernaemontana sphaerocarpa</i>	Apocynaceae	✓		
199	<i>Tagetes erecta</i>	Asteraceae	✓		
200	<i>Tamarindus indica</i>	Fabaceae			✓
201	<i>Tectaria aurita</i>	Dryopteridaceae	✓		
202	<i>Tectona grandis</i>	Verbenaceae	✓	✓	✓
203	<i>Terminalia catappa</i>	Combretaceae			✓
204	<i>Theobroma cacao</i>	Sterculiaceae	✓		
205	<i>Tithonia diversifolia</i>	Asteraceae	✓		
206	<i>Trema orientalis</i>	Cannabaceae		✓	
207	<i>Tridax procumbens</i>	Asteraceae	✓		
208	<i>Urena lobata</i>	Verbenaceae		✓	

No.	Species	Family	U	M	D
209	<i>Voacanga grandiflora</i>	Apocynaceae	✓		
210	<i>Wedelia biflora</i>	Asteraceae	✓		
211	<i>Wrightia tomentosa</i>	Apocynaceae	✓	✓	
212	<i>Xylocarpus granatum</i>	Meliaceae			✓

U (upstream), M (midstream), D (downstream).

One of the characteristics of riparian vegetation is that it can adapt to wetland environments and serves as a habitat for terrestrial and aquatic biota. This vegetation is habitually found to include shrubs, herbs, bushes, and trees. The diversity of riparian vegetation species in the Welang river is described into three river sections, namely: upstream, middle, and downstream.

In the upstream part of the Welang River, 171 species of riparian vegetation have been inventoried. In the upstream riparian vegetation, it is divided into two, namely agricultural riparian vegetation and natural riparian vegetation. Agricultural riparian vegetation is a species of plant that is planted in the riparian zone, such as: rice, corn, chocolate, and various species of fruit plants. While natural riparian vegetation is a plant that grows naturally on the banks of the river such as grass, weeds, bushes, bushes and trees of various other species [6].

In the middle part of the Welang River, there are 67 species of riparian vegetation. Of the 67 species found, they come from 29 families, with the largest family being Fabaceae with 12 species. In general, the riparian vegetation in the middle part of the Welang river has tree habitus and understory vegetation / ground cover. The number of riparian vegetation species in the middle part is less than in the upstream part, because the conditions are in residential areas, factory/industrial areas and agricultural land/ fields that are very close to human activities [15].

In the downstream of the Welang River, 37 species were recorded. Of the 37 species, they came from 21 different families, with the dominant families being Fabaceae and Moraceae. Riparian vegetation found in the downstream of the Welang river generally has tree habitus, which includes mangrove vegetation (13.5%), coastal vegetation (10.8%), and lowland vegetation (75.7%). If observed from the upstream, middle and downstream which are increasingly towards the river mouth, there is less diversity of species. This is due to the increasingly dense population or the destruction of land functions along the river as built-up areas and also in the estuary area which is the final destination of water flow which on its journey is mixed with waste / contaminated with pollutants that are discharged into the river environment [5].

From the description above, it shows that the dynamics of riparian vegetation in the upstream Welang river are 171 species, the middle part 67 species and the downstream part 37 species. When viewed the total number of Welang river from upstream, middle and

downstream has 275 vegetation. However, this does not take into account duplication or the presence of the same species in each part of the river. So if an inventory is carried out based on species, there are 212 riparian vegetation species. The Species found in all parts of the Welang river, from upstream, middle and downstream are: *Albizia falcataria* (Fabaceae), *Ceiba pentandra* (Bombacaceae), *Ficus racemosa* (Moraceae), *Gmelina arborea* (Verbenaceae), *Mangifera indica* (Anacardiaceae), *Muntingia calabura* (Elaeocarpaceae), *Syzygium littorale* (Myrtaceae), and *Tectona grandis* (Verbenaceae). Of the 212 riparian vegetation species as listed in table 1, only 8 species of vegetation are found throughout the Welang river. The eight species have tree habitus and are terrestrial vegetation types.

Table 2. List of Terrestrial Plants in In-Situ Conservation Area (TWA G.Baung)

No.	Species	Family
1	<i>Acacia auriculiformis</i>	Fabaceae
2	<i>Albizia chinensis</i>	Fabaceae
3	<i>Annona muricata</i>	Annonaceae
4	<i>Anthocephalus cadamba</i>	Rubiaceae
5	<i>Artocarpus elasticus</i>	Moraceae
6	<i>Artocarpus heterophyllus</i>	Moraceae
7	<i>Artocarpus sericicarpus</i>	Moraceae
8	<i>Arytera litoralis</i>	Sapindaceae
9	<i>Butea monosperma</i>	Fabaceae
10	<i>Calliandra calothyrsus</i>	Fabaceae
11	<i>Canthium glabrum</i>	Rubiaceae
12	<i>Ceiba pentandra</i>	Malvaceae
13	<i>Chrysophyllum caimito</i>	Sapotaceae
14	<i>Dendrocalamus asper</i>	Poaceae
15	<i>Durio zibethinus</i>	Malvaceae
16	<i>Ervatamia sphaerocarpa</i>	Apocynaceae
17	<i>Ficus hispida</i>	Moraceae
18	<i>Ficus septica</i>	Moraceae
19	<i>Firmiana malayana</i>	Sterculiaceae
20	<i>Gigantochloa apus</i>	Poaceae
21	<i>Gliricidia sepium</i>	Fabaceae
22	<i>Gmelina arborea</i>	Lamiaceae
23	<i>Jacaranda obtusifolia</i>	Bignoniaceae
24	<i>Kleinhovia hospital</i>	Malvaceae
25	<i>Lannea coromandelica</i>	Anacardiaceae
26	<i>Mallotus peltatus</i>	Euphorbiaceae
27	<i>Mangifera indica</i>	Anacardiaceae
28	<i>Melanolepis multiglandulosa</i>	Euphorbiaceae
29	<i>Microcos tomentosa</i>	Euphorbiaceae
30	<i>Parkia speciosa</i>	Fabaceae
31	<i>Parkia timoriana</i>	Fabaceae
32	<i>Persea americana</i>	Lauraceae
33	<i>Psidium Guajava</i>	Myrtaceae
34	<i>Pterocymbium javanicum</i>	Sterculiaceae
35	<i>Reutealis trisperma</i>	Euphorbiaceae
36	<i>Senna spectabilis</i>	Fabaceae
37	<i>Streblus asper</i>	Moraceae
38	<i>Swietenia macrophylla</i>	Meliaceae
39	<i>Syzygium polyanthum</i>	Myrtaceae
40	<i>Tectona grandis</i>	Lamiaceae

The 8 species of riparian vegetation found on the Welang river are terrestrial vegetation. If these species are compared with the natural terrestrial vegetation that grows in the TWA G.Baung area, there are 40 species, as can be seen in table 2, The species taht found in both in the Welang river and those in the TWA G.Baung is *Tectona grandis* (Verbenaceae). Meanwhile, if the species of aquatic vegetation found in the Welang river are compared with those in the KKI Purwodadi Botanic Gardens collection, there are 25 species, as can be seen in table 3, then only two species were found same, namely *Coix lacryma-jobi* (Poaceae) and *Ludwigia octovalvis* (Onagraceae).

Table 3. List of Aquatic Plants in Ex-Situ Conservation Area (KKI KRPurwodadi).

No.	Species	Family
1	<i>Acanthus ilicifolius</i>	Acanthaceae
2	<i>Achanthus montanus</i>	Acanthaceae
3	<i>Acorus calamus</i>	Acoraceae
4	<i>Actinocarpus grossus</i>	Arecaceae
5	<i>Ceratophyllum demersum</i>	Ceratophyllaceae
6	<i>Ceratopteris thalictroides</i>	Adiantaceae
7	<i>Coix lacryma-Jobi</i>	Poaceae
8	<i>Cyperus alternifolius</i>	Cyperaceae
9	<i>Echinodorus radicans</i>	Alismataceae
10	<i>Ipomea aquatica</i>	Convolvulaceae
11	<i>Lasia spinosa</i>	Araceae
12	<i>Lemna minor</i>	Araceae
13	<i>Limncharis flava</i>	Alismataceae
14	<i>Ludwigia octovalvis</i>	Onagraceae
15	<i>Nelumbo nucifera</i>	Nelumbonaceae
16	<i>Neptunia plena</i>	Fabaceae
17	<i>Nymphaea alba</i>	Nymphaeaceae
18	<i>Nymphaea rubra</i>	Nymphaeaceae
19	<i>Nymphaea stellata</i>	Nymphaeaceae
20	<i>Pistia stratiotes</i>	Araceae
21	<i>Pontederia cordata</i>	Pontederiaceae
22	<i>Sagittaria lancifolia</i>	Alismataceae
23	<i>Salvinia molesta</i>	Salviniaceae
24	<i>Thalia geniculata</i>	Marantaceae
25	<i>Typhonodorum lindleyatum</i>	Araceae

The Welang River is located in a strategic hydrological area in East Java Province. The Welang watershed is located in the middle of the Bromo Tengger Semeru Arjuno Biosphere Reserve (CB BTSA). Where the upstream part is a row of hills / mountains from TAHURA (Forest Park) R. Soerjo and TN. BTS (Bromo Tengger Semeru National Park) and the main Welang river upstream passes through in-situ and ex-situ conservation areas and as a boundary between the two areas. The in-situ conservation area is the TWA G.Baung (Nature Tourism Park) and the Scientific Conservation Area (KKI) of the Purwodadi Botanic Garden which is an ex-situ plant conservation area. The strategic position of the Welang watershed can be seen in Figure 2.

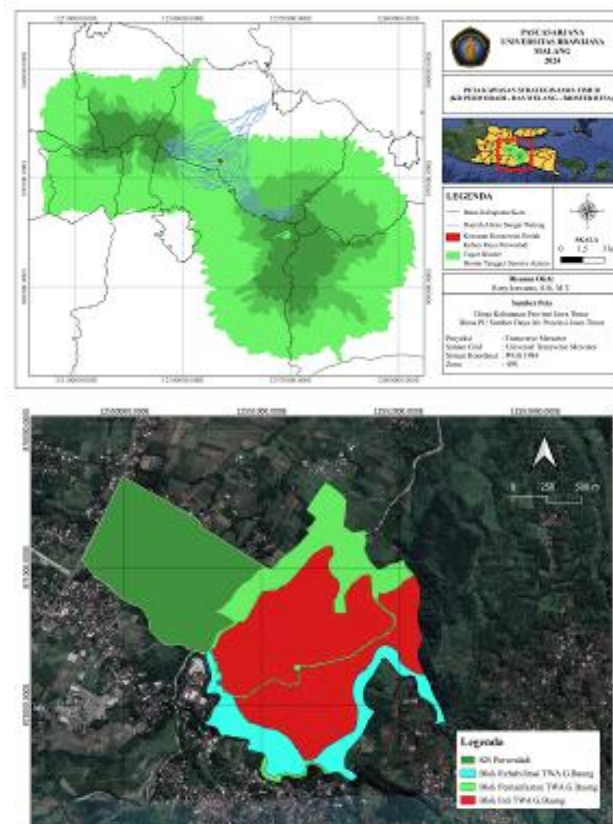


Fig. 2. Map of Strategic Area in DAS Welang (CB BTSA) (a) and Map of Conservation Areas In-Situ and Ex-Situ (b).

The results of riparian vegetation exploration along the Welang eiver from upstream to downstream obtained a total of 212 species. When compared with the inventory data of terrestrial vegetation species in the TWA G.Baung area of 40 species and also aquatic vegetation species in the KKI Purwodadi Botanic Gardens of 25 species.

However, the reality today is that riparian vegetation has experienced a lot of damage and pollution due to human activities that threaten its sustainability. In addition, the lack of attention from area managers or stakeholders and the change of riparian areas into built-up areas, has caused the loss of riparian functions in holding back rainwater flow and other ecological functions. The reduction or even loss of riparian vegetation diversity can be prevented by efforts to restoration, reforestation or revegetation of river boundaries, especially in the upstream area which hydrologically is a forest area that acts as a catchment area.

Therefore, the plants in both conservation areas are very suitable to be used as a recommendation species for habitat restoration in river ecosystems, especially in the Welang Watershed. Other, in the enrichment of riparian vegetation that low vegetation diversity in the downstream part of the Welang River. The existence of riparian vegetation in Welang watershed is very important for monitoring and knowing the condition of the river water

environment. In general, riparian vegetation with tree habitus is important in strengthening river transects, protecting riverbanks from erosion and flooding, where the root structure is strong in gripping the soil and the sturdy stem shape and crown architecture support wildlife habitat. Meanwhile, to maintain the quality of river water, riparian vegetation, especially those with aquatic habitats, can be an indicator as well as a phytoremediator in filtering pollutants and restoring river water so that its quality remains good.

Welang River monitoring efforts were also carried out, considering that the 40.09 km long Welang River only has three monitoring stations, namely Station 1 in Purwodadi, brown water conditions and lots of vegetation. Station 2 in Selowongko, brown water conditions, lots of sediment, and little vegetation. Station 3 in Dhompo, water conditions with little sediment, and not much vegetation. Overall, the condition of the Welang River from the upstream is not very good in terms of physical quality [2]. So direct monitoring of the water quality of the Welang River was carried out at 19 locations from the upstream, middle and downstream,

the results of water quality monitoring are presented in Table 4.

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Table 4 Water Quality Parameters for the Upstream, Middle and Downstream Welang River Basin.

Parameters	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Ph	6.98	7.15	7.89	6.83	7.28	7.76	7.95	7.85	8.16	7.59	7.65	7.5	7.76	6.98	6.89	6.75	8	8	8.3
TDS	84	53.5	95.5	107.5	121	132.5	76.5	110.5	139.5	152	127	151.5	127.5	128.5	150.5	208.5	214	234	1000
Water Temperature	27.6	24.45	28.2	28.2	28.3	31.55	24.35	29.7	28.7	29.34	28.35	27.9	29.55	30.1	28.5	58.7	34.6	31.5	31.5
Hardness	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Alkalinity	180	80	120	80	80	80	80	120	180	120	120	120	160	80	120	120	100	120	120
Free Chlorine	0	0	0	0	0	0.5	0	0	0.5	0.5	0	0.5	1	0.5	0	0	0	0	0
Total Chlorine	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	2	1
Nitrate	100	100	100	100	100	100	100	100	100	100	100	100	25	50	25	25	0	0	0
Nitrite	20	20	20	20	20	20	20	20	20	20	20	20	5	10	5	5	0	0	0
Fluoride (Fluor)	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	0	0	1
Iodine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyanuric Acid	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0
Carbonate Root	20	20	0	20	0	20	20	20	20	20	20	20	20	20	20	20	0	0	0
Free Bromine	0	0	0	0	0	1	0	0	1	1	0	1	1	0.5	0	0	0	0	0
Iron	0	0	0	0	0	5	0	0	5	0	0	0	0	0	0	0	0	0	0
Copper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	3	1
Lead	50	50	50	50	50	50	20	50	50	50	50	50	20	50	50	20	30	30	30

In the upstream part of Welang there are 12 points, number 1-12 points location which are divided into two streams, 6 points from Mount Arjuna and 6 points from Mount Bromo. While the middle part of Welang there are 4 points, which are at location points number 13-16, and the downstream part there are 3 points, at location points number 17-19.

The results of monitoring the pH parameters in the Welang river from upstream to downstream range from 6.7-8.3 which is still considered normal water pH conditions. If the water pH decreases to become acidic or increases to become alkaline, it can disrupt the balance of the aquatic ecosystem. The pH concentration affects the level of water fertility because it affects the life of

microorganisms. Acidic waters tend to cause fish death, as does a pH that is too alkaline. Meanwhile, monitoring the water temperature parameters ranges from 24.35°C-34.60°C which is still considered normal, this is because if the temperature exceeds 35°C it can cause fish death.

The results of chemical parameters obtained from the water test strip, in the upstream section contains Chlorine (Cl), Bromine (Br), Iron (Fe), Lead (Pb), Nitrate (NO₃-), Nitrite (NO₂-), Fluoride (F-), and Root Carbonate (CO₃ 2-), in the middle section predominantly has the same content as the upstream but no Iron (Fe) was found, while in the downstream section Chlorine (Cl), Copper (Cu), Lead (Pb) and Fluoride (F-) were found.

The discovery of Nitrate and Nitrite content in monitoring the water quality of the Welang river can be caused by agricultural waste. Nitrate is a nutrient for the growth of aquatic plants and algae, causing uncontrolled growth of aquatic flora, while nitrite is a toxic compound that can kill aquatic biota [16]. So if high nitrate causes blooming algae/aquatic flora, coupled with high nitrite causes the death of aquatic biota. Then if aquatic plant species are found such as *Coix lacrima-jobi* or *Ludwigia octovalvis* on the riverbanks of the Welang River, it is certain that these species are capable of restoring the river ecosystem or self-purifying river water.

Parameters related to heavy metals such as Iron (Fe) are highest in the upstream, Copper (Cu) is highest in the upstream, and Lead (Pb) is highest in the upstream and middle parts. These heavy metals in waters have an impact on aquatic organisms and humans. Heavy metals are one of the toxic pollutants that can cause death (lethal) or sub-lethal such as disrupting growth, behavior or changes in organism morphology. These heavy metals if they enter the human body are very dangerous for health [17].

Overall, the results of monitoring the water quality of the Welang River in the upstream section have experienced contamination from organic materials, which are likely to come from agriculture and settlements, in the middle section due to human activities, in addition to organic contamination, in-organic materials in the form of heavy metals were also found, which can be ascertained to come from industrial waste that is discharged into the river, so that in the downstream section which is the estuary of all organic and inorganic pollution.

IV. CONCLUSION

Riparian areas are useful for maintaining river water quality and potential for environmental phytoremediation. The diversity of riparian vegetation are 171 species (upstream), 67 species (mid-stream). 37 species (downstream) and 25 species of aquatic (ex-situ) with 40 species of forest terrestrial (in-situ). The Welang water quality at upstream contained organic. The middle part has the same content, no an-organic found. Meanwhile, the downstream contained an-organic.

ACKNOWLEDGMENT

Our deepest gratitude goes to the Phytotechnology and Environmental Management Research Group (2021) who have taken initial steps of riparian research in Welang river and also the support of Water Resources Agency (Dinas PU Sumber Daya Air) East Java Province, which involved researcher in judging of IHRC (Indonesia Healthy Rivers Challenge) 2021.

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Genetic Variation of Porang (*Amorphophallus muelleri* Blume) After Mutation Induction Using Colchicine

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Abstract- Porang (*Amorphophallus muelleri* Blume) is a tuberous plant with the highest glucomannan among *Amorphophallus* genera. However, the low genetic diversity of porang today can affect porang cultivation in the future. Therefore, increasing the genetic diversity of porang by polyploidy induction using colchicine is needed. 30 days after planting porang shoot explants were used for polyploidy induction. After polyploidy induction using colchicine, DNA was extracted using Geneid Genomic DNA Mini Kit. Genetic diversity and clustering analysis was performed to assess the genetic diversity of porang after mutation induction. Mutation induction using colchicine successfully increased the genetic diversity of porang. Polyploidy induction using 0.05% colchicine is recommended to increase genetic variation of porang.

Keywords: *Amorphophallus Muelleri* Blume, Genetic Diversity, Issr, Mutation, Polyploidy

I. INTRODUCTION

Porang (*Amorphophallus muelleri* Blume) is a tuberous plant [1] containing the highest glucomannan (up to 65.2%) [2] compared to other *Amorphophallus* species [3] such as *Amorphophallus paeoniifolius* (45.167%) [4], *Amorphophallus variabilis* (44%), and *Amorphophallus oncophyllus* (55%) [5]. The glucomannan is widely used in both food [6] and cosmetic industries [7]. The food industry processes porang flour into gluten-free noodles [8], shirataki [5], and konnyaku [9]. Glucomannan is also used to inhibit acne growth [10] and as a material for facial cleansing sponges [11].

The numerous benefits of glucomannan in porang tubers have made porang an export commodity for Indonesia [12]. However, the cultivation that still used tubers and bulbils [13] makes porang has low genetic diversity [14] threatening porang production in the future. Therefore, efforts to increase genetic diversity through polyploidy induction [15] using colchicine [16] are needed. Colchicine can double the number of chromosomes [17] by inhibiting the anaphase stage [18], where the spindle fibers bind to tubulin [19]. This results in the

chromosomes not separating [20], ultimately producing plants with more than one pair of chromosomes [21].

The success of polyploidy induction can be detected using inter simple sequence repeats (ISSR) molecular markers [22] due to their very high polymorphism level [23], producing a large number of fragments [24], and requiring a small amount of DNA template [25]. The ISSR 17899A and ISSR 17899B primers have been proven to identify intra- and inter-species genetic diversity in *Hedysarum chaiyrakanicum* with 100% polymorphic bands in ISSR 17899B and 96.7% in ISSR 17899A [26]. In addition, The ISSR can also characterize *Asparagus acutifolius* with 51.57% polymorphic bands [27]. Therefore, this study aims to analyze the genetic variation of porang after mutated by colchicine using inter simple sequence repeats (ISSR) molecular.

II. MATERIALS AND METHODS

A. Sample preparation

Porang (*Amorphophallus muelleri*) shoot explants ($2n=26$) were used for polyploidy induction. Explants were subcultured using Murashige and Skoog (MS) media with the addition of 2 mg/l Benzyladenine (BA). 30 days after planting, porang explants were ready for polyploidy induction.

B. Preparation of Colchicine Solution

The preparation of colchicine solution begins by dissolving colchicine powder in distilled water, then placed in sterile bottles for use as stock or immediate use. A 1% stock solution is prepared by dissolving 0.1 grams of colchicine powder in 10 mL of distilled water. This stock solution is then diluted to various concentrations: 0 (control), 0.01%, 0.02%, 0.03%, 0.04%, 0.05%, and 0.06% using the dilution formula. As per the treatment, the colchicine solution is then sterilized using a 0.22 μ m millipore filter.

C. Polyploidy Induction

Polyploidy induction with colchicine is conducted using semi-solid MS medium supplemented with 2 mg/L of benzyladenine (BA), where the colchicine solution is added to culture media that has been sterilized. The sterile medium is placed in a laminar airflow cabinet and allowed to cool to 70°C. Afterward, the sterile colchicine solution (0%, 0.01%, 0.02%, 0.03%, 0.05%, and 0.06%) filtered with a 0.22 µm millipore filter is added to the culture bottles, each containing 10 mL of media. The explants, approximately 0.5 cm in size and yellowish-green in color, are taken out of the bottles, planted in the media containing the colchicine treatments, and stored on culture racks in the incubation room.

D. Explant Maintenance

Explant grown in colchicine media is subsequently transferred to maintenance media using Murashige and Skoog (MS) media with 2 mg/L benzyladenine (BA). The explants are cultured on racks in the incubation room. Daily observations and sterilizations are performed on the explants using alcohol to prevent contamination.

E. DNA Extraction and Isolation

DNA extraction is performed using the Geneaid Genomic DNA Mini Kit according to the protocol provided in the kit. Extracted DNA was then stored in -23°C.

F. DNA Amplification and Visualization

DNA amplification follows the program as follows: initial denaturation is 94°C for 4 minutes, followed by 35 cycles consisting of denaturation for 30 seconds at 94°C, annealing for 45 seconds at a temperature corresponding to the primer used, and extension for 90 seconds at 72°C, followed by a final extension step for 6 minutes at 72°C [28].

G. Analysis Data

Scoring of amplified DNA bands aims to estimate the level of polymorphism. Scoring is done by assigning a score of '1' if a DNA band appears and '0' if the DNA band does not appear.

Genetic diversity was analyzed using parameters such as the number of observed alleles (N_a), the number of effective alleles per locus (N_e), allele frequency, polymorphic loci, genetic distance, and the Shannon index, using POPGENE software version 1.32.

The genetic characteristics of polyploid Porang were assessed through cluster analysis by comparing the control and treatment groups. Cluster analysis was conducted using the UPGMA (Unweighted Pair Group Method with Arithmetic Mean) algorithm with the Jaccard similarity index in PAST software version 3.0:

III. RESULTS AND DISCUSSION

A. Genetic Variation of Porang Based on ISSR Molecular Markers

Mutation induction using colchicine successfully increased the genetic diversity of porang (Table 1). Genetic variation (H_e) of porang increased from 0.0487 in the control and 0.2595 in the porang after mutation induction using colchicine (Table 1). The results clearly indicate that mutation induction significantly enhances the genetic diversity of porang, as reflected in the increased values of polymorphic loci, allele numbers, heterozygosity, and Shannon's index (Table 1). This suggests that induced mutations are an effective method for broadening the genetic diversity of porang, which could benefit breeding and conservation efforts.

These findings align with previous research on mutation-induced genetic diversity in plants. For example, studies of medicinal plants have reported similar outcomes, where induced mutations through chemical agents or radiation increased genetic variation by changing the chromosomal groups and the number of genes in a cell [29]. The sharp contrast between the control group ($P = 11.76\%$) and the treatment group ($P = 94.12\%$) in this study is consistent with these reports, highlighting the effectiveness of mutation induction in generating genetic variability.

The observed phenomenon can be explained by the mechanism of mutation induction. Mutagens such as colchicine introduce random alterations in the DNA sequence, gene duplication, functional divergence and chromosomal rearrangements [30]. These changes disrupt the uniformity of genetic loci, resulting in the emergence of new alleles and polymorphic loci, as observed in the treatment group. The substantial increase in the number of alleles ($N_a = 15$) and effective alleles ($N_e = 1.4068$) further supports the role of induced mutations in diversifying the genetic makeup of porang.

Additionally, the significant rise in heterozygosity ($H_e = 0.2595$) and Shannon's information index ($I = 0.4097$) suggests enhanced genetic variability and adaptability within the treated population. Higher heterozygosity reflects a greater potential for plants to withstand environmental stresses, which is vital for breeding and conservation programs [31]. This outcome may also be due to the accumulation of advantageous mutations, which increase genetic diversity and promote population robustness.

Interestingly, the relatively low diversity in the control group ($H_e = 0.0487$, $I = 0.0711$) highlights the limited genetic base of porang in its natural or untreated state. This is a common characteristic of many domesticated or underutilized crops, where selective

pressures or low population sizes reduce genetic variability.

In comparison to prior studies, the magnitude of increase in genetic diversity observed here is noteworthy. It may be attributed to the specific mutagenic agent or treatment protocol employed, as these factors greatly influence mutation frequency and spectrum. Further studies are recommended to optimize these parameters and explore the long-term stability and utility of the induced diversity in porang breeding programs.

Table 1. Genetic variation of porang based on ISSR molecular markers.
P(%) = percentage of polymorphic loci, Na = number of alleles, Ne = number of affective allele, He = genetic diversity index, I = Shannon index.

	P (%)	Na	Na	Ne	He	I
Control	11.76	2	1.1176±0.3321	1.0832±0.2348	0.0487±0.1376	0.0711±0.2008
Treatment	94.12	15	1.9412±0.2425	1.4068±0.3022	0.2595±0.1494	0.4097±0.1951

B. Similarity of Porang Based on ISSR Molecular Markers Using the Jaccard Similarity Index

The similarity coefficient of porang samples ranged from 0.08 to 0.75 (Table 2). In this study, the highest diversity is assessed by comparing the lowest similarity coefficient between the control samples and all treatment samples. The lowest similarity coefficient compared to control is K52 (0.05% colchicine treatment), with similarity values of 0.10 and 0.08, respectively. According to Trimanto, 2012 [32], the similarity index is considered low when the value is <0.60, and if it approaches 1, the similarity is high. It can be concluded that the K52 sample has the highest genetic diversity.

Table 2. Jaccard similarity index of 17 porang samples (Amorphophallus muelleri Blume) based on ISSR molecular markers. K01 (Control Replicate 1), K02 (Control Replicate 2), K11 (0.01% Colchicine Replicate 1), K12 (0.01% Colchicine Replicate 2), K13 (0.01% Colchicine Replicate 3), K21 (0.02% Colchicine Replicate 1), K22 (0.02% Colchicine Replicate 2), K23 (0.02% Colchicine Replicate 3), K31 (0.03% Colchicine Replicate 1), K32 (0.03% Colchicine Replicate 2), K33 (0.03% Colchicine Replicate 3), K41 (0.04% Colchicine Replicate 1), K42 (0.04% Colchicine Replicate 2), K51 (0.05% Colchicine Replicate 1), K52 (0.05% Colchicine Replicate 2), K61 (0.06% Colchicine Replicate 1), K62 (0.06% Colchicine Replicate 2).

	K01	K02	K11	K12	K13	K21	K22	K23	K31	K32	K33	K41	K42	K51	K52	K61	K62
K01	1.00																
K02	0.50	1.00															
K11	0.33	0.67	1.00														
K12	0.22	0.30	0.50	1.00													
K13	0.67	0.75	0.50	0.33	1.00												
K21	0.22	0.30	0.36	0.50	0.33	1.00											
K22	0.20	0.40	0.45	0.73	0.30	0.58	1.00										
K23	0.33	0.50	0.33	0.10	0.25	0.10	0.20	1.00									
K31	0.29	0.22	0.30	0.45	0.25	0.45	0.42	0.13	1.00								
K32	0.67	0.40	0.50	0.33	0.50	0.33	0.30	0.25	0.43	1.00							
K33	0.29	0.22	0.30	0.45	0.25	0.45	0.42	0.13	1.00	0.43	1.00						
K41	0.29	0.22	0.30	0.33	0.25	0.45	0.31	0.13	0.75	0.43	0.75	1.00					
K42	0.40	0.29	0.38	0.27	0.33	0.40	0.25	0.17	0.71	0.60	0.71	0.71	1.00				
K51	0.14	0.11	0.20	0.15	0.13	0.25	0.14	0.14	0.44	0.29	0.44	0.63	0.57	1.00			
K52	0.10	0.08	0.15	0.29	0.09	0.20	0.27	0.10	0.45	0.20	0.45	0.45	0.40	0.67	1.00		
K61	0.14	0.11	0.20	0.15	0.13	0.25	0.14	0.14	0.44	0.29	0.44	0.63	0.57	0.71	0.67	1.00	
K62	0.11	0.09	0.17	0.31	0.10	0.21	0.29	0.11	0.50	0.22	0.50	0.50	0.44	0.56	0.89	0.75	1.00

C. Clustering analysis of Porang Based on ISSR Molecular Markers Using the Jaccard Similarity Index

Normal and treatment porang is divided into 4 clusters. The genetic variation of the treatment sample, as seen from the lowest similarity value compared to the control, is K52 which is in cluster 4. The presence of the control sample and sample K52 in different clusters indicates that samples in different clusters exhibit high genetic variation. Sample K52 is on the same branch as K62 in cluster 4. This may be due to the 0.05% and 0.06% colchicine treatment doses producing nearly identical polyploid plants, resulting in a relatively similar number of PCR amplification fragments. The occurrence of polyploidy can be caused by crossing-over events due to the increased number of chromosomes as a result of polyploidy, thereby enhancing physical interactions between homologous chromosomes [33]. Mutations that can arise from crossing-over events include deletions [34], insertions [35], or substitutions [36], which can lead to the formation of identical DNA banding patterns, the addition of new bands, and the loss of DNA bands compared to control plants [37].

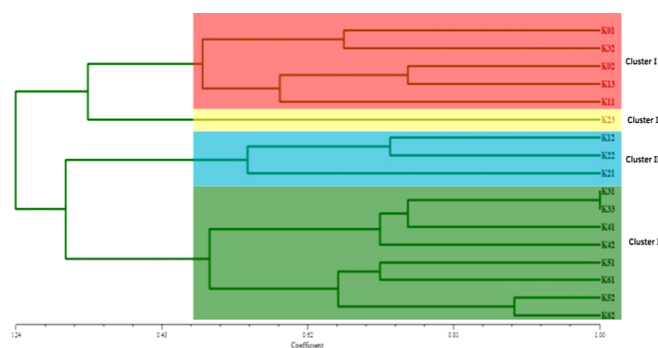


Fig. 1. Dendrogram of 17 Porang Samples Based on ISSR Molecular Markers Using the Jaccard Similarity Index

III. CONCLUSIONS

Mutation induction using colchicine successfully increased the genetic diversity of porang. Polyploidy induction using 0.05% colchicine is recommended to increase genetic variation of porang.

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Effect of Fruit Maturity Level on Morphology, Water Content and Germination of *Eumachia montana* Seeds

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Abstract- *Eumachia montana* is one local plant species from Rubiaceae family that has potential as medicinal plant. Seed storage of *E. montana* depends on seed quality. Seed quality can be determined from fruit harvesting accuracy at physiological maturity through fruit maturity level. The aim of this study was to analyze effect of *E. montana* fruit maturity level to seed morphology, water content and germination. Fruits were harvested based on maturity level which was grouped based on fruit skin color. *E. montana* seeds are morphometric characterized, measured for water content and sown. Data were analyzed by variance analysis, Principal Component Analysis, cluster and correlation analysis using statistical program PAST ver. 3.04. Fruit maturity level of *E. montana* significantly influence to seed morphology and germination, but did not significantly influence to seed water content. Grade III with dark orange (10R 5/10) fruit skin color is recommended as fruit maturity level of *E. montana* for harvesting. Seed length is parameter of seed morphology which influence to fruit maturity level. Correlation between fruit maturity level to seed morphology, water content and germination is low, with seed morphology character is positively correlated to germination of *E. montana* seeds.

Keywords; Conservation; Germination; Maturity; Seed; Storage

I. INTRODUCTION

Genus *Eumachia* (Rubiaceae) was considered to include a single species from Tonga for 185 years. *Eumachia* has added 94 species since 2015 and is a genus of pantropical shrubs, most of whose members were originally included in *Psychotria*. One species of *Psychotria* from Southeast Asia that has been identified as potentially included in the genus *Eumachia* is *Eumachia montana* (Blume) I.M. Turner [1]. Several plant parts of the genus *Eumachia* (such as leaves, roots and rhizomes) have been widely used as ulcers, stomach aches, coughs, and bronchitis. Plants from this species are also commonly used for treatment where there is an infection in the female reproductive system [2]. An example of a species included in the genus *Eumachia* is *E. montana* which is a local plant

native to Indonesia which is spread from Andaman Islands, Bangladesh, Borneo, Cambodia, Southeast China, East Himalaya, India, Java, Lesser Sunda Islands, Malaya, Myanmar, New Guinea, Nicobar Islands, Sumatra, Thailand, Vietnam, to Nusa Tenggara [3,4].

Seeds from Rubiaceae family, especially *Eumachia*, have orthodox seed storage behavior. The success storage of orthodox seeds depends on seed quality, one of which is seed maturity level at harvest. Quality seeds are obtained from seeds that are harvested on time, namely when the seeds are physiologically ripe. Each plant species has a different physiological fruit ripening time [5,6,7]. Physiologically ripe seeds are seeds that have good physiological and genetic quality. Seeds that are harvested before physiological maturity will affect their viability because the seeds do not have sufficient food reserves and the embryos are not yet fully formed [8,9,10]. Fruit maturity level will affect seed germination through germination percentage and seed growth rate parameters [9]. This is because in general, seeds will have high vigor if harvested after fruit reaches physiological maturity. This condition is one of the stages of seed development that can determine seed size, seed weight, and color, resulting in significant differences in seed vigor [11].

Determining the right time for harvesting or collecting fruit to obtain high-quality seeds as indicated by its high seed viability is essential. This is important because the seeds will achieve a high germination percentage and be able to produce new conservation strategies for certain species that require it [12]. Based on [13], *E. montana* seeds collected from conservation areas in Bromo Tengger Semeru National Park (BTSNP) for seed bank purposes did not show any germination. Although the seed quality was good through the cut-test results show that 80% seeds were healthy and fresh seeds. The seed storage character of *E. montana* is also unknown, although most of seeds from genus *Eumachia* are orthodox seeds [14]. *E. montana* fruit collected from BTSNP is fruit with maturity level indicated by red to blackish fruit skin colour. Purwodadi Botanic Garden (PBG) as one of the scientific conservation areas for

dry lowland plants also has a collection of *E. montana* which has not been widely studied in relation to fruit maturity level in order to obtain quality seeds for storage or propagation as an additional collection.

Purpose of this study was to analyze fruit maturity level of *E. montana* on seed morphology, water content and germination of its seeds. Results of this study are expected to be used as a reference in determining the harvest time of *E. montana* seeds in the field, in order to obtain quality seeds as a source of seeds, both for storage, propagation and for other research activities.

II. RESEARCH METHODS

A. Study Site

This research was conducted in August 2022 – June 2023 at seed bank laboratory and Bidara greenhouse, Scientific Conservation Area Purwodadi Botanic Garden, Pasuruan, East Java, Indonesia. Seed materials used in this study came from direct seed collection from *E. montana* plants in block X.A.18, PBG (Fig. 1). This plant collection was obtained from exploration result in Timor, Kupang, Indonesia.

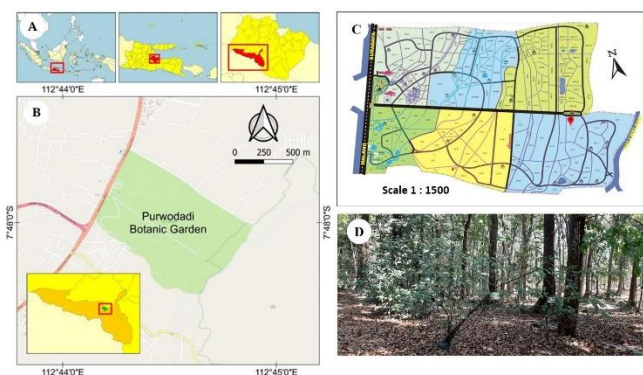


Fig. 1. *Eumachia montana* (Blume) I.M. Turner in block X.A.18, Purwodadi Botanic Garden, Pasuruan, East Java, Indonesia. A. Map of Indonesia, East Java, Pasuruan district, B. Map of Purwodadi Botanic Garden, C. Study site in Purwodadi Botanic Garden (location symbol), and D. Habitus of *Eumachia montana* in block X.A.18

B. Research Procedure

Harvesting *Eumachia montana* fruit

E. montana fruit is harvested by picking directly based on different maturity levels, consisting of 4 levels (grades). If the grade is higher, the fruit maturity level will be higher, or the fruit skin colour will be darker. The differences in the level of maturity of *E. montana* fruit can be seen in Table 1 and Fig. 2.

