

# Optimizing Rattan Waste Processing in Furniture Production with a Green Supply Chain Model Approach

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**Abstract:** This research examines the application of a green supply chain to support the implementation of zero waste in the rattan handicraft industry. In general, the production process of rattan handicrafts uses raw materials with a length of 3 to 5 meters to produce products such as chairs, tables, and baskets. However, there is a significant problem in the form of residual rattan waste measuring 15 to 30 cm that is often discarded by craftsmen, thus triggering waste of raw materials. To overcome this, the concept of green supply chain is applied with the aim of optimally utilizing all available raw materials, including recycling the remaining materials into by-products of economic value, such as key chains, bracelets, and other accessories. A mathematical model is used to formulate an optimization strategy that considers the costs of raw materials, transportation, energy, and waste management. The objective function of the model is to minimize the total cost and maximize the value of the by-products, without applying a closed-loop approach. This research shows that implementing a green supply chain can significantly reduce waste, lower production costs, and improve resource efficiency, without compromising product aesthetics. In addition, the concept supports economic sustainability by utilizing waste as an additional resource, while reducing the environmental impact of the rattan handicraft industry. The implementation of a green supply chain is proven to improve the competitiveness and sustainability of this industry.

**Keywords:** Green Supply Chain, Zero Waste, Waste, Linear Programming, Life Cycle Assessment.

## 1. INTRODUCTION

The rattan handicraft industry is one sector that has great potential for export, especially in countries rich in natural resources like Indonesia. Craft products made from rattan have high aesthetic value and increasing demand in the global market. However, this industry also faces several challenges, one of which is logistics efficiency and waste management. During the production process, rattan waste is often neglected or discarded, even though it has the potential to be processed into value-added products. Additionally, another common issue is the suboptimal utilization of space and weight in cargo, which leads to higher transportation costs and inefficiencies in product distribution. Efficiency in cargo utilization becomes crucial in the context of globalization and increasingly tight competition, where logistics costs can affect product competitiveness in the international market.

In this situation, the concept of cargo maximization through the utilization of rattan waste as additional products emerges as a potential solution. By implementing a green supply chain model, where waste is repurposed as raw materials for new products, the handicraft industry can not only improve resource usage efficiency but also optimize cargo capacity. This will reduce transportation costs per unit of product, enhance operational sustainability, and strengthen the competitive position of handicraft products in the global market.

Cargo maximization aims to utilize every inch of space and every gram of weight available in shipments. By producing additional crafts from rattan waste, the industry can fill empty spaces in cargo containers, which would typically be wasted. This not only reduces the cost per unit of shipment but also allows for more products to be shipped in a single shipment, thereby improving overall logistics efficiency. Reducing empty space and fully utilizing cargo capacity

means fewer shipments are needed for the same volume of products. This directly lowers transportation costs, which is a key component in the selling price of products in the export market. With lower logistics costs, rattan handicraft products can be sold at more competitive prices, or companies can increase their profit margins.

Using waste as raw materials for additional products supports sustainable business practices and a green supply chain. This aligns with global trends increasingly prioritizing environmentally friendly products and socially responsible production processes. Industries that can demonstrate a commitment to sustainability are likely to be favored in international markets, especially in countries with strict environmental regulations. Products made from waste not only add variety to the product portfolio offered by companies but also provide added value. These products can be marketed as part of the company's sustainability initiatives, attracting environmentally conscious consumers. Furthermore, by maximizing cargo, companies can sell more products with relatively the same shipping costs, meaning total export value also increases.

In the context of supply and demand, utilizing waste for additional products allows the industry to be more flexible in adjusting to demand fluctuations. If there is higher demand for certain products, the waste generated from primary production can quickly be transformed into products that meet market demands, without needing to start from scratch. Cargo maximization through the utilization of rattan waste is not just a technical solution for improving logistics efficiency but also a business strategy that can provide a competitive edge in the export industry. By integrating the green supply chain concept, the rattan handicraft industry can reduce costs, enhance sustainability, and add value to the products they offer to international markets. This makes the cargo maximization model relevant and important for adoption by companies that wish to remain competitive in the ever-evolving global market.

## **2. LITERATURE REVIEW**

### **Supply Chain Management**

Supply Chain Management is an approach that is applied to form suppliers, entrepreneurs, warehouses, and storage places in an efficient unit so as to produce products and distribution with the right quality, location, and time to get the minimum cost by satisfying consumer needs [1]. Supply Chain Management is management that is carried out continuously in order to obtain highly competitive business partners without ignoring consumer needs that focus on developing innovative solutions and synchronizing the flow of products, services and information to form unique consumer assessments [2].

Processing activities in the form of obtaining raw materials, transforming these raw materials into goods in process and finished goods, and delivering these goods to consumers through a distribution system with an integrative approach in managing the flow of products, information, and money by involving parties from upstream to downstream consisting of suppliers, factories, distribution networks and logistics services [3][4].

Supply Chain Management has the main components of upstream, internal and downstream. Upstream of the supply chain includes the activities of a manufacturing company with its suppliers (which can be manufacturers, assemblers, or both) and their connections to their suppliers (second-tier suppliers). Supplier relationships can extend to multiple strata, all the way from material origin. In the downstream part of the supply chain, the main activity is procurement. The internal part of the supply chain includes all the in-house processes used in transforming inputs from suppliers into the organization's outputs. It extends from the time inputs enter the organization. Within the internal supply chain, the main concerns are production management, manufacturing, and inventory control. The downstream part of the supply chain includes all activities that involve delivering products to end customers. In the downstream supply chain, more attention is directed to distribution, warehousing, transportation, and after-sales service [5].

## **Green Supply Chain Management**

The implementation of GSCM in the company turns out to have great benefits, especially in improving the environmental and business performance of the company's GSCM aspects by building long-term buyer-supplier relationships. This is supported by collaborative relationships between customers and suppliers can lead to improved environmental performance and better product/service quality. One reason for this improvement is that consumers are now more knowledgeable about business environmental violations. Companies and all their partners in the supply chain will achieve sustainable business if products and services that have a negative impact on the environment are abandoned in favor of environmental principles [6][7][8]. There is a kind of symbiotic mutualism that exists between companies and suppliers if the supply chain also pays attention to environmental aspects.

On the other hand, according to Turnip (2009), the implementation of GSCM in the company will provide the following benefits:

1. GSCM encourages companies to mitigate risks and innovate.
2. The analytical process in GSCM will lead to continuous process innovation which in turn increases the adaptability of the company to changes in its environment.
3. Negotiations with customers and suppliers carried out in GSCM will improve the alignment of strategies and business processes between the company, customers and suppliers.
4. Potential for production cost savings through efficiency in the use of natural resources and energy.
5. The company's reputation as a company that cares about the environment will increase the attractiveness of the company in the eyes of customers.
6. More careful management of the natural resources used by the company will also provide assurance of supply for the company in the future.

## **Components of Green Supply Chain Management**

Green Supply Chain Management (GSCM) is an approach that integrates the principles of environmental sustainability into the entire supply chain, from start to finish. The goal is to minimize environmental impacts at every stage of the supply chain process. GSCM not only focuses on production, but also includes waste management, recycling, and efficient use of resources. The following are the components of the methodology in Green Supply Chain:

### **1. Green Procurement**

Companies should consider the environmental impact of the raw materials they purchase, including using materials that are recyclable, renewable or produced from environmentally friendly processes. This also includes selecting suppliers that implement environmentally friendly practices. This can be implemented by purchasing materials from suppliers that have environmental certifications such as ISO 14001.

### **2. Green Manufacturing**

Reduce the negative impact of production processes on the environment by using clean technology, reducing energy use, minimizing waste, and improving process efficiency by using more energy-efficient production processes.

### **3. Green Distribution**

Reduce the carbon footprint of the distribution process by optimizing delivery routes, arrangement of goods, and form of packaging.

### **4. Green Packaging**

Design environmentally friendly packaging, such as using recyclable materials, reducing the size and weight of packaging, and ensuring that packaging can be recycled or reused.

#### 5. Reverse Logistics

It involves managing products after consumer use for recycling, repair or safe disposal. Reverse logistics plays a role in reducing waste and increasing recycling, as well as maximizing the use of raw materials by creating by-products from leftover furniture materials.

#### 6. Green Transportation

Optimizing energy use during delivery of goods through eco-friendly or fuel-efficient vehicles, and planning optimal delivery routes to reduce greenhouse gas emissions.

#### 7. Waste Management

Involves reducing waste generated from production, distribution and post-consumption processes. The company strives to reduce hazardous waste and manage recycling.

#### 8. Design for Environment (DfE)

Incorporate environmental considerations in the product design stage to minimize negative impacts on the environment. DfE aims to design products that are easier to recycle and have a longer life cycle.

#### 9. Lifecycle Assessment (LCA)

Calculates the environmental impact of a product or process over its entire life cycle, from raw material procurement to final disposal. The goal of LCA is to understand where the greatest environmental impacts occur and take steps to reduce them [9].

### **Zero Waste**

The concept of zero waste comes from a philosophy that seeks to redesign the life cycle of resources, so that all products are reused, recycled, or processed into new materials without anything ending up as waste. Zero waste is an attempt to change the way waste is viewed, not just as something to be disposed of, but as a valuable resource. Zero waste focuses on preventing the creation of waste upstream, different from conventional waste management methods that focus more on downstream management. Zero waste is part of a broader strategy to create a sustainable society that balances environmental and economic needs. There are several key principles in the concept of zero waste including reducing the amount of waste generated in the first place, maximizing the reuse of existing materials and products, as well as facilitating material recycling, designing products and production processes in such a way that they produce the minimum amount of waste possible, and using materials that can be recycled or biodegraded, the application of zero waste also emphasizes the importance of community participation in promoting sustainability practices at the local level [10].

Many sectors have started to implement the zero-waste approach, especially in the manufacturing, construction, and food industries. Many manufacturing companies, especially in the furniture sector, have started to adopt zero waste practices by redesigning products to make them more recyclable and reusing production waste.

Zero waste can reduce a company's operational costs through reduced waste management costs and the purchase of new raw materials. By recycling and reusing materials, companies can reduce dependence on limited resources, which ultimately results in cost efficiency [11].