Table 1 Differences Skin Fruit Color Of *Eumachia Montana* Based On Maturity Level

Grade	Skin fruit color	Color based on Munsell Color Chart
I	Light orange	5YR 6/10
II	Orange	10R 6/10
III	Dark orange	10R 5/10
IV	Red	10R 4/10



Fig. 2. *Eumachia montana* fruit based on maturity levels

Processing *Eumachia montana* fruit

The harvested *E. montana* fruit is then processed to obtain ready-to-use seeds by removing the fruit flesh and rinsing it with running water while gently rubbing the surface of the seed skin to ensure that no fruit flesh is left behind. The seeds are then air-dried for 3 days until they are ready to use.

Measuring water content of *Eumachia montana* seed

The water content of *E. montana* seeds from each grade was measured first before measuring and observing the seed morphological characteristics. There were 10 *E. montana* seeds with 3 replications, each of which was weighed for its wet weight and then oven-dried at a temperature of 108°C for 18 hours [15]. The dry weight of the oven-dried seeds was then measured and the measurement results were entered into (SWC, 1). The oven method is a destructive method.

$$SWC (\%) = \frac{\text{weight of seeds before oven} - \text{weight of seeds after oven}}{\text{weight of seeds before oven}} \times 100\% \quad (1)$$

Measuring and observing morphological characteristics of *Eumachia montana* seed

Measurement and observation of morphological characteristics of *E. montana* seeds were carried out using morphometric method, where measurements were made on the parts of the seeds that could be measured (such as length, width, thickness, and weight of seeds) and other qualitative characteristics such as shape, colour and texture of seeds. Measurements of length, width, and thickness of *E. montana* seeds using a digital calliper, while measurements of seed weight using a 4-digit analytical balance. Observations of seed shape and texture refer to [16], and observations of seed colour refer to Munsell Colour Chart. Seed samples used for each grade were 10 seeds due to the limited samples obtained. The results of observations of

qualitative morphological characteristics of *E. montana* seeds will be scored in numeric.

Sowing *Eumachia montana* seed

E. montana seeds were then sown in cocopeat media in seed trays. Each grade consisted of 15 seeds with 3 replications. The sown seeds were watered daily or, if necessary, when the planting medium began to look dry. Parameters observed during the sowing of *E. montana* seeds include germination percentage [17, (GP, 2)], germination rate [18, (Kct, 3)], and initial seed germination.

$$GP (\%) = \frac{\text{total seeds were germinate}}{\text{total seeds were sown}} \times 100\% \quad (2)$$

$$Kct = \sum_{i=1}^n \frac{(KN)i}{Wi} \quad (3)$$

Whereas: KN is normal seedling and Wi is time of germination

C. Data analysis

Data of seed water content and seed germination of *E. montana* were analysed using analysis of variance (ANOVA) and continued with Least Significant Difference test analysis at 95% confidence level if significant differences were found between fruit maturity levels (grades) using PAST ver.3.04 statistical program. Data of *E. montana* seed morphology observations were analysed descriptively and continued with Principal Component Analysis (PCA) and cluster analysis using PAST ver.3.04 statistical program to determine the seeds morphological characteristics that affect *E. montana* fruit maturity level. Data of seeds morphological characteristics, seed water content, and seed germination will be continued with correlation analysis to determine the relationship between 3 parameters and fruit maturity levels using PAST ver.3.04 statistical program. This analysis aims to determine at what grade *E. montana* fruit can be harvested to produce seeds quality for storage in seed banks or for plant propagation.

III. RESULT AND DISCUSSION

Seed water content of *Eumachia montana* based on fruit maturity level

The results of seed water content measurements showed that seed water content of *E. montana* decreased drastically along with fruit ripening, from 12.019% (grade II, orange skin fruit colour) to 10.156% (grade III, dark orange skin fruit colour) (Table 2). Seed water content varies in *E. montana* fruit maturity level, where seed water content is high at grade II and seed water content is low at the ageing stage in grade III [19]. Seed water content will

decrease with increasing fruit age and reach a minimum water content when fruit is ripe or mature [20].

Table 2 Seed Water Content Of *Eumachia Montana* Based On Fruit Maturity Level

Grade	Seed water content (%)
I	10.756 a
II	12.019 a
III	10.156 a
IV	10.839 a

Seed morphology of *Eumachia montana* based on fruit maturity level

Seeds that are successfully processed based on fruit maturity level can be seen in Fig. 3. Seed colour will appear darker along with the older maturity level. *E. montana* seeds have a wavy in upper surface, and rough in upper and lower surface. The lower surface of seed is flat and the upper surface of seed is convex with an oval shape and narrows at the end (semi-ellipsoid). The seed characteristics of Rubiaceae family generally include seeds that are flat on one side, convex on the other side, and wavy or have distinctive grooves on their surface [21].



Fig. 3. Differences between seed morphology of *Eumachia montana* based on maturity levels

The highest average of the morphometric measurements of seeds at each fruit maturity level (grade) is seeds at grade III, marked by dark orange skin colour fruit (Fig. 4). Seeds harvested at the right level of maturity can achieve maximum seed viability and vigour. If the harvest is delayed, it will cause seed quality to decrease due to adverse environmental conditions such as high humidity,

rainfall, excessive drying, temperature, pest and disease attacks [22].

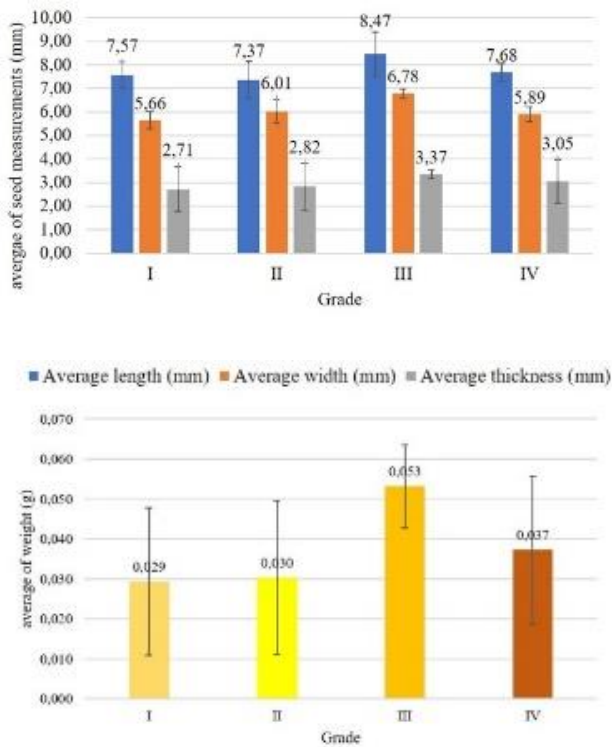


Fig. 4. Graphic of seed morphometric of *Eumachia montana*

Based on Fig. 5, it can be seen that grade III is the recommended fruit maturity level for harvesting and it is influenced by morphological characters with seed length parameters. Other morphological characteristics such as width, thickness, weight, color, texture, and shape of seed do not strongly influence determining fruit maturity level. This is done by grouping seeds based on grade, which shows that grade III is in one cluster while the other grades are scattered (Fig. 6).

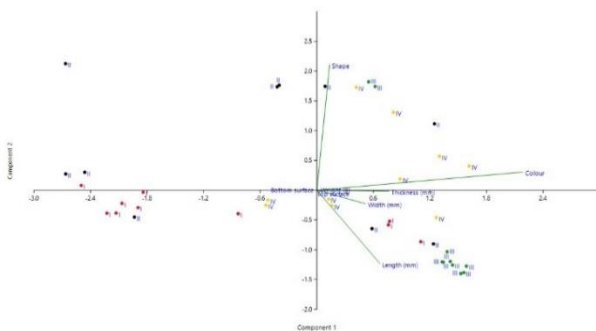


Fig. 5. PCA of seed morphometric *Eumachia montana* based on maturity levels

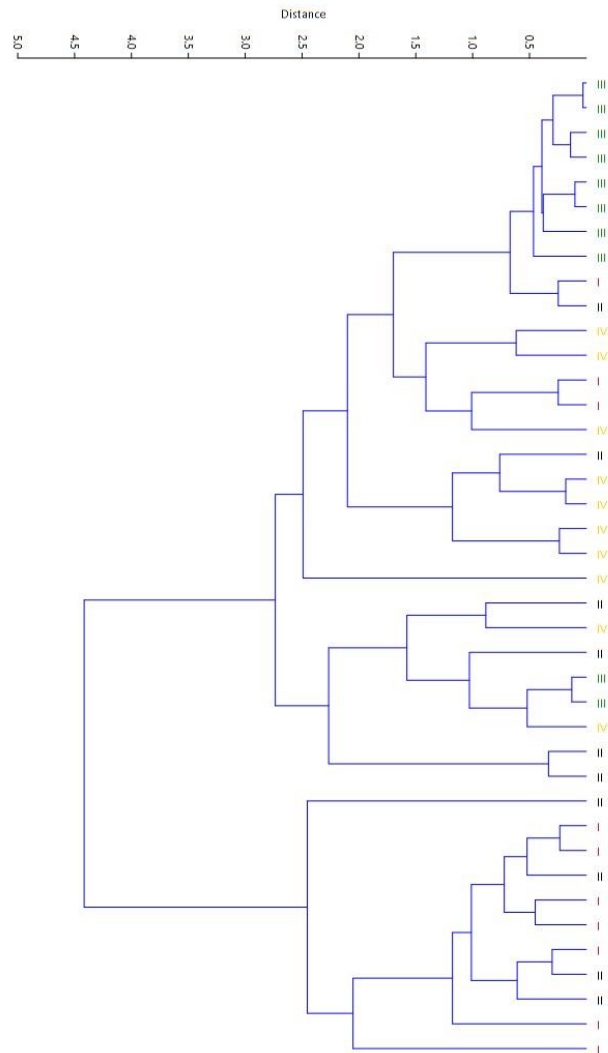


Fig. 6. Cluster of seed morphometric *Eumachia montana* based on maturity levels

Seed maturation is an essential component of seed quality and a prerequisite for successful germination. Study on the physical quality of *E. montana* seeds showed that seeds with maturity in grade III, characterized by dark orange fruits, had the best morphological characteristics (length, width, thickness, and weight of seed) and the lowest seed water content compared to other maturity levels. Seed size and seed water content can be parameters for assessing seed quality. Several studies on seed germination significantly and positively correlated with seed size [23,24]. Seed shelf life is greatly influenced by storage environment, with seed water content being one of the parameters that affect seed viability during storage. Seed germination percentage will decrease as seed water content increases [11]. Therefore, *E. montana* seeds with maturity in grade III, characterized by dark orange skin fruits color, should be harvested and

stored in seed banks because they have the best seed quality in physical and physiological parameters.

Seed germination of *Eumachia montana* based on fruit maturity level

Based on Table 3, maturity level of *E. montana* fruit has a significant effect on seed germination. Fruit with maturity level of grade III can increase the germination of *E. montana* seeds, although the germination percentage is low (<50%). *E. montana* seeds from grade I are unable to germinate. This is probably because the seed embryo has not been fully formed as a food reserve. Seeds from grades II and IV only germinated nine weeks after sowing, while seeds from grade III were slower to germinate, namely 13 weeks after sowing (Fig. 7). The initial emergence of *E. montana* sprouts and the changes in each phase of the sprouts from the emergence of hypocotyls with an epigeal germination type (Fig. 8) to the cotyledons being fully formed are relatively long.

Table 3 Germination Percentage Of *Eumachia Montana* Based On Fruit Maturity Level

Grade	Germination percentage (%)
I	0 a
II	6.667 a
III	20 b
IV	13.333 a

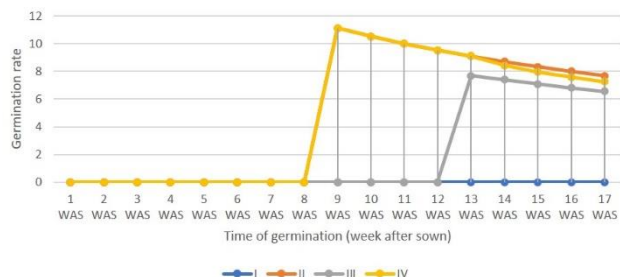


Fig. 7. Germination rate of *Eumachia montana* seed based on maturity levels. WAS = Week After Sown



Fig. 8. Germination of *Eumachia montana* seed from hypocotyl emergence to cotyledon formed

Table 4 shows that fruit maturity level of *E. montana* has a positive correlation with seed germination, whereas the riper fruit, the higher percentage of germination. However, fruit maturity level of *E. montana* negatively correlates with seed water content because the differences in seed water

content between grades is not much different. Seed morphological characteristics in seed width and shape positively correlate with seed water content, where seeds are wide and almost round in shape will have high seed water content. Seeds morphological characteristics such as length, width, thickness, weight and seed color positively correlate with seed germination. The best seeds physical or morphological quality, the higher percentage germination of *E. montana* seeds will be. The resulting correlation between fruit maturity level with seed water content, seed germination and morphological characteristics of *E. montana* seeds is categorized as low or weak correlation as indicated by R² value of <0.4 (Fig. 9, [25]).

Table 4 correlation analysis result between fruit maturity level of *eumachia montana* to seed water content, seed germination, and seed morphological characteristics. %mc=%moisture content, %g=%germination, l=length, w=width, wg=weight, c=color, ts=adaxial surface, bs=abaxial surface, and s=shape

	%MC	%G	L	W	T	WG	C	TS	BS	S
%MC	1									
%G	-0.58	1								
L	-0.31	0.47	1							
W	0.02	0.46	0.36	1						
T	-0.10	0.09	0.38	0.15	1					
WG	-0.34	0.27	0.61	0.38	0.87	1				
C	-0.02	0.27	0.23	0.37	0.76	0.63	1			
TS	0	0	0	0	0	0	0	1		
BS	0	0	0	0	0	0	0	0	1	
S	0.36	-0.19	-0.69	0.21	0.08	-0.07	0	0	0	1

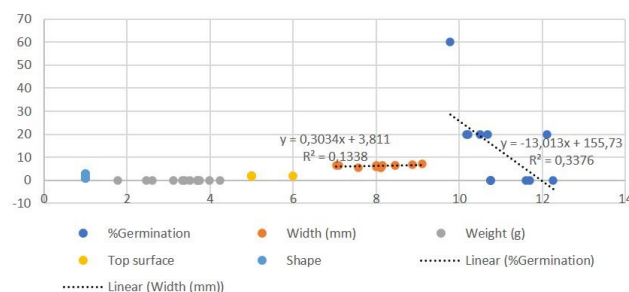


Fig. 9. Graphic correlation between fruit maturity level of *Eumachia montana* to seed water content, seed germination and seed morphological characteristics

Fruit maturity level of *E. montana* does not significantly affect seed water content, but has a significant effect on seed morphology and germination. This condition is likely caused by the seed storage behaviour of *E. montana* seeds is orthodox where seed water content is low (ranging from 10-15%). This is contrast with recalcitrant and intermediate seeds, which have high seed water content when fruit at the physiological ripe stage [26, 27]. The effect of fruit maturity level through fruit skin colour indicator can be used as a reference when fruit harvesting. Fruit harvested when physiologically ripe will affect its seeds viability. However, fruit skin colour as an indicator of physiological maturity in each plant species varies. *E.*

montana fruit can be recommended to be harvested when fruit skin colour is dark orange. [10] stated that coffee fruit maturity indicated by red fruit skin and significantly affects coffee seeds viability. A different thing is shown in harvesting of mango (*Mangifera indica*) fruit, which is recommended to be harvested when fruit is not fully ripe so that seedling growth and vigour index are better than fruit harvested when fully ripe [28]. The difference in fruit maturity level to produce seeds with high viability does not apply to intermediate fruits. Seeds from intermediate fruits do not require maturity based on fruit skin colour to germinate [12]. The low percentage of *E. montana* seed germination (<50%) indicates that *E. montana* seeds likely have dormancy period, requiring specific treatments to encourage seed germination. Further studies on breaking *E. montana* seed dormancy can be conducted, considering that studies on breaking dormancy in orthodox seeds from Rubiaceae family have not been widely studied.

Fruit maturity level also affects seeds size were produced. Fully ripe fruits are produce seed size larger than not fully ripe fruits. Mature seeds will have perfect embryos to be used as food reserves when the seeds are stored or as a source of energy during germination. *E. montana* seeds are longer in size cause better germination percentahe that shorter seeds. This is evidenced by positive correlation between seed morphology and seed germination of *E. montana*, even though the value is low. The correlations produced from seed size to seed germination varies, including height and diameter of seedlings [29], speed of seed germination [30], germination time and seed survival [31]. Based on the results analysis, the recommendation for fruit harvesting at physiological maturiy for *E. montana* to produce high quality seeds from both physical or morphological and physiological characteristics (through seed water content and germination) is fruit with maturity level in grade III, with fruit's skin when ripe is dark orange (10R 5/10). The recommendations can improve seed storage quality in PBG seed bank.

IV. CONCLUSION

Fruit maturity level of *E. montana* has significant effect on seed morphology and germination, but does not have substantial impact on seed water content. The recommended maturity level of *E. montana* fruit for harvesting, which is thought to be physiologically ripe for producing seeds quality, is grade III, with fruit's skin is dark orange when ripe fully fruit. The seed morphology that affects to the fruit maturity level of *E. montana* is seed length. The correlation between fruit maturity level of *E. montana* and water content, germination and morphology of seeds is categorized as low or weak correlation.

ACKNOWLEDGMENT

Sincere thanks dedicated to Purwodadi Botanic Gardens technicians in Rubiaceae block and Slamet Mulyadi who helped author for seeds collecting. Authors would also thanks to the Independent Learning Independent Campus (MBKM) period 2022/2023 for their assistance through research student assistance.

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Optimization of the Biopellet Manufacturing Process: Effect of Adhesive Concentration with Recycled Coffee Grounds and Copeat on Biopellet Properties

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Abstract. Biopellets are an environmentally friendly organic waste management solution. The use of biopellets can help reduce negative impacts on the environment and create a cleaner and healthier environment. In this study, coffee grounds and copeat waste were used as the main raw materials for the biopellet making process with a ratio of 1:1. The quality testing of biopellets includes ash content, calorific value, moisture content, and combustion rate due to the effect of tapioca flour adhesive concentration with variations in composition of 10%, 15%, and 20%. The results of this study show that the concentration of tapioca flour adhesives has a significant impact on the quality of biopellets. The adhesive's concentration increases with moisture and ash content, while decreasing its calorific value. Biopellets with an adhesive concentration of 10% have the lowest moisture content and ash content values of 5.76% and 2.02% and the highest calorific value of 4842.33 Cal/gr with a combustion rate of 2.0 gr/min. Overall, biopellets that meet the SNI 8675:2018 standard are biopellets with adhesive concentrations of 10% and 15%, while biopellets with adhesive concentrations of 20% have not met because the calorific value is still less than 4000 Cal/gr.

Keywords; *Biopellets, Coffee Grounds, Copeat, Adhesive Concentration Effect*

I. INTRODUCTION

Indonesia's population is increasing, with a population of 275,77 million people in 2022, a 1.133% increase from the previous year [1]. This growth is primarily due to the increasing demand for energy, particularly from fossil fuels like coal and oil [2]. However, the increase in energy consumption from fossil fuels is also contributing to the rise in global greenhouse gas emissions [3].

Indonesia possesses a 50,000 MW potential for biomass energy derived from diverse agricultural waste materials, including but not limited to palm coconut, peat grinding, plywood, cocoa, and by-products of sugar factories [1] [4].

Biopellets are a sustainable alternative to traditional fossil fuels, made from organic materials such as wood, agricultural residues, and food waste [5][6]. Biopellets are a type of waste-based solid fuel that is smaller than the size of a brick [7]. The cylinder-shaped biopellet is smaller than the brick size and has a length of about 6-25 mm with a diameter of 10-12 mm [7][8]. The advantages of biopellets as fuel include high density, easy storage and handling. The main factors affecting the strength and durability of the pellets are raw materials, water content, particle size, welding conditions, adhesion of adhesives, densification tools, and post-production treatment [9]. Biopellets have a high combustion efficiency and produce lower emissions compared to fossil fuels. Waste Recycling: Encourages the recycling of biomass waste into energy sources, reducing environmental impact.

Biopellets can be used as alternative fuel solutions in industry, for example in heating and power plants: Biopellets can be used as fuel in industrial heating systems and used for biomass power plants [10]. In manufacturing industries used in manufacturing industry as a source of energy for production processes. In forestry and agriculture industries, forest biomass and agricultural waste can be processed into biopellets, creating added value for this sector.

The manufacturing process involves several key steps, starting with the collection and sorting of raw materials. Once the materials are gathered, they undergo a complex transformation process to create products while minimizing waste generation and optimizing energy and material consumption. This shift towards a more integrated industrial ecosystem emphasizes recycling, conservation, and the use of alternative materials [11]. The final step in the manufacturing process is cooling and packaging the biopellets for distribution and use. Biopellets are gaining popularity as a renewable energy source due to low carbon

emissions, sustainable waste management, and potential role in transitioning to a cleaner future [12][13].

Biopellets offer versatility in residential heating, industrial processes, and power generation, making them a sustainable, environmentally friendly alternative to fossil fuels. They reduce energy costs and create job opportunities in renewable energy.

By making the switch to biopellets, these individuals and companies are not only reducing their impact on the environment but also contributing to the growth of the renewable energy industry. This shift towards more sustainable energy sources has the potential to create new job opportunities in manufacturing, distribution, and installation of biopellet systems. Additionally, as more businesses and households make the transition to biopellets, the demand for these renewable energy sources will continue to grow, further driving innovation and investment in the sector. Ultimately, the widespread adoption of biopellets has the potential to revolutionize the way we heat our homes and power our industries, leading to a cleaner and more sustainable future for all [14][5].

Biopellet production can be improved by reducing waste and increasing efficiency, making it more cost-effective for consumers and benefiting the environment. The production of Refused Derived Fuel (RDF) pellets from food and garden waste offers a sustainable approach to waste diversion, bio-energy generation, and soil enhancement. The pellets demonstrate a notable calorific value, economic viability, and minimal ash residue, making them a promising alternate solid fuel for household and industrial applications [16][18]

II. MATERIAL

The research is intended to conduct research on the utilization of agricultural waste as an alternative solution to biopellet raw materials (environmentally friendly solid fuels) to support green energy in Indonesia. The agricultural debris used in this study is coffee grounds and cocopeat. So far, agricultural waste is often simply disposed of or burned, which can lead to environmental problems such as air pollution and soil contamination or merely becoming a growing medium. The calorie content of dry coffee amps ranges between 19.3-24.9 MJ/kg ($\pm 4610-5947$ kcal/kg) [17][19].

The calorific value of cocopeat waste is affected by the amount of non-combustible material (ash) and the moisture content of the pellet. Pellets produced from cocopeat have an ash content of 6.14%, which is higher than existing standards due to the fragility of cocopeat compared to wood pellets or other biomass resources. Mixing cocopeat with other biomass materials can improve pellet quality [16][17][20]. The calorie value of cocopeat waste is about 17.5-19.8 MJ/kg ($\pm 4180-4740$ kcal/kg). The higher ash

content and fragility of cocopeat waste pellets compared to traditional biomass resources like wood pellets can affect their calorific value. However, by mixing cocopeat with other biomass materials, the quality of the pellets can be improved. Despite these challenges, the calorie content of cocopeat waste is still significant, ranging between 17.5-19.8 MJ/kg ($\pm 4180-4740$ kcal/kg), making it a viable option for energy production[21] [22].

III. METHODS

This research was conducted to determine the quality of biopellets from the combined of recycled coffee grounds and cocopeat by the addition of tapioca flour adhesive composition mixtures with adhesive percentages of 10%, 15%, and 20% with 100 mesh. Testing was carried out to assess the quality of the biopellets based on SNI 8675:2018, which includes ash content, heating value, water content, and burning rate. The research procedure is explained in detail below :

1. Preparation Stage

At the raw material preparation stage, the dirt adhering to the materials is cleaned with running water, then dried under sunlight for 2 days to reduce the moisture content.

2. Pre-Treatment Stage

Re-drying is carried out using an oven at a temperature of 100 °C for 30 minutes. After completely dry, the raw material is crushed with a crusher, and the result is sieved with a 100 mesh size.

3. Biopellet Production Stage

Raw material with a particle size of 100 mesh in Cocopeat: Coffee grounds in a 1:1 ratio are then mixed with an adhesive, where the adhesive used is tapioca with adhesive concentrations of 10%, 15%, and 20% of the total raw materials.

4. Densification Stage

At this stage, biomass will undergo a densification process through compaction (pressing) so that its mass density or potential energy density increases. The densification process of these biopellets uses a vertical pellet press.

5. Drying stage

The bio-pellets that have been molded are dried under the sun for 2 days.

6. Torrefaction Stage

Bio-pellets are dried again through a torrefaction process at a temperature of 200 °C for 30 minutes.

7. Characteristic Testing Stage

The tests conducted include parameters such as water content, ash content, heating value, and burning rate based on SNI 8675:2018.

IV. RESULT AND DISCUSSION

The biopellet trial's outcomes, which included cocopeat and coffee ground with tapioca flour adhesive modifications at 10%, 15%, and 20% with 100 mesh, are displayed in Figure 1.

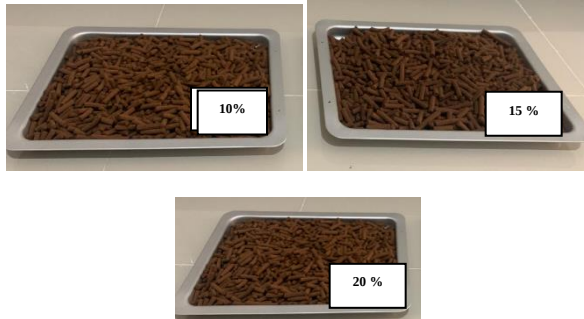


Fig.1. Biopellet from the combined of recycled coffee grounds and cocopeat by the addition of tapioca flour adhesive composition mixtures with adhesive percentages of 10%, 15%, and 20%.

The biopellets from the three varieties appear to have nearly the same texture at first glance. On the other hand, if an examination of its traits is done. There will be multiple distinct values obtained. The compressive strength of biopellets containing 10% tapioca flour binder is lower than that of biopellets containing 15% and 20% tapioca flour binder. Furthermore, compared to the other two versions, biopellets containing a 20% tapioca flour binder have a greater capacity for water absorption. Therefore, it can be said that the features of the final biopellets are influenced by variations in the tapioca flour adhesive.

The results of the quality test of biopellets made from coffee grounds and cocopeat are shown in Table 1. Biopellets made from a mixture of coffee grounds and cocopeat show satisfactory results in terms of quality. Table 1 provides a detailed overview of the quality tests conducted.

Table 1. Result biopellets made from coffee grounds and cocopeat

Material	Adhesive percentage	Water content (%)	Ash Content (%)	Heating Value (Kal/gr)	Burning Rate (gr/minute)
Cocopeat: Coffe Ground	10%	5.76	2,02	4842.33	2,0
	15%	7.87	3.35	4380.64	2,2
	20%	8.36	4.63	3289.84	1,95
Test Methode		SNI 01-1506	ASTM E1755	SNI 01-6235	-
SNI 8675:2018	Household	12% maximum	5% maximum	3940,95 Kal/gr minimum	-
	Industry	10% maximum	5% maximum	3940,95 Kal/gr minimum	-

A. Water Content

Water content is the ratio between total water inside a substance with its dry weight. Material quality is significantly impacted by water content. One of the key factors in determining the quality of biopellets is their water content. This has to do with smoke, the rate of ignition, and the storage of biopellets. Figure 2 shows the water content of the biopellet.

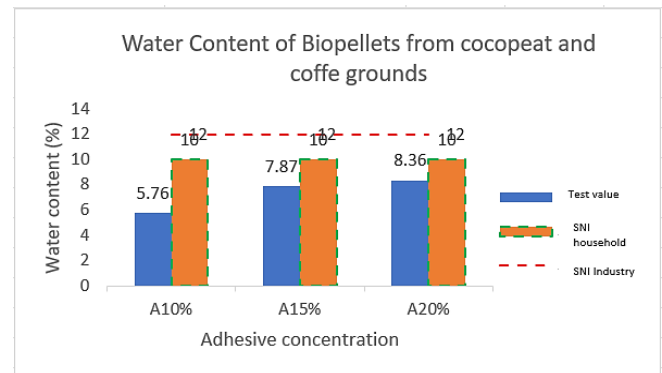


Fig. 2. Water Content of Biopellets from cocopeat and coffee grounds

The results of the quality test of biopellets made from coffee grounds and cocopeat show that with the addition of 20% adhesive, the highest water content is 8.36%. Meanwhile, with the addition of 10% adhesive, the water content is the lowest at 5.76%. This shows that the addition of adhesive to biopellets can significantly affect their moisture content. However, out of the 3 test samples, all of them fell within the range according to the SNI 8675:2018 standard. Thus, it can be concluded that the biopellets made from coffee grounds and cocopeat with the addition of adhesive still meet the established quality standards. Although its water content varies, it remains within the permitted limits.

B. Ash Content

Ash content is an inorganic component that residues from the burning of organic matter. One crucial factor in the grade of biopellet production is the amount of ash. Weight is used to determine the amount of ash present when organic matter is perfectly burned at a high temperature (500–600 °C). Evaporation of organic materials leads to weight reduction. This residue is made up of oxides and salts that include cations like sodium, potassium, calcium, magnesium, iron, and manganese, as well as anions such as phosphates, chlorides, sulfates, and other halides. Fig. 3 shows the ash content of the biopellet.

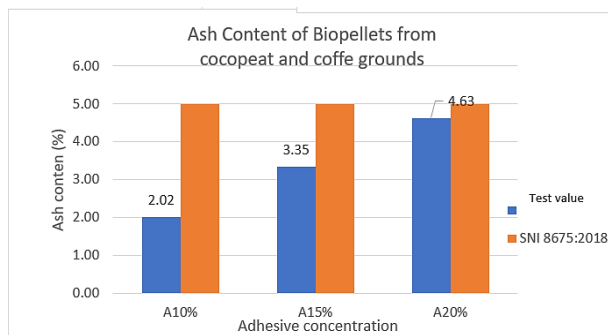


Fig. 3. Ash Content of Biopellets from cocopeat and coffe grounds

The highest ash content in the 20% adhesive mixture is 4.36%. Meanwhile, the lowest value in the 10% adhesive mixture was 2.02%. All bio-pellets still meet the SNI standard for a maximum ash content of 5%. This shows that the produced bio-pellets still meet the established quality standards.

C. Heating Value (Calorific value)

The main parameter for measurement of biomass fuel is calculated from its calorific value. The energy that is chemically bonded in fuel in typical environmental conditions, such as temperature, water phase (vapor or liquid), and combustion emission (CO₂, H₂O, etc.), is indicated by the fuel's calorific value.

Based on Figure 4, it can be seen that the higher the addition of the adhesive, the lower the heating value will be. The addition of 10% adhesive has the highest heating value of 4842.33 cal/g. Meanwhile, the addition of 15% adhesive has a heating value of 4380.64 cal/g. And in the 20% adhesive, it is 3289.84 cal/g. The minimum limit of SNI 8675:2018 related to the heating value is 3940.95 Kal/gr, so the 20% adhesive does not yet meet the SNI standard. This shows that excessive addition of adhesive can reduce the calorific value of the fuel. Therefore, further research is needed to find the optimal adhesive proportion to meet SNI standards. In addition, research also needs to be conducted to consider other factors such as combustion efficiency and exhaust emissions. Thus, environmentally friendly and efficient fuel can be produced.

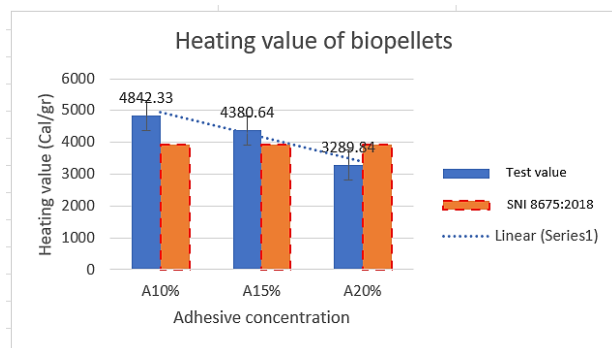


Fig. 4. Water Content of Biopellets from cocopeat and coffe grounds

D. Burning rate

The burning rate of bio-pellets allows them to generate heat quickly and efficiently. The higher the burning rate of the biopellet, the more efficient the utilization of the energy produced by the biopellet.

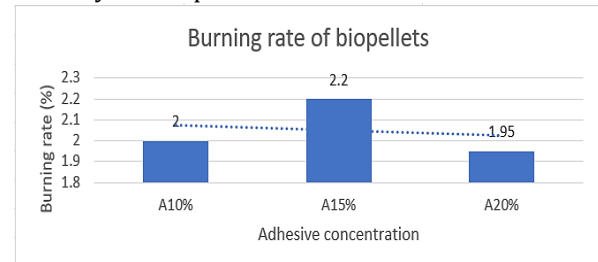


Fig. 5. Burning rate of Biopellets from cocopeat and coffe grounds

Based on Figure 5, it is known that the highest burning rate for the 15% adhesive is 2.2. Next, the highest was with the 10% adhesive and the lowest with the 20% adhesive. This shows that the concentration of the adhesive affects the burning rate of the fuel. The decrease in the burning rate of the 20% adhesive may be due to the excess adhesive content that hinders the combustion process.

The quality test results of bio-pellets made from coffee grounds and cocopeat show that with a binder addition of 20%, the moisture content and ash content are higher, but it has the lowest heating value of 3289.84 Kal/kg. The increase in the adhesive content in the biopellets turns out to affect the water and ash content, resulting in higher levels, but it reduces the thermal energy value produced. Nevertheless, these biopellets can still be used as an environmentally friendly and efficient alternative fuel for generating heat. With further research, it is possible to find an optimal formula to achieve a balance between the quality of the biopellets and the thermal energy value produced.

By optimizing the adhesive content, it may be possible to maintain a higher thermal energy value while still keeping moisture and ash content at acceptable levels. This would enhance the overall efficiency and effectiveness of using bio-pellets as a sustainable fuel source.

IV. CONCLUSION

Based on the results of biopellet berbahan cocopeat and coffee ground, three variations of the perekat 10%, 15%, and 20% memenuhi SNI 8675:2018 based on the categories of water content, ash content, and burning rate; however, the perekat 20% does not meet SNI 8675:2018 for heating value. As a result, it is possible to achieve optimal biopellet quality at a rate of 10% while maintaining optimal values for all parameters except burning rate.

The improvement of biopellet quality can be achieved by finding an optimal formula to balance calorific value and adhesive content. Thus, biopellets can be a more efficient

solution for generating heat without compromising their quality. With further research, it is possible to find an optimal formula to achieve a balance between the quality of the biopellets and the thermal energy value produced. Thus, biopellets can be a sustainable solution to the global energy crisis.

ACKNOWLEDGMENT

We are very grateful to the LPPM of Universitas Negeri Surabaya for funding the research we conducted.

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Removal Ciprofloxacin Through Adsorption-Photocatalyst Properties of $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$

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Abstract- $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ is one of the four-layer Aurivillius compound family and reported having photocatalytic properties. In this research, we synthesized $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ by molten salt method, and then the reducing ciprofloxacin concentration ability by adsorption-photocatalysis process was studied. The diffractogram sample showed that $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ was successfully synthesized with no additional peaks detected which indicates the absence of impurities compound. The micrograph results showed that $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ has a plate-like morphology with an average particle size of 150 μm . UV-Vis DRS results showed a bandgap energy of 3.148 eV (394.16 nm). The adsorption test showed that the ciprofloxacin concentration decreased 17.61% in 30 minutes. Meanwhile, the adsorption-photocatalyst test results showed that $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ reduced the concentration of Ciprofloxacin at around 35% for 90 minutes.

Keywords; $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$, Adsorption-Photocatalyst, Ciprofloxacin

I. INTRODUCTION

Antibiotics are drugs that can cure bacterial infections so that they are widely consumed, causing more and more antibiotic waste that pollutes the environment (Abdurahman, et al, 2021). The toxic side effects of drugs on resources such as cipro are very dangerous and have serious consequences for human, animal, and plant health. Several methods that have been used to handle antibiotic waste include (a) using the microorganism *Xylaria longipes*, (b) fenton oxidation, (c) oxidation with the help of UV light and chlorine gas, and (d) photocatalysts (Rusch, 2018, Giri, 2014, Deng, 2019, and Ansori, 2016). The photocatalyst method is an environmentally friendly and effective method when degrading liquid waste, especially dye waste (Yahya et al, 2018).

One of the compounds that has the potential to degrade antibiotic compounds is the Aurivillius structured compound (Borg, et al, 2002). Aurivillius compounds reported to function as antibiotic and rhodamine B degraders include the $\text{Bi}_7\text{Fe}_2\text{Ti}_{10}\text{O}_{27}\text{Cl}$ compound which degrades tetracycline and rhodamine B antibiotics by 90% for tetracycline antibiotics and 98% for rhodamine B with degradation efficiency achieved in 90 minutes and 60 minutes (Gu, et al., 2022). $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ is a four-layer

Aurivillius compound reported to have a $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ band gap energy value of 3.06 eV (Nayak, et al., 2017).