### 3. METHOD

#### List of Notations

- K : Profit
- M : Manufacturer
- R : Retailer
- X : Quantity of products from manufacturer
- Z : Quantity purchased by retailer
- D : Market demand
- d : Market basic demand
- v : Product volume
- w : Product weight
- V : Container volume limit
- W : Container mass limit
- P : Manufacturer selling price
- C : Production cost
- $P_M$  : Selling price of the product from the manufacturer
- $P_R$  : Selling price of the product from the retailer
- $C_M$  : Production cost of the product from the manufacturer
- $T_M$  : Tax per item shipped
- $F_c$  : Fixed shipping cost
- $C_w$  : Waste processing cost per kilogram
- $\alpha$  : Price elasticity
- $\beta$  : Coefficient of waste product (kilogram/product),  $0 < \beta < 1$
- $\gamma$  : Percentage of waste that can be processed
- y : Recycled waste product purchased by the retailer
- $C_D$  : Production cost of recycled products
- $P_D$  : Selling price of recycled product by manufacturer
- $D_S$  : Secondary demand for recycled product
- $P_S$  : Secondary price of recycled product
- $d_s$  : Basic secondary demand

#### Supply Chain Model Without Waste Processing

Supply chain modeling involves the use of mathematical models and algorithms to analyze and design supply chain systems. These models can be used to optimize various aspects of the supply chain, such as costs, time, and efficiency. The following are some steps and components in supply chain modeling:

$$\begin{aligned}
K_M &= ZP_M - XC_M - \beta XC_W \\
K_R &= DP_R - ZP_M - ZT_M - F_C \\
D &= d - \alpha P_R
\end{aligned}$$

#### Constraints

1.  $X \geq Z \geq D$
2.  $Z \cdot v \leq V$
3.  $Z \cdot w \leq W$
4.  $Z \cdot P_M > XC_M + \beta XC_W$
5.  $(d - \alpha P_R) \cdot P_R > ZP_M + ZT_M + F_C$
6.  $0 < \beta < 1$
7.  $0 < \alpha < \frac{d}{P_R}$

#### Modified Supply Chain Model

$$\begin{aligned}
K_M &= ZP_M + y \cdot P_D - XC_M - \gamma \beta XC_D - (1 - \gamma) \beta C_W \\
K_R &= DP_R + D_S P_S - ZP_M - y P_D - (Z + y) T_M - F_C
\end{aligned}$$

#### Constraints

1.  $X \geq Z \geq D$
2.  $Z \cdot v + y V_S \leq V$
3.  $Z \cdot w + y w_S \leq W$
4.  $Z \cdot P_M > XC_M + \beta XC_W$
5.  $(d - \alpha P_R) \cdot P_R > ZP_M + ZT_M + F_C$
6.  $0 < \beta < 1$
7.  $0 < \alpha < \frac{d}{P_R}$
8.  $\gamma \beta X \geq y \geq D_S$
9.  $0 < \gamma < 1$
10.  $0 < \alpha_S < \frac{d_S}{P_S}$
11.  $P_D > \frac{\gamma \beta X}{\gamma} (C_D - C_W)$
12.  $D_S P_S > y T_M$

## 4. RESULT AND DISCUSSION

The integration of supply chain models and cargo optimization offers an innovative approach to enhance operational efficiency and sustainability in the rattan craft industry. Traditional supply chains, which focus on the flow of goods from raw material sources to end consumers, often face challenges such as high operational costs, suboptimal container capacity, and inefficient waste management. By integrating the principles of green supply chain management, companies can reduce their environmental impact through the utilization of production waste and optimization of shipping capacity.

Table 1 Comparison of Supply Chain Models Before and After Modification for Manufacturers

	Before Waste Processed	After Waste Processed
Product	$X$	$X\gamma\beta X$
Production Cost	$X.C_M$	$X.C_M + \gamma\beta X C_D$
Waste	$\beta X$	$(1 - \gamma)\beta X$
Waste Processing Cost	$\beta X C_W$	$(1 - \gamma)\beta X C_W$
Sales	$Z$	$Z\gamma$
Income	$Z P_M$	$Z P_M + \gamma P_D$

Table 2 Comparison of Supply Chain Models Before and After Modification for Distributors

	Before Waste Processed	After Waste Processed
Purchase	$Z$	$Z\gamma$
Shipping Cost	$Z.T_M + F_C$	$Z.T_M + \gamma T_M + F_C$
Sales	$D$	$DD_S$
Income	$DP_R$	$DP_R + D_S P_S$

Cargo optimization is a crucial component of the green supply chain, with its primary goal being to reduce the number of inefficient shipments by maximizing container capacity usage. This not only lowers transportation costs but also reduces carbon emissions, which is one of the main objectives of the green supply chain. Rattan waste, which typically pose a challenge in traditional supply chains, can be transformed into by-products such as accessories or decorative items, helping to fill empty space in containers and decreasing the need for new raw materials.

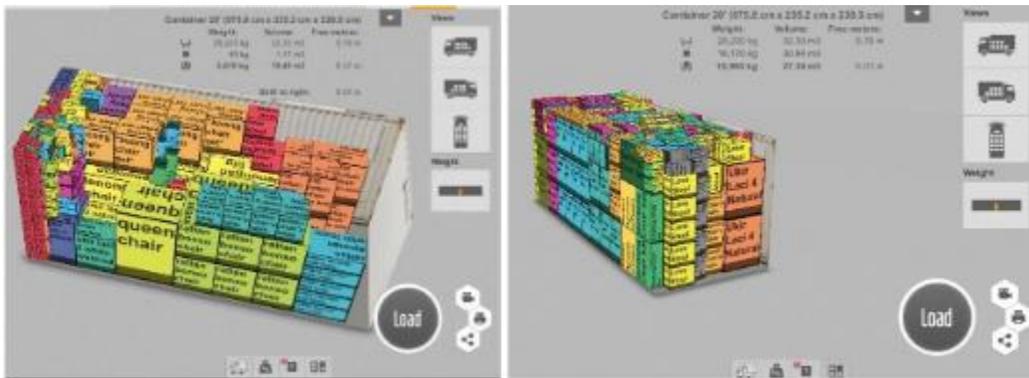


Figure 1 Before and After Cargo Optimization

With this strategy, container usage can be optimized to achieve maximum efficiency in cargo shipping. The mathematical model used to integrate cargo optimization with the green supply chain aims to maximize container utilization while minimizing costs and emissions. In this model, products generated from waste are prioritized to fill empty spaces, allowing companies to reduce waste and enhance shipping efficiency. The impact of this integration is evident not only in terms of reduced operational costs and increased profitability but also in the reduction of the company's carbon footprint, which is becoming increasingly important for meeting global environmental regulations. Furthermore, the adoption of a green supply chain provides a competitive advantage for companies in a global market that increasingly prioritizes sustainability.

Although challenges in implementation, such as operational complexity and the need for eco-friendly raw materials, still exist, the benefits gained from this integration are far more significant. By combining cargo optimization and the green supply chain, companies can not only achieve higher operational efficiency but also play a crucial role in

maintaining environmental sustainability, ultimately enhancing their reputation and competitiveness in the international market.



Figure 2 Export Product of Rattan Craft



Figure 1 Export Product from Rattan Waste

## 5. CONCLUSION

By adding high-density items and reorganizing the arrangement of goods, cargo dimensions can be maximized by reducing empty space and approaching the allowable weight limits of the container. This strategy not only enhances shipping efficiency but also contributes to reducing logistics costs and environmental impact. Thus, a systematic approach to utilizing space and weight will bring significant benefits to the success of the logistics process, maximizing profits for both producers and distributors.

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# Environmental, Social, and Governance (ESG) in Indonesia: Insights from Bibliometric Analysis

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**Abstract:** The implementation of Environmental, Social, and Governance (ESG) criteria is gaining momentum worldwide and in Indonesia. Unlike green financing, which focuses on environmental projects, or climate terminology that often pertains to carbon emissions and climate change mitigation, ESG encompasses a broader spectrum, including social equity and corporate governance issues for a holistic sustainability strategy. This research analyzes the classification, trends, and potential future directions of ESG (Environmental, Social, and Governance) studies in Indonesia. Utilizing the robust and reliable Scopus database, combined with tools such as Publish or Perish, Mendeley, and VOSviewer, this paper examines the keyword “ESG” and “Indonesia” from 2018 to 2024. The findings indicate that research related to this keyword can be categorized into three main clusters: the role of ESG, country-based ESG comparisons, and ESG during the pandemic. Currently, trending topics include the role of ESG, strategy, government policies, and financial performance. However, there is a limited amount of literature on specific topics that present opportunities for future research, such as ESG factors, investment decisions, corporate social responsibility, climate change, and competitive advantage. Additionally, there are research gaps that could be explored further, such as the relationship between ESG activities and investment decisions, or climate change and sustainable development.

**Keywords:** bibliometric analysis, Publish or Perish, VOSviewer, ESG

## 1. INTRODUCTION

Globally, societies are currently confronting similar conditions and an array of challenges. These issues include global warming and climate change, environmental degradation, and increasingly complex social problems. These are some of the negative impacts stemming from development and economic growth. This shared global experience underscores the urgent need for collaborative efforts to mitigate these detrimental effects and foster sustainable development practices. Efforts to advance the economy are implemented through the enhancement of industrial activities and energy utilization, which negatively impact the environment and result in health issues, as evidenced by Turner et al. (1994), Margono et al. (2014), WHO (2016), and Tietenberg and Lewis (2016). Furthermore, economic development also leads to various new social problems within society, highlighted by Stiglitz (2012) and Piketty (2014). This dual consequence underscores the complex interplay between economic progress and sustainable development, necessitating a balanced approach that promotes economic vitality while mitigating environmental degradation and social upheaval. The challenge lies in devising strategies that harmonize industrial growth with ecological preservation and social welfare, ensuring a holistic advancement for future generations. In light of the issues mentioned earlier, various movements and ideas have emerged to address these challenges. One such effort is the adoption of Environmental, Social, and Governance (ESG) principles in corporate activities. This term gained popularity after the UN Global Compact Initiative’s “Who Cares Wins” report introduced the concept. Unlike the “green” concept or terms related to “climate change” that focus mainly on environmental aspects, ESG also highlights social responsibility and good governance. These are essential components of sustainable development, alongside environmental and economic factors (UNDP, 2023) as can be seen on Figure 1.

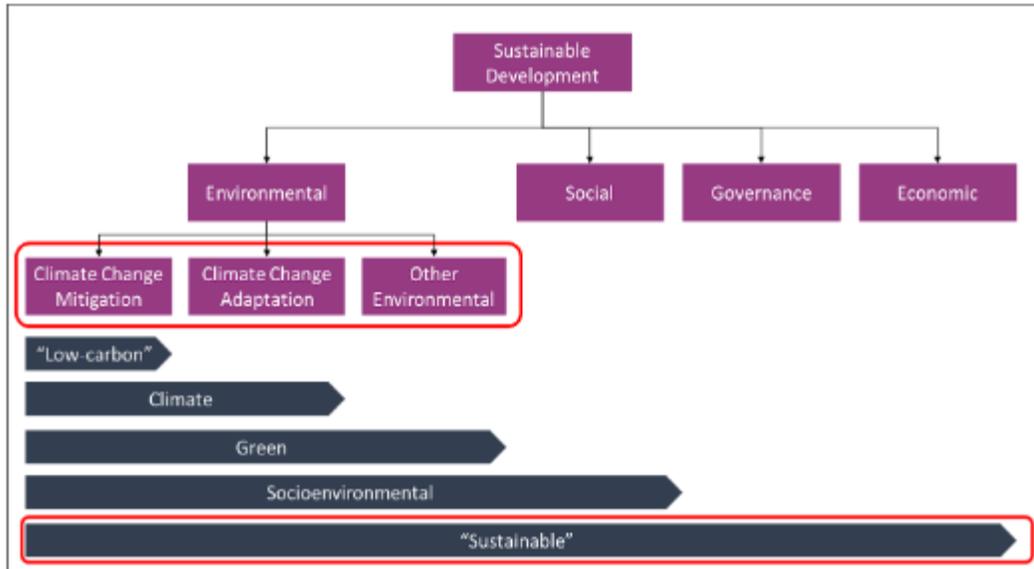


Figure 1. Role of ESG in Sustainable Development

There is now a substantial body of literature addressing the implementation of Environmental, Social, and Governance (ESG) principles from the perspectives of investors, governments, and corporations. Furthermore, discussions on ESG have been extensively conducted both globally and within specific sectors. To effectively analyze the application of ESG, it is imperative to undertake a comprehensive and systematic literature review. One valuable method for this purpose is bibliometric analysis, which assesses the impact and influence of scientific publications based on citation data. This analysis identifies new trends in how articles and journals are performing, understand collaboration patterns and key research contributors, and explore the intellectual framework of a specific field within the existing literature (Donthu, et.al., 2021). Thus, bibliometric analysis can help identify research trends, collaboration patterns, scientific networks, and knowledge gaps. Generally, bibliometric analyses that have been published are more often related to the global implementation of ESG such as Khurshid and Islam (2024) who discuss the ESG literature mapping. However, to the best of our knowledge, there is no literature which discuss bibliometric analysis on ESG application in Indonesia. Therefore, this research fills that gap by conducting a bibliometric analysis of articles related to ESG in Indonesia, with the aim of classifying, identifying trends, and analyzing potential research topics on ESG in Indonesia for the future.