The adsorption properties of photocatalysts play a crucial role in the degradation process of organic pollutant compounds. The adsorption process is one of the physical methods that has better properties compared to other wastewater treatment technologies due to its low cost, convenient design, greater availability, and high dye purity at high concentrations (Ziyaadini, et al., 2020). However, the adsorption-photocatalytic activity of the $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ compound in reducing the concentration of antibiotic compounds has not been reported therefore this study become important. In this research, $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ compound was synthesized by molten salt method and then the adsorption-photocatalyst activity of $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ for ciprofloxacin concentration decreasing was studied.

II. MATERIAL AND METHODS

Materials

CaCO_3 (Merck, 99% powder), TiO_2 (Aldrich, 99% powder), Bi_2O_3 (Himedia, 99% powder), NaCl (Merck, 99.5% powder), KCl (Merck, 99.5% powder), AgNO_3 (Merck, 2.5% solution), acetone (Merck), ciprofloxacin, and distilled water.

Synthesis

The precursors of TiO_2 , CaCO_3 , Bi_2O_3 , were ground in agate mortar for 1 hour and then acetone was added to homogenize the sample and the was mixed with NaCl/KCl salt with a salt ratio of 1:1 and a sample and salt ratio of 1:7. Then it was ground again and homogenized with an agate mortar for 1 hour. Then the product was calcined at a temperature of 750 and 820 $^{\circ}\text{C}$ for 6 hours. Then the product was removed from the furnace and washed repeatedly with hot water to remove the salt. The presence of salt can be detected by dripping AgNO_3 solution onto the filtrate, after the salt is removed the product is dried.

Characterization

The characterization techniques used are The characterization technique: (a) X-ray diffraction (XRD) characterization was carried out to determine the phase of

compound (b) Scanning electron microscopy (SEM) was used to determine the morphology of the synthesized compound, (c) Ultraviolet-Visible diffuse reflectance spectroscopy (UV-Vis DRS) was used to determine the light absorption area and used to calculate the band gap energy

Adsorption-photocatalytic activity test

100 mg of $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ was mixed with 100 ml of an 8 ppm ciprofloxacin solution in a 100 ml beaker glass and stirred for 30 minutes. After that, the mixture was then filtered using filter paper to separate the catalyst residue from the supernatant. The supernatant was subsequently transferred to a cuvette for absorbance measurement using UV-Vis spectroscopy.

The Adsorption-Photocatalytic activity test used 100 mg catalyst and ciprofloxacin 8 ppm and mixed in beaker glass and then put to homemade photoreactor (exposure with lamp: 80 LEDs 220 V E27 UV) for 90 minutes. After that, the mixture was then filtered using filter paper to separate the catalyst residue from the supernatant. The supernatant was subsequently transferred to a cuvette for absorbance measurement using UV-Vis spectroscopy.

III. RESULT AND DISCUSSION

A. Characterization Results

The sample diffractogram was shown in Figure 1 and compared to the standard data in the Joint Committee on Powder Diffraction Standards (JCPDS) $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ with the number 96-152-8631. It can be seen that there is a match between the peaks of the product and the JCPDS standard diffractogram peaks. It indicates that the $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ compound was successfully synthesized and the absence of additional peaks indicates the absence of impurity compounds. The typical peaks of the $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ compound were found at 2θ (°); 12.82; 16.90; 21.56; 27.97; 30.57; 32.90; 39.9; 44.56; 47.47; 52.72; 57.38; 62.04; 63.79; 66.70.

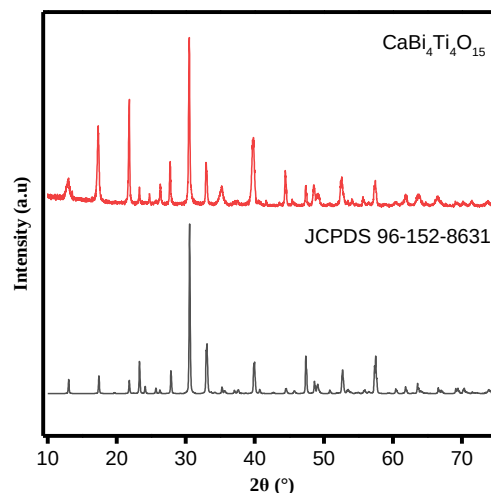


Figure 1 Diffractogram of $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ compound

The SEM image results shown in Figure 2 of the $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ product compound can be seen that the sample has a plate-like morphology with a non-uniform size. This morphology is typical of the Aurivillius compound reported by many parties (Zulhadjri, et al., 2022). Figure 3 shows the results of particle size distribution measurements and the particle have size at around 150 μm .

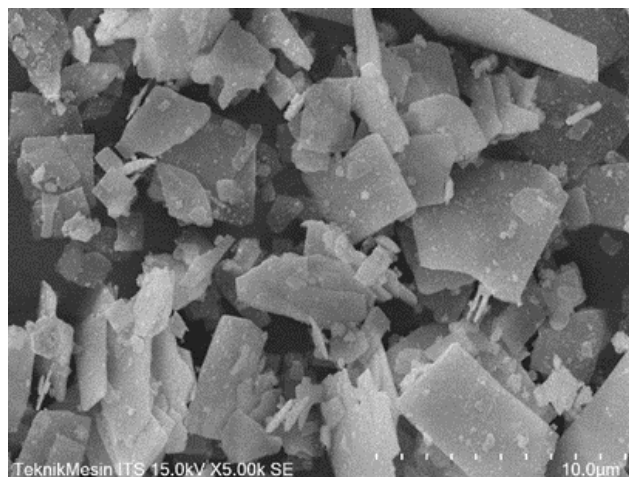


Figure 2 SEM Results of $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$

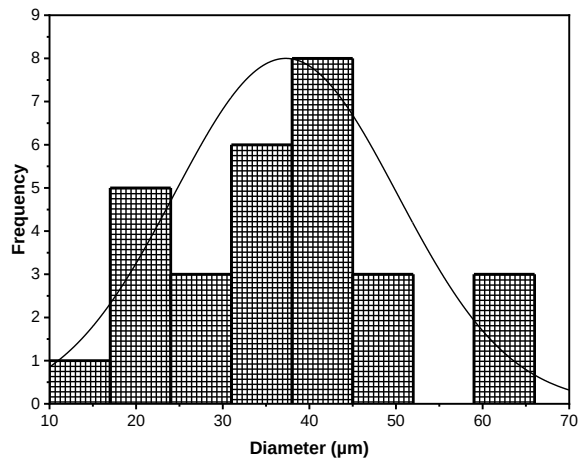


Figure 3 Distribution of $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ particles

The reflectance spectra of the $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ compound was shown in Figure 4 and then processed using the Kubelka-Munk equation to calculate the band gap energy. Figure 5 showed that the results of the Kubelka-Munk calculation (band gap energy value) is 3.48 eV.

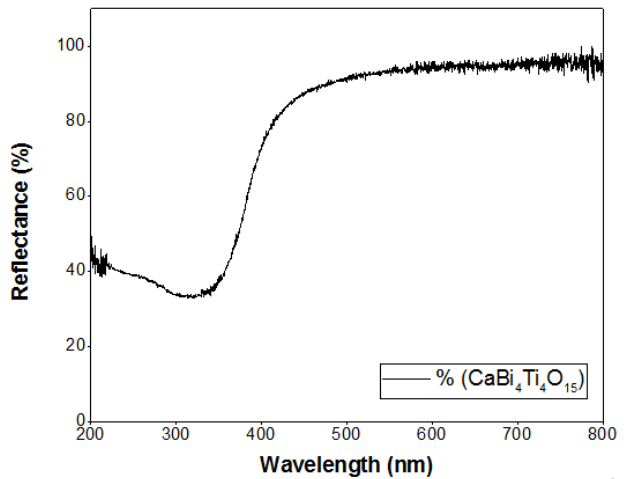


Figure 4 Reflectance spectra of the compound $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$

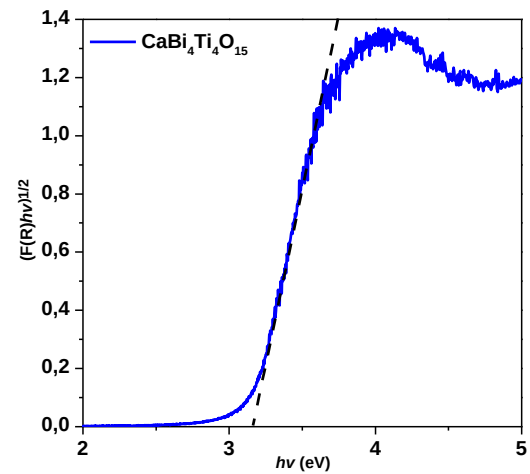


Figure 5 Tauc plot of $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ compound

Photocatalytic Activity Test of $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ Using Ciprofloxacin

B. Adsorption Test of $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ Compounds Against Ciprofloxacin

Figure 6 showed that the $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ compound has the ability to adsorb ciprofloxacin compounds. The adsorption ability of CBT is consistent with previous reports. The adsorption properties of Aurivillius compounds have been documented by several studies. Al-Abror et al. (2022) reported that the absorbance of the Aurivillius compound $\text{SrBi}_4\text{Ti}_4\text{O}_{15}$ slightly decreases as the concentration of methylene blue decreases. This suggests that $\text{SrBi}_4\text{Ti}_4\text{O}_{15}$ is capable of absorbing methylene blue.

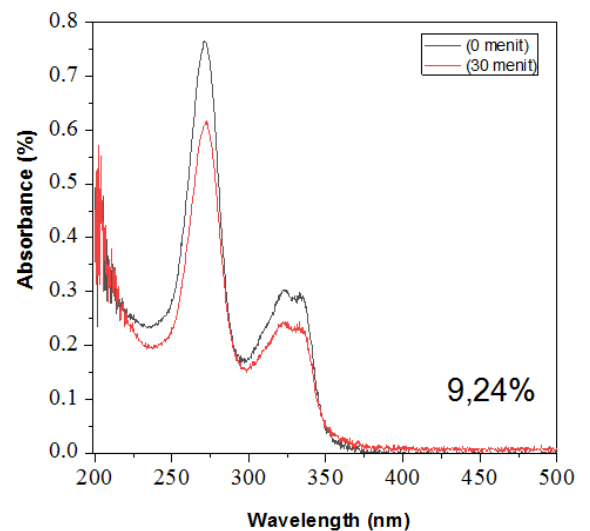


Figure 6 Results of the adsorption test of the $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ compound

C. Adsorption-Photocatalyst Test of $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ Compounds Against Ciprofloxacin Using UV Lamps

Figure 7 shows a decrease in absorbance of approximately 35%, indicating a reduction in ciprofloxacin concentration by the same percentage. When compared to the adsorption capability (Figure 6), which is 9.24%, it becomes evident that the photocatalytic mechanism contributes more significantly than adsorption. The presence of the photocatalytic mechanism results in a substantial reduction in ciprofloxacin concentration.

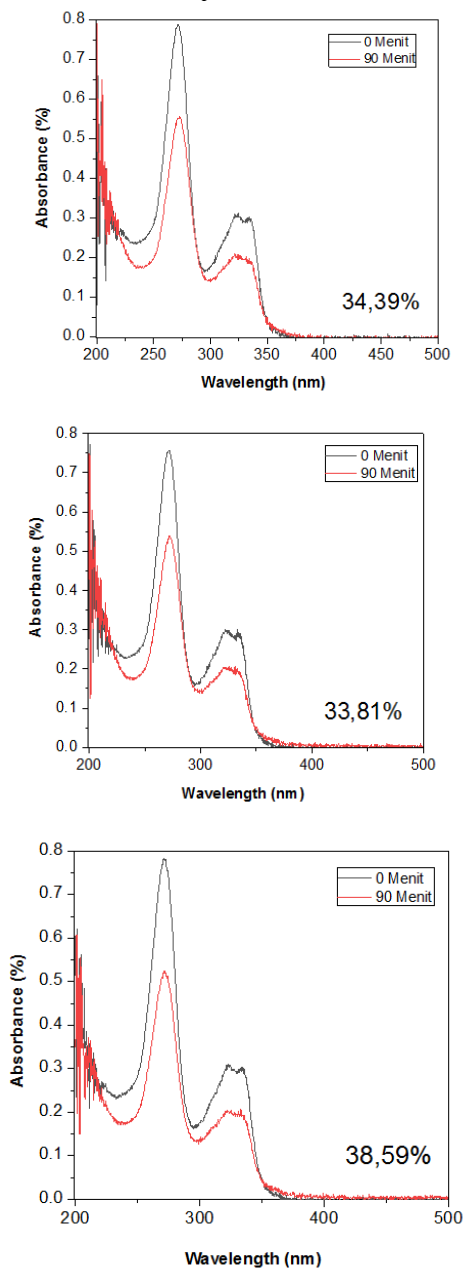


Figure 7 Results of the degradation test of the $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ compound

IV. CONCLUSION

The $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ compound was successfully synthesized using the NaCl/KCl by molten salt method. The SEM image showed that the $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ morphology is plate-like. The results of the Kubelka-Munk calculation showed that the band gap energy value of $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ is 3.148 eV. The results of the adsorption-photocatalyst test showed that $\text{CaBi}_4\text{Ti}_4\text{O}_{15}$ can decrease ciprofloxacin concentration at around 35%.

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Student Communal Space Optimization Using Space Syntax Method Case Study: UIN Maulana Malik Ibrahim Malang (Campus 1)

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Abstract- Communal spaces are essential for students to engage in various activities on campus. Previous research on student communal spaces has primarily focused on the internal aspects of these spaces, such as their capacity to accommodate student activities, students' perceptions of the communal space, the social interactions that occur within them, and behavioral analyses of students in these spaces. Consequently, this study seeks to examine student communal spaces from an external perspective, specifically by investigating the connectivity and visibility of the surrounding environment to identify the most optimal areas that hold significant potential for development into student communal spaces. UIN Maulana Malik Ibrahim Malang has yet to provide high-quality and optimized communal spaces for students within the campus environment. Using the Space Syntax method, this study reveals three areas with the potential to be developed into student communal spaces on campus based on the results of Axial Graph Analysis (AGA) and Visibility Graph Analysis (VGA): the area between the Science and Technology Building and the Megawati Building, the area in front of the microteaching lab, and the grand staircase area. The findings of this study are expected to serve as recommendations for the university in planning the development of student communal spaces within the campus environment.

Keywords; *Student Communal Space, Space Syntax, Optimization*

I. INTRODUCTION

Students at all levels of education tend to form small to large groups and identify specific locations for gathering and interacting [1]. In addition, to serving as a place for teaching and learning, the campus functions as a social space that fosters interaction and socialization among its members. These interactions often occur in hallways, corridors, staircases, cafeterias, or other common areas [2].

The spatial arrangement that shapes communal spaces is fundamentally influenced by the characteristics of

the communal space itself, the activities of students utilizing the space, and the behavior of users. To determine an appropriate design for campus development, it is essential to consider the available facilities and the quality of the learning environment [3]. The presence of communal spaces, such as public open areas, plays a critical role in enhancing the quality of life and well-being of academics, particularly students [4], [5], [6], [7]. Public open spaces are significant as they promote active lifestyles and foster beneficial interactions between humans and nature, contributing to both physical health [8] and mental well-being [9], overall well-being [10], and quality of life [11].

The criteria for public open spaces as social spaces on a university campus often include proximity to the campus's main circulation routes [12], due to their high accessibility, the presence of safe pathways [13], and strategic placement at crossroads or near essential student services (e.g., photocopy shops or cafeterias). These spaces are typically equipped with seating areas and shade-providing elements, which may consist of either specific materials or natural elements such as trees [1]. However, it is not only the distance that influences usage but also the size and attractiveness of public open spaces. Larger public open spaces tend to draw users from greater distances, whereas smaller spaces, even if located nearby, may be less attractive [14]. The concept of proximity pertains to the physical distance between two destinations, while the concept of choice relates to the variety of accessible alternatives. Beyond the physical form of green spaces, factors such as accessibility [15], [16], and the selection of specific spaces [17], [18] can influence how effectively a space serves as a venue for public interaction.

Earlier studies on student communal spaces have largely concentrated on their internal characteristics, including their ability to support student activities [19], students' perceptions of the spaces [20], social interactions within them [21], and analyses of student behavior in these

areas [22]. In response, this research aims to explore student communal spaces from an external standpoint, focusing on the connectivity and visibility of the surrounding environment to identify the most suitable areas for potential development into student communal spaces.

UIN Maulana Malik Ibrahim Malang students tend to do their assignments outside the campus locations, such as coffee shops, cafeterias, and mosques, due to the inadequacy of on-campus communal spaces. The limited availability of suitable communal areas forces students to seek alternative spaces that better support their informal activities. Additionally, the quality of the provided communal spaces fails to meet students' needs, particularly regarding supportive facilities, accessibility, and visibility. Based on these considerations, UIN Maulana Malik Ibrahim Malang was selected as an appropriate case study.

This research aims to identify areas with optimal spatial configurations for use as communal spaces on the UIN Maulana Malik Ibrahim Malang Campus 1 and to optimize the spatial conditions surrounding these spaces to serve as effective communal areas for students. The study employs the Space Syntax approach, considering the proximity of public open spaces as communal areas and the ease with which students can access them. Measurements of connectivity and the accessibility of public open spaces for learning and interaction can be conducted using the Space Syntax method. Originally introduced by Hillier and Hanson at University College London in 1984, Space Syntax represents spatial structures through axial maps, the basic unit of measurement in Space Syntax from which all syntactic calculations are derived. This research focuses on the campus pathways at UIN Maulana Malik Ibrahim Malang as the unit of analysis. By identifying the characteristics of communal spaces and examining road access configurations, this study seeks to evaluate their effectiveness as public open spaces. The findings are expected to provide useful insights for campus designers and decision-makers to enhance the design of public spaces that support productive social interactions and meaningful learning experiences for students.

II. MATERIAL AND METHODS

In this study, the data utilized includes a map of UIN Maulana Malik Ibrahim Malang, comprising buildings and open spaces (solid-void), as illustrated in Figure 1. Field observations were subsequently conducted in the UIN Maulana Malik Ibrahim Malang area to identify building zones, parking areas, and other spaces that are unsuitable for communal purposes due to specific conditions. The research employs both quantitative and qualitative methods.



Figure 1 UIN Maulana Malik Ibrahim Map
(Personal Documentation, 2024)

The study uses the DepthmapX software to analyze the spatial configuration, aiming to identify the most effective spaces based on the highest values of connectivity, integration, and visibility. The data collected is processed and analyzed through these metrics. The analysis focuses on measuring integrity, connectivity, and visibility to assess the compactness of the road network in supporting public spaces (Mohammed & Abaas, 2024). The integrity value represents the relative distance from one observed space to all other spaces within the spatial system (Turner et al., 2005; Claudia Yamu et al., 2021). Connectivity is calculated based on the number of spaces directly connected to a specific path.

DepthmapX will compute the axial graph (connectivity, integration, and choice) and visibility graph for the UIN Maulana Malik Ibrahim Malang area. This analysis will result in recommendations for potential areas that could serve as communal spaces for students.

III. RESULT AND DISCUSSION

A. Axial Graph Analysis (AGA)

The axial map is used to analyze the potential movement and accessibility of communal spaces from both

roads and academic buildings. The higher the level of accessibility, the redder the color index produced. Conversely, the bluer the color index, the lower the accessibility and movement in the area. There are three main aspects calculated in an axial map: connectivity, integration, and choice.

Connectivity

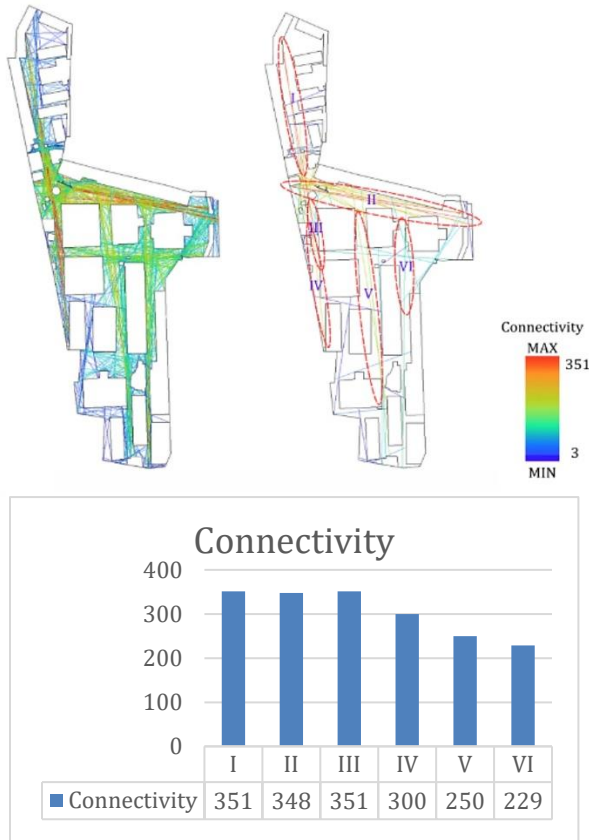


Figure 2 Connectivity Analysis
(DepthmapX Analysis Result, 2024)

Connectivity identifies areas that are directly connected (Mohammed & Abaas, 2024). The use of connectivity analysis aims to locate areas with the highest levels of interaction, facilitating student access to these spaces. As shown in Figure 2, the area with the highest connectivity is located along the corridor of the male dormitories (Area I) with a score of 351, in front of the Saintek Building (Area III) with a score of 348, and in front of the microteaching lab building (Area II) with a score of 348. Areas with red to yellow color indices have a high potential to serve as communal spaces due to their high accessibility from surrounding buildings. However, because Area I is restricted to male students, it is considered a more private space, limiting access for the wider student population. In Area III, there are no spaces with the potential to serve as communal areas for students, as the

space is already fully occupied by parking lots. In contrast, Area II still has available green open space, which could be optimized to create a communal area for students.

Local Integration

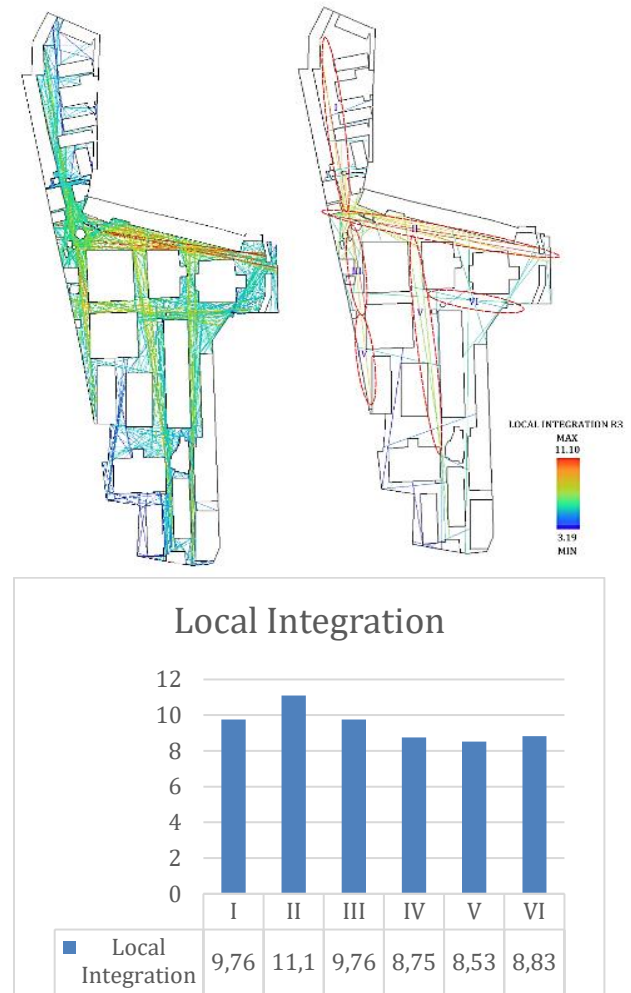


Figure 3 Integration Analysis
(DepthmapX Analysis Result, 2024)

This analysis identifies the potential movement within the area, with a relatively low value scale. Local integration examines the local movement of pedestrians and their access to specific destinations. The integration analysis of the UIN Maulana Malik Ibrahim Malang campus (Figure 3) shows that the area in front of the microteaching lab building (Area II) has the highest integration value, at 11.1. The second highest is the area in front of the Saintek Building (Area III) and the male dormitory area (Area I), both with an integration value of 9.76. The third highest is the grand staircase area (Area VI), with an integration value of 8.83. However, only two areas are identified as having the potential to be developed into student communal spaces: Areas II and VI. Filtration of natural peat water showed a

persistent brownish-red color, which suggests the presence of lignin compounds and substances from the humification process, including minerals like iron (Fe) and manganese (Mn). This high color indicates a natural color with positively charged colloidal particles that cannot be deposited by gravity [13]. The 20 μm filter effectively retained larger particles but failed to remove dissolved colorants. The peat water exhibited a low pH, attributed to fulvic and humic acids. Other parameters, including removal of total dissolved solids (24,4%), alkalinity (10,8%), organic matter (2,7%), and turbidity (5%), showed minimal reduction post-filtration, with the decrease in TDS correlating with turbidity, indicating a low concentration of suspended solids. The test results of natural pH peat water samples with a temperature of 25-27°C are shown as follows.

Local Choice

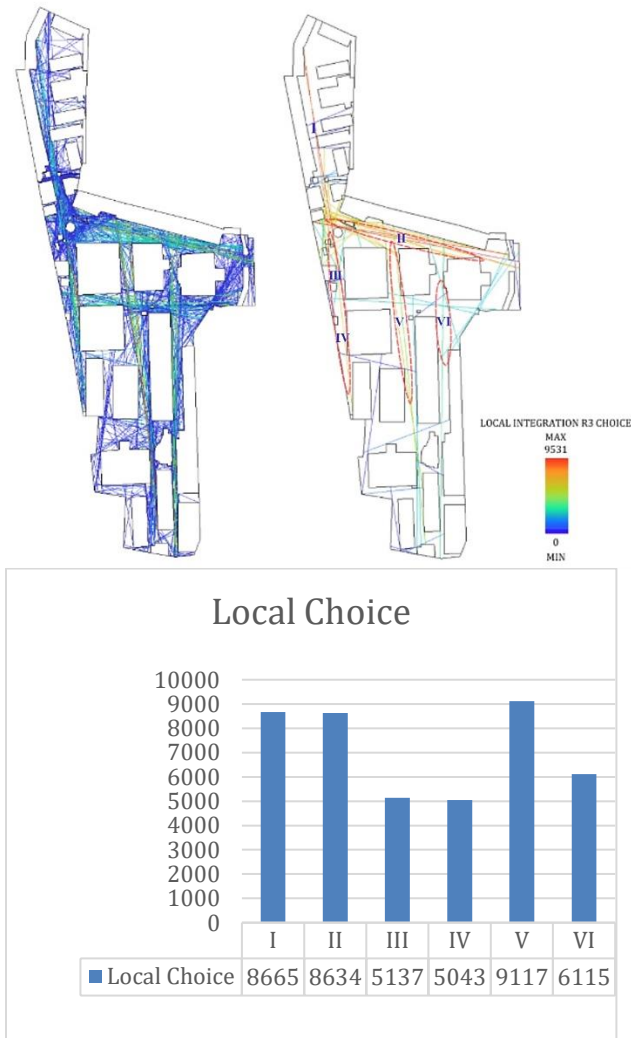


Figure 4. Local Choice Analysis
(DepthmapX Analysis Result, 2024)

The local choice analysis aims to identify areas within UIN Maulana Malik Ibrahim Malang that offer high access options, thereby facilitating user access to these locations. The results of this analysis (Figure 4) indicate that the area between the Megawati Building and Building B (Area V) has the highest local choice value, at 9,117. The male dormitory area (Area I) and the area in front of the microteaching lab building (Area II) have nearly identical local integration values of 8,665 and 8,634, respectively. The third highest value is found in the grand staircase area (Area VI), with a score of 6,115. Among these four areas, only three are identified as having the potential to be optimized into student communal spaces: Areas II, V, and IV.

B. Visibility Graph Analysis (VGA)

In this study, visibility graph analysis is employed to identify areas within UIN Maulana Malik Ibrahim Malang that have the potential to serve as communal spaces based on their visibility characteristics. As illustrated in Figure 5, several areas on the campus exhibit the highest visibility, indicated by shades ranging from red to orange. The five areas with the highest visibility values include the area in front of the microteaching lab building (Area II), the area in front of the Humanities Building (Area VIII), the grand staircase area (Area VI), and the area between the Megawati Building and Building B (Area V). Based on field conditions, only three areas are identified as suitable for optimization into student communal spaces: Areas II, V, and VI.



Figure 5 Visibility Graph Analysis
(DepthmapX Analysis Result, 2024)

After analyzing all areas within UIN Maulana Malik Ibrahim Malang using Axial Graph Analysis (AGA) and Visibility Graph Analysis (VGA) techniques, along with observations of real conditions on site, only three areas are identified as most suitable for maximizing their function as student communal spaces. These areas are the space in front of the microteaching lab building (Area II), the area between the Megawati Building and Building B (Area V), and the grand staircase area (Area VI). Table 1 demonstrates that the AGA and VGA values for each of these areas are relatively high, indicating significant potential for their design as student communal spaces based on actual field conditions.

Tabel 1. Potential Areas and The AGA-VGA Value

	II	V	VI
Area			
Connectivity	348	300	229
Local Integration	11,1	8,53	8,83
Local choice	8634	9117	6115
Visibility graph			

(Personal Analysis, 2024)

Furthermore, the findings of this analysis align with previous research indicating that effective communal spaces are those located near roadways and public areas. These three areas are recommended to UIN Maulana Malik Ibrahim Malang for consideration in the planning and development of student communal spaces within the campus environment.

When compared to the factual conditions on-site, among the three areas, Area V is the most suitable for development into a student communal space. This is because Area V has the largest expanse of land compared to Areas II and VI, and is predominantly composed of green

spaces. As a result, students can engage in activities while enjoying a lush, cool, and refreshing environment.

IV. CONCLUSION

Communal spaces for students within the campus environment are crucial for enhancing student productivity. These spaces are not only utilized for completing assignments but also serve as venues for personal development, particularly in soft skills. Students can socialize, engage in organizational activities, and build their confidence. Previous studies have predominantly focused on the internal aspects of student communal spaces, while research addressing external aspects, such as connectivity and visibility, remains lacking. This is where the primary contribution of this study lies.

UIN Maulana Malik Ibrahim has many potential areas that could be developed into student communal spaces; however, in reality, these spaces have not been fully utilized despite the significant demand from students. This study demonstrates that there are three areas with the potential to be optimized as student communal spaces based on the results of the Axial Graph Analysis (AGA) and Visibility Graph Analysis (VGA). The results of this study are anticipated to provide guidance to the university in formulating plans for the development of student communal spaces on campus.

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Commercializing Traditional Green Spaces: A Sustainability Analysis of *Telajakan* Transformations Along Karna Street Ubud Bali

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Abstract. This study explores the transformation of *telajakan*—traditional green buffer spaces in Bali—into commercial zones, analyzing the influence of economic, social, environmental, and cultural factors. *Telajakan*, once important for maintaining environmental quality and cultural values, is increasingly being converted into commercial spaces, particularly in tourism-heavy areas. The research was conducted among 44 business operators along Jalan Karna, Ubud, where *telajakan* spaces are being transformed into kiosks. Data were collected using a Likert scale survey to assess the impact of these factors. The regression analysis revealed that while cultural factors significantly resisted the transformation ($p = 0.008$), economic and social pressures, such as financial incentives and community influence, had a greater impact. Environmental factors were not significant. The negative relationship between cultural factors and commercialization suggests that, although respondents did consider cultural values, these considerations were ultimately overpowered by economic priorities or cultural values were adapted to accommodate commercial needs. This study provides empirical insights into how economic forces and social dynamics are driving the commercialization of Bali's traditional green spaces.

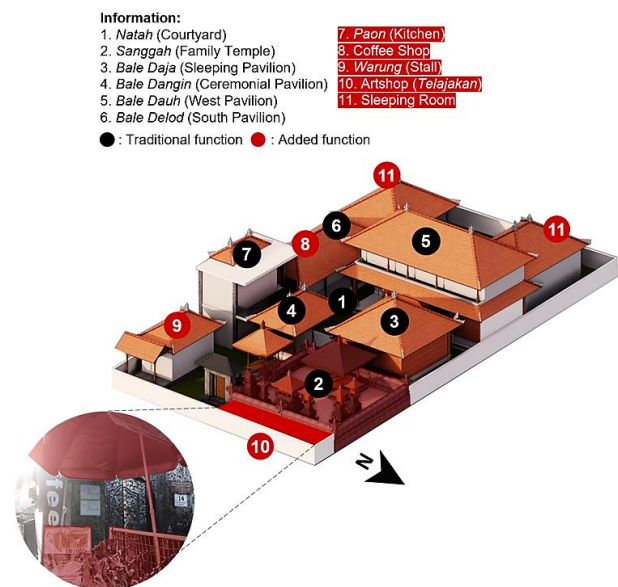
Keywords; Four Pillars Of Sustainability, *Telajakan* Transformation, Traditional Green Spaces, Tourism-Driven Change

I. INTRODUCTION

Telajakan, the traditional green space between housing compound walls and roadsides in Bali, plays a crucial role in providing a buffer for noise reduction, improving air quality, and maintaining the aesthetic and cultural values of traditional settlements [1]. However, the rise of tourism and urbanization in Ubud has led to significant transformations of *telajakan* into commercial spaces [2,3]. This research aims to explore the key factors driving these changes and the extent to which economic, social, environmental, and cultural factors influence the transformation process, addressing the central question: What are the primary factors driving the transformation of

telajakan from traditional green spaces into commercial areas, and how does the permanence of kiosks correlate with these transformations?

From Tradition to Transaction: The Commercialization of Vernacular Spaces



Adapted *Telajakan* as Artshop

Figure 1. *Telajakan* in Balinese Traditional Housing

The transformation of *telajakan*—once a culturally and socially significant green buffer—into commercial spaces highlights a profound shift in how vernacular architecture adapts to modern economic pressures [1,4]. Traditionally, *telajakan* served multiple functions, including improving air quality, reducing noise, and providing a space for cultural rituals. These spaces were integral to the social fabric of Balinese communities, representing not just a physical buffer but a symbolic connection between residents and their environment. However, as tourism has become a

dominant economic force, *telajakan* is increasingly being converted into commercial areas to cater to the needs of tourists and business operators. This shift underscores the growing trend of prioritizing economic transactions over the preservation of traditional, community-centered spaces [5,6].

The transformation from community-centered spaces to tourism-driven commercial areas disrupts the original purpose of *telajakan*. Where once these spaces fostered social cohesion and supported cultural practices, they are now redefined to accommodate kiosks, cafes, and shops aimed at generating economic benefits. This commercialization is often seen as a necessary adaptation to meet the demands of urbanization and tourism, but it alters the way communities engage with these spaces. Instead of serving as areas for social interaction or environmental preservation, *telajakan* becomes a commodity, catering to the flow of tourists and external economic needs, which shifts the focus away from local, communal values. As *telajakan* spaces transform, the social impacts of commercialization become more apparent. The shift toward commercial use redefines the community's relationship with the space, altering the way it is perceived and utilized. The once shared, community-centric use of *telajakan* is replaced by commercial ownership and individual profit-making. Furthermore, community pressure plays a key role in this transformation. While some members may support commercialization as a way to increase income, others may resist the change, creating a tension between maintaining cultural integrity and pursuing economic growth. This tension reflects broader societal changes, where economic priorities often override the preservation of traditional, communal spaces.

The transformation of *telajakan* illustrates the broader challenge faced by many traditional spaces in tourism-heavy regions: the need to balance economic growth with social and cultural preservation. While commercialization can bring economic benefits, it often comes at the cost of social cohesion and cultural identity. As these spaces evolve to meet economic demands, it becomes essential to consider how to preserve their social function and maintain a sense of community within the commercial landscape. In the case of *telajakan*, finding a sustainable balance that integrates both commercial activities and the social needs of the community will be crucial in ensuring that these spaces do not lose their cultural and social significance entirely.

The Sustainability Imperative in Vernacular Architecture

As urbanization and tourism continue to reshape traditional landscapes across the globe, the balance between economic growth and sustainability becomes increasingly precarious [7]. In regions like Bali, where vernacular architecture such as *telajakan* plays a critical role in the cultural and environmental identity of the community, the pressures of commercialization threaten to undermine these traditional spaces [8]. This paper addresses the growing challenge of preserving the social, environmental, economic, and cultural values embedded in vernacular architecture while accommodating modern economic demands. By examining the transformation of *telajakan* spaces, this study seeks to highlight the critical importance of integrating sustainable development practices that ensure long-term preservation of community heritage and environmental health without sacrificing the potential for economic growth. The discussion of sustainability across multiple dimensions—social, environmental, economic, and cultural—is essential to understanding how to protect these spaces from unchecked modernization and commercialization.