## 2. LITERATURE REVIEW

This research employs the methodology of bibliometric analysis, which is an integral part of a comprehensive literature review. Bibliometric analysis involves examining the relationships between various reported physical units, bibliographic units, and their substitutes (Broadus, 1987). This methodological approach can reveal the accuracy and relevance of aspects related to scientific publications, such as authors, recurring keywords, and citations (Rusly, et al., 2019). By transforming qualitative informative data into quantitative data, bibliometric analysis allows for a detailed assessment of the strength and impact of research studies and their topics (Baraibar-Diez et al., 2020). Bibliometric analysis is particularly useful for analyzing journal articles, books, and other written scientific documents (Heersmink et al., 2010). It provides a systematic way to measure and evaluate the influence of these publications within the scientific community. This method can uncover patterns and trends in research, helping to identify key areas of focus and emerging topics within a specific field.

This bibliometric analysis encompasses two main aspects: performance analysis and science mapping analysis. Performance analysis is based on bibliometric indicators that measure the productivity and impact of individual

researchers, institutions, countries, and journals. It evaluates the number of publications and citations to determine the influence and reach of these entities within the scientific community. This aspect of bibliometric analysis helps to highlight the most prolific and impactful contributors to a particular field of study. Science mapping analysis, on the other hand, represents the topological and chronological arrangement of cognitive and social structures within a specific research discipline (Cobo et al., 2012). This type of analysis provides a visual representation of the relationships and connections between different research topics, authors, and institutions. It helps to identify the intellectual structure of a field, showing how various concepts and ideas are interconnected. Science mapping can also reveal the evolution of research trends over time, highlighting shifts in focus and emerging areas of interest. The objective of bibliometric analysis is to summarize bibliographic data to present the latest developments in the structure of knowledge and research trends on specific topics (Donthu et al., 2021). By providing a comprehensive overview of the existing literature, bibliometric analysis can identify gaps in knowledge and suggest potential directions for future research. This method is invaluable for researchers, policymakers, and practitioners who seek to understand the current state of research in a particular field and to make informed decisions based on this understanding.

### 3. METHOD

Fahimnia et al. (2015) proposed a comprehensive framework for bibliometric analysis, delineating five critical stages:

1. initial search;
2. presentation of initial search results,
3. refinement of search results,
4. presentation of statistical descriptions of the final search results, and
5. data analysis.

This research adheres to these stages meticulously, employing the “Publish or Perish” application in conjunction with the Scopus database. The “Publish or Perish” application is a sophisticated tool designed to retrieve and analyze academic citations. It leverages multiple data sources to gather raw citation data, which it then processes to present a variety of citation metrics, including the number of papers, total citations, and the h-index (Harzing, 2023).

In this study, we utilized data from Scopus, a comprehensive abstract and citation database introduced by Elsevier in 2004 (Baas et al., 2020). Scopus is renowned for its extensive content coverage, encompassing a wide range of disciplines and providing detailed information on authors and their affiliations. Its user-friendly interface, robust impact indicators, and resistance to data manipulation make it an ideal choice for bibliometric analysis (Pranckute, 2021). The selection of Scopus as the primary data source is aligned with the stringent requirements of bibliometric analysis, which demands high-quality information and reliable citation data (Bosi et al., 2022).

The initial search phase involves identifying relevant literature using specific keywords and search criteria. This is followed by the presentation of initial search results, where the retrieved data is organized and displayed for preliminary review. The refinement stage entails narrowing down the search results to exclude irrelevant or redundant entries, ensuring that the final dataset is both comprehensive and focused.

Subsequently, the presentation of statistical descriptions of the final search results provides a quantitative overview of the dataset. This includes metrics such as publication counts, citation frequencies, and the distribution of research outputs across different journals and institutions. Finally, the data analysis phase involves a detailed examination of the refined dataset to uncover patterns, trends, and insights related to the research topic.

By following these stages, this research aims to provide a thorough and systematic bibliometric analysis of ESG-related literature in Indonesia. The insights gained from this analysis will help identify key research trends, collaboration patterns, and knowledge gaps, thereby contributing to the advancement of ESG research in the region.

#### 4. RESULT AND DISCUSSION

When conducting a Scopus search using the “Publish or Perish” application, we utilized the keyword “ESG” and “Indonesia” to identify relevant literature concerning the implementation of ESG principles in Indonesia. In the initial stage, no limitations were applied regarding the year of publication. Consequently, the results encompass all literature related to the implementation of ESG in Indonesia or any relevant studies on ESG in Indonesia, without any time constraints. The initial search yielded 98 papers that met the criteria as listed in Table 1.

Table 1. Result of Initial Search

<i>Type of Document</i>	<i>Number of Document</i>
Journal Articles	63
Book Chapters	6
Conference Papers	24
Review Articles	5

However, it is important to note that the acronym ESG can also refer to other technical terms such as Environmental Safe Guard and Ecological Species Group. Therefore, we excluded any literature where ESG did not pertain to Environmental, Social, and Governance.

In the third stage, after filtering out irrelevant literature, we were left with 83 papers that specifically addressed ESG topics in Indonesia as shown in Table 2.

Table 2. Result of Refinement Search

<i>Type of Document</i>	<i>Number of Document</i>
Journal Articles	56
Book Chapters	5
Conference Papers	18
Review Articles	4

A list of the 10 most cited papers among the 83 relevant documents on ESG in Indonesia as shown on Table 3.

Table 3. List of the 10 Most Cited Papers

<i>Authors</i>	<i>Title</i>	<i>Years of Publication</i>	<i>Cites</i>
Qoyum, A., Sakti, M.R.P., Thaker, H.M.T., & AlHashfi, R.U.	Does the islamic label indicate good environmental, social, and governance (ESG) performance? Evidence from sharia-compliant firms in Indonesia and Malaysia	2022	41
Chairani, C. & Siregar, S.V.	The effect of enterprise risk management on financial performance and firm value: the role of environmental, social and governance performance	2021	30
Gunawan, J., Permatasari, P., Sharma, U.	Exploring sustainability and green banking disclosures: a study of banking sector	2022	29
Singhanian, M., Saini, N.	Quantification of ESG Regulations: A Cross-Country Benchmarking Analysis	2022	28
Khalil, M.A., Khalil, R., Khalil, M.K.	Environmental, social and governance (ESG) - augmented investments in innovation and firms' value: a fixed-effects panel regression of Asian economies	2024	26
Harymawan, I., Nasih, M., Agustia, D., Putra, F.K.G., Djajadikerta, H.G.	Investment efficiency and environmental, social, and governance reporting: Perspective from corporate integration management	2022	25
Harymawan, I., Putra, F.K.G., Fianto, B.A., Wan Ismail, W.A.	Financially distressed firms: Environmental, social, and governance reporting in indonesia	2021	25
Adeneye, Y.B., Kammoun, I., Ab Wahab, S.N.A.	Capital structure and speed of adjustment: the impact of environmental, social and governance (ESG) performance	2023	20
Fuadah, L.L., Mukhtaruddin, M., Andriana, I., Arisman, A.	The Ownership Structure, and the Environmental, Social, and Governance (ESG) Disclosure, Firm Value and Firm Performance: The Audit Committee as Moderating Variable	2022	17
Qoyum, A., Al Hashfi, R.U., Zusryn, A.S., Kusuma, H., Qizam, I.	Does an Islamic-SRI portfolio really matter? Empirical application of valuation models in Indonesia	2021	17

The next step involves presenting the statistical data from the final selection. The final search results using the keywords “ESG” and “Indonesia” with the Publish or Perish application from the Scopus database for publications from 2018 to 2024 yielded a total of 83 articles, as shown in Figure 2. From this figure, we can also observe that research on ESG is becoming increasingly popular, as evidenced by the significant rise in the number of papers on the topic.

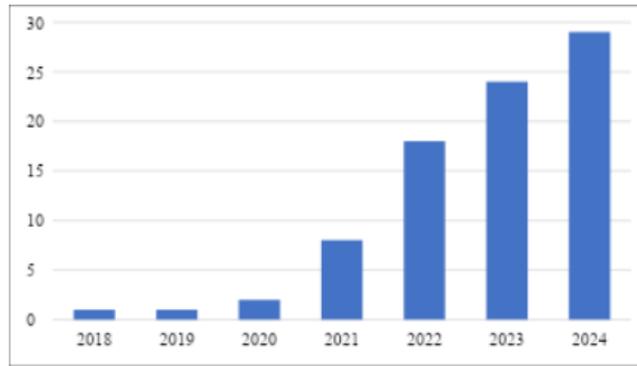


Figure 2. Number of Publication per Year

The subsequent analysis employs the VOSviewer application, a sophisticated tool for classifying scientific publications and analyzing clustering results (van Eck & Waltman, 2017). The initial step involves extracting data from the titles and abstracts of 83 articles using VOSviewer. During the data extraction process, a minimum occurrence threshold of 5 was set, meaning that a word must be mentioned in at least 5 articles to be considered. Out of the 2235 terms identified in the titles and abstracts of 83 papers, 71 terms met this threshold. From these 71 terms, only the top 60% of the most relevant terms were selected, resulting in 43 terms being deemed relevant for the bibliometric analysis of ESG.

The bibliometric analysis conducted with VOSviewer generates three types of visualizations: network visualization, overlay visualization, and density visualization. The primary objective of this research, which is to analyze the classification of studies on ESG in Indonesia, is illustrated through the network visualization results. Figure 3 presents the network visualization mapping. Interrelated keywords are depicted in three distinct colors, each representing a different cluster. VOSviewer automatically maps the visualization of 83 research articles into three clusters or classifications.

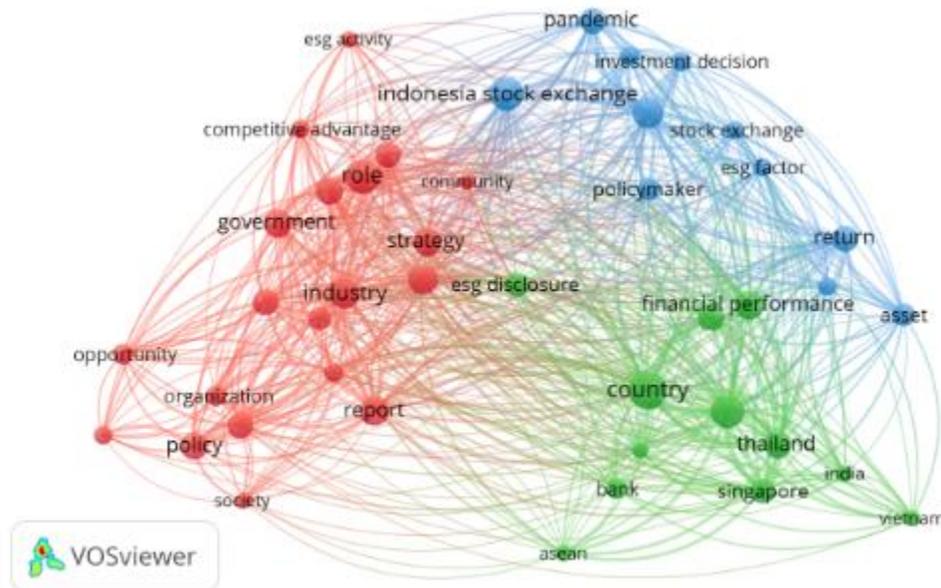


Figure 3. Result of Network Visualization Analysis

Twenty keywords form the first cluster (red): business, climate change, community, competitive advantage, corporate social responsibility, development, ESG activity, firm value, framework, government, industry, management, opportunity, organization, policy, report, role, society, strategy, and sustainability report. The keyword “role” has the highest occurrence in this cluster, appearing 22 times. This indicates that the topic “role” is the most researched within the red cluster. Research on ESG in this cluster is heavily related to the role of ESG in various contexts, such as its impact on business practices, community engagement, and corporate strategies. The frequent occurrence of “role” suggests a significant focus on understanding how ESG principles are integrated and operationalized within organizations.