Vernacular architecture inherently supports social sustainability by fostering strong community bonds, traditions, and shared practices. In traditional spaces like *telajakan* in Bali, these architectural features are not just physical spaces but areas that reinforce social cohesion [9]. The community gathers, interacts, and participates in cultural rituals, all of which strengthen the social fabric. However, as these spaces transform to accommodate commercial activities driven by tourism, the risk of losing this social connection grows. To maintain social sustainability, it is essential to find ways to adapt traditional spaces for modern use while ensuring that they continue to serve their community-building functions. From an environmental sustainability perspective, vernacular architecture like *telajakan* is often naturally aligned with climate-responsive and resource-efficient design principles. These spaces, which traditionally feature greenery, open layouts, and natural materials, help improve air quality and reduce noise pollution. The shift toward commercial use, however, poses a threat to these environmental benefits. The addition of permanent structures and kiosks can reduce green space, contribute to urban heat islands, and increase pollution. Preserving the environmental benefits of traditional architecture during modernization requires strategies that integrate green infrastructure with new developments, allowing spaces to maintain their role as environmental buffers. In terms of economic sustainability, the transformation of vernacular spaces like *telajakan* is

often driven by the desire for economic growth, particularly in tourism-heavy areas like Ubud. Commercializing these spaces can bring economic benefits to local business owners and communities, helping to increase income and improve living standards. However, the challenge lies in ensuring that this economic development is inclusive and long-term, rather than sacrificing the cultural and environmental value of the spaces for short-term gains. Sustainable economic growth in these contexts requires balancing profitability with the preservation of traditional landscapes, ensuring that modernization doesn't undermine the very qualities that make the space attractive to visitors.

Table 1. Literature Review of the *Telajakan* Transformation Study

Aspect	Variable
Transformation Level (Y)	Degree of transformation from green space to commercial space ^b
	Permanence level of kiosks in <i>telajakan</i> spaces ^c
Social Aspect (X)	Influence of the community or neighbors on the decisions to commercialize <i>telajakan</i> ^d
	The consideration of social relationship changes ^e
Economic Aspect (X)	Impact of economic benefits on the decision to commercialize ^b
	Impact of transformation costs on decisions ^b
Environmental Factors (X)	Impact of air quality degradation on <i>telajakan</i> commercialization decisions ^a
	Impact of noise pollution on <i>telajakan</i> commercialization decisions ^a
	Impact of green space reduction ^a
	Waste management considerations ^c
Cultural Factors (X)	Impact of traditional ceremonies on decisions to maintain <i>telajakan</i> ^b
	The importance of traditional aesthetics in decision-making ^b
	Impact of daily rituals on the maintenance of traditional elements ^e
	Importance of cultural value preservation in commercialized areas ^e

Note: The table provides a comparative analysis of multiple sources, adapted as follows

^aSource: Adapted from [5]

^bSource: Adapted from [10]

^cSource: Adapted from [11]

^dSource: Adapted from [12]

^eSource: Adapted from [13]

II. RESEARCH METHODOLOGY

This study employs a quantitative research methodology to examine the factors influencing the transformation of *telajakan* into commercial spaces and how the permanence of kiosks correlates with these changes. A regression analysis was chosen due to its ability to quantify the relationship between multiple independent variables (economic, social, environmental, and cultural factors) and the dependent variable (the level of *telajakan* transformation) [14]. SPSS software was used for this analysis because it provides robust tools for handling large datasets and conducting precise statistical evaluations. The research surveyed 40 respondents, all of whom are business operators along Jalan Karna in Ubud, Bali. These respondents were selected due to their direct involvement in the commercialization of *telajakan* spaces, which allowed for detailed insights into the transformation dynamics in this region. A Likert scale was used to assess the degree to which these factors affected respondents' decisions. The data were analyzed using regression analysis to determine the significance of each factor in predicting the level of *telajakan* transformation.

The dependent variable (Y) was the *Telajakan* Transformation Level. The independent variables (X) were social, economic, environmental, and cultural factors (Table 1). The research hypotheses were structured to examine the influence of each factor:

Economic Factors:

- Ho1: Economic factors do not significantly influence the level of *telajakan* transformation.
- H1a: Economic factors significantly influence *telajakan* transformation.

Social Factors:

- Ho2: Social factors do not significantly influence the level of *telajakan* transformation.
- H1b: Social factors significantly influence *telajakan* transformation.

Environmental Factors:

- Ho3: Environmental factors do not significantly influence the level of *telajakan* transformation.
- H1c: Environmental factors significantly influence *telajakan* transformation.

Cultural Factors:

- Ho4: Cultural factors do not significantly influence the level of *telajakan* transformation.
- H1d: Cultural factors significantly influence *telajakan* transformation.

IV. RESULT AND DISCUSSION

The Shifting Landscape: Telajakan Transformation and Kiosk Permanence Level

The commercialization of *telajakan* spaces in Bali, driven by tourism and urbanization, has resulted in significant changes to these traditional green areas. Once serving key environmental and cultural functions, *telajakan* are increasingly being repurposed for commercial use. This section presents the results of the study, focusing on the extent of *telajakan* transformation and the corresponding kiosk permanence. By analyzing these factors, the data provides a clearer understanding of how commercialization is reshaping *telajakan* spaces, with important implications for both cultural preservation and economic development.

Table 2. *Telajakan* transformation and kiosk permanence level

Transformation Level	Number of Respondents	Percentage (%)	Kiosk Permanence Level	Number of Respondents	Percentage (%)
No Change (1)	0	0.0	No Kiosk (1)	0	0.0
Slight Change (2)	1	2.27	Temporary Kiosk (2)	3	6.81
Moderate Change (3)	6	13.64	Semi-Permanent Kiosk (3)	11	25.0
Significant Change (4)	32	72.73	Partially Permanent Kiosk (4)	27	61.36
Complete Change (5)	5	11.36	Fully Permanent Kiosk (5)	3	6.82

The data presented in Table 2 provides a comprehensive overview of the transformation of *telajakan* spaces and the corresponding kiosk permanence levels. *Telajakan*, traditionally functioning as cultural and environmental buffer zones in Bali, are increasingly subject to commercialization due to the pressures of tourism and urbanization. The transformation of these spaces is categorized into five levels: No Change, Slight Change, Moderate Change, Significant Change, and Complete Change. Notably, the data reveals that 72.73% of respondents reported a significant transformation of *telajakan*, highlighting that a large proportion of these spaces have undergone extensive modification. Furthermore, 11.36% of respondents indicated that their *telajakan* had experienced complete transformation, signaling a total departure from the traditional functions of these green spaces. In contrast, 13.64% of respondents reported moderate changes, while only 2.27% indicated slight changes. Significantly, none of the respondents

reported no change, which underscores the pervasiveness of commercialization in the studied areas.

In parallel, the table also presents data on the permanence of kiosks established in these transformed spaces. Kiosk permanence is an important indicator of how entrenched commercialization has become within *telajakan* areas. The data shows that 61.36% of respondents reported the presence of partially permanent kiosks, suggesting that commercial structures have been integrated into *telajakan* spaces in a relatively fixed manner, yet still allow for some degree of temporary use. Additionally, 25% of respondents identified semi-permanent kiosks, which indicates that commercial activities, while not entirely permanent, are expected to persist for extended periods. Moreover, temporary kiosks account for 6.81%, while fully permanent kiosks represent 6.82% of the structures, signifying that in certain cases, commercialization has fully taken hold, making these kiosks a lasting presence within the space.

The relationship between *telajakan* transformation and kiosk permanence is evident in the data. As *telajakan* spaces undergo more significant transformations, the permanence of kiosks increases correspondingly. For instance, a substantial number of respondents who reported significant changes in *telajakan* also indicated the presence of partially permanent kiosks, reflecting a direct correlation between the extent of transformation and the integration of more permanent commercial structures. Similarly, respondents who noted complete transformation of their *telajakan* spaces were also more likely to report the presence of fully permanent kiosks. This relationship highlights the progressive nature of commercialization, where initial temporary kiosks evolve into semi-permanent and eventually fully permanent fixtures as *telajakan* spaces are increasingly utilized for economic purposes.

These findings point to the increasing entrenchment of commercialization within *telajakan* spaces, driven largely by tourism-related activities. The predominance of significant and complete transformations, coupled with the presence of semi-permanent and fully permanent kiosks, suggests that these spaces are being fundamentally repurposed for commercial use. The absence of no change responses underscores the idea that commercialization is nearly universal in the studied areas, raising concerns about the long-term implications for both the cultural and environmental sustainability of these traditionally significant spaces. The transition from a primarily green and communal space to one dominated by commercial structures reflects the tension between preserving cultural heritage and meeting the economic demands of tourism. In conclusion, the data in Table 2 provides clear evidence of

the widespread commercialization of *telajakan* spaces in Ubud. The levels of transformation and the permanence of kiosks suggest that the traditional role of *telajakan* is being increasingly compromised. As these spaces continue to be repurposed for tourism and commercial activities, the presence of semi-permanent and permanent kiosks signals that these changes are becoming long-lasting and difficult to reverse. The findings highlight the need for sustainable urban planning to ensure that *telajakan* spaces can continue to serve their traditional cultural and environmental functions while accommodating the growing demands of tourism. It is crucial to develop strategies that balance economic development with the preservation of cultural identity and environmental value to prevent the complete erosion of these significant vernacular spaces.

Regression Analysis: Factors Shaping the Commercialization of Telajakan

Table 3 presents the results of a regression analysis, which examines how economic, social, environmental, and cultural factors affect the transformation of *telajakan* spaces. The R-squared value is 0.274, indicating that these four factors explain about 27.4% of the variation in *telajakan* transformation. While this suggests that the model has moderate explanatory power, it also implies that other factors not included in the analysis may be influencing the transformation process. Regarding economic factors, the positive coefficient of 0.2880 suggests that as economic pressures increase, the transformation of *telajakan* spaces becomes more likely. However, the p-value of 0.123 is higher than the standard threshold of 0.05, meaning this result is not statistically significant. This outcome is unexpected, given the common assumption that economic pressures, especially from tourism, would play a major role in driving the transformation of these traditional spaces. While economic factors may still influence decisions, their impact does not appear to be statistically strong in this case.

Table 3. Regression analysis: Significance of each aspect to the transformation of *telajakan*

Aspect	Coefficient	p-value	Significance
Economic Factors	0.2880	0.123	Not Significant
Social Factors	0.0976	0.522	Not Significant
Environmental Factors	0.1797	0.277	Not Significant
Cultural Factors	-0.2539	0.008	Significant
R-squared	0.274		

Social factors show a positive coefficient of 0.0976, indicating a slight positive relationship with *telajakan* transformation. However, the p-value of 0.522 shows that this relationship is also not statistically significant. This result implies that social dynamics, such as community influence, do not strongly affect the decision to transform *telajakan* spaces. Even though social factors are often considered influential in communal decision-making, they appear to have a minimal role in this particular context. Environmental factors exhibit a positive coefficient of 0.1797, suggesting that environmental pressures, such as degradation or loss of green spaces, might be associated with increased *telajakan* transformation. Nevertheless, the p-value of 0.277 indicates that environmental factors are not statistically significant in this model. This is noteworthy because *telajakan* traditionally serve important environmental functions, such as improving air quality and reducing noise pollution. The insignificance of environmental factors suggests that these concerns may be overlooked in favor of other priorities, such as economic or cultural factors. In contrast, cultural factors show a statistically significant influence on *telajakan* transformation, with a negative coefficient of -0.2539 and a p-value of 0.008. This indicates that stronger cultural values are associated with a decrease in the likelihood of *telajakan* spaces being transformed into commercial areas. This finding underscores the importance of cultural preservation efforts in resisting commercialization. Communities that value their cultural heritage are more likely to retain the traditional functions of *telajakan*, using them as cultural and environmental buffers rather than converting them into commercial spaces.

In conclusion, the regression analysis indicates that cultural factors play the most significant role in preserving *telajakan* spaces, while economic, social, and environmental factors have less significant impacts. This highlights the critical importance of cultural values in resisting the pressures of commercialization, particularly in tourism-driven areas. Communities that prioritize cultural preservation are more likely to protect the traditional functions of *telajakan*, emphasizing the need for cultural sustainability amid rapid urbanization.

Discussion: Insights from Correlation Analysis of *Telajakan* Transformation

Based on the correlation heatmap between social, economic, environmental, and cultural factors, several key relationships emerge that provide insights into the dynamics of *telajakan* transformation. The most notable observation is the moderate positive correlation (0.61) between economic and cultural factors. This suggests that as economic pressures increase, there may be a corresponding emphasis on cultural considerations, perhaps due to efforts to maintain a balance between commercialization and cultural preservation. It highlights the nuanced interaction where economic growth and tourism could potentially coexist with the safeguarding of traditional values. Similar findings have been observed in studies on cultural landscapes, where economic opportunities, such as tourism, often drive transformations but also incentivize communities to preserve cultural elements that attract visitors [15]. However, these studies also caution that while economic growth may foster cultural preservation initially, it can eventually lead to cultural commodification if not managed sustainably [16].

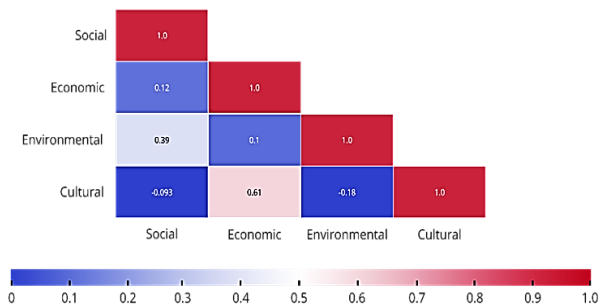


Figure 2. Correlation heatmap between aspects

The mild positive correlation (0.39) between social and environmental factors suggests that communities with stronger social cohesion are more likely to prioritize environmental impacts, such as preserving green spaces or reducing pollution during commercialization. However, in contrast, studies in other tourism-heavy regions, such as Chiang Mai in Thailand, have shown that social cohesion can weaken under intense economic pressures, leading to the neglect of environmental concerns. This suggests that while social cohesion may currently support environmental preservation in areas like Karna Street, it may diminish if economic drivers become too dominant [17].

The weak negative correlation (-0.18) between cultural and environmental factors suggests a potential trade-off between preserving cultural heritage and

promoting environmental sustainability. For example, efforts to maintain cultural rituals or aesthetic elements may sometimes conflict with environmental priorities, such as preserving green spaces. This tension is reflected in studies by Rapoport (2005), who argued that built environments often prioritize symbolic cultural meanings over ecological considerations, particularly in urbanized settings [18]. Additionally, the weak negative correlation (-0.093) between cultural and social factors suggests that efforts to preserve cultural traditions do not always align with strong social pressures or community influence. This finding aligns with previous research, which highlighted that cultural preservation in Bali often operates independently of social dynamics, especially when cultural values are institutionalized through policy or tourism-driven narratives rather than grassroots community initiatives [19,20].

In conclusion, the heatmap shows how different factors interact with each other in the process of *telajakan* transformation. Economic and cultural factors often work together, which suggests that economic growth might still respect cultural traditions. However, social and environmental factors don't always align perfectly with cultural preservation, meaning that efforts to protect green spaces can sometimes clash with maintaining cultural practices. This highlights the complex challenges in balancing tourism, economic growth, and cultural preservation when it comes to managing traditional green spaces like *telajakan* in Bali.

IV. CONCLUSION

In this study, the transformation of *telajakan*—Bali's traditional green buffer spaces—was analyzed through both regression and correlation analyses, revealing the intricate interplay of economic, social, environmental, and cultural factors. The regression analysis indicated that cultural factors were the most significant in reducing *telajakan* transformation, with a negative coefficient (-0.2539) and a significant p-value (0.008). This means that stronger cultural values actively discourage the commercialization of *telajakan* spaces, demonstrating the role of cultural preservation in resisting change. Interestingly, social, economic, and environmental factors did not show statistically significant results in the regression analysis, contrary to what might be expected in a tourism-driven region.

The correlation analysis further revealed that economic and cultural factors have a moderate positive relationship (0.61), suggesting that as economic pressures

grow, there is a parallel emphasis on cultural considerations. This may indicate that economic development in Bali still respects cultural values, perhaps as a strategy to attract tourists by maintaining the area's cultural authenticity. However, the weaker and sometimes negative correlations between other factors, such as the weak alignment between social and cultural factors (-0.093), highlight the potential conflicts between community pressures and cultural preservation in the context of transformation.

Sharpening these findings through Amos Rapoport's theory of environmental behavior and meaning, we can better understand why cultural factors emerge as significant in *telajakan* transformation [18]. According to Rapoport, the physical environment, including elements like *telajakan*, serves not just functional needs but is deeply intertwined with meaning and cultural symbols. In this context, *telajakan* spaces are not merely green buffers; they are imbued with cultural significance that reflects the identity, rituals, and values of the Balinese community. Rapoport argues that people use the built environment to express and sustain their cultural identity, and thus, transformations that threaten this symbolic meaning—such as commercialization—are met with resistance, as shown by the significant role of cultural factors in the regression analysis.

In conclusion, the study supports the idea that while economic and social drivers are powerful forces in tourism-heavy regions, it is the cultural meaning of spaces—in line with Rapoport's theory—that plays the most critical role in resisting change. *Telajakan* spaces, as cultural artifacts, are preserved not merely for functional reasons but because they embody the core values of the community. Therefore, any future planning or development strategies should carefully balance economic development with cultural preservation to maintain the integrity and meaning of these traditional spaces.

ACKNOWLEDGMENT

The authors are grateful to *Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi* (Center for Higher Education Funding - BPPT) and Endowment Fund for Education Agency (LPDP) for supporting this study.

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The Scope of Pesantren Area In The Perspective of Nusantara Islamic Architecture

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Abstract- Pesantren is an education that is still very typical in Indonesia. Space in architecture is closely related to the activities that arise in a community organization. One of them is within the scope of pesantren. In pesantren has core elements in it. Pesantren studies on architecture are very minimal, so this research develops how the urgency of architectural research on a regional scale, as well as on a micro scale in more important aspects and the sustainability of research that has been carried out. With the literature review method, it will later see the previous research process, which can then be abstracted again in the course of new research on architectural aspects in Pesantren. The result of the related discussion of this review literature is to see the research journey and combine the urgency of Islamic boarding school research and architecture.

Keywords; Space; Pesantren; Spatial

I. INTRODUCTION

According to Kaimuddin that the important role of Kiai (caregivers) in paying attention to education based on local wisdom in this case is Islamic boarding schools, it is not impossible to strengthen national character in the next generation of young people in order to create a culture that is beneficial for Indonesia. [1] [2]

Pesantren always develop along with the dynamics of their environment, so according to Muttaqien it is very possible to survive [3]. The development of the Islamic boarding school area has elements that are able to survive and develop to prioritize the distinctive identity of the pesantren itself. The meanings of space formed in order to advance the development of Islamic boarding schools will make Islamic boarding schools more existing and survive with the times. So in the four pesantren that became the locus of research, they still maintain the main building and mosque building as historical witnesses and maintain the meaning of the construction of the pesantren at the beginning of its development. So that the widespread development of knowledge about architecture in details that are more constricted on space and the development of

the survival of Islamic boarding schools is an important thing to be studied in the future.

This research was then developed so as to explain that there are several characteristics of the development of pesantren that do not follow standard rules, and remain in their establishment, including the traditional system, the spirit of democracy, simplicity, idealism, brotherhood [4].

Then the growth and development of pesantren developed in political and cultural implications, so that religious leaders and great scholars of community organizations in the archipelago became great Kiai-Kiai as an implementation of the development of pesantren and their philosophy in developing to be very good and can be a benchmark for the development of pesantren to date.

As facts found in the field, the social construction of pesantren spatial planning especially in pesantren Al-Muayyad involves the power of Kiai and the consequences of socio-religious changes that lead to development involving the character of buildings such as mosques, dormitories, ndalem (nanny houses), school buildings and so on. That is, Kiai as an individual who creates social reality in pesantren as well as an individual who is affected by current social changes, which according to Berger and Luckmann is known as a continuous dialectic process in which it is generated by the subject, then absorbed by the structure and returns it again to influence the subject's consciousness through the process of internalization. In addition, the social construction of spatial pesantren involves ideological meaning and economic meaning in its achievement, considering spatial pesantren as reality does not come from empty space but from the results of construction. Spatial pesantren whatever their material form has meanings and values that are considered by individuals through spatial patterns to influence the pattern of social relations in pesantren [5].

II. RESEARCH METHOD

This study used a literature review study approach. Reviewing and criticizing then discussing or dialoguing both ways between research and other research. Suggest that the systematic review should detail the time frame within which the literature was selected, as well as the methods used to evaluate and synthesize the research findings in order to evaluate and synthesize the intended research findings. So that readers understand and are able to assess the validity and reliability of the discussion, the reviewer needs to describe the right aspects that can be used to: 1. Formulate research questions, 2. Set inclusion or exclusion criteria, 3. Select and access literature, 4. Assess the quality of the literature included in the review, 5. Analyze and synthesize and disseminate research findings [6].

In a study on an article with a literature study approach, the stages are: providing a background /

theoretical basis for the research to be carried out, studying the depth of existing research related to the topic that will then be discussed, answering various practical questions regarding understanding the studies that have been produced by previous research [7]. In the stages are choosing the topic to be reviewed, tracking and selecting relevant articles, conducting analysis and synthesis of the literature found, and then organizing the writing of the review that has been done [7]. So that a result was found that can be continued in a deeper discussion. So reviewing the review literature is related to the suitability of paradigm selection in architectural and urban science.

IV. RESULT AND DISCUSSION

From the results of the analysis, researchers divided it into 3 parts as in the following table. Which sorting is by considering several things, scientifically Architecture, then according to the science of Pesantren and which combines both.

Table 1. Architecture and Space

Research Title	Research Objectives	Research Results
Transformasi dan Tipologi Bangunan Indo-Europeeschen Architectuur Stijl Kawasan Braga Bandung [8]	To find out the basic form of the Indo-Europeeschen Architectuur Stijl building typology by looking at the pattern of changes that occur in buildings in the Braga area.	Knowing the basis of the pattern of change in building typology in the Braga area.
Pemaknaan Kembali Kearifan Lokal Dalam Arsitektur (Keterkaitan Manusia, Budaya Dan Alam Nusantara) [8]	Extracting the values of local wisdom for the sustainability of harmony and sustainability of the human environment	Exploring the value of local wisdom as the harmony of the human environment in the surrounding environment.
Typology of social space in Kauman Kampong Semarang [9]	Looking for the shape and typology of spatial space in Kauman Village, Semarang	Finding spaces in spatial space typology in Kauman Village, Semarang.
Arsitektur Jawa pada Wujud Bentuk dan Ruang Masjid Agung Surakarta [10]	Knowing the representative form of Javanese architecture and finding elements of Javanese life values so that they can make a prototype mosque	Javanese architecture as an implementation of form and space in the Great mosque and found elements of Javanese life values and became the prototype of the mosque in general.
Dwelling form and culture in the traditional Najdi built environment, Saudi Arabi [11]	built neighborhoods in historic settlements preserved in Saudi Arabia's Najd region, provide insight into the shared core concepts and forms that were generally shared throughout settlement residences prior to the Kingdom's modernization period.	The concept and core form of togetherness that was able to be given to settlements before the modernization of the kingdom. Urban spatial hierarchy arises in the absence of a conflict, resulting in complementary physical forms.
Sacred Space in Community settlement of Kudus Kulon, Central Java, Indonesia [12]	Kudus Kulon, the existence of the available sacred space, and around the area of Kudus Kulon.	Sacred space is a form and container of religious worship activities and a tradition that can be strengthened in the existence of sacred space that is available and survives to this day.

From the author's observation journey related to aspects of architecture and space, space is the basic transformation of the pattern of change in a typology of buildings in an area in Bandung. In the meaning of an architecture in a study conducted by rest pitanti in the National Seminar, that the meaning in architecture is in exploring local wisdom as harmony with the environment of human sustainability in the surrounding environment.

The spaces formed in a more specific spatial area have several existing specificities, namely spaces in the typology of spatial space in Kauman Village Semarang conducted by previous researchers, finding typologies of

social space that exist in areas that have existing characteristics. The next research is in the corridors of Javanese architecture, namely them as an implementation of form and space in a Great Mosque and rediscovering elements of the value of community life in Java and becoming a mosque design followed by the development of further mosques. On research in the form, shape and space of the Great mosque of Surakarta.

Alnaim in his writings explains that the concept and essence of togetherness were able to be given to settlements before the modernization of the kingdom. Thus producing physical forms that complement each other. In

the spatial area, both the built environment is still simple in scale, to a specific environment, for example based on race, ethnicity, religion. There are found sacred or sacred spaces as a form and container of religious activities and a tradition

that can be strengthened in the existence of sacred spaces that are available and survive to this day.

Table 2. Pesantren

Research Title	Research Objectives	Research Results
Sejarah Pesantren di Indonesia [13]	Find the meaning of pesantren that has elements of santri, Kiai and dormitory.	Discover the meaning, history, and elements of Islamic boarding schools and the development of their periodization.
Sistem Pendidikan Pondok Pesantren Salafiyah Di Era Modern [14]	Salafi Islamic boarding schools will make changes and abandon their traditions.	Salafiyah Islamic boarding schools in the modern era will make changes and leave traditions to their unique in Islamic boarding schools in Sibuhuan.
Eksistensi Pesantren Salaf Di Tengah Arus Pendidikan Modern [15]	The role of kiai, various values, curriculum, and dedication of salaf pesantren in the midst of modern education.	The survival of the salaf Islamic boarding school in the midst of the development of modern education that still maintains its Islamic boarding school elements such as Kiai, students, curriculum and service.
Kearifan Lokal (Local Wisdom) Sebagai Basis Pendidikan Karakter [16]	Unearthing and instilling local wisdom inherently through education	The survival of the salaf Islamic boarding school in the midst of the development of modern education that still maintains its pesantren elements such as Kiai, students, curriculum and service.
Pondok Pesantren: Lembaga Pendidikan Pembentukan Karakter [17]	Finding the existence of an ideal pesantren as a government institution to improve the basic quality of character in the world of education	Islamic boarding schools that become character building education to always have an existence so as to improve the basic quality that remains in the corridor of improving the quality of education.
Pondok Pesantren Dan Ciri Khas Perkembangannya [4]	Finding figures of Islamic boarding school civilization in Indonesia	The development of Islamic boarding schools and their characteristics are able to survive on civilization in Indonesia because of the basic role of Kiai as the main holder in the key to survive Islamic boarding schools.
Peran Kiai Dalam Pembinaan Akhlak Santri di Pondok Pesantren [18]	Recognize the character of students and the sustainability of aspects of kiai and to sanad an science as authentication of maintained science	The role of kiai is one of the most original and real in maintaining the authenticity of science and the sustainability of character education and student development in Islamic boarding schools.

The history of pesantren can be explained in the form of (Herman) discovering the meaning of pesantren which has elements of santri and Kiai and Dormitory. Salafiyah Islamic boarding schools in the modern era will make changes and improve traditions to be unique to existing Islamic boarding schools (Hasibuan). This survival is then maintained and considered because it is able to survive because of its loving system, or survive because of the elements that make up the Islamic boarding school.

Research by Daniah, that character education prevails inherently as a real situation. This is reinforced by the explanation from Syafe'I that Islamic boarding schools are character-building education that always exists in improving the basic quality that remains alive and survives in improving the quality of education in the archipelago. However, according to the characteristics of its development in Ferdinan explained that civilization in the archipelago which is increasingly rapid with the existence of Islamic boarding schools always exists and survives due to the active role of Kiai as the main key control holder in Islamic boarding schools. The role of Kiai in fostering morals was also explained by Hakim and Sopwandin that one of Kiai's original and real roles in maintaining the authenticity of knowledge and continuing character education in Islamic boarding schools in fostering students.

So that Islamic boarding schools are very good in developing their education.

Table 3. Architecture-Space- Nusantara Islamic Architecture

Research Title	Research Objectives	Research Results
The Islamic City-Historic Islamic Essence , And Contemporary Relevance [19]	to examine and critique some basic works in that tradition and then	The various ways that can be desired in building a contemporary city based on its main religious principles are Islam.
ARSITEKTUR ISLAM: Seni Ruang dalam Peradaban Islam [20]	Discovering the fact that Islamic architectural works around the world that are based on Islamic ethical values and behavior do not represent a single and identical form	Discover a fact of Islamic architectural works around the world. Everything is based on Islamic ethical values and behavior. But it has a variety of Islamic architectural products that lead to humans to rahmatan lil'alam.
Perubahan Sosial, Budaya dan Ekonomi Di Kampung Kauman Semarang 1962-1998 [21]	Knowing the general description, socio-cultural, economic changes of the people of Kauman Village Semarang.	The santri village located in the center of Semarang is able to change and develop, with their basic guidelines that are not significant. Despite the sophisticated technological advances, it was able to survive because the people of Kauman village became a cultural heritage for the next generation.
Green Architecture and Islamic Architecture: The Islamic Arabic City and the Green Architecture and Islamic Architecture: The Islamic Arabic City and the Traditional Islamic House [22]	Clarifying the concept of sustainable architecture or green architecture in the perspective of Islam	The concept of human and environmental conservation in an Islamic perspective became a sustainable architectural concept that became the forerunner of Traditional Islamic architecture.
Segresi Gender dalam Organisasi Spasial Pesantren-Pesantren Besar di Pulau Jawa [23]	shows that gender segregation in the spatial organization of pesantren is revealed through the concept of gender-specific zones, territoriality and boundaries.	Zoning on gender is able to create territoriality and boundaries so that kiai as a very influential figure in this matter makes zoning the strongest choice.
Architecture according to the Perspective of the Qur'an: An Evaluation [24]	The definition of architecture in debate over the concept, philosophy and purpose of Islamic architecture itself and in the context of man's relationship	Islamic architecture that can only be seen from the mosque building has unique characteristics.
Permukiman Dan Nilai-Nilai Budaya Pesantren Dalam Konteks Penataan Kawasan Di Sidosermo Surabaya	Looking for the cultural values of pesantren applied in the arrangement of Sidosermo settlements	The interaction between pesantren and the surrounding environment has a very close strength. So that it can affect non-physical aspects that indirectly and unconsciously have a very large effect.
Objek Amatan Pada Tipo-Morfologi Ruang Pondok Pesantren Salaf-Tradisional [25]	Knowing what objects of observation can be a guide to observe the morphology of the "mother" type or the basic/traditional type of spatial arrangement.	Spatial typo-morphological limitations in traditional salaf-Islamic boarding schools in spatial maintenance.
Pengaruh Pesantren Terhadap Tata Ruang Permukiman di Dusun Pesantren Jombang [26]	Knowing the influence of pesantren on settlement spatial planning in the residential area of Pesantren Peterongan Jombang	There is a significant influence on Islamic boarding schools with the layout of surrounding settlements in Peterongan Jombang.
The impact of generative principles on the traditional Islamic built environment: The context of the Saudi Arabian built environment [27]	explore and examine Saudi Arabia's traditional architecture through the lens of broader Islamic principles, which through history have encouraged the formation of several types of cities	Saudi Arabia's traditional architecture has a broader lens in an effort to balance originality in enhancing local identity.
Kajian Penerapan Arsitektur Islam Pada Masjid Agung Al-Anwar Kota Pasuruan [28]	knowing about the application of six principles of Islamic architecture to the Great Mosque of Al-Anwar Pasuruan City.	The application of Islamic architecture to the Great Mosque of Al-Anwar from the form, site, and elements and spaces that all remember the majesty of Allah.
Tinjauan perilaku santri terhadap penataan ruang asrama dan kawasan pondok pesantren [29]	positive and negative consequences arising from the laying of mass positions in Islamic boarding schools and the arrangement of dormitory rooms on student behavior,	The arrangement of dormitory rooms in the Islamic boarding school area has a positive and negative impact on student behavior.
Nilai Spasial Dan Transformasi Ruang Berdasarkan Material Lokal Pondok Pesantren Pabelan, Muntilan [30]	analyze the common space used by students in carrying out daily activity patterns, regarding the potential and problems that exist in the Pabelan Islamic Boarding School	The values of transforming common spaces based on local materials in Islamic boarding schools. Also the influence in the transformation of the space in daily activities.
Development Of Spatial Pattern Of Darul 'Ulum Islamic Boarding School Jombang, East Java [31]	Development in one of Pesantren at Jombang City, East Java.	Zoning Islamic boarding school, namely: the Education Combination zone, settlement zone, pesantren zone and free zone.

The Discussion section or discussion is the most important part of the author's manuscript. Through data evaluation and discussion, the author must be able to make

the manuscript interesting to readers who are the target group. Make the Discussion section closely related to the

Results section but do not do Results reps in the Discussion section.

The relationship between space and pesantren is very strong, with the role of character education in Islamic boarding schools and the underlying thing of the formation of pesantren is from the activities and spaces formed. The arrangement of dormitory rooms in an Islamic boarding school area has a negative and positive impact as well. so that it has an impact on the behavior, activities and activities of students in Islamic boarding schools, as explained by Ridho, et al. Further research by Afnan, et al. explained that the value of transforming shared space based on local materials of Islamic boarding schools also affects the daily activities of students.

Lughod mentions how to build a contemporary city based on its main religious principles in Islam, is better than a more general work of city architecture. The main explanations in the principles of Islamic architecture are also discussed by Fikriarini i.e. in architectural works around the world able to adopt from Islamic ethical values and behavior. So that Islamic architecture has a variety of products that bring humans to rahmatan lil 'alamin, becoming humans who serve perfectly.

Within the scope of the Islamic or Muslim region, it was discussed by Azizah. Namely the santri village located in the center of Semarang, which is able to change and develop with their basic guidelines that are more insignificant. Even in advanced technological advances, they are able to survive because the surrounding community becomes a cultural heritage for their successors, so they are able to survive with the development of this increasingly recent era. Islamic architecture is a concept in the preservation of humans and the environment in the perspective of Islam itself. It is a sustainable architectural concept that became the forerunner of Traditional Islamic Architecture according to Nangkula, which was developed and expected by some people. However, in terms of development, it must be able to change and maintain activities that distinguish between mahrom or other types.

Triyoga said that gender zoning is able to create territories and boundaries so that the influence of increasingly equalizing gender is not shakable to influence it. Islamic architecture that can only be seen is not just from the architecture of the mosque. But according to Anisah that the architecture of this mosque even though the building is commonly referred to as a relic of Islamic architecture, inside it contains a lot of its own characteristics and uniqueness. The application of Islamic architecture in a mosque has also been done by Rizal, et al, that the shape, site, and elements of space are all reminiscent of the majesty of God.

The development between Islamic architecture in a region must have good interaction, and be strong. As

explained by Kurniadi, et al that strong interactions can affect non-physical aspects that indirectly and unconsciously have a very large and significant effect. According to Lestari, et al the limitation of a spatial typomorphology in traditional salaf-Islamic boarding schools has an impact on the implementation of space and activities themselves, so that the interaction in them is very influential. This interaction was also explained by Mubarak, that there was an influence between the surrounding settlements that merged and merged with Islamic boarding schools which made the spatial layout of the settlements better. So that in a more spatial development, that balancing originality in increasing locality identity is very good in terms of territory, because it is less in development and territoriality that often follows current trends, as in research conducted by Alnaim, et.al. in a village in Saudi Arabia.

IV. CONCLUSION

Islamic boarding schools are residential areas that are able to develop and survive into education with character for the archipelago. So that its development is also greatly influenced by Kiai's active role in developing it. This survival is also unique and distinctive so that Islamic boarding schools are special and main education in the development of education in the archipelago. This area of Islamic education developing on a spatial scale has a significant influence without changing and eliminating various kinds of harm, because in continuing it becomes more careful and in accordance with religious guidance.

Space is evolving through a series of complexities of overlapping and intersecting societal standings. This means that society becomes a focal point on the development of space that focuses on external factors. The development of a region is not far from the development of something that first existed. So that the development of an area and a settlement begins with Islamic principles that indirectly teach the human instinct to develop. Islamic architecture has a very special space, including the Mosque. The mosque is an architecture that surrounds the activities of Muslims so that it is able to image Islam itself. The characteristics of the building are related to the culture and dignity of its inhabitants. This is what is able to distinguish between Muslim architecture and architecture in general. The mosque is a characteristic of the Nusantara Architecture section.

So that further research related to the results of this review literature study is to develop more deeply related to spaces in the Islamic Boarding School area specifically. Research can be carried out that is more directed at the space-architecture aspect, so that it can

develop architectural science in the world of Islamic boarding schools or education that is more indigenous.

ACKNOWLEDGMENT

I want to thank all those who have helped so that this research paper can be completed, including the authors of books, journals, etc., who helped with the writings that I quoted to enrich the scientific treasures in this paper.

This research paper is still far from perfect, so input from various parties is expected. In the future, this paper can be a reference for academics, practitioners, and the public in seeing legal cases that arise in the community. To The Indonesian Education Scholarship Program (BPI), The Indonesia Endowment Funds for Education (LPDP) and balai pembiayaan pendidikan tinggi (BPPT), and who have provided enthusiasm and support regarding funding.

FUNDING

This work was supported funding by the Lembaga Pengelola Dana Pendidikan [202209090939]; Beasiswa Pendidikan Indonesia [202209090939]; Balai Pembiayaan Perguruan Tinggi [202209090939].

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Evaluating the Configuration of Space at SMK Negeri 12 Malang Utilizing Spatial Syntax

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Abstract. These instructions give you basic guidelines for preparing papers for conference proceedings. SMKN 12 Malang is located at Jl. Pahlawan, Balearjosari, Kec. Blimbing, Malang City, East Java 65126. This school results from the function transfer from SMA Negeri 12 Malang. Previously, this high school had also experienced a change of location in a relatively short period of time. An evaluation of the spatial configuration of SMKN 12 Malang showed that the transfer of the building from SMA to SMK without careful spatial planning had a significant impact on the quality of the learning environment. Using the Space Syntax method, this research aims to analyze the connectivity, integration, and intelligibility of the existing and proposed spatial layouts. The results showed that the existing layout had several shortcomings regarding connectivity and space utilization efficiency. Simulation and re-analysis resulted in the proposal of a new, more optimized layout. The evaluation of the proposed layout showed significant improvements in all three aspects studied, so it can be concluded that the application of Space Syntax principles has the potential to create an effective and efficient learning environment.

Keywords; *Space Syntax; Connectivity, Integration; Intelligibility*

I. INTRODUCTION

SMK Negeri 12 Malang, located in Blimbing, Malang City, East Java, transitioned from an academic high school to a vocational institution in 2007 to address the demand for specialized technical training. Despite this shift, the school's spatial layout has remained largely unaltered, lacking a tailored configuration to support its expanded curriculum, which now includes programs in automotive, multimedia, software engineering, and accounting. The current layout presents significant challenges, particularly in circulation and zoning, resulting in inefficient space usage that affects the quality of both learning and operational flow within the school environment.

Using spatial syntax analysis, this study examines the existing configuration of SMKN 12 Malang to assess connectivity, integration, and intelligibility across the

school's facilities. Through tools like DepthmapX, the analysis identifies key spatial issues, such as insufficiently connected circulation routes and poorly integrated zones, which limit access between classrooms, labs, and communal areas. These constraints disrupt the flow of movement and create barriers to effective learning interactions. The findings underscore the need for a more strategic layout that could address both functional and accessibility requirements.

By implementing a redesigned spatial plan based on these insights, SMKN 12 Malang stands to significantly improve its operational efficiency and enhance the learning experience for its students and staff. Improved connectivity and integration between key areas could foster better interactions, facilitate easier navigation, and support diverse educational activities within a cohesive structure. Ultimately, this restructuring would not only streamline school operations but also contribute to a more conducive and dynamic learning environment that better supports the goals of a vocational high school.

II. RESEARCH METHODS

This research adopts an evaluative and comparative approach to examine the spatial changes in the existing layout of SMKN 12 Malang, focusing on key metrics of connectivity, integration, and intelligibility. Using the space syntax method within DepthmapX v0.8.0, the study applies quantitative techniques to measure spatial effectiveness, while descriptive methods support a comprehensive discussion of results. The focus is to highlight how the building's reconfiguration, transitioning from its original academic high school (SMA) layout to a vocational school (SMK) layout, impacts operational flow and accessibility across the school's varied facilities.

The research process begins with an in-depth observation and assessment phase, which includes precise measurements and modeling to establish a complete layout plan for the current building structure. This layout is initially analyzed through a bubble plan to clarify

relationships between different spatial zones. Following this, a detailed analysis is conducted using the convex map function in DepthmapX v0.8.0, providing quantitative insights into the layout's connectivity, integration, and intelligibility. These insights are obtained independently of the existing spatial arrangement, allowing for an objective assessment of each space's potential to facilitate smooth navigation and interaction. The final stage involves using DepthmapX's visual graph analysis tool to identify layout patterns, offering further insights into spatial organization and user flow throughout the school.

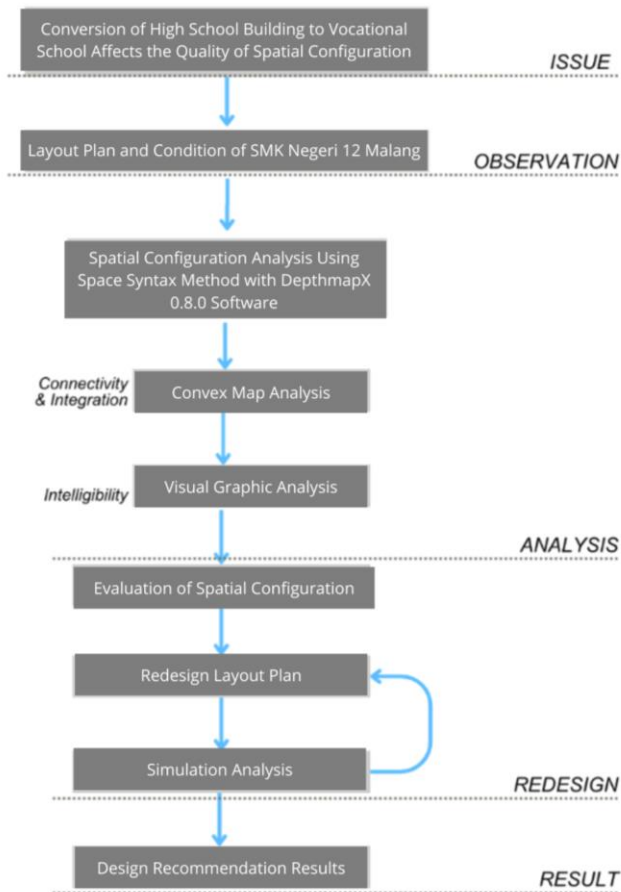


Figure 1 Research Procedure Diagram

Based on these analyses, the study proposes a redesigned layout for SMKN 12 Malang, which is re-simulated within DepthmapX to assess improvements in spatial efficiency and overall functionality. This reconfiguration is compared against the existing layout to determine the positive impact of the proposed changes. By optimizing connectivity, integration, and accessibility, the redesign is expected to streamline movement within the building, enhance ease of access to educational spaces, and foster a learning environment more suited to a vocational high school. Ultimately, these improvements are

anticipated to create a more conducive, interactive, and supportive setting for both students and staff, reinforcing SMKN 12 Malang's role as a modern vocational institution.

IV. RESULT AND DISCUSSION

In the existing layout plan, circulation axes are not clearly defined, which results in each zone being somewhat isolated and distinct, creating a spatial organization that resembles a clustered arrangement. This lack of interconnectivity leads to a disjointed flow throughout the space, where movement between areas is limited, and interaction among users is restricted by the segmented structure. Zones appear independent of one another, making navigation less intuitive and reducing spatial efficiency. In the redesigned layout plan, however, clear and intentional circulation axes are introduced, connecting each zone in a structured, cohesive manner. This redesign follows an axial spatial organization, establishing primary and secondary pathways that interlink the spaces more fluidly and encourage continuous movement. The axial layout enhances spatial clarity, supporting a more efficient and accessible environment where users can navigate seamlessly, interact across zones, and utilize the space more effectively (Figure2).



Figure 2 Building Layout plan

In the existing layout plan, the spatial organization is inconsistent, with several areas following a linear organization that creates a segmented and somewhat disconnected arrangement, while one specific area adopts an axial organization. This mixed approach results in a layout that lacks coherence, as the linear zones do not align with the axial organization present in other sections. The segmentation reduces the overall connectivity, making navigation less intuitive and hindering the flow of movement between spaces. In the redesigned layout plan, however, all areas are unified within a single, cohesive configuration based on an axial spatial organization. This unified axial approach establishes clear circulation routes that interconnect every zone, creating a seamless flow that promotes easy navigation, accessibility, and interaction throughout the entire layout. The redesign optimizes spatial connectivity and transforms the previously disjointed areas into a more efficient, integrated environment where movement is more intuitive, and the

overall spatial organization supports both functionality and accessibility (Figure3)..



Figure 3 Building Plan Second Floor

In the existing configuration, the layout organizes spaces into a single zone; however, the connections between these areas are not well-defined, as shown in the bubble plan (Figure 4). This lack of clear pathways and spatial relationships creates a sense of ambiguity, making navigation within the zone inefficient and reducing overall functionality. Users may find it difficult to intuitively move from one area to another due to the unclear connections, which impacts both spatial flow and accessibility. In contrast, the redesigned configuration maintains the single-zone approach but incorporates a central circulation space that significantly improves the clarity of connections between spaces. The bubble plan of the redesigned layout illustrates these enhanced connections, with each area now clearly linked through the central circulation, allowing for more intuitive movement and improved spatial coherence. This central organization not only facilitates smoother navigation but also reinforces a sense of unity within the zone, supporting a more functional and user-friendly environment that promotes accessibility and interaction across all areas.

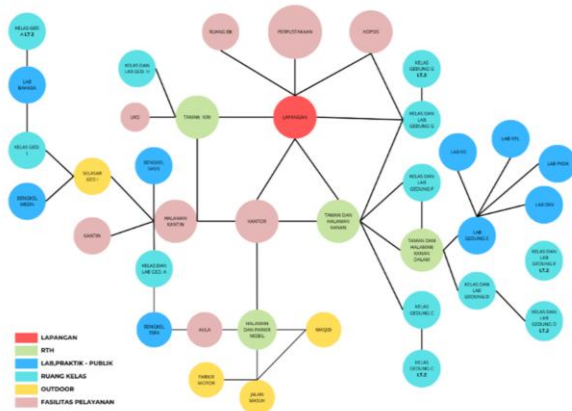


Figure 4 Building Room Configuration Existing

In the existing space configuration, circulation spaces lack interconnection, resulting in limited pathways and reduced spatial integration. This disconnected layout means that users have fewer options for navigating between spaces, which restricts movement and creates a

less efficient flow throughout the area. The absence of multiple pathways not only reduces accessibility but also limits the adaptability of the space, as individuals must follow a constrained route to reach their destination. In the redesigned configuration, however, circulation spaces are thoughtfully connected, creating a network of pathways that significantly enhances spatial integration. With multiple circulation routes available, users have more flexibility in their movement, which promotes smoother transitions and supports a more dynamic, accessible environment. This interconnected layout fosters an improved spatial experience by enabling easier navigation and offering versatile circulation options, making the space more user-friendly, adaptable, and cohesive (Figure 5).

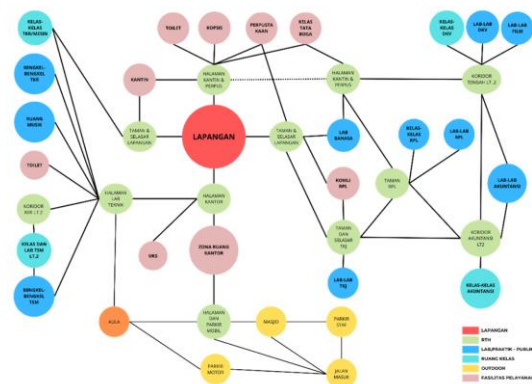


Figure 5 Bubble Diagram of Room Connection

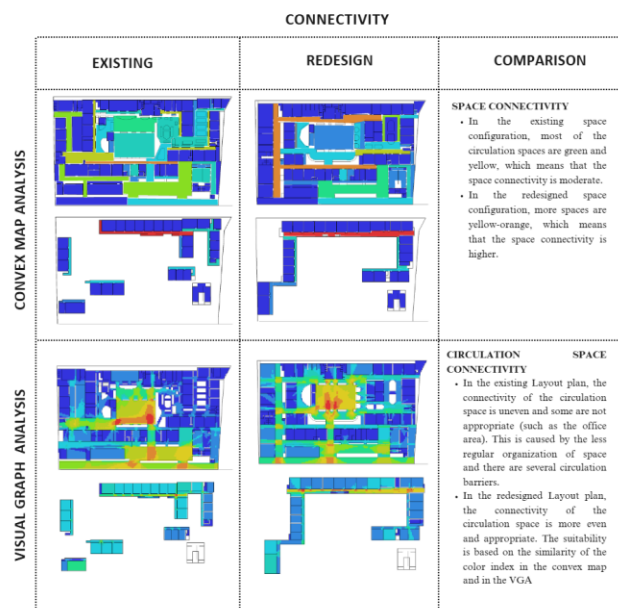


Figure 6 Conectivity Analysis

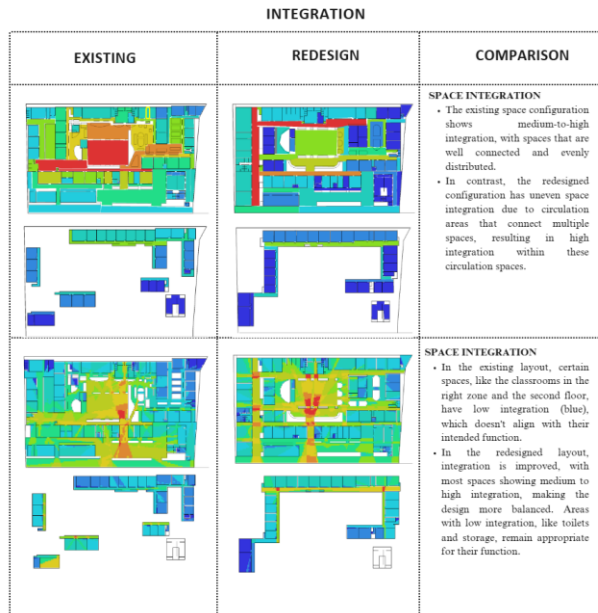


Figure 7 Integration Analysis

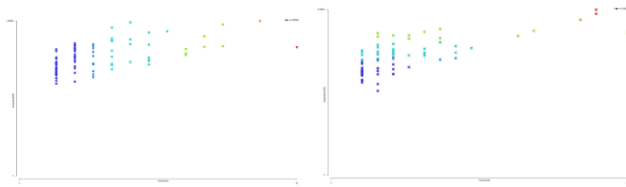


Figure 8 Analytical Diagram of intelligibility value

The redesigned space configuration enhances readability, making it clearer and more intuitive for users to navigate. This improvement is reflected in an increase in the intelligibility value, which rises from an existing score of 0.38 to 0.42, indicating a modest gain of 0.04 in spatial clarity. While this increase marks progress in making the layout more user-friendly, the value of 0.42 remains relatively low, suggesting that further adjustments could improve the space's overall readability and accessibility. The lower intelligibility score is largely influenced by the limitations of the convex map tool, which relies on a more abstract, imaginary indexing of spaces that does not fully capture the complexity of the actual environment. Consequently, the space clarity analysis produced by the convex map is less precise than that generated by Visual Graph Analysis, which is applied directly to the layout plan and offers a more accurate, real-world evaluation of spatial readability. This difference highlights the importance of using a tool that aligns more closely with the physical layout, as it provides a clearer picture of how well the

configuration supports intuitive movement and spatial comprehension for users.

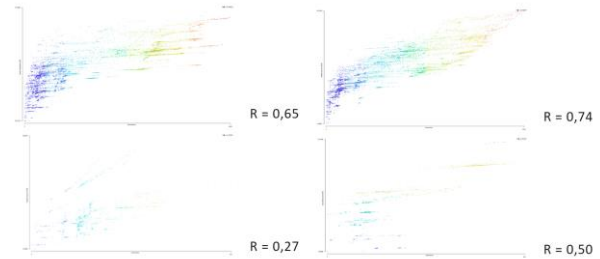


Figure 9 The Intelligibility value in the redesigned layout plan

The Intelligibility value in the redesigned layout plan saw a significant increase, reflecting a marked improvement in the clarity and organization of the spaces. Specifically, on the 1st floor, the Intelligibility value by 0.9, elevating it from a moderate level to quite high, which indicates a more coherent spatial arrangement. Meanwhile, on the 2nd floor, there was an increase of 0.23, transitioning from a low level to a moderate level of Intelligibility. This enhancement in intelligibility is further substantiated by the visual graph analysis, which demonstrates that the redesigned layout provides better clarity of space overall. The improvements can be attributed to a more orderly organization of space on the 1st floor, coupled with enhanced connectivity between areas on the 2nd floor, thus contributing to a more intuitive and user-friendly environment.

IV. CONCLUSION

Various factors influence the functionality of a school, one of which is the conversion of buildings, such as SMKN 12 Malang, which transitioned from SMAN 12 Malang in 2007 without having well-prepared spatial planning documentation.

The results of this research indicate that the absence of a well-structured spatial planning leads to a spatial configuration and arrangement patterns that do not meet the expected standards. This is evidenced by the comparison of the spatial configuration analysis results between the existing layout plan and the layout plan resulting from the evaluation. With zoning based on function and an organized, interconnected arrangement pattern, the analysis of the evaluated layout plan produces higher values of connectivity, integration, and intelligibility.

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Rest Area Development as an MSME Center in Kenongo Village, Malang Regency

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Abstract- The growth of MSMEs can create job opportunities, build infrastructure and increase community income at the village level. For example, Kenongo Village in Jabung District, Malang Regency has become an MSME-based village. The Kenongo Village Government is currently planning the design of a Central Area which includes a Rest Area and MSME Shopping Center. This central area aims to optimize MSME activities through several design approaches which will answer existing problems. In preparing the Rest Area design concept, several stages were carried out. The first stage is an analysis of the needs and potential of the area. The second stage is concept design. The third stage is detailed design. The final stage is evaluation and improvement, which includes design evaluation and improvement based on input from the village and community. The method used in this design is participatory design, which is an approach to the design process that involves users. The goal is to create products and services that better suit users' needs and expectations by leveraging people's knowledge and experience. Design solutions in this design include master plan design solutions for the Kenongo Village shopping tourism center and the Kenongo Village Rest Area.

Keywords; Rest Area; MSME, Participatory Design

I. INTRODUCTION

In 2019, the Ministry of Cooperatives and SMEs reported 65 million Micro, Small, and Medium Enterprises (MSMEs) that were able to absorb up to 123,300 workers. This shows the great potential of MSMEs in reducing unemployment rates in Indonesia. With the number of MSMEs continuing to increase, it is expected to help reduce the number of unemployed in the country. MSMEs play an important role in building a strong and sustainable local economy. In many cases, MSMEs become the backbone of the village economy, providing local jobs, utilizing local natural resources and culture, and strengthening social ties in the community. By strengthening MSMEs, we are also indirectly supporting the development of villages.

Thus, improving MSMEs can help increase the National GDP and reduce unemployment rates in Indonesia. Therefore, efforts need to be made to strengthen MSMEs and raise public awareness about the importance of MSMEs in building a strong and sustainable local economy. The

growth of MSMEs can create job opportunities, build infrastructure, and increase people's income at the village level. For example, Kenongo Village in Jabung District, Malang Regency has become an MSME-based village. The economy of the people of Kenongo Village is inseparable from the MSME sector which has become the backbone and a factor in improving the welfare of the village community. The Kenongo Village government is currently proclaiming the design of a Central Area which includes a Rest Area and an MSME Shopping Center. The chosen location is also quite strategic and is a route for tourists heading towards Bromo, as well as a commercial area to attract tourists and develop the potential of Kenongo Village MSMEs to the general public. However, this has not been able to be run optimally due to lack of branding and locations that tend to be difficult to access. Therefore, this central area aims to optimize MSME activities through several design approaches that will later answer the existing problems.

Problem Formulation

1. What is the condition of MSMEs in Kenongo Village.
2. How can the Kenongo Village area be developed through the design of a Central Area that includes a Rest Area and an MSME Shopping Center?

Research Objectives

The aim of the research and design of the Kenongo Village Central Area is to produce a design idea that can develop the MSMEs of the Kenongo Village community as the center of the community's economy as well as a tourist center in the Kenongo Village area.

Research Benefit

Research and design of the Central Area of Kenongo Village using a contextual approach can be a solution in overcoming problems as well as raising the potential that occurs in Kenongo Village. The benefits of designing the Central Area of Kenongo Village include:

1. Elevating the Kenongo Village area into a tourist center so that it can improve the economy of the surrounding community.

2. As a safer and more comfortable place for buying and selling activities, it is hoped that the quality and quality of products will be better.
3. Providing interaction space, recreation areas and other multi-functional supporting facilities for the local community and visitors.

Urgensi of Reesearch

The urgency of providing efforts to design a Central Area Based on MSME Development in Kenongo Village using this contextual architecture approach is that there is potential for the local community in the MSME sector and its strategic location makes it possible to make it a tourist center in Kenongo Village as well as to promote local MSME products so that they can be recognized. by outside audiences.

II. METHODS

In the preparation of the Rest Area design concept, several stages of the method are used. The first stage is the analysis of the needs and potential of the area, which includes analysis of physical conditions, potential analysis, and community needs analysis. The second stage is concept design, which includes architectural design, interior design, and landscape design. The third stage is detailed design, which includes architectural detail design, interior detail design, and landscape detail design. The final stage is evaluation and improvement, which includes design evaluation and improvement based on input from the village and community. The method used in this design is participatory design, which is an approach in the design process that involves users. The goal is to create products and services that are more in line with user needs and expectations by utilizing community knowledge and experience.

III. RESULT AND DISCUSSION

Development of Kenongo Village as a Center for MSME Shopping Tourism

Kenongo Village is located in Jabung District, Malang Regency, at an altitude of approximately 450 meters above sea level. Its coordinates are latitude -6.7318 and longitude 111.5736. This geographical condition provides the village with a cool climate, with an average temperature of around 19°C. Kenongo Village in Jabung District, Malang Regency, possesses diverse potentials that make it attractive and competitive. Kenongo Village is particularly appealing in the culinary sector, showcasing local delicacies. Furthermore, there are various MSMEs producing distinctive products such as lidi noodles, fried onions, and others, which contribute to the economy of Kenongo Village.

Development of MSMEs in Kenongo Village as a Center for Shopping Tourism

The development of Kenongo Village as a center for MSME tourism is a strategic step that can not only advance the local economy but also improve the overall welfare of the village community. Kenongo Village is known for its diverse range of high-quality MSME products, such as Bakso Majeng, Kerupuk Pak Min, Bawang Goreng, Mie Biting Super Hot, and RF Berkah Tahu. The rest area in Kenongo Village has great potential to be transformed into a shopping tourism center for MSMEs due to its strategic location on the main road of the village, making it easily accessible.

Development of Kenongo Village as a Center for MSME Shopping Tourism

There are design recommendations for each MSME home industry to improve comfort and interest of visitors. Signage helps customers, suppliers, and visitors find home industry locations easily.

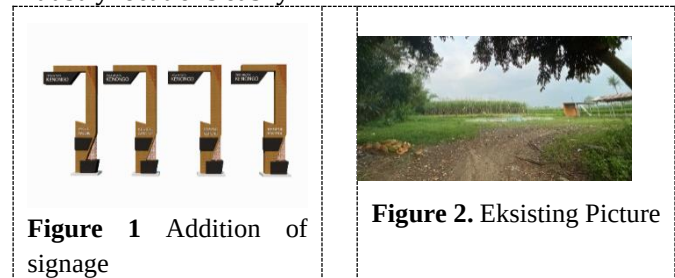


Figure 1 Addition of signage



Figure 2. Eksisting Picture

There are design recommendations for each MSME home industry to improve comfort and interest of visitors. Signage helps customers, suppliers, and visitors find home industry locations easily.



Figure 3. Perspective of Rest Area Spatial Design Solutions

The layout of the Kenongo Village Rest Area was designed taking into account functional and aesthetic aspects. The layout of the Kenongo Village Rest Area includes a parking area, prayer room, toilet, MSME kiosk and MSME restaurant



Figure 4. Parking Area



Figure 5. Musholla

Large parking area, able to accommodate 18 cars and 40 motorcycle. Apart from the parking area, this rest area is also equipped with Strategic gas station to meet fuel needs vehicle.

Other supporting facilities available in this rest area include a prayer room. The prayer room design has a circular layout with a capacity of 20 people, equipped with an ablution area. The design concept carries a tropical concept using natural materials.



Figure 6. Toilet



Figure 7. MSME Center

The Toilet Rest Area design uses an almost facade concept the same as a prayer room with a circle shape and roof the cone resembles a circle hut. In each The toilet has four bathroom stalls which are also equipped other facilities such as a sink.

The Kenongo Village Shopping Center and MSMEs were designed with a contextual approach that adapts characteristics local environment so as to produce designs which prioritizes comfort and sustainability aesthetics. This building uses traditional elements, creating an attractive and functional space for visitors. Use of quality local materials as well as designs that suit the context of the site created its own uniqueness that differentiates Shopping Centers and Kenongo Village MSMEs from other places.

IV. CONCLUSION

Based on the research we have conducted, the following conclusions can be drawn:

1. Great Potential for MSMEs in Kenongo Village: There is great potential for MSMEs in Kenongo Village as the backbone of the local economy. With a significant number of MSMEs, there is an opportunity to improve community welfare and reduce unemployment levels through the development of micro, small and medium enterprises.

2. The Role of Central Areas in MSME Development: The planned Central Areas, including Rest Areas and MSME Shopping Tourism Centers, are expected to become centers of economic and tourism activities. This will provide a centralized platform for MSMEs to increase the visibility and sales of their products.
3. Development Objectives: The main objective of the Central Area development is to improve the economy of Kenongo Village and expand tourism potential. In this way, it is hoped that it can increase people's income, improve the quality of MSME products, and provide an interesting travel experience for visitors.
4. Expected Benefits: From the design of this Central Area, it is hoped that several benefits will occur, such as increasing people's income, improving product quality, as well as providing interaction and recreation space for local communities and visitors.
5. Urgency of Design: The urgency of designing the Central Area is based on the great potential of MSMEs and the strategic location of Kenongo Village. With this effort, it is hoped that Kenongo Village can become a center for tourism and sustainable economic development.

Thus, developing a Central Area based on MSME development in Kenongo Village is a strategic step in supporting local economic growth and improving community welfare.

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Placemaking Analysis on Improving The Quality of Merjosari Park Public Space

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Abstract- Merjosari Park has recently experienced significant quality degradation due to prolonged neglect and insufficient maintenance. This study aims to assess the public space quality of Merjosari Park and analyze it based on placemaking principles. A descriptive quantitative methodology was employed, involving the identification of phenomena and environmental issues affecting public space quality, followed by numerical assessments derived from community perceptions. The study evaluated aspects of placemaking—including Uses and Activities, Access and Linkages, Comfort and Image, and Sociability. The analysis revealed a score of 125, with the highest contributions from Comfort and Image elements, such as user comfort, safety, cleanliness, and functionality. Despite being classified as good quality, the park's score sits at the lower threshold of this category. The study concludes that Merjosari Park requires targeted improvements to achieve higher quality standards and offers recommendations for development.

Keywords: Placemaking, Public Space, Parks, Quality

I. INTRODUCTION

Green open spaces are vital to urban environments, providing ecological, social, and aesthetic benefits. According to Taylor and Hochuli (2017), green spaces can be defined through quantitative and qualitative approaches. These approaches were explored in a study of 125 related journals, revealing that while definitions vary depending on the focus of the study, the primary goal remains consistent—to provide green spaces that support ecosystem balance. However, Boulton et al. (2018) highlight that urban green spaces often face quantitative gaps, as their provision is frequently measured against recreational standards rather than ecosystem benefits. Aalbers and Sehested (2018) emphasize that community participation is critical to ensuring green spaces are designed inclusively and appropriately.

Urban green spaces, both formal (e.g., city parks and urban forests) and informal (e.g., vacant land and roadsides), play an essential role in urban life by fostering social interactions and providing health benefits. However, Kimpton (2017) identifies a social inequality in the

distribution of urban green spaces, which tend to be more abundant in affluent areas than poorer neighbourhoods. This disparity highlights the importance of equitable planning in urban green space development.

In Indonesia, the Minister of Public Works Regulation No. 5 of 2008 mandates that at least 30% of urban areas be allocated for green open spaces (RTH). These spaces are categorized into natural green spaces, such as wild habitats and national parks, and built green spaces, such as urban parks and sports fields. Despite this regulation, implementation remains suboptimal, as evidenced by persistent ecological and social issues in urban areas. Increasing the role of RTH to meet community needs requires a holistic and integrated approach supported by active collaboration among stakeholders.

Placemaking offers a promising framework to address these challenges by fostering community-driven transformations of public spaces. The Project for Public Spaces (2022) defines placemaking as a process that integrates physical, cultural, and social elements to reimagine and reinvigorate public spaces. This framework emphasizes creativity and participation to unlock the potential of existing spaces, making them appealing and functional for daily life. Schneekloth and Shibley (1995) describe placemaking as a process where communities collectively transform a physical space into an environment they identify as home. Similarly, Ackerman (2012) highlights the transformative nature of placemaking in fostering a sense of belonging.

Placemaking is particularly crucial for urban open spaces as it prioritizes user-centric design, ensuring spaces cater to the diverse needs of communities. By emphasizing accessibility, usability, and sociability, placemaking enhances urban spaces' social and cultural vibrancy. For example, the redesign of Bryant Park in New York City and Federation Square in Melbourne demonstrates how placemaking can turn neglected areas into thriving public spaces, attracting diverse users and encouraging a sense of ownership. These projects illustrate the potential of placemaking to integrate functional design with

community-driven objectives, resulting in inclusive, interactive, and sustainable spaces.

Placemaking involves engaging local communities, analyzing spatial needs, and incorporating cultural and social contexts. Key steps include conducting participatory workshops, mapping existing assets, and co-creating design solutions. These activities ensure that public spaces reflect community values and are adaptable to changing needs. Previous studies, such as Habibullah et al. (2021), emphasize the role of community input in enhancing public space functionality, while Alauddin and Pramitasari (2023) highlight the importance of integrating local culture into placemaking efforts.

Despite its proven benefits, gaps remain in applying placemaking principles to urban green spaces in Indonesia. Many spaces are underutilized due to a lack of maintenance, inadequate infrastructure, and limited community engagement. In the case of Merjosari Park, these challenges are compounded by social and ecological degradation, necessitating a targeted analysis using a placemaking approach. By identifying existing gaps and leveraging placemaking principles, this study aims to propose actionable recommendations to restore Merjosari Park as a vibrant and inclusive public space.

II. RESEARCH METHODS

This study employs a descriptive quantitative approach to examine phenomena and issues related to environmental degradation impacting the quality of public spaces in Merjosari Park, Malang City. Subsequently, an evaluation was conducted using numerical data derived from community perceptions, which was then analyzed through descriptive interpretation. This assessment is based on various aspects of placemaking theory ie. Uses and activities, access and linkages, comfort and image and sociability. The findings serve as a foundation for evaluating and formulating recommendations for the future development of Merjosari Park.

The research site is Merjosari Park, covering an area of 10,766 m². The park is bordered by Merjosari Flower Park to the east, stalls to the north, a soccer field to the west, and Insan Karim Mosque along with residential settlements to the south.

Data Collection Methods

This research uses data collection methods with a focus on three age groups, namely adults aged 18–30 years, middle-aged 31–50 years, and elderly 51 years and over, including both women and men who live in Malang City. Each variable in this study involved 22 respondents obtained through a stratified random sampling technique. This technique is used to determine the number of samples

in a stratified population, in this case, based on age levels, as explained by Sugiyono (2013, p. 83).

Data Analysis Technique

Placemaking variables used as data analysis relied on two main data sources. First, primary data sources were obtained through direct observation, field observations, and distributing questionnaires to relevant respondents. Second, secondary data sources refer to the literature used to explore relevant elements, parameters, and variables in the context of placemaking and regional spatial policies (RTRW/RDTR) in Malang City. The research variables are in the table below:

Research variables

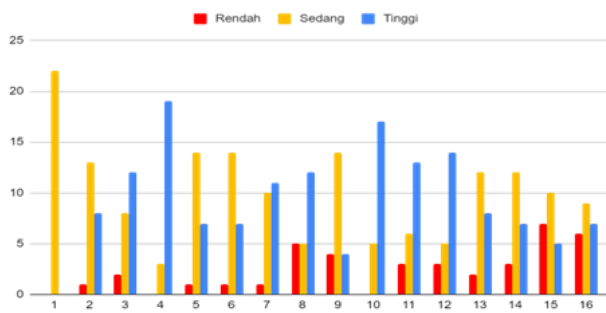
Elements of Placemaking	Variable	Parameters
Uses and Activities	<i>Fun</i>	availability of play areas
	<i>Active</i>	availability of exercise area engagement with user/community activities
	<i>Vital</i>	quality of accessibility ability to attract users usability that suits its function
	<i>Special</i>	availability of places to accommodate special activities availability of garden uniqueness
	<i>Real</i>	meet the conditions and quality as the park
	<i>Useful</i>	flexibility in use the ability to accommodate every circle
	<i>Indigenous</i>	availability of park uniqueness>> segmentation (facilitate zoning in activities)
	<i>Celebratory</i>	engagement with user/community activities
	<i>Sustainable</i>	ease of maintenance availability of waste management bins availability of drainage
Access and Linkages	<i>Continuity</i>	Connectedness and continuity of roads and walkways within the park There is a network of roads and walkways Consistent use of design to maintain visual continuity
	<i>Proximity</i>	Consideration of the distance between facilities and important areas within the city park for easy access by visitors Recreation areas and public facilities are placed in close proximity to each other Placement of directional signs and maps around the park to guide visitors
	<i>Connected</i>	Connectivity between the park and outside areas
	<i>Readable</i>	Ease of reading maps and markings in the park

		There are signboards with clear information about locations and facilities	Sociability	<i>Diverse</i>	Varied types of activities, visitors and traders
	<i>Walkable</i>	Safe and comfortable walking within the park, including level road surfaces and good sidewalks		<i>Stewardship</i>	Good garden management
		Unobstructed paths, including wheelchair-friendly paths		<i>Cooperative</i>	A sense of community to protect and manage the park
		Adequate lighting to provide a sense of security for nighttime users		<i>Neighborly</i>	Availability of space for interaction between individuals or a group
	<i>Convenient</i>	Availability of facilities such as seating, trash bins, and lighting		<i>Pride</i>	A recognizable image, characteristic, or identity
		Seating scattered along the walkway		<i>Friendly</i>	Friendliness between users or a group
	<i>Accessible</i>	Regularly available trash bins		<i>Interactive</i>	Communication between users, even if they don't know each other
		Accessibility for everyone, including people with special needs, through facilities such as barrier-free roads and access ramps		<i>Welcoming</i>	Openness to welcome all visitors from all walks of life, including those with disabilities
		Access ramps to allow access for visitors with special needs such as wheelchairs			
		Restrooms and other facilities designed to accommodate the needs of people with disabilities			
Comfort and Image	<i>Safe</i>	The placement and maintenance of vegetation are high and there are no negative spaces	These variables are measured in perceptions of park visitors. Then the summation of the assessment of placemaking aspects divided into three score levels: high (3), medium (2), and low (1), the maximum score is 159 (53 variables x score 3), and the minimum score is 53 (53 variables x score 1). So that the value classification is obtained, namely high (125-159), medium (89-124), or low (53-88). With the interval formula as follows: Interval : Maximum score - Minimum score Number of tiers (1)		
		Maximum visibility across the park			
		wider road corridors			
		safe park surface materials			
		limiting the number of entrances			
		there is a garden guardrail			
		procurement of garden lights that are evenly distributed			
		There is a pavement bench on the pedestrian side			
		Guide block on the pedestrian			
		Ramp for wheelchair users			
	<i>Clean</i>	there are segregated trash bins			
		provision of separate male and female toilets			
		good drainage channels			
	<i>Green</i>	diverse vegetation types			
	<i>Walkable</i>	wider road corridors with appropriate materials			
		arrangement of park facilities based on function			
	<i>Sittable</i>	provide garden benches or shelters with standardized sizes			
		park benches that are in good repair			
		pavement benches at the side of the pedestrian walkway			
	<i>Spiritual</i>	provision of a mushola or built near a place of worship			
		Tribune			
	<i>Charming</i>	Themed garden landscaping			
	<i>Attractive</i>	Gated and signed			
		There are landmarks			
		Sculpture			
	<i>Historic</i>	providing facilities with the aim of erasing the impression of the previous site or to maintain			

IV. RESULT AND DISCUSSION

A. Uses and Activities Score

The Uses and Activities assessment of Merjosari Park scored 34, indicating moderate functionality. While accessibility quality rated well (3), aspects such as play areas, exercise spaces, and user engagement scored 2, highlighting the need for improvements. The park provides flexibility (3) but lacks uniqueness and proper zoning (2). Spaces for special activities and community interactions also require enhancement (2). Sustainability elements, including maintenance, waste management, and drainage, scored 2, suggesting room for better management. Overall, while the park serves its purpose, further development is needed to enhance usability, accessibility, and community engagement as shown in figure below.

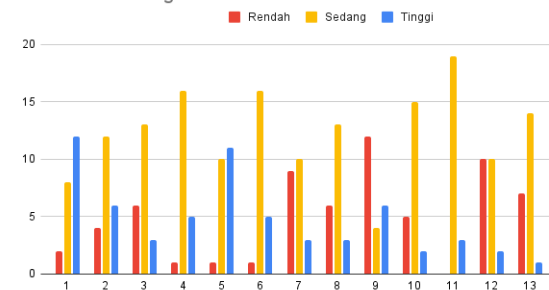


Variable	Parameters	Score
<i>Fun</i>	availability of play	2
<i>Active</i>	availability of exercise area	2
	engagement with user/ community activities	2
<i>Vital</i>	accessibility quality	3
	ability to attract users	2
	usability that is ini line with its function	2
<i>Special</i>	availability of places to accommodate special activities	2
	availability of garden uniqueness	2
<i>Real</i>	meet the conditions and quality as the park	2
<i>Useful</i>	flexibility in use	3
	ability to accommodate every circle	2
<i>Indigeno us</i>	availability of park uniqueness>> segmentation (facilitate zoning in activities)	2
	engagement with user/community activities	2
<i>Sustaina ble</i>	ease of maintenance	2
	availability of waste management bins	2
	drainage availability	2
SCORE		34

B. Access and Linkages Score

The Access and Linkages assessment of Merjosari Park scored 26, indicating moderate connectivity and accessibility. The park has a functional network of pedestrian paths (2) but lacks strong visual continuity. Proximity between facilities and the availability of directional signage scored 2, suggesting the need for improved wayfinding. Connectivity with external areas, readability of signage, and overall walkability also scored 2, highlighting areas for enhancement, particularly in lighting and safety. Seating, trash bins, and accessibility features for individuals with disabilities were rated 2, indicating basic provisions but room for improvement. Overall, while the park is accessible, better connectivity, clearer signage, and enhanced walkability would improve user experience.