In the second cluster (green), there are 12 keywords: ASEAN, bank, country, ESG disclosure, ESG score, financial performance, India, Malaysia, Singapore, sustainability development, Thailand, and Vietnam. The keyword with the highest occurrence is “country,” appearing 25 times. This cluster highlights the comparative studies of ESG implementation across different countries, particularly within the ASEAN region. The focus on “country” indicates a strong interest in examining how different national contexts influence ESG practices and outcomes. Research in this cluster often explores the variations in ESG disclosure, scoring, and financial performance among countries like India, Malaysia, Singapore, Thailand, and Vietnam, providing valuable insights into regional differences and best practices. In the third cluster (blue), 11 keywords appear: asset, COVID, ESG factor, ESG practice, Indonesia Stock Exchange, investment decision, pandemic, policymaker, return, stock exchange, and sustainability performance. The keywords with the highest frequency are “pandemic” and “COVID,” with a total frequency of 30 times. This cluster is particularly relevant in the context of the recent global health crisis. The high occurrence of “pandemic” and “COVID” reflects the increased attention to how ESG factors and practices have been impacted by and responded to the pandemic. Research in this cluster examines the role of ESG in mitigating the effects of the pandemic on financial markets, investment decisions, and corporate sustainability performance. It also explores the responses of policymakers and the implications for the Indonesia Stock Exchange and other stock exchanges.

In the network visualization, the thickness of the lines indicates the intensity of the relationship between keywords. Thicker lines mean that the keywords appear together more frequently in the same research. For example, “role” and “government” are connected by a thick line, indicating that these two topics are often used together in research. This suggests a strong linkage between the role of ESG and government policies, highlighting the importance of regulatory frameworks in shaping ESG practices. Next, in the second part of the study aimed at identifying research trends related to ESG, the researchers conducted an overlay visualization analysis, as shown in Figure 4. This figure shows that the keywords in yellow (brighter) are more popular in recent research. Based on Figure 4, the most popular current topics are related to the pandemic and COVID. This trend underscores the growing interest in understanding the intersection of ESG and global health crises, and how companies and governments are adapting their ESG strategies in response to such unprecedented challenges.

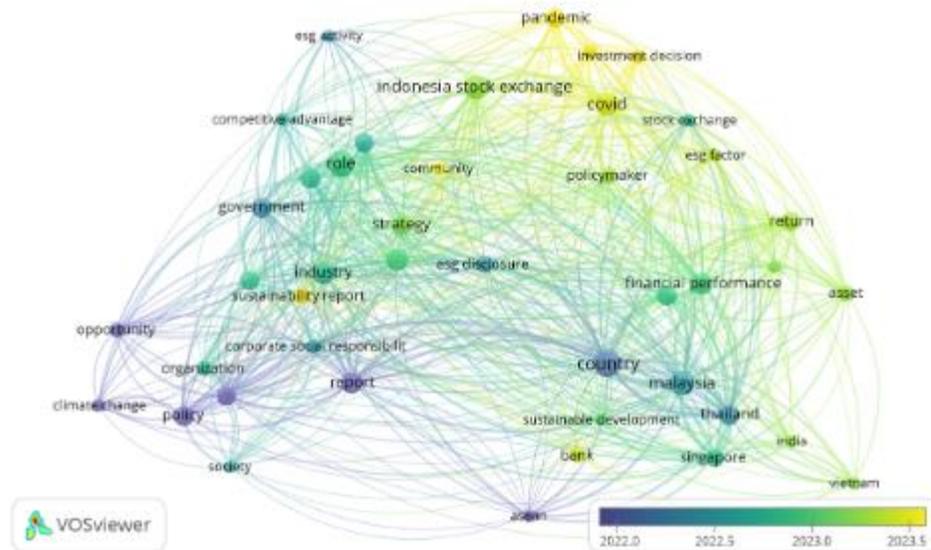


Figure 4. Result of Overlay Visualization Analysis

The third research objective, as depicted in Figure 5, illustrates the results of a density visualization analysis aimed at identifying both popular and less-researched topics within the field. The visualization uses the size and brightness of keywords to indicate their popularity among researchers.

Large and bright keyword visualizations signify that a topic is widely studied and holds significant interest in the research community. For instance, the keyword 'role' stands out with the largest and brightest visualization, indicating its prominence. Other keywords that also appear quite large and bright include "financial performance," "strategy," "industry," and "country." These topics have been extensively explored and are well-established in the literature, reflecting their importance and the substantial amount of research dedicated to them.

On the other hand, small and dim keyword visualizations suggest that a topic has garnered less attention from researchers. For example, keywords like "climate change," "ESG factor," and "asset" are depicted with the smallest and dimmest visualizations. This indicates that these topics are not as widely studied and may represent emerging areas of interest or gaps in the current research landscape. Despite their current lower visibility, these topics hold significant potential for future research and development. Researchers might find valuable opportunities in exploring these less conventional choices, contributing to the advancement of knowledge in these areas.

In summary, the density visualization analysis provides a clear picture of the research landscape, highlighting both widely used and underexplored topics. This can guide researchers in identifying areas that are ripe for further investigation and those that are already well-covered, helping to balance the research efforts across different topics.



opportunities associated with ESG in small and medium enterprises (SMEs), which are often overlooked. Recognizing the potential benefits of extending ESG practices to SMEs could lead to more comprehensive and inclusive sustainability efforts. Therefore, it is imperative that future research explores ESG implementation in SMEs to fully understand its impact and to develop tailored strategies that support these smaller businesses in their sustainability journeys. These under-researched areas present valuable opportunities for future studies to contribute to the growing body of knowledge on ESG.

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# Development Monitoring Laundry Management System Based on Ios Core Data

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**Abstract:** Laundry is an alternative service that can help people wash their clothes. Nowadays, there are a lot of laundry users, from teenagers to adults. It's no wonder that we often carry out and encounter this business because it is indeed a great business opportunity and can be developed. Even so, there are still problems that often occur in using laundry services. These problems include laundry service users who forget their own laundry clothes, clothes that are lost or lacking during washing, and forget to take laundry clothes. Therefore, the writing team discusses how the Apparel Management Application for Laundry Users Using iOS-Based Core Data can help solve many people's laundry problems. Based on our survey with questions, most users are onboarding in the DiLaundry application. With the results obtained, 96.8% of respondents answered yes, 1 respondent (3.2%) answered no, and all the respondents agreed 100% that they could properly manage and check their laundry clothes through the DiLaundry application. Based on our research, we wish this monitoring laundry application could continue with more utility and facility in serving the laundry client.

**Keywords:** laundry, mobile application, management, Core Data, iOS

## 1. INTRODUCTION

People these days also have lifestyle changes in terms of clothing due to the influence of the internet and social media. The number of clothes has become an important part of life today. The emergence of new trends that continue to be the thing that makes human dressing styles also change. For example, from usually only wearing 1 t-shirt, now the t-shirt is layered again with other clothes, which means that the clothes worn by a person are getting more and more. So, the clothes owned by humans today are quite a lot. Clothes must also be washed regularly, while most people today want everything to be practical. That is why this causes problems for many people. From the two things above, namely a lot of activities and clothing matters, many people today use the help of laundry to overcome it. Laundry is an alternative that can be used easily and has the opportunity to be developed. Laundry is a practical and fast laundry service that only takes about 1-3 days. All groups are currently using this service, from students to parents. This service is also still very profitable, so this service is easily found everywhere. The high public interest in using laundry services is partly due to the large number of people who currently live in rental or boarding houses.

However, there are some shortcomings that laundry currently has. The current laundry system, which is still manual, makes some people difficult and less helpful. Difficulties are experienced, such as a manual counting system for clothes, so it is possible that there are incidents of missing or lack of clothes. Then the management system is long, and sometimes people forget the estimated time or time to pick up the clothes that have been completed. Therefore, the solution that can be done must provide more convenience for laundry users. The solution that will be done is to create an application that is able to record the clothes to be laundered, based on the type of clothing. After that, the application is also able to provide reminder notifications for users to notify laundry pickup schedules. This notification works after the user enters the pickup date according to the information from the laundry place. With the appearance

of this application, problems regarding laundry that may occur will be minimized, and then users will become more helpful and feel confident when going to use laundry services anywhere.

## 2. LITERATURE REVIEW

Laundry has a definition, namely the process of cleaning an object by removing unwanted particles or impurities from the object so that the original state of the difference is obtained [1]. To help solve laundry-related problems in today's society, a practical and appropriate solution is needed. One of them is through mobile applications. Mobile application is software that can only be obtained and run on mobile devices [2]. Why use a mobile application? Because many people today like mobile applications because they are cheap, flexible, and portable. In that case, the laundry application that will be created is iOS-based. In making applications, of course, we use programming languages. A programming language is a language that is a tool for programmers to use in the process of making software [3]. The programming language used in this application is Swift programming language. Swift Programming Language is a hybrid programming language that has a functional object orientation. Swift is a fast and secure programming language. Swift is currently used to develop apps and systems for iOS, watchOS, and tvOS [4]. Furthermore, Xcode, which is software and part of Apple's development tools, helps in coding [5]. The application will be core data-based, as core data serves as the framework used to manage the model layer objects in the application [6].

In creating this application, the design pattern used is MVVM (Model-View-ViewModel). This MVVM concept is a design pattern with 3 layers, which involves a new concept of ViewModel and is a companion object for ViewController on iOS [7]. To call and facilitate communication with other applications, an API is needed in the application [8]. After that, the Rest API is needed, which is a protocol that utilizes HTTP (Hypertext Transfer Protocol) [9]. If the API is to communicate with other applications, then the Rest API is the architectural design of the API. This API was built and documented using software called Postman. [10]. For the framework, Laravel Middleware is used. Laravel is a PHP website-based backend and has an MVC (Model-View-Controller) pattern [11]. Some of the advantages of using the Laravel framework are the lightweight template, support for MVC, many object-oriented libraries, artisan tools available, and individual and independent modules [12]. The process of modeling and implementing the system in the application will be done through UML (Unified Modeling Language). UML aims to make developers have a reference, and users also have a reference for how to use the application. [13]. After the model of the system has been formed, it is also necessary to model the form of the application itself. Therefore, a prototype is needed. A prototype is a product model that already includes some of the main features of the product before proceeding to the final phase [14].

After the application is ready to be given to the user, testing will be carried out. Testing is done in several ways, one of which is the black box testing method. This method is done by testing a person or group of people who do not know anything about the system of the application and how the application works [15].

Here are some of the features loaded in this app:

- Users can have data on their clothes that are being laundered.
- Users can view and know the laundry time in progress.
- Users can get an automatic reminder if the laundry process has been completed.
- Laundry users become more helpful to check laundry clothes.

### 3. METHOD

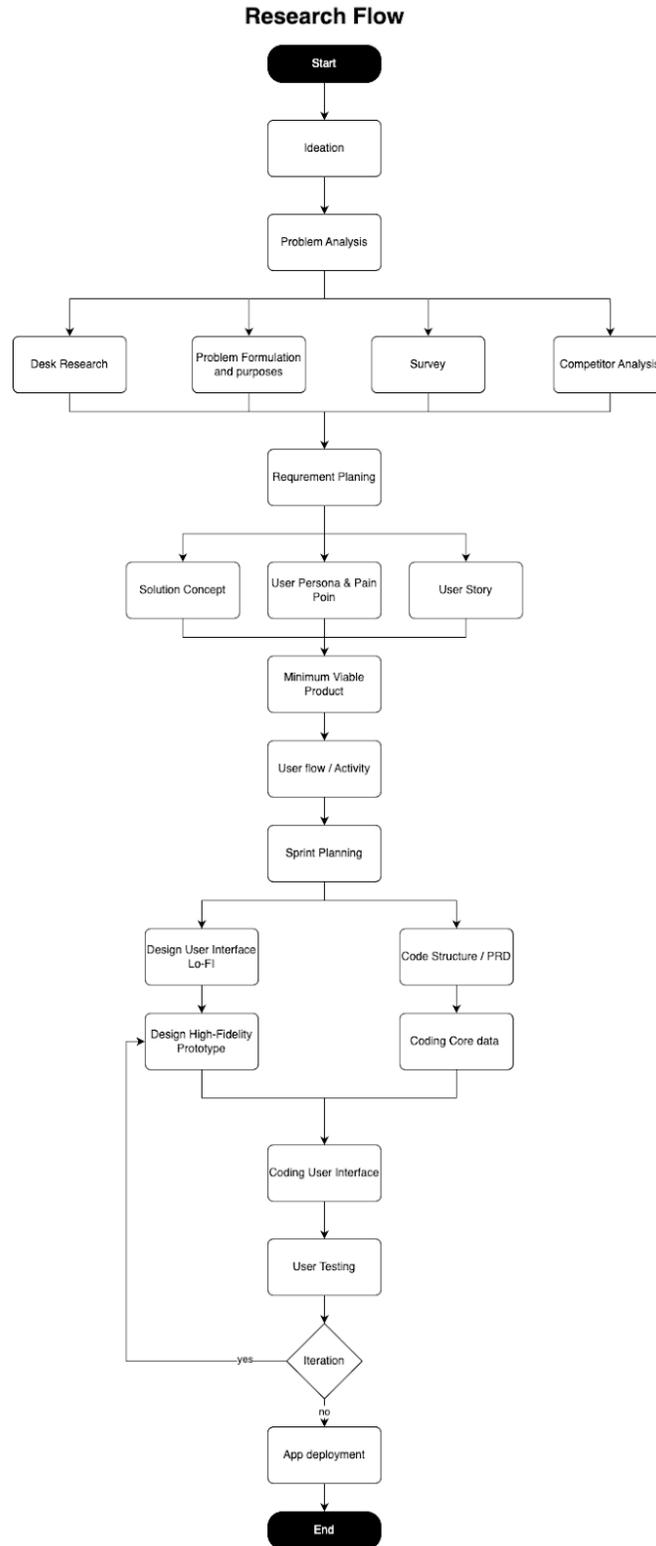


Figure 1. Application Development Process

The author sets the name for the application to be made with the name DiLaundry. There are several stages of the research method carried out by the author in making this DiLaundry application. First, the author develops the idea of what application will be made. The application that the author thinks of is one that does not currently exist but is needed by the community. The author has several ideas at this early stage. Finally, the author chose to make this laundry application. This is because there are not many laundry applications that exist and are known by the public. Then, the author analyzes the problems of the laundry-related community. Several problems were found that could be overcome by the author through the application to be developed. In the next stage, the author conducts searches related to books, journals, and information from various sources that contain laundry, goods, and data management systems, as well as about the application base that will be made, namely iOS. Next, the author formulates the problem and purpose of this application. The author then conducts a survey of the community, ranging from teenagers to adults. This is useful so that the targets and objectives of this application can and are appropriate. After the survey data is collected, the author also collects data from surveys of applications that are similar to what the author wants to develop. The author found several applications that refer to laundry purposes. From all these data, the author can finally formulate the needs of the community to be included in the application. In the next stage, the author compiles a series of good solutions so that later they can be used by the community. Therefore, the author must create user personas, pain points, and user stories. Next, the author creates an MVP (minimum viable product) to get appropriate results by reducing things that can mess up the final result of the application. After that, the author creates an activity diagram related to the process of working the application. Followed by sprint planning to discuss the next work steps. The next series of work is to create a Lo-FI User Interface Design, which is then followed by a High Fidelity Prototype Design. At the same time, the author also created a code structure/PPRD and created the core data. After that, the author did the coding for the application interface. Because this application is for the community later, the next step is testing with the user. This testing aims to examine how the user experiences the interface and the workings of the application. If there are shortcomings, then iteration of prototyping is carried out. The author must ensure that this application is working properly. And finally, the author can deploy the application that has been developed.

#### **4. RESULT AND DISCUSSION**

In designing DiLaundry, it really requires needs analysis which is very supportive in the design and development of this application.

##### **A. Requirement definition**

The following are the supporting needs in the development of this application:

- 1) Create a system that can record the amount by categorizing the user's clothes when they want to do laundry.
- 2) Help laundry users to record how long the laundry process takes from the estimate given by the service provider.
- 3) Provide reminders in the form of notifications for picking up laundry clothes for users after the laundry process is complete.
- 4) Creating a useful system so that laundry users can confirm the clothes they receive.

##### **B. Software and Design System**

After all the requirements are carried out by users, start by designing the system using use cases and UML.

###### **1) System Design**

At the beginning, we planned by making a Use Case Diagram which can be seen in figure 2.

- Use Case Diagram

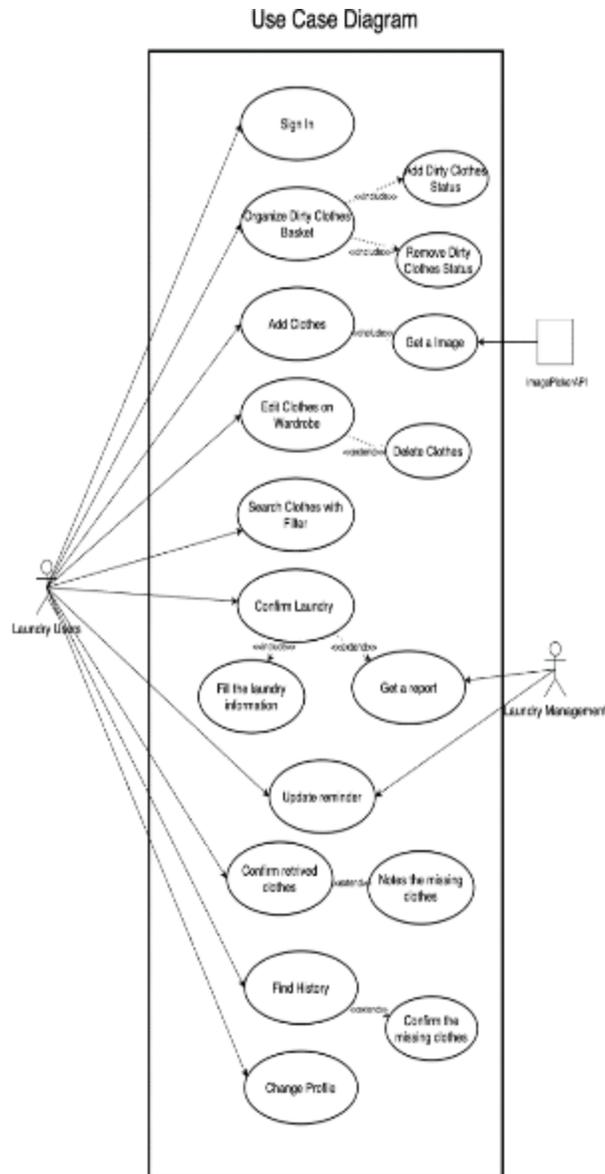


Figure 2. Use Case Diagram DiLaundry

Figure 2 explains the use case diagram of DiLaundry. In this use case, there are 3 actors: laundry users, laundry management, and the image picker API. The use case diagram explains activities that can be carried out by actors in using the application.

- Activity Diagram

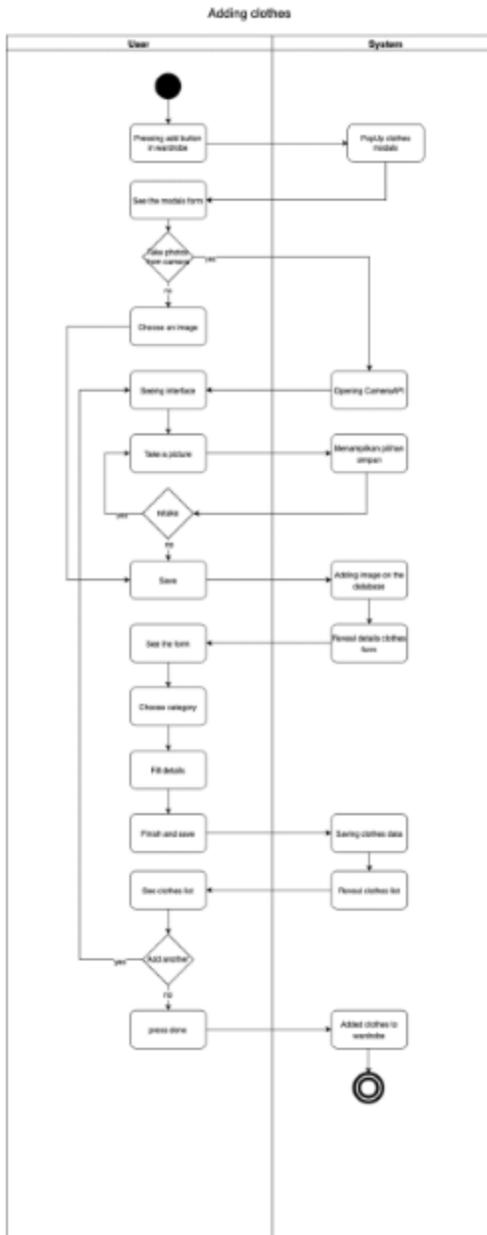


Figure 3. Activity Diagram

In figure 3 describes the activity diagram for adding clothes features within our DiLaundry application. From this figures there will be interaction between the users and system.

- Class Diagram

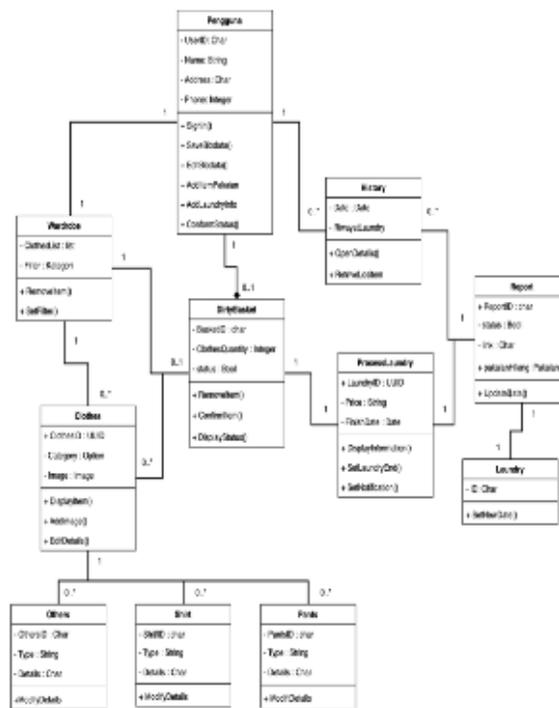


Figure 4. Class Diagram

In figure 4 describes the class diagrams that have been created for the DiLaundry application.