Access and Linkage



Variable	Parameters	Score
Continuity	Connectedness and continuity of roads and pedestrian paths within the park	2
	There is a network of roads and pedestrian paths	2
	Consistent use of design to maintain visual continuity	2
Proximity	Consideration of the distance between facilities and important areas in the city park for easy access by visitors	2
	Recreational area and public facilities are placed in close proximity to each other	2
	Placement of directional signs and maps around the park to guide visitors	2
Connected	Connectivity between the park and outside areas	2
Readable	Ease of reading maps and markings in the park	2
	There is signage with clear information about the location and facilities	2
Walkable	Safe and comfortable walking within the park, including a flat walking surface and good sidewalks	2
	Barrier-free roads, including wheelchair-friendly paths	2
	Adequate lighting to provide a sense of security for nighttime users	2
Convenient	Availability of facilities such as seating, trash bins, and lighting	2
	Scattered seating along the pedestrian walkway	2
	Regularly available trash bins	2
Accessible	Accessibility for everyone, including people with special needs, through facilities such as barrier-free roads and access ramps	2
	Access ramps to allow access for visitors with special needs such as wheelchair	2
	Toilets and other facilities designed to accommodate the needs of people with disabilities	2
SCORE		26

C. Comfort and Images

The Comfort and Image assessment of Merjosari Park scored 46, reflecting a moderate level of safety, cleanliness, and aesthetic appeal. Safety measures, including visibility, surface materials, and lighting, were rated 2-3, indicating that while some aspects are adequate, improvements are needed, particularly in pedestrian accessibility (1-2). Cleanliness scored 2, suggesting basic waste management and drainage systems are in place but could be enhanced. Vegetation diversity, walkability, and seating facilities were rated 2, showing the need for better arrangement and infrastructure maintenance. Spiritual and aesthetic

elements, including a mushola, tribune, themed landscaping, and sculptures, also scored 2, highlighting the park's potential for cultural enrichment. Overall, while the park provides essential comfort features, enhancements in security, seating, greenery, and accessibility would significantly improve user experience.

Variable	Parameters	Score
Safe	Laying and maintaining tall vegetation there is no negative space	2
	Maximum visibility across the entire park	2
	Wider road corridors	2
	Safe garden surface materials	2
	Restrictions on the number of access points	2
	There is a garden boundary fence	2
	Procurement of garden lights that are evenly distributed	3
	There are pavement benches on the pedestrian side	2
	Guide block on pedestrian	1
	Ramp for wheelchair users	2
Clean	There are segregated trash bins	2
	Provision of separate toilets for men and women	2
	Good drainage channels	2
Green	Diverse vegetation types	2
Walkable	Wider road corridors with appropriate materials	2
	Arrangement of park facilities based on function	2
Sittable	Provide park benches or shade with standardized sizes	2
	Usable garden bench	2
Spiritual	Bench pavement on the pedestrian side	2
	Provision of a mushola or built near a place of worship	2
Charming	Tribune	2
Attractive	Themed garden landscaping	2
	Gated and signed	2
	There are Landmarks	2
	There is a Sculpture	2
SCORE		46

D. Socialibility

The Sociability assessment of Merjosari Park scored 19, indicating a moderate level of social interaction and community engagement. The park supports diverse activities and attracts varied visitors (3), but garden management and community involvement in maintenance scored lower (2), suggesting room for better stewardship. The availability of spaces for social interaction was rated 3, highlighting its role in fostering connections. However, aspects such as park identity, friendliness, and user interactions scored 2, indicating a need for stronger engagement and social cohesion. The park was rated 3 for

inclusivity, showing openness to all visitors, including those with disabilities. Overall, enhancing community participation, park identity, and interactive features would strengthen the park's role as a vibrant public space



Variables	Parameters	Value
Diverse	Varied types of activities, visitors and traders	3
Stewardship	Good garden management	2
Cooperative	A sense of community to protect and manage the park	2
Neighborly	Availability of space for interaction between individuals or a group	3
Pride	A recognizable image, characteristic, or identity	2
Friendly	Friendliness between users or a group	2
Interactive	Communication between users, even if they don't know each other	2
Welcoming	Openness to welcome all visitors from all walks of life, including those with disabilities	3
SCORE		19

IV. CONCLUSION

Placemaking proved to be an effective strategy to improve the quality of public space in Merjosari Park. The findings of this study provide valuable insights for urban planners and policymakers who aim to develop sustainable and vibrant public spaces. Future research should continue to explore the long-term impacts of placemaking and identify best practices for its implementation.

Based on the quality assessment of Merjosari Park with a placemaking approach, there are several development suggestions that need to be made. First, it is necessary to improve facilities such as children's play areas, jogging trails, comfortable seating, and the use of environmentally friendly technology such as solar lights. Second, strengthening the park's identity with elements of local art and culture and creating special themes for different areas can attract more visitors. Community

participation is also important, through community service programs and educational activities about the environment, to increase the sense of ownership and awareness of protecting the park.

Further research on what visitors want can help with better development. Cooperation with government and non-profit organizations can provide the needed support. Regular evaluation and use of monitoring technology will ensure that the development has a positive impact. With these steps, it is hoped that Merjosari Park can become a better public space and become an example for other parks in Malang City.

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Decolorization of Peat Water by Catalytic Ozonation Process

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Abstract. Peat water is a potential source of raw water in Indonesia, especially on the island of Kalimantan. However, the high concentration of natural organic matter, color, dissolved iron, and low pH in peat water is challenging for conventional water treatment systems such as coagulation-flocculation. This work investigated ozonation-based processes as potential pre-treatment for color and organic removal. Experimental comparisons were made between O_3 , O_3 /UV, O_3 /Fe, and O_3 /UV/Fe to analyze the effect of UV and iron catalysts on the effectiveness of the ozonation process. The most promising result was obtained in the O_3 /UV/ZVI process at pH 5 with initial conditions including stirring speed during ozonation 300 rpm, temperature 27°C, system volume 250 mL, and ZVI catalyst dosage (1 g/L) with a continuous process for 60 minutes. O_3 /UV/ZVI was able to color removal (77%), COD (72%), and total Fe (90%). In addition, the figure-of-merit of studied processes was carried out through Electric Energy per Order (EEO). In conclusion, the catalytic ozonation process as a pre-treatment proved efficient for removing color, organic compounds, and neutralizing pH.

Keywords; Peat Water, Ozonation, Hybrid Process, Color Removal, Water Treatment

I. INTRODUCTION

Indonesia is the fourth country with the largest percentage of peatlands in the world [1]. However, the potential of peat water has not been optimally utilized as a source of drinking water for the community, especially in Central Kalimantan. The high organic matter content makes it unsuitable for sanitation purposes [2]. The high concentration of NOM in peat water, specifically hydrophobic NOM in the form of humic and fulvic acids, causes the water to be acidic and brownish [3][4].

Peat water represents peat water that is characterized by high concentrations of organic compounds and poses significant health risks due to its unsuitability for direct consumption. The challenge of removing color and organic substances using conventional wastewater treatment methods remains a major concern. To address this issue, Indonesia has invested in developing various treatment

methodologies, including coagulation-flocculation-sedimentation, adsorption, filtration, and ozonation [5]. However, the efficacy of these techniques varies depending on the specific contaminants present. Coagulation-flocculation, while effective for removing larger particles, exhibits limitations in precipitating fine particles such as organic dyes, heavy metals, and certain organic compounds [6]. Similarly, filtration processes, while demonstrably viable, encounter challenges related to membrane fouling, leading to decreased filtration rates and increased operational costs [7].

One of the most promising peat water treatment processes is ozonation. Ozonation is a treatment method using ozone to oxidize and remove organic compounds, chemicals, and microorganisms in peat wastewater [8]. Typical ozone process characteristics include non-toxic, environmentally friendly material, relatively harmless and can react specifically to complex organic compounds (aromatic organics, phenol groups). The ozonation process involves the injection of ozone through an ozone generator, which will react with organic compounds and microorganisms in wastewater. Ozonation using microbubbles has been widely used in water and wastewater treatment to reduce various pollutant concentrations [9].

The ozonation process is enhanced by using UV light illumination and catalysts. It is an advanced oxidation process that includes photochemical and catalytic methods. The addition of iron ions (Fe^{3+} or Fe^{2+}) has been reported to accelerate UV-enhanced ozonation of some pollutants. $Fe(III)$ is thought to increase the amount of hydroxyl radicals through the reduction of O_3 with Fe^{2+} generated by Fe^{3+} photoreduction [10]. O_3 /UV and O_3 /UV/Fe (III) combinations were compared with single ozonation, with respect to TOC and COD reduction, respectively, for experiments conducted at room temperature, free pH and 7.4 g/h ozone production [10]. There was no difference of TOC reduction from single and photolytic ozonation of 40-45%. However, photo-fenton reaction of aqueous ferrous iron with UV resulted in higher efficiency. As for COD

reduction, the difference was smaller, reaching 85% COD elimination after two hours with single and photolytic ozonation and 100% with UV/Fe (III)-enhanced ozonation [10]. Another study related to O_3 /UV in congo red colour removal obtained a high colour removal efficiency of up to 97% in 1 hour [11]. In addition, this study also found that the effect of UV irradiation on ozonation is beneficial in mineralisation efficiency.

This study aims to evaluate the decolorization of peat water by the ozonation process with and without the addition of UV light and iron catalyst. The scope of this study is limited to the parameters to be tested including pH, COD, color, UV365, UV465, and Total Fe.

II. MATERIAL AND METHODS

Preparation of Peat Water

Peat water samples were collected from the Sebangau River in Sebangau National Park, Palangkaraya, Central Kalimantan. Peat water was taken by grab sampling method at 18 L of surface water and collected in a jerry can. The samples were then preserved at low temperatures in a freezer before analysis. Before the ozonation process began, peat water was filtered using a cellulose acetate (CA) filter combined with Whatman 1001-047 filter paper (20 μ m pore size) and a continuous vacuum pump. The filtration process was conducted to simulate field conditions in preparation for subsequent ozonation treatment.

Catalyst

Iron (Fe) powder catalysts in the ozonation process will compare commercial catalysts namely ZVI (Zerovalent Iron) and construction waste catalysts namely Rebar Flakes Waste (RFW). The iron content in the RFW catalyst was 60.19% [12]. Meanwhile, ZVI catalyst with $\geq 99\%$ iron content, was supplied from Sigma-Aldrich.

Analytical

The peat water samples were analyzed using a pH meter for pH measurement, color concentration was measured with a UV-Vis spectrophotometer DR 6000 using the HACH 8025, COD was measured with a spectrophotometer DR 2000 using the HACH 8000, total Fe was analyzed using the HACH 10249 method, and UV 365 and UV 465 measurements were performed with a spectrophotometer DR 6000 following the standard method 5910.

Experimental Procedures

The ozonation process was evaluated using two distinct operational schemes: continuous (60 minutes ON) and sequential (5 minutes ON, 10 minutes OFF) for a total duration of 60 minutes. The experimental setup included an

ozone generator, a reactor box equipped with UV lamps (6W + 8W), syringe filters (0.45 μ m), a hot plate maintaining room temperature (25–27°C), and a magnetic stirrer set to 300 rpm for consistent agitation.

In the catalytic ozonation process (O_3 /UV/Fe), the procedure begins by pouring 250 mL of peat water into a beaker, followed by adding the catalyst at the predetermined dosage. The ozone generator is then activated with a power of 11 watts, and the UV lamps are turned on with a combined power of 6W and 8W, while maintaining constant agitation throughout the process. After 60 minutes of ozonation, samples were collected at specific intervals which were t_0 , t_{10} , t_{20} , t_{30} , and t_{60} . Moreover, each sample was filtered through a 10 mL syringe filter and then diluted 5-fold with distilled water for subsequent analysis.

III. RESULT AND DISCUSSION

Characterization of Peat Water

Filtration of natural peat water showed a persistent brownish-red color, which suggests the presence of lignin compounds and substances from the humification process, including minerals like iron (Fe) and manganese (Mn). This high color indicates a natural color with positively charged colloidal particles that cannot be deposited by gravity [13]. The 20 μ m filter effectively retained larger particles but failed to remove dissolved colorants. The peat water exhibited a low pH, attributed to fulvic and humic acids. Other parameters, including removal of total dissolved solids (24,4%), alkalinity (10,8%), organic matter (2,7%), and turbidity (5%), showed minimal reduction post-filtration, with the decrease in TDS correlating with turbidity, indicating a low concentration of suspended solids. The test results of natural pH peat water samples with a temperature of 25–27°C are shown as follows.

Tab. 1. Characteristics of Peat Water After Filtration

Parameters	Units	Filtered Peat Water
Total Coliform	MPN/100 mL	26
Color	PtCo	708
TDS	ppm	34
pH	-	4.56
Alkalinity	mg/L	36.6
Iron	mg/L	0.55
Organic Substances	mg/L	11.066
Soluble CO	mg/L	161
UV 365	-	0.1
UV 465	-	0.05
Turbidity	NTU	10.5

Continuous vs Sequential Ozonation

Ozonation experiments were conducted on peat water samples at natural pH and room temperature (25–27°C).

The highest color reduction after 60 minutes was achieved using the continuous ozonation method, with an efficiency of 72.71%, compared to 53.74% in the sequential ozonation process. The most significant decrease in color occurred between 10 and 20 minutes of ozonation, with a reduction of 285 PtCo as seen in **Figure 1**. During the ozonation process, ozone molecules decompose into highly reactive hydroxyl radicals (OH⁻), which are produced in greater quantities in continuous ozonation. These free radicals then attack hydrophobic compounds, breaking them into smaller particles that dissolve in water.

In contrast, during the sequential ozonation process, an increase in color intensity was observed between 20 and 30 minutes, which coincided with the ozone device being turned off. Initially, a decrease in color occurs as organic compounds break down into smaller, colorless molecules. However, over time, ozone continues to react with these smaller molecules, resulting in the formation of colored intermediate compounds. These intermediate compounds can cause an increase in color intensity during testing [14].

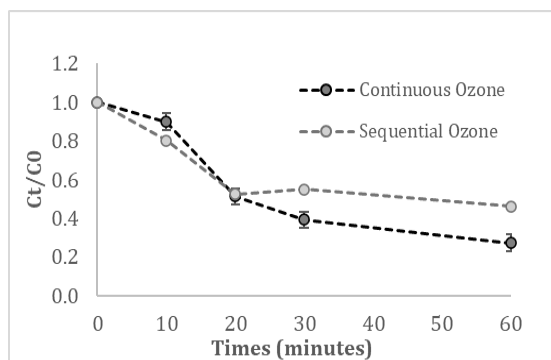


Fig. 1. Effect of Continuous vs Sequential Ozonation

Effect of UV Light Irradiation on Ozonation

UV experiments were conducted on peat water samples at natural pH and room temperature (25–27°C) using UV (6+8W) treatment. The results indicated that UV treatment slightly increased the color by 3.41%. In contrast, the combination of ozone and UV (O₃/UV) led to significantly greater color removal than ozone alone. The O₃/UV treatment achieved a color removal efficiency of 90.26% after 60 minutes, surpassing the 72.91% color removal observed in continuous ozonation. The highest color reduction in the O₃/UV experiment occurred within the first 10 minutes, with a reduction of 262 PtCo.

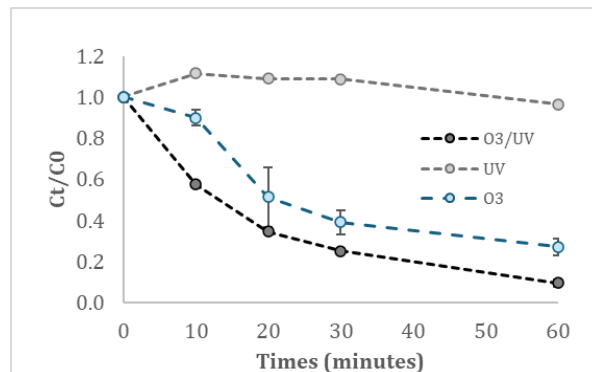


Fig. 2. Effect of UV Irradiation on Ozonation

Electric Energy per Order (EEO)

The O₃/UV/ZVI process effectively reduces COD from 161 mg/L to 45 mg/L, demonstrating its high efficiency with an EEO of 110 kWh/m³. This significant COD removal reflects the enhanced degradation of organic compounds, which is achieved through the synergistic action of ozone and the ZVI catalyst, resulting in the generation of more hydroxyl radicals (•OH). These radicals are key to breaking down complex organic pollutants effectively. The low EEO value of 110 kWh/m³ indicates that this process is more energy-efficient compared to continuous ozonation and O₃/UV processes, which have higher EEOs of 135 kWh/m³ and 137 kWh/m³, respectively. The combination of the iron catalyst and UV light optimizes energy use, leading to greater COD reduction at lower energy consumption.

Tab. 2. Total Electrical Energy Requirement for Each Experiment

Schemes	Total Ozonation Duration (minutes)	Relative Dose O ₃ (mg/L)	Light Intensity	Electricity Consumption during 60 minutes (Watt.hour) ¹	EEO (kWh/m ³ /order)
O ₃ 60 ON	60	150	-	14	135
O ₃ 5 ON 10 OFF	20	50	-	8	188
UV	-	-	96	11	1408
O ₃ /UV	60	150	96	25	137
O ₃ /ZVI	60	150	-	14	603
O ₃ /UV/ZVI	60	150	96	25	110

Effect of Catalyst on Ozonation

In color removal with a variation of four doses, the optimum dose was obtained at a dose of 1 g/L at 95% compared to a dose of 0.5 g/L at 84%, a dose of 0.25 g/L at 84%, a dose of 2 g/L at 50%. The dose of 1 g/L ZVI catalyst was able to reduce the color up to 33 PtCo at the end of 60 minutes. The ZVI catalyst, in this case homogeneous catalytic, will act to initiate ozone decomposition and result

¹ F. A. Zahrandika, S. Adityosulindro, and S. N. Felia, "Hybrid O₃ / UV / Fe process using rebar flakes waste for removal of congo red

in the production of hydroxyl radicals through indirect processes (O_2 - and O_3 -). $HO\cdot$ reacts mainly by abstracting H atoms or adding to unsaturated bonds [15]. The higher yield of radicals will be utilized to achieve rapid removal of organic compounds.

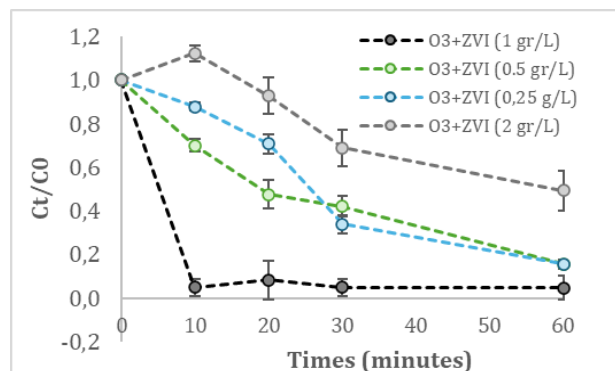


Fig. 3. Effect of Catalyst Dosage on O_3 /ZVI

From Figure 3, the value in C_t/C_0 values exceeding 1 at a 2 g/L catalyst dose during the ozonation process is likely due to the high catalyst dose interacting with other compounds in the sample, thereby altering the measured color and absorbance. The formation of by-products can lead to the generation of new aromatic compounds or result from imperfections in the ozonation process.

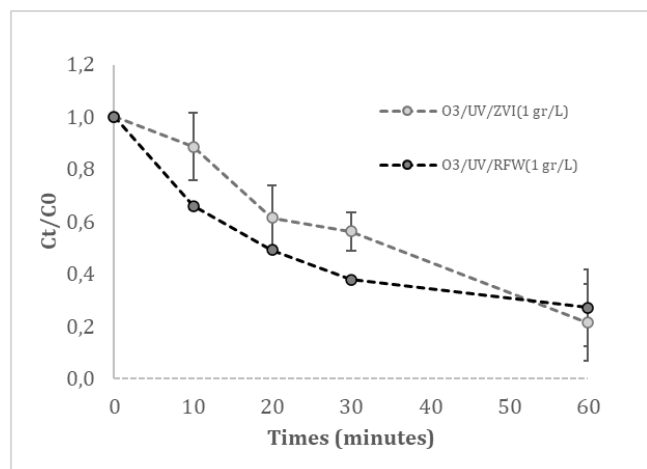


Fig. 4. Effect of Catalyst Dosage on O_3 /UV/Fe

Furthermore, the graph above shows the downward trend of O_3 /UV/Fe, where after 60 min, O_3 /UV/ZVI decreased significantly at 60 min of 188 PtCo from 922 PtCo compared to O_3 /UV/RFW of 285 PtCo from 798 PtCo. The stability of a catalyst impacts its oxidizing ability, with RFW being prone to frequent degradation over time. Ozonation can erode its surface, reducing its active area and effectiveness. In contrast, ZVI is more stable and durable due to its inert nature, enabling higher performance. ZVI is particularly effective in breaking down complex, hard-to-

degrade organic compounds, offering longer-lasting decoloration effects.

Evaluation on pH, Iron, COD and E3/E4

The highest absorbance observed in natural peat water was 317 nm, indicating the presence of aromatic organic compounds like humic acid. The E365/E465 ratio was used to assess organic matter decomposition, with a higher ratio indicating greater humification and an older peat sample, while a lower ratio suggests younger peat. This ratio is proportional to dissolved organic carbon (DOC) content, with a higher ratio reflecting higher DOC and oxygen demand. Absorbance readings were taken at t_0 and t_{60} for each sample, with the ratio linked to the molecular size of organic fractions in the peat water. The E365/E465 ratio is associated with the molecular size of the organic fractions present in the peat water [16]. From the several experiments conducted, the experimental results are summarised in the following figure.

No	Schemes	pH		Fe (mg/L)	COD %removal	E3/E4		Color removal %removal
		t_0	t_{60}			t_0	t_{60}	
1	O_3 Continuous	4.26	4.66	-	61	2.03	5.96	73
2	O_3 sequential	4.43	4.54	-	25	3.8	4.7	54
3	UV	3.8	3.56	-	10	4.46	4.46	3
4	O_3 /UV	3.94	3.5	-	81	4.24	4.63	90
5	O_3 /ZVI (0.25 g/L)	3.93	4.88	0.15	17	4.04	7	84
6	O_3 /ZVI (0.5 g/L)	3.97	4.96	0.03	1	7.97	18	84
7	O_3 /ZVI (1 g/L)	4.08	5.04	0.01	19	4	2	95
8	O_3 /ZVI (2 g/L)	4.12	5.22	0.02	29	4.27	1.26	50
9	O_3 /UV/ZVI	4.62	5.89	0	88	4.07	5.66	79
10	O_3 /UV/RFW	4.4	5.09	0.03	76	4.24	5.7	67
11	O_3 /UV/ZVI pH 5	5.4	6.38	0.07	72	3.7	4.64	77
12	O_3 /UV/ZVI pH 7	7.01	5.97	0.45	65	1.05	4.86	28
13	O_3 /UV/ZVI pH 8	8.18	6.47	0.25	68	5.67	1.97	38

Fig. 5. Recapitulation of Whole Experiment Results

The COD analysis following continuous ozonation revealed a reduction of 61%, with concentrations decreasing from 161 mg/L to 62 mg/L. In contrast, sequential ozonation (5 minutes ON, 10 minutes OFF) achieved a lower COD reduction of 25%, with concentrations decreasing from 161 mg/L to 120 mg/L. These results demonstrate that continuous ozonation optimizes ozone utilization by providing a constant supply of the reactive species, which enhances the oxidation process and improves COD removal efficiency. Furthermore, the E3/E4 ratio in the continuous ozonation treatment increased significantly from 2.03 at t_0 to 5.96 at t_{60} , indicating a higher abundance of aromatic organic

compounds with lower molecular weight lignin in the peat water. This shift suggests that continuous ozonation promotes the breakdown of larger, more complex organic molecules into smaller, aromatic fractions. The combined COD reduction and increased E3/E4 ratio demonstrate the improved effectiveness of continuous ozonation in treating organic contaminants in peat water.

A similar pattern was observed for COD reduction in the O₃/UV system proportional to the E3/E4 ratio, with the E3/E4 value increasing from an initial value at 4.26 to 4.63 after 60 minutes, compared to 4.46 for UV treatment, remaining stables from an intial value. The higher E3/E4 ratio in the O₃/UV treatment indicates a significant alteration in the dissolved organic matter (DOM) structure, where ozone effectively degrades aromatic compounds (with high E3 absorbance) into smaller oxidized products (with high E4 absorbance). Beside that, the COD concentration in the O₃/UV experiment decreased to 30 mg/L after 60 minutes, representing an 81.3% removal efficiency. In comparison, the UV-only method achieved a COD reduction of 9.93%, with the final concentration reaching 145 mg/L. These findings highlight the significantly greater efficacy of the O₃/UV combination in reducing both color and COD levels compared to using UV or ozone alone.

Meanwhile, in the process of adding iron catalyst (O₃/ZVI), the highest total Fe reduction was at a ZVI catalyst dose of 1 mg/L by 99%, but it was not effective in COD removal by 19%. Although HO[•] is highly reactive, its slightly electrophilic nature makes it slower to attack organic compounds with strong electron-withdrawing groups, such as carbonyl groups [15]. This means to show in some cases that COD reduction in peat water is not always maximal, especially for certain organic compounds that are more difficult to oxidize.

Therefore, the highest efficiency of ozonation was obtained at O₃/UV/ZVI 1 gr/L with pH 5 with removal of color (77%), COD (72%), Fe (90%). In this process, acidic conditions enhance the formation of hydroxyl radicals (•OH), which are highly reactive and increase the degradation of organic pollutants, where ZVI (Zero-Valent Iron) enhances the reduction of Fe and promotes the generation of reactive species like hydroxyl radicals. In addition, UV light accelerates the breakdown of ozone (O₃) into hydroxyl radicals, making the ozonation process more efficient in degrading contaminants.

IV. CONCLUSION

This study shows that the combined O₃/UV/Fe process is the most effective in treating peat water. Continuous ozonation without catalysts showed higher efficiency in removing color (73%) and COD (61%) than sequential ozonation in removing color (54%) and COD

(25%). While the combination of ozone and UV light (O₃/UV) gave higher removal rates but higher energy consumption. However, the addition of zero-valent iron (ZVI) to the O₃/UV process with pH 5 adjustment improved color removal (77%) and was effective in reducing COD (72%), and total iron (90%). Overall, the O₃/UV/Fe with pH 5 process offers a promising approach for peat water treatment due to its high efficiency in removing organics and color, and low energy consumption (110 kW h m⁻³ order⁻¹).

ACKNOWLEDGMENT

The author would like to thank the SEED scholarship, generously offered by the Alumni of Civil and Environmental Engineering at Universitas Indonesia, for their support of this work. Additionally, appreciation is extended to Anjar Fitriarashtra for technical assistance with the samples, as well as to Licka Kamadewi and Pipit Fitriah from the Laboratory of Engineering and Water Quality at the Faculty of Engineering, Universitas Indonesia.

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Physical Modeling of Greywater into Clean Water with Fragrant Root (*Vetiveria Zizanoides*) in View of pH, Turbidity

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Abstract. Vetiver grass or what is locally known as vetiver grass, is a type of aquatic plant that has long grown wild so it is very easy to find. It turns out that the potential of vetiver grass can not only be used as a handicraft and ornamental plant, but can also be used as a waste water remediation agent. The method used is to plant vetiver roots in soil submerged in tilapia pond waste water with variations in discharge, number of vetiver stems and time. The results of the description of the turbidity parameters show that with a total of 150 vetiver stems and each additional water discharge at different residence time periods will be able to reduce the turbidity value and increase the pH so that the quality of the waste water discharge increases. It can be concluded that: the initial pH of 7.30 increased to 7.90 and was standard (6.5 – 8.5) with a residence time of 7 days. And the initial turbidity of 119 decreased to 5.44 NTU and standard (<3 NTU), with a remaining time of 7 days. So, the residence time must be longer in order to meet the specified standards.

Keywords; Clean water, Greywater, *Vetiveria*

I. INTRODUCTION

Domestic sewage is ranked as one of the largest sources of pollutants to the aquatic environment, especially rivers [1]. This pollutant load contaminates up to about 57% of river flow [2, 3]. Meanwhile, the river water itself should still be able to be used for various purposes, such as for agricultural and landscaping irrigation needs, washing vehicles and tools, and so on [4, 5, 6, 7]. Domestic waste makes the benefits of river water reduced, where river water when used can have a negative impact, such as disrupting the quality of plant growth and development if used for irrigation, and so on [8, 9, 10, 11].

Given the high production of domestic wastewater, as well as its high pollution potential, the topic of sewage treatment will always be needed as one of the solutions that can be pursued. Various previous studies have formulated various waste treatment technologies that are easy to apply and have the potential to produce optimal outcomes

through various approaches [2, 3, 4, 5, 11]. One approach that is currently being developed is the utilization of aquatic plants as phytoremediators [12, 13]. Waste treatment media equipped with aquatic plants are not only able to precipitate or filter pollutants, but can also improve the treatment process because pollutants are absorbed by plant roots [14].

Vetiver grass (*Vetiveria zizanioides*), or locally known as fragrant root, is one type of aquatic plant that has been growing wildly so that it is easily found [15]. The potential of vetiver grass not only can be utilized as handicrafts and ornamental plants, but can also be utilized as a wastewater remediation agent [16, 17]. This potential has been proven from various research [18]. This potential can be an excellent solution for the fulfillment of clean water, especially in urban areas.

This community service-based research is simply an effort to treat household wastewater to support the availability of clean water sources in urban areas. The type of waste processed here is graywater waste, which is wastewater that comes from kitchen and bathroom sink or washing water (not feces and urine) [19]. The reason for choosing the type of graywater waste is because of its high production, which is up to 70-75% of the total liquid waste generated from domestic activities [20]. Generally, graywater wastewater is directly discharged through the drainage system and of course leads to the river [21]. So it is quite unfortunate if this high quantity is not attempted to be reprocessed so that it can be utilized for various purposes.

II. MATERIAL AND METHODS

A. Conceptual Framework

Tilapia pond wastewater treatment and its output is processed into clean water to improve water quality so that it can be reused. To provide a clear picture of how the variables in this study interact with each other, a conceptual framework of the study is made based on the background, problems and objectives of the study: background,

problems and objectives of the study. The variables in this study include the following:

1. Free Variable:
 - a. Stay time (2 days, 4 days, 7 days) Where each is distinguished based on the type of plant used in the wetland, that is called the Fragrant Root plant (*Vetiveria zizanoides*) with soil media.
 - b. Variation of discharge
 - c. Number of vetiver stems
2. The dependent variable consists of selected parameters, which are as follows:
 - a. pH (Potential of Hydrogen)
 - b. Turbidity

As for the quality standards of each parameter above referring to the Minister of Health Regulation No. 2, 2023 concerning Hygiene and sanitation (clean water), The Research Parameters are described as follows:

Table 1. Clean Water Quality Standard Research Parameters

Parameters	Clean water standard	Unit
pH (Potential of Hydrogen)	6,5 - 8,5	-
Turbidity	< 3	NTU

B. Wetland Construction

The building model is planned using a scale ratio of 1:1000. With a discharge scale. For wetland, a box is sized (70 x 30 x 30 cm). in this physical model using waste discharge taken from the tilapia fishpond output (figure 1).

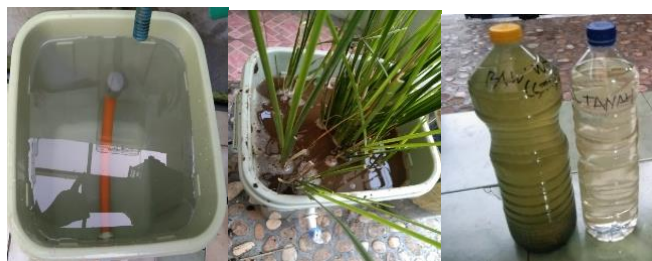


Figure 1 Constructed Wetland

III. RESULT AND DISCUSSION

This section presents the results of the description of water quality parameters including pH, color, turbidity, TDS, nitrate, nitrite, Fe, odor, and fecal coli. The effect on water quality is influenced by water discharge, number of vetiver stems, and residence time. The test results are presented using a line graph with the following results.

pH Parameter

Table 1 Results of Greywater waste treatment with submerged soil media pH (6.5 - 8.5)

Number of AW stem	Water Discharge (liters/day)	Greywater	Time		
			2 days	4 days	7 days
50	1000	7,30	7,50	7,70	7,80
	1500	7,30	7,49	7,68	7,81
	2000	7,30	7,46	7,72	7,80
100	1000	7,30	7,55	7,76	7,87
	1500	7,30	7,55	7,73	7,83
	2000	7,30	7,57	7,73	7,85
150	1000	7,30	7,60	7,84	7,93
	1500	7,30	7,63	7,82	7,97
	2000	7,30	7,58	7,88	7,90

Source: Calculation Results

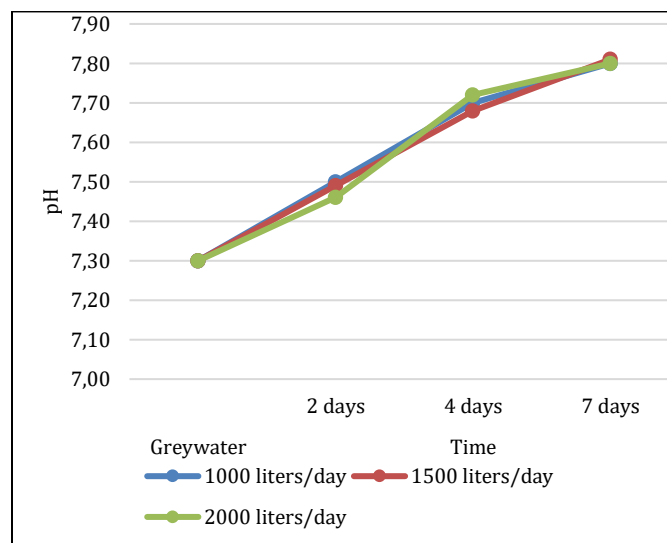


Figure 2 Graph of pH Based on Water Discharge and Residence Time with 50 Number of Stems

The results of the description of the pH parameter show that with the number of vetiver stems as many as 50 stems and each addition of water discharge at different residence time periods will be able to increase the pH value (Figure 2).

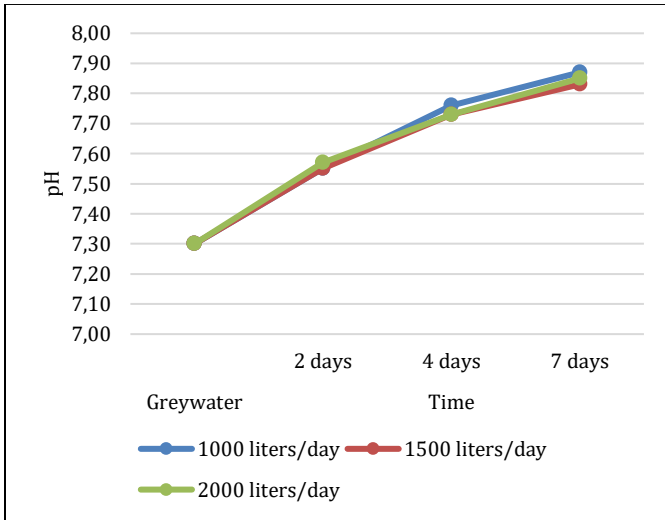


Figure 3 Graph of pH Based on Water Discharge and Residence Time with 100 Number of Stems

The results of the description of the pH parameter show that with the number of vetiver stems as many as 100 stems and each addition of water discharge at different residence time periods will be able to increase the pH value (Figure 3).

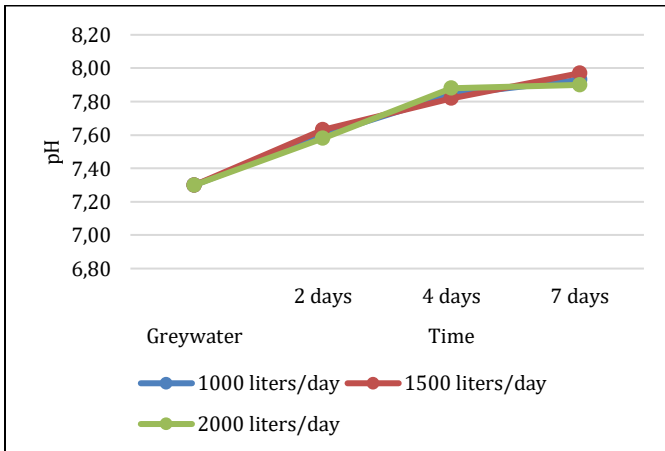


Figure 4 Graph of pH Based on Water Discharge and Residence Time with 150 Stems

The results of the description of the pH parameter show that with the number of vetiver stems as many as 150 stems and each addition of water discharge at different residence time periods will be able to increase the pH value (Figure 4).

Turbidity Parameters

Table 2 Results of Greywater waste treatment with submerged soil media

Number of AW Stems	Water Discharge (liters/day)	Greywater	Turbidity		
			2 days	4 days	7 days
50	1000	119	67,00	20,00	6,36
	1500	119	69,68	20,20	6,30
	2000	119	63,65	20,40	6,42
100	1000	119	60,30	19,00	5,85
	1500	119	61,51	18,81	5,91
	2000	119	60,30	18,43	5,68
150	1000	119	54,27	17,48	5,38
	1500	119	53,73	17,65	5,11
	2000	119	54,27	18,00	5,44

Source: Calculation Results

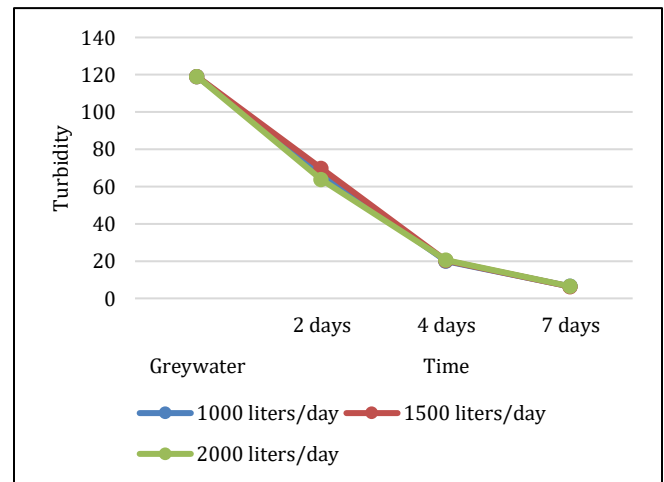


Figure 5 Turbidity Graph Based on Water Discharge and Residence Time with 50 Number of Bars

The results of the description of the turbidity parameter show that with the number of vetiver stems as many as 50 stems and each addition of water discharge at different residence time periods will be able to reduce the turbidity value (Figure 4).

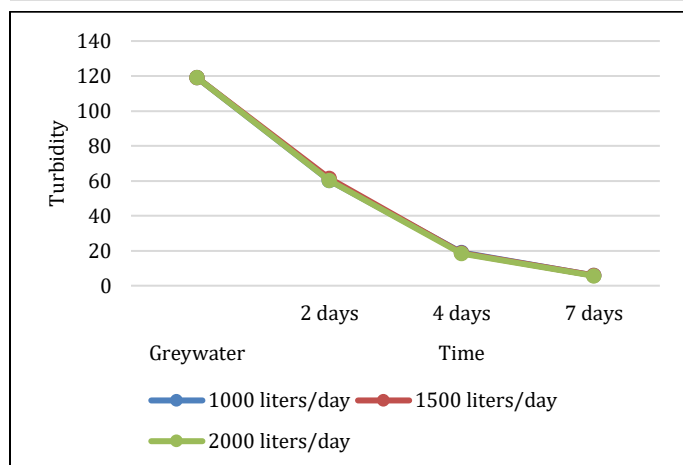


Figure 6 Turbidity Graph Based on Water Discharge and Residence Time with 100 Number of Bars

The results of the description of the turbidity parameter show that with the number of vetiver stems as many as 100 stems and each addition of water discharge in different residence time periods will be able to reduce the turbidity value (Figure 6).

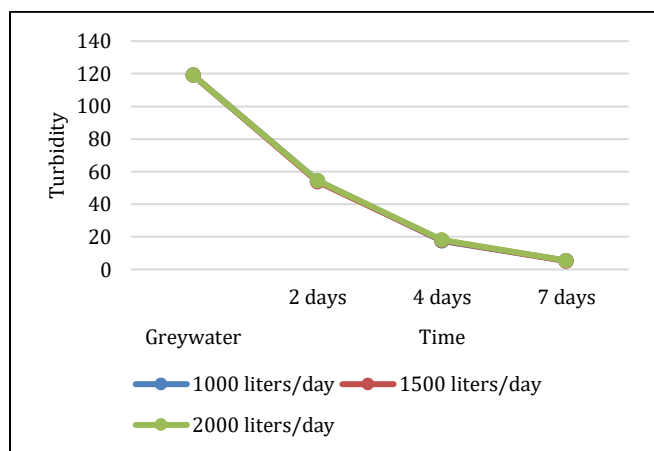


Figure 7 Turbidity Graph Based on Water Discharge and Residence Time with 150 Number of Bars

The results of the description of the turbidity parameter show that with the number of vetiver stems as many as 150 stems and each addition of water discharge in different residence time periods will be able to reduce the turbidity value (Figure 7).

IV. CONCLUSION

Based on the research results of the physical model of gray water waste of tilapia fish ponds, it can be concluded as follows:

1. Tilapia pond waste treatment results show that :
 - a. Initial pH 7.30 rose to 7.90 and standard (6.5 - 8.5) with a residence time of 7 days
 - b. The initial turbidity dropped to 5.44 NTU and the standard (<3 NTU), with a residence time of 7 days. So the residence time must be longer in order to meet the specified standards.
2. The equation in the physical model is :
 - a. pH

$$Y = 7.339 - 6.667 \times 10^{-6} X_1 + 0.001 X_2 + 0.061 X_3 + e$$
(X1 discharge, X2 residence time, X3 number of vetiver stems)]
 - b. Turbidity

$$Y = 79.479 - 0.0003 X_1 - 0.054 X_2 - 10.419 X_3 + e$$
(X1 discharge, X2 residence time, X3 number of vetiver stems)]

ACKNOWLEDGMENT

This research would like to thank the support from the Malang National Institute of Technology - East Java and thank you for the presentation at UIN Malang

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Bridging the Gap: Legal Perspective, Technology Limitation, Cultural Behavior into Solid Waste Management in Bekasi and Sumedang

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Abstract- Indonesia faces increasing waste management challenges, driven by rapid urbanization, population growth, and inadequate infrastructure. This study examines the limitations of waste management technology in Bekasi City and Sumedang Regency by analyzing governance, legal frameworks, and cultural behavior. A mixed-method approach was employed, incorporating interviews, observations, and questionnaires with key stakeholders, supported by multiple linear regression analysis. The result reveals that governance is a significant factor, depicting the highest regression coefficient ($B = 0.166$). Weak regulatory enforcement and institutional inefficiencies are identified as primary barriers to effective waste management as governance issues. Additionally, cultural resistance to adopting new technologies significantly hampers the progress of waste processing systems. Comparative insights from other ASEAN countries, such as the Philippines, reveal similar governance-related obstacles. This study contributes to enriching the literature on the dynamics of waste management in Indonesia and providing objectivity in formulating policies. This study offers a unique perspective on policy formulation that combines law enforcement with cultural considerations to ensure the implementation of sustainable waste management technologies. The findings emphasize that technological solutions should be combined with governance reform and cultural alignment to effectively address the waste management crisis.

Keywords; Bekasi, Cultural Behavior, Governance, Sumedang, Waste Management

I. INTRODUCTION

Indonesia is confronting a rising waste management challenge, driven by rapid urbanization[1], population growth [2], and inadequate infrastructure[3]. Recent data indicates that Indonesia generates 38.4 million tons of waste annually, with only 62.36% being managed [4]. This problem impacts environmental quality [5], public health [6], social cost and economic development [7]. Addressing these complex waste management issues requires a comprehensive strategy [8]. This entails the integration of

technological, legal, institutional, and stakeholder participation. These five aspects are interconnected and must be considered to establish an effective waste management system [9].

The lack of progress in technology and the stagnation of infrastructure and facilities are clear indicators of inefficient waste management in Indonesia. Several factors, such as operational inefficiencies, budgetary constraints, and insufficient governance, contribute to the underperformance of waste processing technologies. The requisite technology is already available; thus, the focus of the Global Waste Management Outlook 2015 is on addressing governance issues, including regulatory laws, collaborations, and financing, to build sustainable waste solutions [10]. However, it also points out that some nations have failed to implement the necessary legislative and regulatory instruments for a long-term waste management system.

Additionally, cultural factors play a crucial role in shaping waste management practices, as highlighted in several studies. Research underscores that cultural participation and behavior significantly influence household recycling and waste reduction efforts [11]. Conversely, in urban centers, cultural practices such as preferences for non-biodegradable packaging and individualistic attitudes contribute to increased solid waste generation [12]. The findings suggest that integrating cultural considerations into governance and policy frameworks can enhance public perception, decision-making, and participation in solid waste management. This underscores the importance of aligning governance reforms and technological solutions with cultural contexts to ensure sustainable waste management systems.

Bekasi City and Sumedang Regency were selected as the study sites to represent metropolitan and regency contexts in Indonesia. In both areas, numerous waste facilities remain underused or not functioning properly. For instance, in Bekasi City, particularly in the North Bekasi sub-district, technical regulations for the sorting, collection,

transporting, and processing of waste—as well as facilities such as small Material Recover Facility (small-MRF) or ‘Tempat Pemrosesan Sampah 3R (TPS 3R)’—have been provided. However, public awareness regarding waste sorting, collection, and processing remains insufficient. In some cases, residents use their own communal containers and procedures for waste management that do not comply with established regulations. A similar situation is observed in Sumedang Regency, where local wisdom is incorporated into waste management practices. However, the enforcement of technical-operational regulations remains insufficient, particularly regarding the provision of appropriate waste management facilities. The community relies on a self-managed waste disposal system, which substantially deviates from regulatory standards, leading to the ineffective implementation of both individual and communal waste disposal models. These challenges highlight governance issues, including difficulties with regulatory enforcement and insufficient institutional support, which hinder the operation and maintenance of waste management technologies.

Several studies indicate that governance, rather than technology, becomes the main obstacle to efficient waste management. Inadequate implementation and enforcement of solid waste management (SWM) rules and regulations has also made the disposal of municipal solid waste (MSW) a major concern for governments, especially in developing countries. A study in Kenya identified the patchwork of laws and regulations as one of the main causes of waste management failures. Additional factors, including corruption, inaction, political interference, and lack of public support, further exacerbate these challenges [13]. No amount of cutting-edge technology can ensure efficient operation without strong governance. A supportive regulatory framework is essential for effective and sustainable waste management practices, and the institutions responsible for enforcement must be adequately empowered and equipped to fulfill their roles. The experiences in Bekasi and Sumedang underscore the importance of governance in the effectiveness of waste management [14–16].

Effective law enforcement is fundamental for effective waste management [17]. In Bekasi and Sumedang, inadequate enforcement of laws and regulations weakens efforts to implement waste management technologies. Governments may enact legislation mandating recycling technology; however, in the absence of sanctions or regulatory oversight, compliance remains weak. Additionally, cultural behavior toward waste management influences the effectiveness of such regulations. A lack of public awareness appears to undermine the law and its implementation, making sanctions necessary to establish good governance [18]. This creates a cycle in which

technologies are not sustained, exacerbating environmental and public health problems.

This research focuses on the specific challenges facing Bekasi and Sumedang, two regions with unique waste management issues. Additionally, deep-rooted cultural practices and public resistance to change further hinder these efforts. While both regions have attempted to adopt waste processing technologies, progress has largely stalled. This case study investigates the factors behind technological stagnation, focusing on the interactions between legal frameworks, institutional capabilities, and cultural behavior in waste management. By analyzing these two areas, the study provides insight into the critical role of good governance and the social barriers that undermine the effectiveness of technological waste management solutions.

II. METHODS

This study used a mixed-method approach, combining qualitative and quantitative data collection techniques to ensure a comprehensive understanding of the issues. Data collection included in-depth interviews, direct observations, and structured questionnaires targeting a wide range of stakeholders, including government officials, waste management practitioners, community members, and business entities. This study utilized purposive sampling to select respondents based on their relevance and involvement in waste management processes.

To identify the root causes behind the failure of legal enforcement in waste management, this research used a multiple linear regression analysis to examine the relationships between various variables or factors influencing law enforcement in waste management. Multiple Linear Regression is a regression equation that involves two or more variables in its analysis [19]. This model shows the relationship between independent variables and dependent variables. The independent variables used include government (X_1), law and regulation (X_2), financial (X_3), operational techniques (X_4), information and community participation (X_5), as well as enforcement activity (X_6). The Statistical Package for Social Science (SPSS) tool was used to analyze the data from 200 respondents.

Additionally, this research employs socio-legal research, which is a method that analyzes the law in practical contexts and investigates its functioning within society. The socio-legal study aims to examine the practical implementation of law concerning persons, organizations, communities, and legal institutions by concentrating on their behaviors in connection to the application or enactment of legal statutes [20]. This study utilizes both a conceptual and a comparative methodology. A conceptual framework is used to clarify the legal concepts included in the waste management system. The comparative approach

aims to highlight policy concepts and exemplary practices in waste management systems from similar countries, such as the Philippines. In contrast, the socio-legal approach is interdisciplinary [21]. Therefore, a non-juridical method is utilized as a tool to examine relevant legal issues, specifically through the Public Policy Science approach. This approach involves a dynamic systems analysis of the factors influencing cultural differences and the legal implications of waste management technology, thereby presenting new challenges within this framework [22]. The analysis results are presented through a descriptive-analytical framework, providing an evaluation of the legality of facts or legal issues identified from the study findings.

III. RESULT AND DISCUSSION

Technology, Governance, and Cultural Behavior of waste problems in Bekasi city and Sumedang City

Norms and objectives have shifted due to the significant impact that technology has had on culture in recent years. The possibility of cultural conflict will increase as these changes become more apparent due to technological advancements [23]. Unfortunately, people are not aware of the technological systems that are in place for this purpose, even though technology should make it easier for people, including make it easier for people to manage waste [24,25]. Poor waste management in metropolitan and regency such as Bekasi City and Sumedang Regency shows that it is not only due to inadequate infrastructure, lack of human resources, and the legal framework, but also when technology availability and the cultural behavior as users integrate improperly.

In Bekasi City and Sumedang Regency, inconsistencies in waste management practices from storage to final processing, reveal significant gaps in infrastructure, governance, and social behavior. The influence of socio-cultural practices and inadequate government support further exacerbate these issues, leading to ineffective waste-handling systems that contradict existing regulations. For instance, the government of Bekasi City has regulated community behavior to manage waste from its source through Bekasi City Regulation Number 2 of 2021 [25]. This regulation has been revised twice to accommodate changes in behavior, including the integration of technology and facility considerations to encourage efficient waste management. However, a significant challenge remains, as the availability of technology does not fully align with the community's cultural behaviors as users of these systems.

Bekasi City, a metropolitan area with a population of approximately 2.627 million people [26], generates about 1,839 tons of waste daily. The relationship between population density and the organization of settlements significantly impacts waste management practices, which

are further influenced by geographical and demographic factors, including cultural behaviors. In Bekasi City, settlements are categorized into three classifications: (1) irregular settlements with minimal formal management, (2) managed areas with regular landed settlements, and (3) managed areas with regular vertical settlements. Despite the availability of waste management facilities and technologies, which vary in complexity according to the specific requirements of each classification, regulations are not consistently followed across all areas [27]. Even where building managers have appointed third-party operators to handle waste management, community behavior has not yet aligned with optimal waste management regulations, particularly in waste sorting and processing.

At the waste sorting level, interviews with neighborhood heads (for landed housing) and area managers, including those from apartments and housing complexes in North Bekasi District, indicated that waste sorting facilities, such as segregated trash bins, are available at some managed landed-settlement locations. However, in unmanaged areas, waste sorting facilities are nearly nonexistent. Despite the availability of facilities, proper waste sorting practices among residents remain limited. Currently, waste is typically collected at a central point, transported, and then disposed of at the landfill using an open dumping system. Law enforcement related to waste management is minimal, consisting primarily of verbal outreach efforts to encourage waste sorting, as well as verbal warnings directed mainly at managed areas. In contrast, in irregular settlements without structured waste management, the practices of burning and illegal dumping of waste are common, with little supervision or enforcement.

Observations revealed that waste collection has not been adequately enforced in the area. It has been reported that waste is still being combined and collected in a single truck or basic container provided by the local authorities. Despite a mutual agreement on collection practices, the Bekasi City Environmental Agency has occasionally encountered delays in the waste collection schedule. Initially, the agency had planned to collect waste twice a month but later revised this to monthly collection. Although a timetable was established, inconsistent implementation led the community to adopt a simpler, self-managed waste management approach. They reached a consensus to set up self-maintained trash bins near the residential gate entrance, finding this arrangement more accessible and efficient. However, some community members have resorted to alternative disposal methods, such as burning waste or leaving it for scavengers to collect. In one instance, a garden was converted into a makeshift dumping site where waste was burned. This practice has had negative effects on the community, including house fires and

unpleasant odors, especially during the rainy season when waste leachate becomes more noticeable.

Regarding waste processing, the Prima Harapan small-MRF in Bekasi City has supported the local community in the corresponding sub-district by providing access to organic and inorganic waste management services. The facility is equipped with waste processing technology, including plastic shredders, organic waste processors, and categorized waste sorting facilities. However, critical facilities such as residue containers for waste processing and biogas production units are not available. The government has adequate human resource capacity to operate this technology, having re-recruited five former civil servants or retired honorary employees for this purpose. While technical regulations for small-MRFs have not yet been adopted at the local level, Prima Harapan small-MRF meets national regulatory standards for infrastructure. Despite the simplified waste processing approach, the community initially opposed the establishment of the Prima Harapan small-MRF site due to concerns about leachate odors and the untidy appearance of the facility. Waste processing technology continues to face cultural challenges within the community, where negative public perceptions persist. Nevertheless, Prima Harapan small-MRF has established a partnership with waste collectors who purchase processed waste, thereby contributing economic value to its operations.

Waste processing technology in Bekasi City has reportedly continued to expand its capacity to convert waste into electricity through Waste-to-Energy (WtE) plants, known locally as “Pembangkit Listrik Tenaga Sampah” (PLTSa). This initiative was formally outlined in the city’s medium-term regional development plan for 2018-2023, a key technocratic development planning document. Bekasi City originally planned to construct a PLTSa facility at the Sumur Batu landfill, but despite completing the trial stage, the project ultimately failed, leading to the contract’s termination. The PLTSa project required a budget of approximately IDR 1.6 trillion, funded primarily by the central government. According to a representative from the Bekasi City Environmental Service, the project failed due to insufficient collaboration, as the power plant network was unable to meet electricity provision requirements. Although a new procurement process has been conducted, bureaucratic obstacles and changes in regional leadership have further hindered the project’s progress.

Additionally, the Bekasi City Government faced challenges in managing grants provided by donors, revealing governance issues in waste management. The Sumur Batu Landfill—a joint initiative between the Bekasi City Government and private companies—received advanced waste processing technology grants from international sources. However, one of these plants, the

Waste Gas Management Plant at Sumur Batu, ceased operations after its contract expired in 2015 due to malfunctioning flaring machines needed for waste incineration. The methane gas processing project site was abandoned, with few visible remnants of prior activity. It was estimated that processing methane gas at Sumur Batu would require incinerating around 700,000 tons over a seven-year period. This partnership initially advanced a carbon credit program with the World Bank, which anticipated profits from carbon sales potentially exceeding \$15,000 per tonne of CO₂. However, volatility in the global carbon market caused prices to fall to \$5,000 per tonne of CO₂, undermining the partnership’s financial viability. As a result, the collaboration to reduce carbon emissions through waste processing ultimately collapsed.

The Bekasi City government has frequently secured funding from the Japanese government for large-scale organic waste management initiatives. Through the “Kompos Patriot” initiative, the government has facilitated third-party collaborations to establish composting and sorting facilities. This facility receives shredded waste from various markets across Bekasi, including Bantargebang, Kranji Market, and Pasar Baru Market. The partnership has achieved positive outcomes, including converting waste into fertilizer and granulating it, with a production capacity of 50 tons per day. One of Indonesia’s leading fertilizer producers has purchased this fertilizer. However, the partnership has since ended, as the company has recently started sourcing livestock waste from outside the region for composting. The local government’s commitment to improving organic waste management reflects ongoing issues in governance, particularly in auditing and overseeing waste management grants within government operations.

The Bekasi city government not only failed to manage grants but also failed to provide incentives to the community to support the waste-to-energy program. Based on Bekasi City Regulation Number 2 of 2021, Bekasi City Government has expanded the authority of the neighborhood head, village head and sub-district head as waste management institutions at the grass-root level. However, the authority to enforce effective waste management has not been fully realized due to a lack of awareness among the public regarding the proper sorting of waste at the source. Some community associations or “Rukun Warga” (RW) have been given incentives to build their own waste banks. One example is a competition that offers prizes in the form of waste processing machine technology. Besides the misdirected incentives, the community is also poorly educated on how to use the technological equipment.

In the meantime, Sumedang Regency, which has 1,205,685 residents overall, produces a substantial amount of waste—roughly 602.8 tons per day. The availability of

land remains proportional from a geographical standpoint, provided that the conditions of settlement and population density are not excessively dense. The Regency of Sumedang maintains a rural culture and strong emotional bonds among its residents. This also affects how the local government implements waste management regulations that consider local cultural wisdom.

Concerning cultural wisdom, an intriguing case study has been conducted on the occurrence of cultural conflict and technological stagnation in Sumedang Regency. The government has introduced a village-level communal waste segregation system known as "Wadah Sampah Desa" (WASADES) based on Regent Regulation Number 105 of 2020 to manage organic waste and address illegal dumping with simple sanitary landfill method. Despite two rounds of regulatory improvement, WASADES aims to prevent each village from disposing of waste in a single location without addressing the underlying issues, particularly by reducing the less effective enforcement efforts against illegal waste disposal. However, the persistence of illegal dumping sites presents a paradox, as the availability of waste processing facilities has not effectively resolved the issue. Interestingly, the community has developed a cultural tendency to dispose of waste carelessly, especially when the recommended waste processing technologies have proven ineffective. At the same time, the community chooses to use self-managed containers such as drums, plastic bags, paint cans or buckets, and sacks that do not meet legal requirements.

The Sumedang Regency Government has established Temporary Waste Disposal Sites known as "Tempat Penampungan Sementara" (TPS) to mitigate the incidence of unlawful waste disposal. Facilities such as wheeled bins and waste carts are used to collect waste; however, these do not ensure proper categorization by waste type. Currently, only 37 TPS and four small-MRFs are operational, while an additional four small-MRFs remain under development. Despite these efforts, the facilities remain inadequate and inconsistent, particularly in providing optimal waste processing technologies. The limited availability of waste management services forces the community to adopt alternative methods of waste disposal, including the establishment of illegal dumpsites. This situation has led to practices such as burning waste or the accumulation of refuse in specific locations, posing environmental and health risks.

In line with the Smart City masterplan of Sumedang Regency for the year 2022, the Sumedang Regency government has encouraged the use of environmentally friendly technology. Improving waste management systems for energy, such as biogas and converting plastic waste into asphalt, is a primary goal of the smart city plan. However, public awareness about the importance of maintaining cleanliness is still low. The use of environmentally friendly

waste management technology has not encouraged the community to process waste at its source. The utilization of technology has not yielded satisfactory outcomes due to the lack of widespread education about waste management in the community. Meanwhile, the officials of the Environmental Agency have stated that the enforcement of legislation becomes increasingly challenging when education, outreach, and legal awareness-raising by the municipal government are not conducted concurrently.

In Sumedang Regency, a significant challenge in waste management is the government's ongoing effort to secure land for a landfill, which has led to the development of joint Regional Landfills with neighboring cities and regencies. However, these Regional Landfills often prove ineffective due to large institutional structures that lack functional efficiency. A major issue is the coordination among institutions at the regional level, where overlapping responsibilities across districts hinder problem resolution, particularly when landfills are unavailable. Despite the existence of a legal framework, such as the Waste Management Act, the implementation of regional waste disposal policies continues to be hindered by institutional inefficiency.

According to the case studies mentioned earlier, inadequate financing, a lack of expertise, outdated infrastructure, and a weak system of oversight and enforcement are the main reasons why solid waste policies are not well implemented. Poor leadership is the main cause of solid waste policy implementation failure. Various issues with waste management arise at every level due to inadequate governance. The goal of good governance approaches is to fix problems with waste management policy implementation across all levels of stakeholders [28]. The cultural divide between Bekasi City and Sumedang Regency is a result of poor waste management facilities and technological governance, according to this research. It highlights the reality that poor leadership is one of the main reasons why systems like municipal solid waste fail. It is believed that all parties involved in waste management policy implementation would be able to fix their weaknesses via good governance procedures. The principles of involvement, consensus orientation, accountability, openness, responsiveness, efficacy, efficiency, equality, inclusion, and rule of law should all be upheld by waste management governance that is successful [28].

Figure 1 below illustrates the technological stagnation in Bekasi and Sumedang Regency regarding legal frameworks and cultural behaviors. The cycle begins with minimal to no law enforcement, where weak regulatory frameworks fail to ensure compliance with waste management standards. This lack of enforcement leads to the ineffectiveness of waste processing technologies, which are often underutilized or operate below capacity due to

limited technical capabilities (from basic to low-tech solutions). As a result, communities develop an instant cultural pattern of choosing alternative waste management methods, often deviating from formal regulations. This includes improper disposal practices, communal waste management systems, or reliance on self-managed waste handling methods. Consequently, the public exhibits a low level of perception regarding the use of technology, driven by a lack of trust and familiarity with the existing waste management infrastructure. Finally, this cycle is compounded by a lack of education on proper technology use, where communities are not sufficiently informed or trained on the importance and functioning of waste processing technologies. This figure highlights the critical need for improved governance to break the cycle of stagnation and enhance waste management outcomes.



Figure 1. Cycle of technology stagnation in Bekasi City and Sumedang Regency using Dynamic System Analysis Model

Benchmarking countries with significant similar stagnant problems: a Study Case in Philipines

In the Philippines, between 15% and 60% of waste is improperly disposed of, with the Metro Manila-the country's largest metropolitan area-achieving a maximum waste collection rate of 85%, while access to controlled landfill facilities remains below 15%. Several factors contribute to the country's waste management challenges, including limited operational vehicles, outdated regulations, weak policy enforcement, and poor governance. Waste management is often deprioritized by local mayors, and municipalities frequently lack both the necessary personnel and adequate government support. While expensive technologies, such as MRF, may not always be required, simpler and more cost-effective waste segregation methods can be more practical. The effectiveness and sustainability of such methods can be

enhanced through promotion, education, and incentives, allowing for the integration of technology and cultural behavior at the same level [29]. Mayors in Metro Manila found that weak enforcement of waste collection laws hampers proper segregation, as people don't see the consequences. When infrastructure, services, and economical alternatives are accessible, it becomes easier and more intuitive for the public to adopt the desired waste segregation behavior, fostering intrinsic motivation.

Cebu City, a city in the Philippines, has demonstrated that poor governance and bureaucracy, such as inadequate human resources staffing and proper waste processing technology facilities, result in ineffective implementation and coordination of waste management policies, yielding unsatisfactory outcomes [30]. The system has had challenges in implementation due to financial limitations and low levels of public knowledge and compliance. Despite claims of 100% waste collection coverage, uncollected waste still accumulates on streets and in waterways. Issues include lack of political leadership, insufficient strategic planning, and limited public awareness, compliance, and expertise in managing composting facilities, all of which hinder effective waste management implementation.

In 2004, the Municipal Government of Cebu City approved Local Ordinance No. 2031, mandating source-sorting of garbage, setting fines for non-compliance, and establishing an incentive fund. Since April 2011, the city has implemented a segregated waste collection system for biodegradable, recyclable, and residual waste under the guiding principle of "No segregation, no collection." One of the most notable achievements of this initiative has been the formation of the Cebu Environmental Sanitation and Enforcement Team (CESET). This team fosters cooperation among government officials, appointed residents, and civil society groups to pursue and penalize offenders, with participating parties receiving 20 percent of collected fines. Although the city has made significant progress, challenges remain, including limited political commitment, inadequate strategic planning, and the lack of financial, legal, and institutional support frameworks. Additionally, significant gaps in knowledge, capacity, and awareness persist concerning the operation and management of composting facilities [31].

Another best practice is the Alaminos Zero Waste Project in the Philippines, supported by GAIA, which transformed waste management through community-driven efforts and compliance with the 2000 Ecological Solid Waste Management Act. Within two years, the project nearly eliminated open burning, increased waste separation to over 80%, and boosted composting to 53%, establishing essential infrastructure like composting facilities. Strict policies, such as "No separation, no collection," reinforced the zero-waste vision, showcasing

effective change through collaboration between communities and local government [32].

Multiple linear regression test results

According to Table 2, the multiple linear regression analysis resulted in a model indicating that the government variable (X_1) has the highest regression coefficient ($B = 0.166$), signifying that government factors exert the greatest influence on waste law enforcement in Bekasi and Sumedang compared to other variables such as legal frameworks, financial resources, operational techniques, public participation, and enforcement activities. The significance value for the government variable was 0.014, below the $\alpha = 0.05$ threshold, confirming a significant impact on waste law enforcement effectiveness.

Table 2. Multiple regression test result

Independent Variables	B	Significance
(Constant)	1.099	0.016
Government	0.166	0.014
Law and regulation	0.143	0.013
Financial	0.143	0.013
Operational technique	0.157	0.004
Information and community participation	0.119	0.014
Enforcement activity	0.103	0.040

a Adjusted SPSS output results

This confirms the results of previous research that found that governance influences waste management policies in Indonesia through strategy and policy development, the application of norms, standards, procedures, and criteria, and the regulation of programs and policies related to waste management [33,34]. The effectiveness of the waste management system relies on government involvement in providing technical and financial assistance, as well as guidance, to local governments. Municipal government commitment and broad societal participation are also crucial for successful waste management systems [18]. Therefore, governance—especially regarding commitment, government human resource capacity, bureaucracy, and coordination—exerts a considerable influence on waste management policies in Bekasi and Sumedang, particularly about law enforcement and waste regulation.

IV. CONCLUSION

The technological stagnation of solid waste management in Bekasi City and Sumedang Regency is driven by a cycle of weak law enforcement, ineffective solid waste technology, and instant cultural behavior, highlighting the need for stronger governance. The most significant factor, especially related to law enforcement that results in inefficient technical and operational waste management in Bekasi City and Sumedang Regency is the governance. Governance, especially in terms of law enforcement, emerges as the most critical factor contributing to inefficient technical and operational waste management in Bekasi City and Sumedang Regency. As a benchmark case, in Cebu City and Metro Manila, the Philippines experience similar challenges but address them through improved governance, particularly by promoting education, awareness, and offering incentives to the community.

This study acknowledges certain limitations, including the geographic scope confined to Bekasi City and Sumedang Regency, the timeframe during which the research was conducted, and the selection of subjects and informants, which may not fully represent the diverse perspectives of all stakeholders. Additionally, constraints in accessing comprehensive data from government institutions and private entities posed challenges in achieving a more extensive analysis. Future research could address these limitations by expanding the study to other regions in Indonesia to replicate or test the findings, offering a comparative analysis across various localities.

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IDEF-0 Framework: Developing New Method of Self-Managed Procurement Type1 in Construction Project

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Abstract. Indonesia Public Procurement has introduced a new method of Self-managed Procurement Type-1 for construction projects. This method is designed specifically for small to medium-sized construction projects that can be managed independently. The research aims to develop a conceptual framework using the IDEF-0 analytical method. The method uses qualitative descriptive and data collection from a case study analysis of a government project. The result is a conceptual framework model of the New Self-managed procurement method. It comprises three stages which generate a process model including preparation, implementation, and supervision. The framework could be implemented and adopted by the industries, as well as the institutions and government agencies.

Keywords; *Self-Managed Procurement; IDEF-0; Construction Project.*

I. INTRODUCTION

Selecting the appropriate procurement method is essential to ensure success in construction projects. Indonesia's government has amended the Public Procurement Regulation to determine the most suitable public procurement method. For instance, in 2021 the Educational local authority used Traditional Procurement according to the terms and procedures of the National Public Procurement Agency (LKPP) (Article 9(2), Institutional Regulation of LKPP). In the following year, it was amended to Self-Managed Procurement Type-1. The amendment stipulated under the Ministry of Education Regulation No. 3 of 2022, article 8(2), which allows for the application of Traditional and/ or Self-Managed Procurement methods. This implies that the authorities may use a customized procurement method traditional procurement and self-managed procurement, known as self-managed procurement type-1.

The authority then applied Self-managed procurement Type-1 which has been started from 2022. There are some opportunities to use the new method in construction projects. Firstly, Project delays could bring more challenges in construction. The new method could bring in faster methods due to simple procurement

processes which could be managed by the authorities independently. For instance, in construction project funded by DAK (The Specific Allocation Fund) has encountered a project delay according to the project's

duration[1]. Hence, the new method could bring the projects on time and reduce delays.

Secondly, self-managed procurement type 1 could use professional participants to monitor the projects. The past Self-managed procurement method has challenges in terms of project quality due to unqualified human resources[1]. However, the government had amended the procurement method by Presidential Decree Number 12 of 2021 Concerning Goods/Services Procurement. It has a provision to use a professional certificate for the procurement's stakeholders to give more skills in specific needs such as infrastructure projects.

The third reason is the involvement of local values by local society participants[2]. The method can improve Local economic growth through community empowerment by local workers participating in construction projects. It reflects a sustainable economy by encouraging job opportunities in line with Sustainable Development Goals (SDGs).

However, Since the application was still new, there was an obstacle due to a lack of understanding of the new method. The adoption is still new and needs guidelines to apply the procurement methods, especially in construction projects.

Subsequently, this research will analyze and propose a conceptual framework for addressing the procurement mechanisms in implementing the New Method of Self-Managed Procurement Type-1.

II. SELF-MANAGED PROCUREMENT

A. Self-managed Procurement

There are two public procurement methods in Indonesia, Traditional Procurement and Self-managed Procurement (Institutional Regulation of LKPP). Traditional procurement is acquiring goods and services from providers or service providers, the contractor,

subcontractors, agents, and the cloud service provider under the contract [3]. Self-managed procurement or In-House procurement is the procurement method, which is managed independently by Ministries, Institutions, Regional Apparatuses, civil society, or community groups (Article 1, Paragraph 23 of the Institutional Regulation LKPP Number 3 of 2021).

According to the regulation of LKPP No.8 of 2018, there are four types of Self-managed procurement:

1. *Self-managed Procurement Type-1*

Self-managed procurement method that is organized independently by the government authority, encompassing planning, implementing, and supervising.

2. *Self-managed Procurement Type-2*

Self-managed procurement Type 2 is the procurement process which is planned, planned and supervised by the government institutions but implemented by another institution.

3. *Self-managed Procurement Type-3*

Self-managed procurement Type-3 is the procurement process which is planned and supervised by government authority but implemented by Community Groups.

4. *Self-managed Procurement Type-4*

Self-managed procurement Type-3 is the procurement method which is planned by government institutions but carried out and supervised by Community Groups. Requirements for Type IV Self-Management Organizers include a Letter of Confirmation issued by an authorized official

This study is focused on the Self-managed Procurement Type-1 method in the local authority. It was selected as the adoption in the educational local authority was still new and problems identified in the procurement implementation include time, cost, and quality[4]. The limitation of time identified in the projects and it is essential to have better teamwork by improving communication and coordination [5]. In addition, it is difficult to maintain a construction project to obtain a reasonable project cost [6]. The poor management and skills to construct the building are identified as the project quality challenge. Inadequate planning and poor execution caused problems with cost overruns and project delays [7].

B. Procurement Regulations

The regulation of Self-managed procurement goods and services in Indonesia is regulated under the Institutional Regulation of LKPP. The regulation consists of primary rules and derivative regulations. The primary rules are explained to be more technical and detailed under the derivative regulations[8]. However, procurement regulation is different according to the project type and resources. Self-managed procurement Type-1 in

the Educational Local Authority project has several regulations, which is explained in Table 1.

Table 1 Self-managed procurement regulation

The Primary Rules (Government Procurement Regulation of Republic Indonesia)	
Presidential Regulation No. 12 of 2021 (latest)	
Amended	
Presidential Regulation No. 16 of 2018	
Restricted	
Presidential Regulation No. 4 of 2015 (4 th amendment)	
Presidential Regulation No. 172 of 2014 (3 rd amendment)	
Presidential Regulation No. 70 of 2012 (2 nd amendment)	
Presidential Regulation No. 35 of 2011 (1 st amendment)	
Presidential Regulation No. 54 of 2010	
Derivative Regulations	
Traditional Procurement (Contract by Provider)	Self-Managed Procurement (In-house Procurement)
Institutional Regulation No. 12 of 2021 (Operational Procedures on Government Procurement by Provider)	Institutional Regulation No. 3 of 2021 (Procedures on Self-Managed Procurement)
Amended	
Institutional Regulation No. 9 of 2018	Institutional Regulation No. 8 of 2018

C. Procurement Organization and Stakeholders

There are four stakeholders in Self-managed procurement Type-1:

1. PA/KPA(Proxy of Budget User)
2. Commitment Making Officer (PPK)
3. Facilitator
4. Procurement officer/ organizer which consists of three procurement project teams including Preparation Team, Implementation Team, and Supervisory Team. The procurement organization structure is shown in Figure 1.

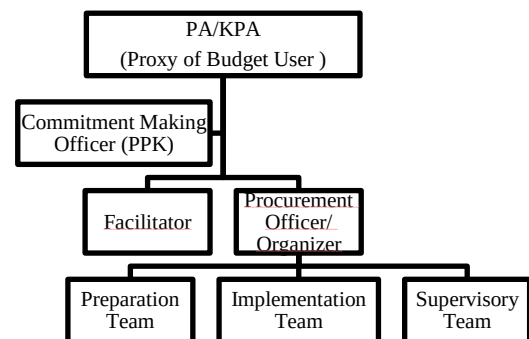


Fig. 1. General Elements of IDEF-0 Modelling Approach

D. Self-managed Procurement Processes

According to the Institutional regulation of LKPP, there are terms and procedures for Self-managed procurement Type-1 processes. The following details and explanations will be provided in the regulation on Article 2 which comprises: Planning the method; Preparation;

Implementation; Supervision; and Project hand-over. Globally, there are three main stages of Self-managed procurement:

1. Preparation

Firstly, PPK coordinates the preparation of type I Self-managed procurement after the establishment of the DIPA/DPA by considering the determination of targets set by the PA/KPA. Secondly, preparing the planning documents which include work breakdown structure, Implementation schedule, and review of technical specifications/TOR. The third is to carry out a contract document including HPS, contract design, and technical specifications/ TOR.

2. Implementation

The implementation stage includes the construction stage. Firstly, the documents will identify and analyse the problems which might arise[9]. According to the regulation of LKPP No.3 of 2021, the implementation stage includes: determining the project by PPK, Submitting local workers' participation, using an expert who understands the construction project, preparing the project's report, and payments by PPK according to the progress of the project.

3. Supervision

According to the institutional regulation of LKPP, the supervision stage is carried out by the supervisory team. The Team reports and provides recommendations to the PPK, preparation team or implementation team to immediately take corrective action according to the supervision result.