## 2) User Interface Design

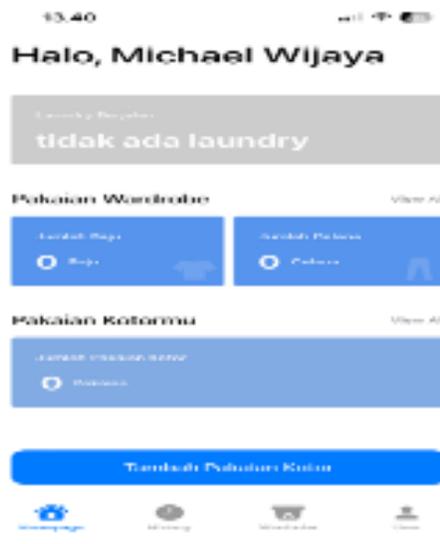


Figure 5. User Interface of Home Page

In figure 5 is a view of the home page of the DiLaundry app. In this application inform some menu to support the system.

### C. Application Development

After completing the application development design with diagrams and prototypes, we started to create projects according to their needs, including the main thing is to creating Core Data as an essential backend in our application so that it can accommodate data and make your application work.

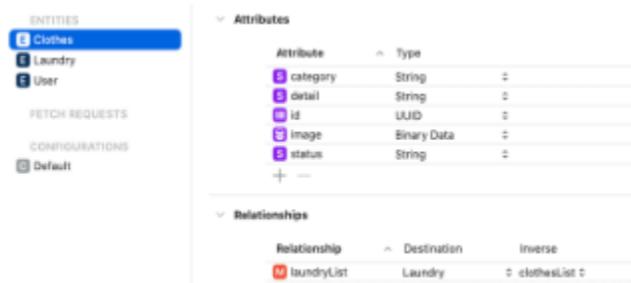


Figure 6. Core Data Laundry

In the figure above is a Core Data figure that is accommodated based on the entities that have been designed in the Entity Relation Diagram, including users, clothes, and laundry. Each entity has its own attributes and is related to recording the data involved. This core data creation only adds entities to the core data model, then adds their functions to each model.

```
import CoreData
class ClothesModel{
    private var context: NSManagedObjectContext
    init() {
        self.context = PersistenceController.shared.container.viewContext
    }
    init(context: NSManagedObjectContext) {
        self.context = context
    }
}
```

The source code of the SwiftUI Model is a coded part of the Clothes Model. Core Data can transform entities as a data model; you no longer need to create structs to insert data. Therefore, we must import Core Data at the top of the file. Use this import on every file that will deal with core data. Core Data runs in the background task so it doesn't interfere with the main thread. Make this context variable a global variable so you don't have to create this variable repeatedly.

```
func saveClothes(image: Data, category: String, status: String = "clean") -> Bool {
    let clothes = Clothes(context: context)
    clothes.id = UUID()
    clothes.image = image
    clothes.category = category
    clothes.status = status
    clothes.detail = ""
}
```

Then, we will create a function to save the core data. The creation of this method is optional, but since we will use it repeatedly Without using this method, the existing data model will be a regular structure. The data contained in it will not be saved into Core Data.

```
import SwiftUI
struct ImagePicker: UIViewControllerRepresentable {
    @Binding var image: UIImage?
    @Binding var isShown: Bool
    var sourceType: UIImagePickerController.SourceType = .photoLibrary

```

Then in the next source code is correlated with API. The use of the ImagePicker API is embedded in our application for image capture needs in the clothing addition feature. This function in it will call the camera to take a picture.

D. Testing

After developing the DiLaundry application, testing is carried out to confirm whether the application created is suitable in terms of system and functionality. Testing was carried out using the Black Box Testing method. In this test, all functions contained in the DiLaundry application were tested to ensure whether the functions, flows, and appearance of the application were running as needed. The DiLaundry application was tested with a total of 22 test cases. The results of the tests are that 22 test cases were declared passed.

E. Questionnaires

To get evaluation data from users of the DiLaundry application, questionnaires are needed for that. The questionnaires are meant to find out whether users are interested or not in the DiLaundry application. Then, get information about things that are lacking from the DiLaundry application. The following are some of the questions contained in the DiLaundry application questionnaires:

- 1) Did you see the On Boarding screen when you first opened the DiLaundry application?

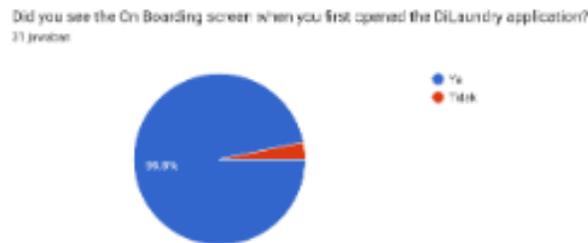


Figure 7 User see the boarding room

In Figure 7, the conclusion of the question is that of the 31 respondents, most saw OnBoarding in the DiLaundry application. With the results obtained, 30 respondents (96.8%) answered yes, and 1 respondent (3.2%) answered no.

- 2) Can you add your dirty clothes in the DiLaundry application?

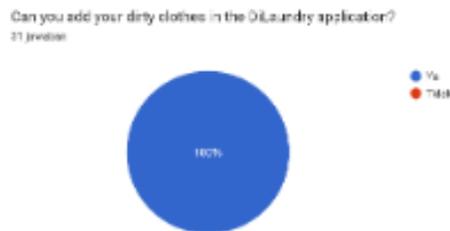


Figure 8 User can add their dirty clothes

In figure 8, the conclusion of this question is that of the 31 respondents, all respondents 100% agreed that the DiLaundry application could add their dirty clothes.

3) Can you manage and check your laundry clothes properly through the DiLaundry application?

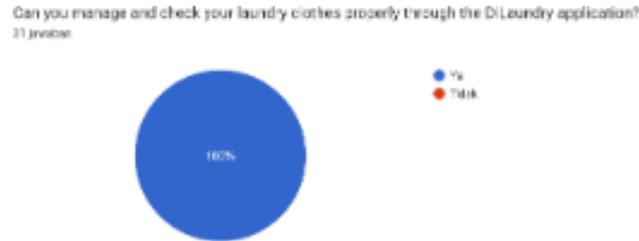


Figure 9. User can manage and check their laundry

In figure 9, inform the conclusion of the questionnaire question that all the respondents agreed that they could properly manage and check their laundry clothes through the DiLaundry application.

4) Can you send a report on your laundry clothes to the laundry manager in the DiLaundry application?

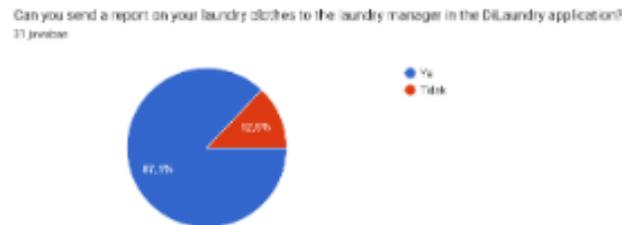
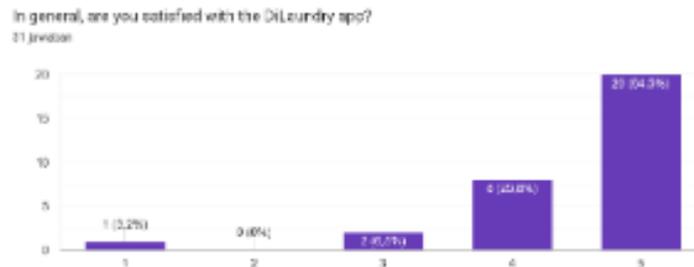


Figure 10. User can send a report their laundry

In figure 10, the conclusion of the questionnaire question is that, from 31 respondents, most of the respondents were able to send their laundry report to the laundry manager. With the results obtained, 27 respondents (87.1%) answered yes, and 4 respondents (12.9%) answered no.

5) In general, are you satisfied with the DiLaundry app?



In figure 11, inform the conclusion that of the 31 respondents, most agreed that they were satisfied with the DiLaundry application. With the acquisition of results, 20 respondents (64.5%) gave a value of 5, 8 respondents (25.8%) gave a value of 4, 2 respondents (6.5%) gave a value of 3, 1 respondent (3.2%) gave a value of 1.

## 5. CONCLUSION

- 1) Based on the DiLaundry application that has been developed using the Swift programming language with the main database using core data, the survey results from user evaluations that have been carried out show that most users feel helped by the features presented in the DiLaundry application. Then it can be concluded that the flow of using the DiLaundry application is easy to understand and makes it easier for most respondents to manage their dirty clothes. Not only that, the laundry manager also feels helped by the link report, which is presented by the DiLaundry application to see a summary of the clothes of their laundry service users while at the same time being able to change the date of collection of the laundry.
- 2) DiLaundry application development is built from database management system theory, which is in line with changeable and flexible management theory. Users will find it easier to categorize clothes, organize their dirty clothes, set reminders for picking up laundry clothes, and be assisted in checking laundry collection to minimize errors/lost clothes in the return process. Of course, these features are presented to help laundry users and managers so that the laundry process can run smoothly.
- 3) From a comparison of other similar applications related to laundry, there is no application that has functions like the DiLaundry application. This is what makes the DiLaundry application a new invention that can solve the main problems of laundry users.

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# Integrating Sustainability in Active Street Frontage: Strategic Planning for Ubud's Tourism Development

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**Abstract:** Active Street Frontage (ASF) in Ubud, Bali, poses a critical role and challenge due to the tourism destination development. ASF strongly linked with environmental conservation, social-culture, and economic activity. This paper explores strategic planning for integrating sustainability into ASF to support high-quality tourism destination in Ubud. Utilizing a case study approach, the research focuses on examining basic formulation and identifying strategic measures to ensure the quality of Ubud street frontage. This research found the importance of integrating sustainability aspects within ASF to create a socially-dynamic, attractive, vital, and ecological-friendly destination. Very important to maintain the quality of the place (aesthetic form, meaning, and activity) along with environmentally friendly, social stability, and economic vitality in Ubud. The findings indicate that a holistic, community-based approach significantly enhances collaboration in ASF development, ensuring alignment with local cultural values and environmental preservation. The study emphasizes the pivotal role of local eco-friendly materials, such as bamboo and natural stone and the importance of green space that also create uniqueness identity of ASF Ubud. These local materials not only reduce environmental impact but also foster a sense of pride and connection to our cultural heritage. Recommendations are provided for stakeholders to foster sustainable urban planning and incentives for fostering the sustainable ASF.

**Keywords:** Active Street Frontage, eco-friendly, sustainability, strategic-planning, tourism, Ubud, Bali

## 1. INTRODUCTION

The Ubud area, Bali, is one of the leading tourist destinations offering a unique combination of local culture and international tourism (Bappeda, 2021; Krista, 2023). As tourism grows, the need to preserve the environment is increasingly urgent. Active Street Frontage (ASF) has essential contribution in creating attractive and environmentally friendly public and shared spaces (J. Jacobs, 1992). Still, the development of an ASF that does not pay attention to sustainability principles can disrupt the environmental, economic and social balance. Therefore, the sustainable oriented planning of ASF is not just important, but urgent in planning the Ubud tourism area. This article aims to identify planning strategies that can integrate sustainability aspects into ASF design in the Ubud area.

Ubud, located in the middle of the island of Bali in Gianyar regency, has long been known as a tourist destination that combines the richness of local culture with natural beauty. Ubud become Bali's first international tourist destination because its well-known beauty of landscape, art, and ritual (MacRae, 1997). According to the Bali Provincial Tourism Office (BPS Provinsi Bali, 2022), Ubud attracts more than 15% of foreign tourists visiting Bali, making it one of the most significant tourist areas on the island. Tourism in Ubud is booming, but this growth also presents new challenges related to environmental impacts, land use, and pressure on local infrastructure. In other side, Ubud's highest attractor for tourist are physical and cultural motivation (Putri & Abdillah, 2019; Sari & Zuraida, 2019). Integrating



Based on the background and urgency described, this study focuses on formulating the following problems: How can the concept of sustainability be integrated into the planning of ASF in the Ubud tourism area? What are the critical challenges in implementing strategic planning for sustainable ASF in Ubud? How can sustainable ASF development support sustainable tourism in Ubud?

This study aims to:

- 1) Identify sustainable design elements that can be integrated into the development of ASF in Ubud.
- 2) Analyze the challenges and opportunities in strategic planning that support sustainability in ASF in Ubud.
- 3) Provide strategic recommendations for stakeholders in the sustainable development of ASF as part of efforts to support sustainable tourism.

This paper strength provides a basic approach needed to integrating sustainability in ASF design and planning, particularly in the context of Ubud, Bali, which is a significant contribution due to the region's unique cultural and environmental characteristics. The study effectively utilizes a case study approach, which allows for a detailed examination of the interaction between strategic planning and public space design. Furthermore, the paper emphasizes the use of local and eco-friendly materials, which not only supports environmental sustainability but also aligns with the local cultural values of Bali. The research provides actionable recommendations for stakeholders, making it highly practical and relevant for architects, urban planners and policymakers.

While many studies have explored sustainable tourism planning in Bali, there is still a gap in the literature regarding the specific application of sustainability in ASF planning in Ubud. Some research examines ASF as a livable shared space that encourage walkability and sustainability in order developing vibrant place along main roads in urban areas (Ewing et al., 2015; McAllister, 2021; Simpson et al., 2019; Zordan et al., 2019). Still, no study has focused on tourist areas such as Ubud, which have very different cultural and environmental characteristics.

This paper contributes significantly to sustainable urban planning and vibrant street by providing a novel approach to integrating sustainability within ASF in a culturally rich context like Ubud. The study fills a gap in the literature by addressing the specific application of sustainability principles in ASF, particularly in tourism-driven economies. Doing so offers valuable insights that can be applied to other regions facing similar challenges. This research offering an approach that focuses on the local context, primarily cultural and ecological influences, in the integrating sustainability principles on ASF in the Ubud tourism area.

## **2. LITERATURE REVIEW**

### **Active Street Frontage as an Important Component of Livable and Sustainable Development**

Active Street Frontage (ASF) theory was first introduced by (Gehl, 2011) in his book *Life Between Buildings*. Gehl argues that well-designed public spaces, especially in street areas, can increase social interaction, improve people's quality of life, and encourage economic activity. ASF is a design approach that places buildings with an open orientation towards the street, enabling visual and physical connectivity between indoor and outdoor spaces (Dumbaugh & Gattis, 2005). The main goal is to create vibrant and interactive pedestrian-friendly environment that is visually appealing and supports sustainable commercial activities. A livable and a success place will create sense of place for people that contains visually attracted physical form, vibrant activity, and meaning attachment and its perception (Montgomery, 1998)

ASF also plays a vital role in creating high walkability (Hermawan & Laskara, 2022; McAllister, 2019; Moughtin, 2003), which, according to (Gehl, 2011), can increase social activity by up to 60%. In addition, this design can encourage sustainability by walkability oriented planning that reducing the use of private vehicles, reducing carbon

footprints, and supporting biodiversity and green mobility in tourism areas (Rafiemanzelat et al., 2017; Ujang & Muslim, 2015; Zainol et al., 2011). This concept suitable for cultural tourism area such as Ubud.

ASF is an essential component of success urban design that can integrates sustainable development in various aspects, including economic, environmental, and social dimensions that support city sustainability (Rafiemanzelat et al., 2017). This concept aims to create a dynamic and interactive shared space that improves the quality of life while encouraging sustainable development that has direct impacts on economic, environmental, and social aspects (Heffernan et al., 2014; Kickert, 2019).

From an economic perspective, ASF significantly contributes to the economic vitality of urban areas by fostering a dynamic and attractive environment that encourages pedestrian activity and local business engagement. Transparent storefronts, operable entrances, and outdoor dining areas enhance aesthetic appeal and increase the desire to pay for better street facilities (McAllister, 2021; Yoojin & Chong, 2017)

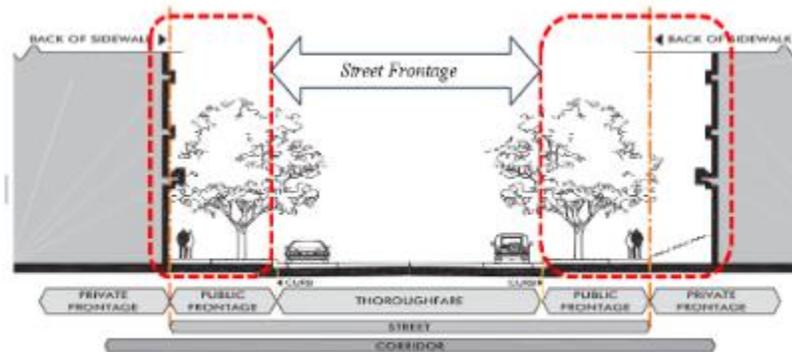


Figure 2. Street frontage elements  
Source : Adaptation (Gehl, 2011)

Studies have shown that improving pedestrian routes can significantly increase economic benefits. For example, a 2020 study by the Transport Agency New Zealand found that trees or plants on the road can increase the desire to pay by 20%, while sheltered pedestrian routes can improve it by 28%. Similarly, the Ashburton City Centre streetscape renewal project in New Zealand saw an increase of 40% or more in pedestrian willingness to pay due to better landscaping and broader pedestrian walkways (Corbett-Davies & Abley, 2024).

In the environmental aspect, ASF also plays a vital role in achieving ecological sustainability. By incorporating natural landscape, green infrastructure and promoting pedestrian-friendly spaces, these facades can reduce ecological issues such as noise pollution, rainwater runoff, and the heat island effect (Abdulmawla et al., 2022; Moughtin, 2003). Beautiful and shady pedestrian ways, a unique and aesthetic diversity of vegetation that is vital element for ASF on tropical climate. Various vegetation, colors, and aromatic flowers along the road and pedestrian paths and drainage system creates a vibrant atmosphere. This approach beautifies urban landscapes and provides many environmental benefits, including rainwater management and carbon emission reduction. For example, the design of green roads in Medan involves planting between 20% to 30% of the street space, improving the urban-ecological complex, and reducing urban ecological damage (Fachrudin et al., 2023).

In the social aspect, ASF is very important for social sustainability because it facilitates interaction between pedestrians and places and increases a sense of community and security (Dover & Massengale, 2013; A. B. Jacobs, 1993). The presence of ASF increases natural surveillance, reduces the fear of crime, and enhances safety measures in the surrounding environment. Local community participation in designing their urban communities is essential for social sustainability. ASF encourages community engagement by providing spaces for social interaction, such as cafes and open-air exhibition activities. This integration helps create a neighborhood that meets local needs and allows

residents to adapt and manage their built environment according to their changing needs (Loper et al., 2022; Shekfa & Ahmed, 2022).

According to the (UNWTO, 2005), sustainable tourism is "managing all resources in such a way that economic, social, and aesthetic needs can be met while maintaining biodiversity, essential ecological processes, life support systems, and cultural heritage." This concept underlies the importance of balancing tourism development and preserving the local environment and culture.

Sustainable tourism, especially in cultural tourism destinations, is a multifaceted approach that integrates economic vitality, social stability, and environmental sustainability. The concept aims to preserve local cultural heritage while promoting sustainable development, ensuring that tourism activities benefit local communities and protect the environment (Angelevska-Najdeska & Rakicevik, 2012; N K A Dwijendra et al., 2020). Sustainable tourism in cultural destinations prioritizes the integration of three dimensions: economic growth, social justice, and environmental protection. This holistic approach ensures that tourism activities generate positive economic benefits for local communities while respecting social and cultural norms and minimizing ecological impacts (Hall, 2000; Jing & Loang, 2024; Syafi'i & Suwandono, 2015; Wijaya, 2014).

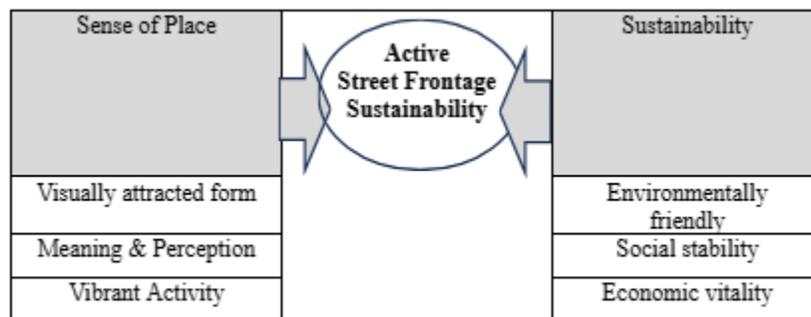


Figure 3. Formulation of basic contributors for active street frontage sustainability

Sustainable principles in the context of ASF planning involves various criteria, such as 1) using environmentally friendly materials, 2) energy efficiency; and 3) contextual green space. Sustainable ASF design must use local and renewable materials that easily found around the site. This material will have a low carbon footprint, and also durable with the site climate (Ngakan Ketut Acwin Dwijendra, 2019). Energy efficiency, buildings, and infrastructure along the ASF must be designed and construct efficiently to minimize energy consumption and carbon footprint. Energy efficiency can be achieved by applying environmentally based design and energy-saving technologies, such as energy-saving lighting or natural ventilation systems (Toh, 2022). Green space in ASF can function as a heat trap, improve air quality, filter noise, and create a more attractive visual experience for tourists and local communities (Anak Agung Ngurah Aritama, Gede Windu Laskara, 2022; Femy et al., 2017). In Ubud, this concept has become very relevant, considering that the area relies on unique cultural and natural attractions. Ubud street frontage applied local green space concept called Telajakan, that creates many local identity and environmental benefit for sustainable ASF (Adhika & Putra, 2020; Kato et al., 2017, 2019). Therefore, implementing designs that are in harmony with the local environment and culture is essential to maintain the sustainability of tourism in this region.