III. METHODS

This research uses a descriptive qualitative case study to analyze the implementation of a Self-Managed Procurement Type 1 approach within the Local Authority of Indonesia. The case study of Indonesia Local authority provided to understand the implementation of the New Self-managed procurement method. It investigated a public construction project which was a School project, including the reconstruction of a School Mosque, the Construction of Toilets, and the Construction of a Health facility. The data was collected through semi-structured interviews with government representatives, such as PPK (Procurement Making Officer), and stakeholders such as providers, and official employees.

The results of semi-structured interviews will be analyzed by the IDEF-0 analytical method to produce a conceptual framework. IDEF-0 is a graphical method which was initially created by the US Air Force to identify documents of processes system[10]. Selecting the IDEF-0 as the analytical technique due to the language of IDEF0is standardized with respect to syntax and semantics[11].

This structured approach allows users to better comprehend the relationships between different components and functions within an organization[12]. IDEF-0 is represented by four arrows (ICOM) which are input, output, control, and mechanism[13]. The following figure shows the graphical concept of the IDEF-0 analytical method, which includes four arrows: input, output, control, and mechanism.

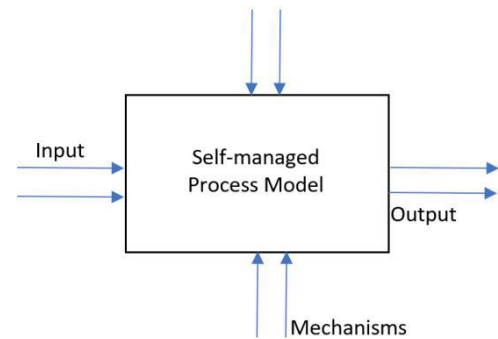


Fig. 2. General Elements of IDEF-0 Modelling Approach

The next step is to produce a more complex framework including three procurement stages, including preparation, implementation, and supervision. It is represented in Figure 3. There are three main activities which represent the first level of the IDEF-0 model. Prepare the project (A1), implement the project (A2) and supervise the project(A3). In giving the detailed system, each activity will be explained in detail by the second level of IDEF-0.

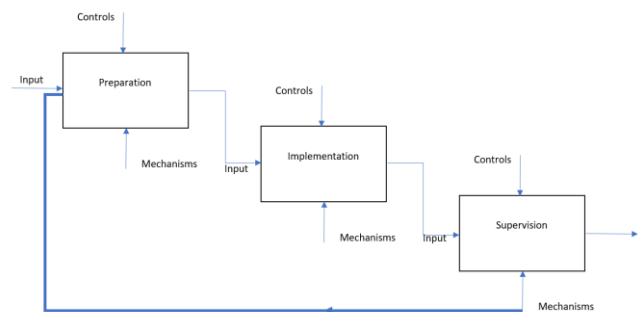


Fig. 3. IDEF-0 Structural model by n=3

IV. RESULTS AND DISCUSSION

The conceptual framework aimed to address the procurement mechanism processed model of Self-managed procurement Type-1 in understanding the mechanisms of the new procurement method. The IDEF-0 conceptual framework draws on data gathered through case study analysis, which was analyzed across four key elements: input (project requirements), control (project regulation and procurement), mechanisms (procurement

management by project team), and output (project processes).

The development of the IDEF-0 conceptual framework for Self-managed procurement is using Microsoft Visio to construct the IDEF-0 Process Model. The Framework consists of three levels. The first level is the (A0) node which is a basic element of procurement processes. It is illustrated in Figure 4.

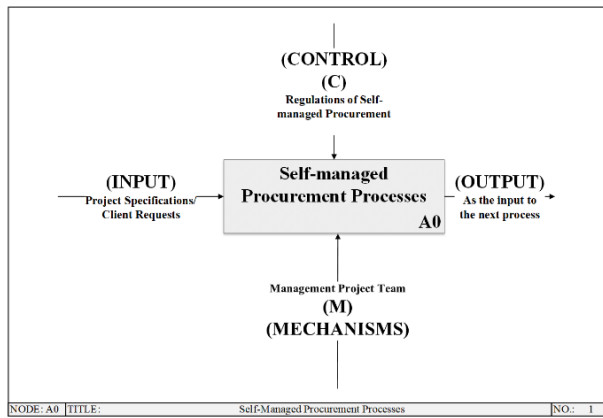


Fig. 4. IDEF-0 basic elements of Self-managed procurement system

The second level of the IDEF-0 conceptual framework is the detail of (A0) and it consists of three activity boxes, including (A1) Prepare the Project; (A2) Implement the Project; (A3) Supervise the Project. produced in three-layer process stages. It is illustrated in Figure 5. The hierarchical structure of the first level and the second level is illustrated in Figure 5.

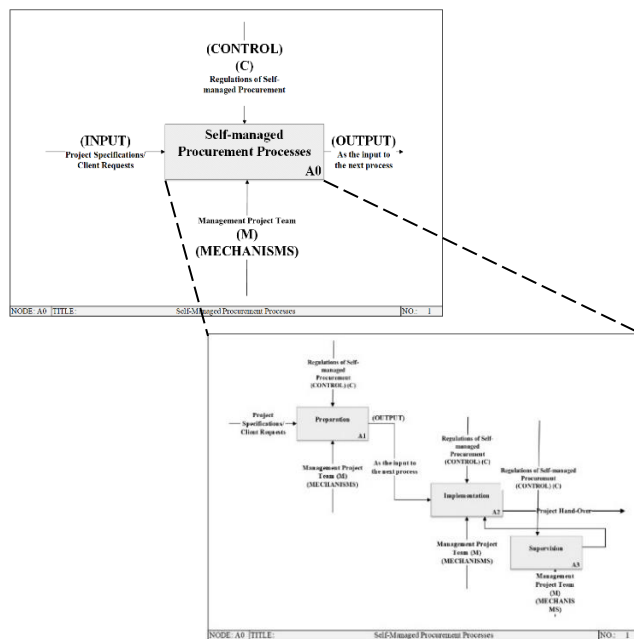


Fig. 5. (A0) Processes ID Mechanism

The third layer of the IDEF-0 model provides detailed information about process ID. For instance, the Preparation process (A1) is broken down into three activity boxes, labeled (A1.1), (A1.2), and (A1.3). The decomposition structure of the IDEF-0 model begins with the first layer continues through to the second layer and is detailed with the third layer.

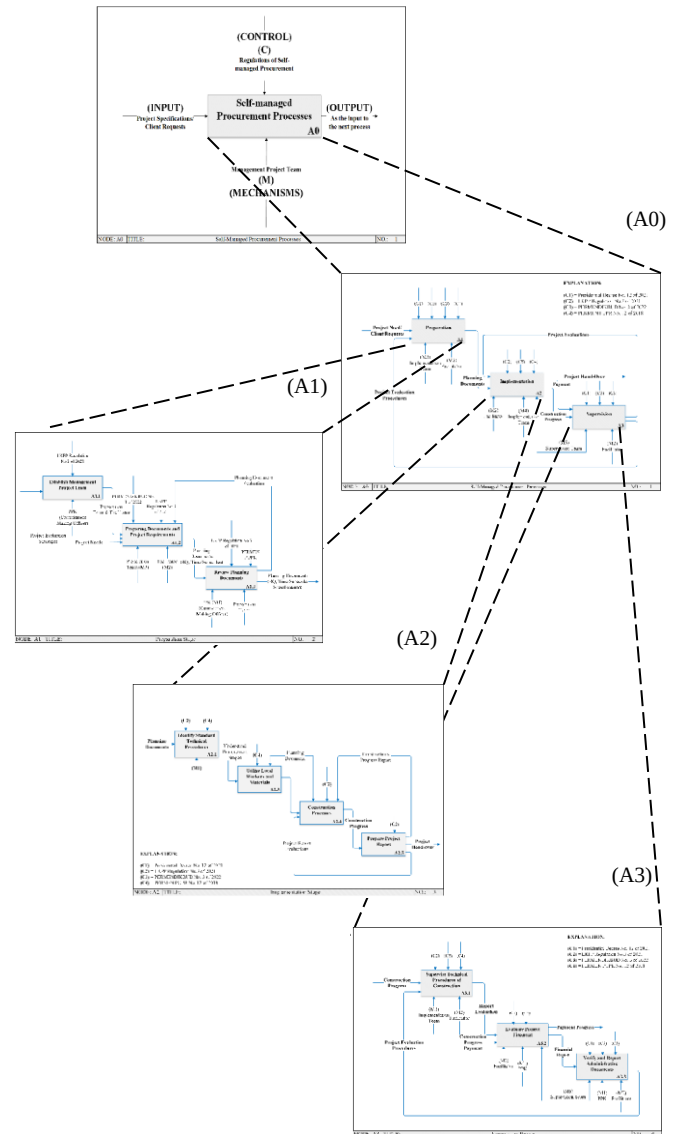


Fig. 6. Decomposition of IDEF-0 Conceptual Framework

The whole IDEF-0 structural model was developed by four frameworks:

1. "A0" Self-managed procurement process. It consists of three activity boxes: prepare the project (A1), implement the project (A2) and supervise the project (A3).
2. "A1" Prepare the project which consists of: Establish a management team (A1.1), Preparing Project

Document (A1.2), Review Planning Documents (A2.3).

3. "A2" Implement the project, consisting of: Identify standard technical procedures (A2.1), Utilize local workers and materials (A2.2), Construct the buildings (A2.3), Prepare project report (A2.4).
4. "A3" Supervise the project, consists of: Supervise technical procedures (A3.1), Evaluate project financial (A3.2), Verify and report administrative documents (A3.3).
5. The IDEF-0 hierarchical structure is showed in Figure 6. The first level detailed in (A0) which is the second level of IDEF-0 framework. The third level is the explanation of (A0), comprises of (A1), (A2), and (A3).

A. Self-managed Procurement Process Model (A0)

The A0 Diagram of the Self-Managed Procurement Process model consists of three activity boxes: Prepare the Project (A1), Implement the Project (A2), and Supervise the Project (A3). The main output from each activity serves as the input for the next activity.

Specifically, the output of Prepare the Project (A1) is project documents, which then serve as the input for Implementing the Project (A2). The primary output of Implement the Project (A2) is building progress, which becomes the main input for Supervise the Project (A3). The progress of the building, as the output of A2, is evaluated and supervised by A3. Ultimately, the final output of the procurement project is the building handover. A0 Diagram of the Self-managed procurement process is illustrated in Figure 7.

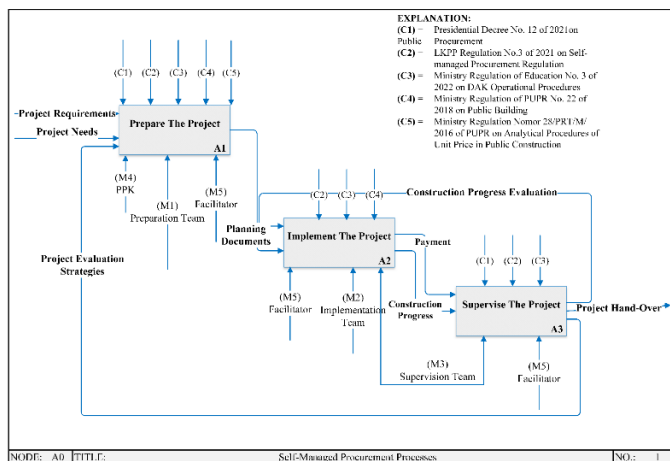


Fig. 7. Decomposition of IDEF-0 Conceptual Framework

The (A0) Framework consists of three main activity boxes which explain the whole procurement process of Self-managed procurement Type-1. There are five procurement stakeholders who have their responsibilities in each

procurement stage. The Preparation Team (M1) prepares the project (A1); the Implementation Team (M2) implements the project (A2). It is obliged to construct the building and report the progress of construction; The Supervision Team (M3) supervise the project (A3). The other mechanism in the process model is PPK (M5) as the Commitment Making Official and Facilitator (M4) that is obliged to help all procurement processes including preparing, implementing, and supervising the projects.

IDEF-0 model explains the details of process ID. For example, the Preparation process (A1) consists of three activity boxes represented by (A1.1), (A1.2), and (A1.3).

B. Prepare The Project (A1) Diagram

The first activity box in the A0 diagram is "Prepare the Project" (A1). The PPK (M4) and the preparation team (M1) identified the project criteria, specifications, and needs as inputs. These inputs align with the regulations outlined in the Public Procurement standards (C1) and (C2) under Institutional Regulation No. 3 of 2021 for Self-Managed Procurement. Additionally, they reference (C3) PERMENDIKBUD (The Ministry of Education Regulation) No. 3 of 2022 regarding DAK fund guidelines.

The primary activity in the planning process involves the facilitator (M5) collaborating with (M1) to create the main output: the planning document. This process is regulated in accordance with (C3) and (C4) under the Ministry of Public Works and Development (PERMEN PUPR) Regulation No. 12 of 2018, which pertains to Public Building Specifications, as well as (C5) under the Ministry Regulation No. 28/PRT/M/2016 regarding the Analytical Procedures of Unit Pricing in Public Construction. (A1) diagram is showed in Figure 8.

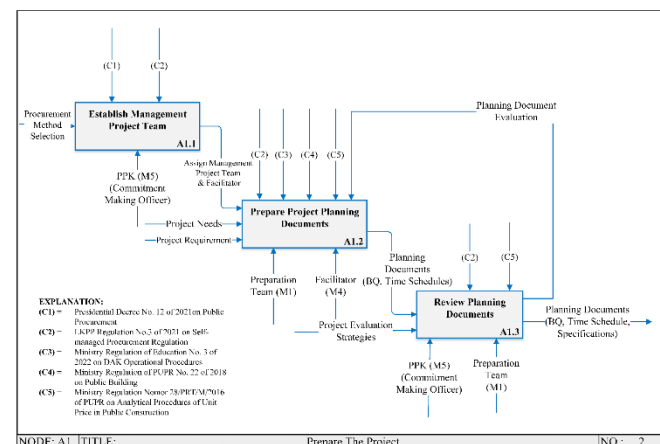


Fig. 8. Prepare the Project (A1)

C. Implement the Project (A2) Diagram

The implementation stage is the construction process. It consists of four activities. The Implementation Stage (A2) Diagram is illustrated in Figure 9.

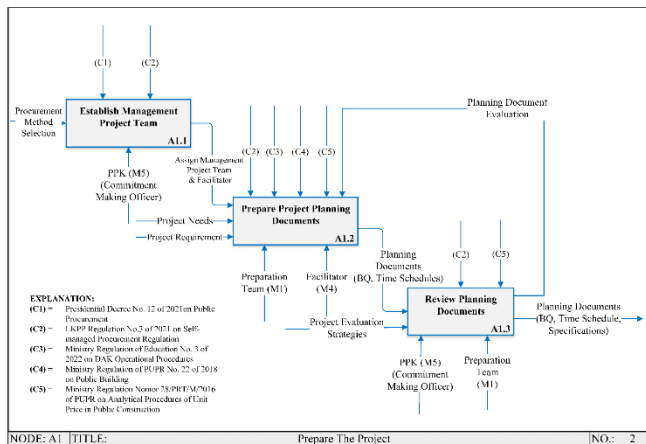


Fig. 9. Prepare the Project (A1)

There are four activities in the Implementation Stage Diagram:

1. (A2.1) Identify Technical procedures.

The activity is based on the Planning Documents which has the output on understanding the Planning Documents. Three stakeholders are responsible for this activity, including PPK, the Facilitator, and the Implementation Team. The activity is controlled under the (C2) Regulation of LKPP No.3 of 2021 and (C4) PUPR Regulation No.22 of 2018 on Public Buildings.

2. (A2.2) Utilize Local Workers and Material

The implementation team and facilitator work together who responsible for utilizing local value. It is based on the (C2) Regulation of LKPP No.3 of 2021 and (C4) The PUPR Regulation No.22 of 2018 on Public Buildings. The output utilises local goods/materials and services.

3. (A2.3) Construct the Building

The activity is based on the Planning Document and the (C2) Regulation of LKPP No.3 of 2021 on Self-managed procurement regulation. The Output is construction progress which becomes the input for preparing the project report. Two stakeholders were responsible for the construction process, including the implementation team and facilitator.

4. (A2.4) Prepare the Project Report

The project report is prepared by the Implementation Team and supervised by the Facilitator. The report will be used for payment according to the construction progresses.

D. Supervise the Project (A3)

The third activity is to supervise the projects (A3), which involves overseeing the construction progress of buildings. The supervision team (M3) is responsible for three key activities:

1. Supervise technical procedures (A3.1)

The first activity is to supervise technical procedures (A3.1), which involves auditing the technical procedures of the construction project. The main responsibilities lie with the Supervision Team (M3), the Facilitator (M4), and the Project Control Officer (PPK) (M5). They are committed to monitoring and evaluating the project by overseeing the technical procedures throughout the construction process.

2. Evaluate project finances (A3.2)

The second activity is to evaluate project finances (A3.2). There are two inputs for supervising the payment report: the first is the evaluation report from the previous stage, and the second is the construction progress payment. Payments are conducted three times based on the progress reports. When the progress reaches 25%, the supervision team (M3) will evaluate the project alongside the payment reports to determine the payment progress. The evaluation of payments is conducted in accordance with the regulations of self-managed procurement and the regulation of the DAK fund (C3).

3. Verify and report administrative documents (A3.3)

The third detailed activity of the Evaluate project (A3) is to verify and report administrative documents (A3.3). This activity culminates in the project's final output: the project handover. All administrative documents, including input from the previous activity regarding the financial report of the project, must be verified.

If construction processes are complete and the administrative and financial reports have been finalized, the Project Manager (PPK) and the Supervision Team will verify the project, preparing it for hand-over to the user, which is the School's party. This process adheres to the regulations of public procurement and the guidelines for DAK funds.

This structured approach ensures effective monitoring and management throughout the project lifecycle. (A3) Diagram of Supervised the Project is shown in Figure 10.

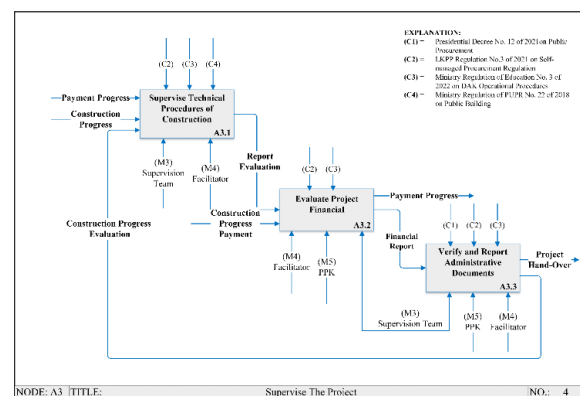


Fig. 10. Supervised the Project (A3)

V. CONCLUSION

In conclusion, the research has examined the Conceptual framework model using the IDEF-0 analysis method by producing the framework processes model in three stages, including preparation, implementation, and supervision of the project. It also substitutes to explain the frameworks in detail by explaining the activity box in three hierarchical structures. Each activity box is detailed on the four arrows by ICOM'S (Input, Output, Control, Mechanism).

The framework was developed from a case study analysis of Self-Managed Procurement Type-1 in a public construction project by Educational Local Authority. The data was generated by semi-structured interviews with the procurement stakeholders who participated in the project.

The development of the IDEF-0 framework concept model contributed to understanding the whole processes of Self-managed procurement comprehensively. It contributed to other authorities, as well as government agencies to adopt Self-managed procurement Type-1 as the procurement method selection.

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AR E-books Offer a Safe, Eco-friendly Solution to Combat Oxidation in Children's Storybooks for Green Libraries

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Abstract. This research explores the application of Augmented Reality (AR)--based e-books as a sustainable and safe alternative to printed books within the context of green libraries. Green libraries aim to minimize environmental impact by optimizing energy use, efficient waste management, and leveraging digital resources. Although printed books remain popular in supporting children's literacy, they pose health risks due to the chemical content of materials like formaldehyde and benzene. Thus, this study evaluates the health risks associated with printed books and examines the potential of AR e-books as a safer and more eco-friendly solution for children. The method employed is a literature review, which includes product life cycle analysis, health risk evaluation, and user engagement assessment through AR technology. The findings reveal that AR e-books reduce carbon footprints and paper consumption, provide a more interactive learning experience, enhance children's reading interest, and eliminate the risks of exposure to harmful chemicals. AR e-books in green libraries can support environmental sustainability public health, and extend the lifespan of literary collections without physical degradation.

Keywords; AR e-books, Children, Green Library, Health, Sustainability.

I. INTRODUCTION

Green libraries represent a significant initiative in environmental sustainability, where implementing sustainable practices is paramount to minimizing negative impacts on the environment. A key aspect of green libraries is optimizing energy use and efficient waste management. In this regard, libraries must adopt technologies and practices that support sustainability, including the transition toward a paperless ecosystem. Research indicates that using printed books can pose health risks due to hazardous chemicals found in paper, such as formaldehyde and benzene, which can be released through oxidation [1]. This is particularly concerning for children, who are more vulnerable to exposure to these toxic substances [2]. The health risks associated with printed books compel green libraries to consider safer and more environmentally friendly alternatives, such as Augmented

Reality (AR)--based e-books. AR e-books not only mitigate the risk of exposure to harmful chemicals but also have the potential to reduce paper consumption and lower carbon emissions.

Studies have shown that AR e-books can create interactive and engaging reading experiences, enhancing children's interest in reading [3]. Furthermore, e-books provide easier information retrieval and better accessibility than printed books, improving the learning experience [4]. Implementing AR e-books in green libraries also supports children's digital literacy development. By leveraging AR technology, libraries can create more engaging and interactive learning environments, increasing children's involvement in reading [5]. Research has demonstrated that e-books facilitate better access to information and enhance digital literacy skills, which are crucial in today's information age [6]. Therefore, green libraries must formulate better strategies to support environmental sustainability and public health by considering AR e-books a safer and more sustainable alternative. Green libraries should also focus on developing policies and practices that promote sustainability in this context. This includes training library staff to understand and implement sustainable practices in their collection management and services [7]. Research indicates that libraries adopting green practices contribute to environmental sustainability and enhance their reputation within the community [8].

Consequently, green libraries can serve as models for other institutions in implementing sustainable practices and educating the public about the importance of sustainability [9]. Despite the challenges in implementing green practices, such as budget and resource limitations, libraries can overcome these barriers through effective collaboration and partnerships [10]. Studies have shown that libraries engaged in sustainability initiatives often find innovative ways to address these challenges and create positive impacts in their communities [11]. Therefore, libraries must continue exploring and adopting sustainable practices that can enhance public health and environmental well-being. To evaluate the health risks posed by using printed storybooks and explore AR e-books' effectiveness,

further research is needed to understand the impacts of both formats. By comprehending the risks and benefits associated with printed books and e-books, libraries can develop better strategies to support environmental sustainability and public health. This research can also provide valuable insights for policymakers in designing policies and practices that support green libraries. Overall, green libraries have significant potential to contribute to environmental sustainability and public health by implementing sustainable practices and using innovative technologies. By adopting AR e-books as a safer and more sustainable alternative, libraries can create better learning environments for children and society. Therefore, libraries must continue innovating and adapting to technological advancements and community needs to support sustainability.

II. RESEARCH METHODS

This study uses a literature review method by analyzing various scientific sources related to the health and environmental impacts of using printed storybooks and AR e-books. The steps taken include:



Figure 1. Steps in this method

A. Data Collection

Data was collected from scientific journals, research reports, and other publications relevant to green libraries, the chemical impact of printed books, and the implementation of AR technology in education. The literature reviewed covers the environmental impact of paper production, the health risks of chemicals in paper, and studies on the effectiveness of AR in enhancing children's reading engagement.

B. Environmental Impact and Sustainability

Through Life Cycle Assessment (LCA), this study compares printed book production's environmental impact

with AR e-books. This analysis focuses on the carbon footprint generated by the production, transportation, and distribution of printed books and how AR e-books reduce these impacts.

C. Health Risk Evaluation

The study examines hazardous chemicals commonly found in paper, such as formaldehyde and chlorine, and how long-term exposure to these substances affects children's health. This data is compared with the near-zero risk posed by AR e-books, which do not contain harmful physical materials.

D. Durability and Lifespan Assessment

This study compares the durability of printed books, which are prone to physical damage and degradation due to oxidation, with AR e-books, which are digital and more durable. The lifespan of electronic devices is also considered, with an evaluation of the average lifespan of devices such as tablets or smartphones.

E. User Engagement Evaluation

The study also reviews how AR enhances children's reading experiences. Literature on the impact of visual and audio interactions from AR e-books on children's reading interest and comprehension is used to evaluate the potential benefits of AR technology in green libraries.

The findings from this research can build a strong argument for the benefits of AR e-books in improving health, sustainability, and children's literacy experiences in green libraries.

III. RESULT AND DISCUSSION

This research focuses on using Augmented Reality (AR) e-books as an environmentally friendly solution to address the oxidation issue in children's storybooks in green libraries. The findings of this study are discussed through several key points, including environmental impact and sustainability, durability and lifespan, user engagement and learning experience, and the practical implications of implementing AR e-books in green libraries.

A. Environmental Impact and Sustainability

Traditional children's storybooks printed on paper have a significant environmental impact. Paper production requires large amounts of energy and water, contributing to deforestation and carbon emissions. According to research, the production and distribution of a single paper book typically generate between 7.5 and 9.5 kg of CO₂ [12]. Additionally, physical damage to books caused by oxidation and environmental changes such as humidity and temperature often force libraries to replace damaged books, which adds to waste and operational costs. Paper-

based storybooks can be considered less sustainable than digital alternatives in this context.

In contrast, e-books with augmented reality (AR) technology offer a more environmentally friendly solution. AR e-books do not require physical raw materials like paper; their distribution only requires digital devices such as tablets or smartphones that can be used repeatedly [13]. Thus, this technology aligns with sustainability principles by reducing carbon emissions from producing and transporting physical books. While electronic devices also have a carbon footprint, they tend to have a longer lifespan. They can be used for various other functions, making their environmental impact more efficient than physical books.

In the context of green libraries, AR e-books support resource efficiency and energy savings. Paper books require significant storage space and controlled temperature and humidity to prevent damage. In contrast, AR e-book collections can be stored on digital servers without requiring substantial physical space. This aligns with green library goals to reduce environmental impact and promote sustainable resource usage. Furthermore, using AR e-books in libraries can reduce paper consumption, waste, and carbon emissions from the physical book production process.

From a health perspective, paper books often contain harmful chemicals such as chlorine, formaldehyde, and heavy metals used in bleaching and printing. These substances can pose health risks to children, who often have habits of touching and biting books. In contrast, AR e-books do not contain these harmful chemicals, making them safer for children. Additionally, digital devices that read e-books can be cleaned regularly, maintaining hygiene and reducing the risk of spreading germs or allergens.

Comparing traditional storybooks and AR e-books shows that AR e-books offer greater sustainability and user health benefits. AR e-books in green libraries can reduce paper consumption, waste, and carbon emissions while minimizing health risks from exposure to chemicals commonly found in physical books.

B. Durability and Lifespan

Traditional children's storybooks, especially those intended for young readers, have significant limitations in terms of lifespan due to the physical properties of paper, which are prone to damage. These books often need help with wear and tear due to repeated use, rough handling, and exposure to less-than-ideal environmental conditions. The oxidation process in paper causes books to yellow, become brittle, and tear easily [14]. Furthermore, fluctuations in temperature and humidity and exposure to sunlight accelerate physical damage to paper books, particularly in libraries frequently used by children [15].

In contrast, Augmented Reality (AR) e-books offer a much more durable solution because they are digital. AR e-

book content is not susceptible to the physical damage that affects paper books. AR e-books do not degrade in quality due to oxidation, environmental exposure, or repeated use, giving them a much longer lifespan [16]. As a result, green libraries that adopt AR e-book technology can reduce the frequency of book replacements and minimize paper consumption and the associated waste.

The durability of AR e-books depends largely on the electronic devices used to access them, such as tablets or smartphones, which typically have a lifespan of 4-7 years [17]. As long as these devices function properly, AR e-book content can be accessed continuously without any degradation in quality. Therefore, regarding content longevity, AR e-books far surpass physical books, which often require replacement due to damage or wear [18].

The advantages of AR e-books in terms of durability within green libraries include several aspects. First, AR e-books are free from physical damage, such as tearing or staining, which commonly occurs with physical books, especially when handled by children [19]. This extends the lifespan of the content and reduces the need for book replacement or repair. Second, AR e-books are unaffected by oxidation, eliminating the need for environmental controls like temperature and humidity necessary to preserve physical books in traditional libraries [20]. Third, AR e-book content can be updated digitally without reprinting, reducing resource waste and production costs [21]. Finally, the electronic devices that access AR e-books can store hundreds to thousands of books in a single unit, making them highly efficient in space and resource usage.

However, there are some challenges related to the durability of electronic devices. Devices such as tablets and smartphones require regular maintenance and battery charging. If the device experiences technical issues, access to AR e-book content may be disrupted. Nevertheless, with proper care, these devices can last for several years [22]. Additionally, AR e-book use requires supporting technological infrastructure, including internet access to download or access content and compatible devices [23]. The initial investment cost for electronic devices is relatively high. However, this can be offset in the long term by reducing the need for physical book replacements and collection maintenance costs.

AR e-books offer superior durability compared to traditional children's storybooks. Due to their digital nature, AR e-books are not prone to physical damage or degradation from environmental factors, resulting in a longer lifespan. Green libraries adopting AR e-books can reduce waste, enhance resource efficiency, and lower book replacement costs. However, challenges related to electronic device maintenance and technological infrastructure must be managed effectively to realize this technology's benefits fully.

C. User Engagement and Learning Experience

Augmented Reality (AR) e-books offer a far more interactive and engaging reading experience than traditional storybooks. AR e-books create a more immersive world for young readers by integrating visual, audio, and textual elements. For example, characters in the book can "come to life" through AR animations, sounds, and other visual effects, which enhance children's engagement with the story [24]. Research indicates that AR e-books can increase children's interest in reading, improve their comprehension of stories, and assist with language learning. AR e-books can hold children's attention longer than traditional paper books, thanks to interactive features like the ability to move or touch elements on the screen, significantly enhancing their engagement with the content [25].

AR technology has enhanced interactive and engaging student learning, particularly in children's literacy. AR e-books offer a more captivating reading experience and support the development of better literacy skills. A study found that children using AR e-books improved their early literacy skills, which are crucial for their academic and future success [25]. Furthermore, AR e-books allow children to interact with the book's content, enriching their learning experience and making reading more enjoyable [26].

While paper books hold sentimental value and offer a unique tactile experience, the engagement provided by AR e-books tends to be higher, especially for younger generations growing up in a digital environment. AR e-books in libraries can expand access to a more diverse range of storybooks tailored to individual reader preferences, including customizable text options, audio narration, and translations in various languages [27]. Thus, AR e-books serve as learning tools and a medium to enhance children's reading experience and overall engagement.

D. Practical Implications for Green Libraries

Adopting Augmented Reality (AR) e-books in green libraries presents various practical implications that align with sustainability goals and environmental preservation. One of the main advantages of using AR e-books is the reduction in operational costs. Libraries that have integrated AR e-books report that they no longer need to allocate funds to maintain and replace damaged paper books, which can often involve significant expenses [28]. Additionally, AR e-books can be accessed by multiple users simultaneously through shared or personal devices, allowing for more efficient use of space and resources [29]. This is particularly important for green libraries, which often have limited space and prioritize eco-friendly design.

AR e-books also offer flexibility in terms of storage and accessibility. Digital collections can be stored in cloud

computing systems, eliminating the need for large physical spaces like traditional bookshelves [30]. As a result, green libraries can optimize available space for more productive and environmentally friendly activities. Research indicates that the transformation of books into digital formats improves storage efficiency and reduces the carbon footprint associated with the production and distribution of printed books [30].

However, the adoption of AR e-books also presents certain challenges. Initial investments in digital devices, staff training, and technological infrastructure must be considered [28]. Nevertheless, these costs are often offset by long-term savings and the sustainability benefits of AR e-books compared to traditional paper book collections [31]. Another challenge lies in users' acceptance of the technology, particularly among older generations, who may feel uncomfortable with new technology [29]. Therefore, libraries must provide adequate training and support to ensure all users can effectively utilize AR e-books.

Overall, despite the challenges associated with adopting AR e-books, their sustainability and operational efficiency benefits make them an attractive option for green libraries. With the right approach, libraries can integrate this technology to support their sustainability goals while enhancing user experience. This makes the story more interesting and captivating, particularly for young readers who tend to enjoy interactive and entertaining visual elements [32].

E. Creation of AR E-books as a Solution

Augmented Reality (AR) e-books provide an innovative solution to address health and environmental concerns associated with using paper books. Key benefits of AR e-books include:

1. **Safety from Harmful Chemicals:** AR e-books eliminate the need for paper, ink, and adhesives that may contain harmful chemicals, making them safer for children, especially those sensitive to such substances.
2. **Reduction of Paper Waste and Deforestation:** Using a digital format, AR e-books help reduce tree cutting and paper waste while lowering the carbon footprint associated with producing and distributing physical books. AR e-books contribute to sustainability by reducing the need for paper, which in turn decreases deforestation and waste generation. By offering digital solutions, AR minimizes the carbon footprint associated with printing and distributing physical books, aligning with broader environmental protection goals [33].
3. **Enhanced Engagement and Reading Experience:** With interactive features like visuals, audio, and animation, AR e-books make reading more engaging, increasing children's interest and improving their

comprehension of stories. The interactive nature of AR e-books—incorporating audio, visuals, and animations enhances engagement and improves comprehension, particularly for young readers. Moreover, AR e-books can be adapted for accessibility, including features like audio narration and adjustable text size, making them suitable for children with special needs [34]

4. Easy Content Updates: AR e-books allow for easy and cost-effective updates without the need for reprinting, reducing waste and expenses.
5. Accessibility and Inclusion: AR e-books can be accessed on various devices, offering customizable features like audio narration and larger text, making them inclusive for all children, including those with special needs.



Figure 2. Storybooks that have implemented AR technology.

Creating children's storybooks integrating Augmented Reality (AR) technology involves a combination of visual narration with animation and interactive digital elements that can be accessed through devices like smartphones or tablets. Users must first install an AR application on their smartphone to activate the AR feature. Once the app is installed, users can scan the images available on each book page. For example, in the storybook "Kupu-kupu Penyelamat," each printed page has AR elements accessed by scanning the images with the smartphone camera. After scanning, the animal characters in the story can be visualized in three-dimensional (3D) form, creating an interactive experience where the characters seem to come to life on the device screen.

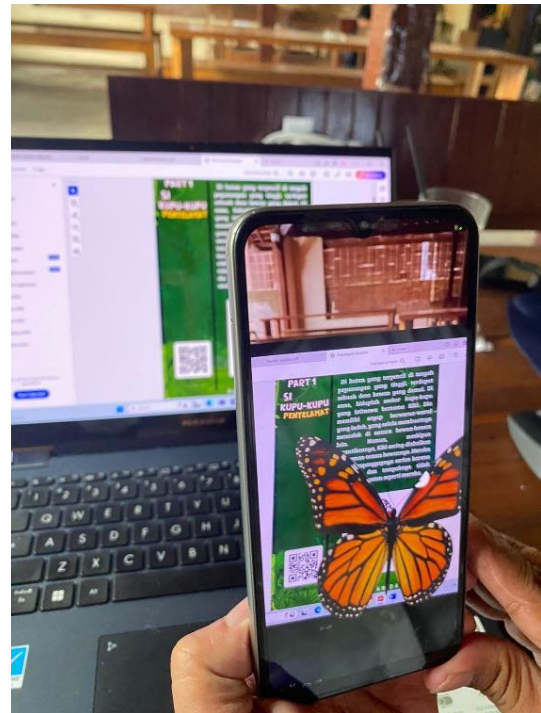


Figure 3. Visualization of a smartphone pointed at the images in the storybook.

Based on the visualizations, AR technology brings characters in the story to life, such as butterflies, owls, and ants, which appear in three-dimensional (3D) form when the images are scanned using a smartphone camera. The resulting images come alive on the device's screen, providing readers with a more dynamic and interactive visual experience. For instance, the butterfly character appears with flying wings, creating an immersive effect. AR technology enhances reader engagement, especially for children, as they read the story and see the animal characters move as if they exist in the real world. This makes the story more interesting and captivating, particularly for young readers who tend to enjoy interactive and entertaining visual elements.

The narrative remains in text form, but adding 3D visuals of characters, such as butterflies, owls, and ants, provides a richer visual context for the story. Readers understand the story through words and see visual representations of the characters involved. The implementation of AR technology in this book serves as entertainment and an educational tool. Storybooks can help children become more familiar with animals, understand their characteristics, and learn important values such as cooperation and bravery through the tale of Kiki the butterfly, which helps save other animals from the danger of a flood.

IV. CONCLUSION

The use of Augmented Reality (AR) e-books has proven to be effective as an environmentally friendly solution in green libraries. AR e-books reduce the negative impacts of printed book production, such as carbon emissions, deforestation, and paper waste, while reducing energy and resource consumption. Regarding health, AR e-books eliminate the risk of exposure to hazardous chemicals in printed book paper, such as formaldehyde and chlorine, making them safer for children. In addition, AR technology increases children's engagement in reading with dynamic visual and audio interactions, creating a more immersive learning experience. AR e-books also have a longer lifespan than printed books because their digital content does not experience physical degradation. By adopting AR technology, green libraries can save space and operational and maintenance costs and support sustainability by reducing resource consumption and carbon emissions. The implementation of AR e-books supports green libraries' sustainability goals and enriches children's educational experience while contributing to environmental conservation and health improvement.

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