ASF principles are essential in maintaining and enhancing sustainable cultural tourism, those principles creating dynamic public spaces encouraging walkability, visually attracted places, community engagement, collaboration and artistic preservation (Asriana, 2021; Laskara et al., 2023). ASFs with transparent storefronts, frequent openings, windows and attractive signage contribute to a dynamic and interactive environment that enhances visitors' creative experience. This transparency encourages "eyes on the street" encouraging pedestrian activity and social interaction, which is essential for a rich cultural experience (A. B. Jacobs, 1993; Laskara et al., 2020; Law et al., 2020)

ASF also facilitates community engagement by providing space for social interaction. For example, incorporating façade design can give a sense of unity and diversity, encouraging community participation in cultural activities and events. By preserving traditional architectural elements and integrating them into modern design, ASF can help preserve cultural heritage. For example, restoring old gathering places for locals and tourists can preserve cultural facilities and redesign existing functional spaces to form cultural areas, the significance of cultural tourism innovation in enhancing tourist experiences and promoting authenticity (Jing & Loang, 2024).



Figure 4. Ubud Street Frontage  
Source : (Sun, 2023)

Studies on the application of Active Street Frontage in sustainable tourism are still limited. Still, some studies show that proper strategic planning can reduce negative environmental impacts while maintaining the attractiveness of tourist areas. In his research, (Jones, 2019) entitled *Sustainable Tourism and Active Street Frontage Design: Challenges and Opportunities in Tourist-Driven Economies*, highlights the importance of strategic planning focusing on sustainable design. Jones found that integrating renewable energy and using recycled materials can reduce the carbon footprint of tourist areas by up to 25%. In addition, green spaces incorporated into ASF can increase the comfort of tourists while improving air quality in urban areas. The study also emphasizes the need for a more holistic approach to ASF planning, where the involvement of local communities and industry players is critical to successful implementation.

Another study by (Beatley, 2011) in his book *Biophilic Cities: Integrating Nature into Urban Design and Planning* shows that integrating ecology in urban spatial planning can improve people's welfare. According to Beatley, environmentally friendly ASF design contributes to environmental preservation and the community's quality of life by creating a healthier, beautiful, and functional environment. This approach is particularly relevant for the Ubud region, where residents and tourists highly value the harmony between the natural environment and local culture. Successful implementation of ASF in tourist areas such as Ubud requires a holistic approach. This means that every element, from economic booster to social and ecological integration, must be considered to create an environment that functions well and is in harmony with the local nature and culture. Research by (Newman & Kenworthy, 1999) in *Sustainability and Cities: Overcoming Automobile Dependence* shows that reducing dependence on motor vehicles

through strategic planning of public spaces can reduce greenhouse gas emissions by up to 30%. In the context of Ubud, implementing pedestrian-first ASF can contribute to reducing pollution and congestion and supporting greener mobility. Overall, this literature review highlights the importance of implementing sustainable design to develop Active Street Frontage in tourist areas. Previous researches by showed that integrating the concept of sustainability into the design of public spaces not only provides ecological but also economic and social benefits. In the context of Ubud, applying these concepts will support sustainable tourism development, maintain the attractiveness of local culture, and ensure environmental sustainability.

### 3. METHOD

This research uses a case study approach chosen because of its relevance in analyzing specific phenomena in an accurate and in-depth context (Yin, 2018). The case study is considered appropriate for exploring how sustainability can be integrated into the design of Active Street Frontage (ASF) in the Ubud tourism area. Through this approach, the research can explore in detail the interaction between strategic planning and public space design and challenges and opportunities in applying sustainability in the region. Case studies also provide flexibility in combining various data collection methods to obtain a comprehensive understanding, including interviews, observations, and document analysis (Craswell, 2014). The Ubud area was chosen because of the challenges in maintaining a balance between tourism development, environmental preservation, and local culture. This study uses qualitative methods, which involve several data collection techniques to obtain in-depth and contextual information about the sustainable implementation of ASF in Ubud. The following are the data collection methods used:

Semi-structured interviews were chosen because of their flexibility in digging into in-depth information while allowing respondents to explain their views (Kvale & Brinkmann, 2015)

1. Interviews were conducted with registered architects and city planner to understand the technical and aesthetic aspects of the ASF design, and also to obtain information on policies and regulations related to the development of ASF in Ubud. Interviews also to Tourism industry players to understand the needs and expectations from an economic point of view and how they manage their building façade that can increase tourist attraction. The questions focused on the challenges, opportunities, and experiences in designing and implementing sustainable aspect on their property on the street frontage.
2. Field observations were conducted to observe firsthand how ASF appearance in Ubud. Researchers observe building façade and its design, which is how buildings along the street interact with public spaces. Use of green spaces: How natural elements such as trees, parks, or green open spaces are integrated into the design—social and economic activities: Tourists and locals utilize street spaces that function as ASF. Non-participant observation is used, in which the researcher is not involved in the observed activity but notes the phenomenon that occurs (Spradley, 1980).
3. The document's analysis was used to review policies related to ASF's spatial planning and development in Ubud. The records analyzed included local government regulations related to the management of public spaces and sustainable tourism in Ubud, spatial studies, and environmental reports published by local agencies. The study of this document serves to obtain information related to regulations and policies that affect ASF's planning and development in the Ubud tourist area.

After the data was collected, this study used thematic analysis to identify the main patterns in the qualitative data. Thematic analysis is a technique used to organize and interpret data by finding recurring themes or patterns in interviews, observations, and documents (Braun & Clarke, 2006). The stages of analysis include:

1. Data obtained from interviews and observations are encoded using an open coding method, where each relevant piece of data is assigned a specific label or category (Strauss & Corbin, 1998). These codes represent critical themes related to sustainability in ASF design, such as using place theory and sustainable theory that linked to ASF. Also found that environmentally friendly materials, green spaces, and energy efficiency are critical aspect.

2. Identify themes after coding, the next step is to group the codes into broader themes. These themes reflect critical issues faced in implementing sustainable ASF in Ubud, such as regulatory challenges, local community engagement, and design innovation.
3. Interpretation is carried out by connecting the themes found with the theoretical framework and concept of sustainability discussed in the literature review. Triangulation is carried out by comparing the results of interviews, observations, and documents to ensure the validity of the data (Denzin & Lincoln, 2011).

To ensure the validity and reliability of the research, several steps are taken:

1. Triangulation method: This study combines interviews, observations, and document analysis to ensure that the data comes from various sources, providing a richer and more in-depth perspective (Patton, 2002).
2. Member checking: After the interview, the results and interpretation will be reconfirmed with the respondent to ensure that the researcher's interpretation is based on the respondent's original views (Craswell, 2014).

Although the case study approach provides in-depth insights, this study's results are limited to the context of the Ubud tourism area. They may not be broadly generalized to other regions in Bali or Indonesia. In addition, obstacles to collecting field data, such as weather and access to certain areas, need to be anticipated.

#### 4. RESULT AND DISCUSSION

Based on the comprehensive analysis of the data collected from observations and interviews, strategic planning were obtained that integrate sustainability in the ASF in tourism area of Ubud through the matrix description below. The strategic planning emphasizing eco-friendly local material, green space, energy efficiency that creates physical ambience for sustainability on ASF in Ubud.

Table 1. The matrix of strategic planning on integrating sustainability principles in Ubud's ASF

	Visually attracted form	Meaning & Perception	Vibrant Activity
Environmentally friendly	Using unique and eco-friendly local materials that represent Ubud and its nature landscapes	Emphasizing Ubud's green space <i>telajakan</i> , the diversity of natural landscape as a tourist experience at ASF	Eco-vibrant that implement smart system technology to promote energy efficiency, and green infrastructure
Social stability	Local culture and its architecture identity as basic guidelines for the design of building façade and frontage	Maintaining local culture, social and traditional spaces as a top priority above tourism activities.	Cultural activities that carried out at ASF area engage tourist's contributions and community collaboration
Economic vitality	Innovative and creative design with flexibility, durability and easy maintenance as main aspect	Socio-cultural activities that attract tourism must provide benefits and profit to the local community	The diversity of commercials and attractive retails activities that supporting walkability, that prioritized local enterprise

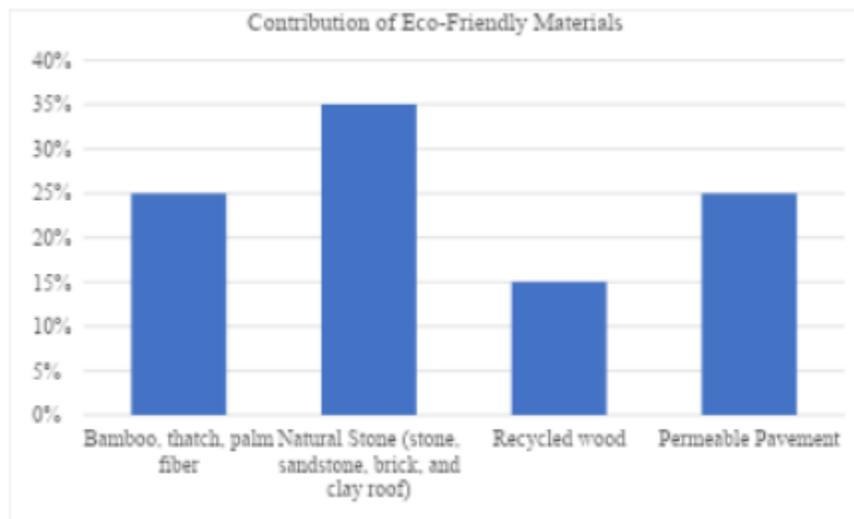
Further studies, based on interviews with 25 (twenty-five) architects and planners in Ubud, it was found that one of the essential components in creating sustainable and also unique ASF in Ubud is the use of locally-produced and environmentally friendly materials, such as bamboo, thatch, palm fibers (ijuk), various natural stone, and also recycled materials. Their decision also considered Bali's building design regulation for building appearances materials and style, and also imagining the presence of space experiences (shades of Ubud) in the design of tourist accommodation ASF through the architect's knowledge of the nuances of Ubud (Primadewi et al., 2021). This situation supports environmental sustainability and aligns with Bali's local cultural values, which consider nature part of spirituality and daily life in Ubud.

The following are the observation data related to the materials used in the application of ASF in Ubud:

Table 2. Local and Environmentally Friendly Materials in ASF in Ubud

Material	Usage (%)	Environmental Benefits
Bamboo, Thatch, Palm Fibers ( <i>Ijuk</i> )	25%	Local vegetation, fast-growing, and renewable materials
Natural Stone - Stone, Sandstone, Brick, Clay Tile and Roof	35%	Local production and reduces carbon emissions because no need for long delivery
Recycled wood	15%	Reducing waste, bring a specific ambient, and sustainable resource utilization
Permeable pavement	25%	Improves water absorption and reduces rainwater runoff

In addition, creating traditional green spaces (*telajakan*) along the ASF is essential in improving air quality, reducing overheating, and providing a refreshing atmosphere for tourists and residents. It's found about 30% of the building façade on the main road frontage area has been equipped with green space. And it's about 40% of the building façade on the secondary road frontage has been equipped with green space. This green space such as of *telajakan*, small gardens, shade trees, and hanging or removeable vegetation, these all which also serve as microclimate controllers. Here is a graphic showing the contribution of materials and green elements in ASF design in Ubud:



Graph 1. Contribution of Eco-Friendly Materials on ASF in Ubud

In addition to planning with environmentally friendly materials, the use of technology has also been carried out. Energy-saving technologies such as energy-saving LEDs and solar panel technology are used for garden lighting in the terrace area. The ASF area has adopted rainwater management through permeable paving and bioswale/biopharma. This model reduces energy consumption, improves water efficiency, and repels potential local flooding. Water management is heritage aspect of Bali, while traditional irrigation system and drainage called *subak* inspires water management, such as gutter system below the pedestrian way on ASF (Geria et al., 2023).

Table 3. Efficiency of the Use of Environmentally Friendly Technology in ASF in Ubud

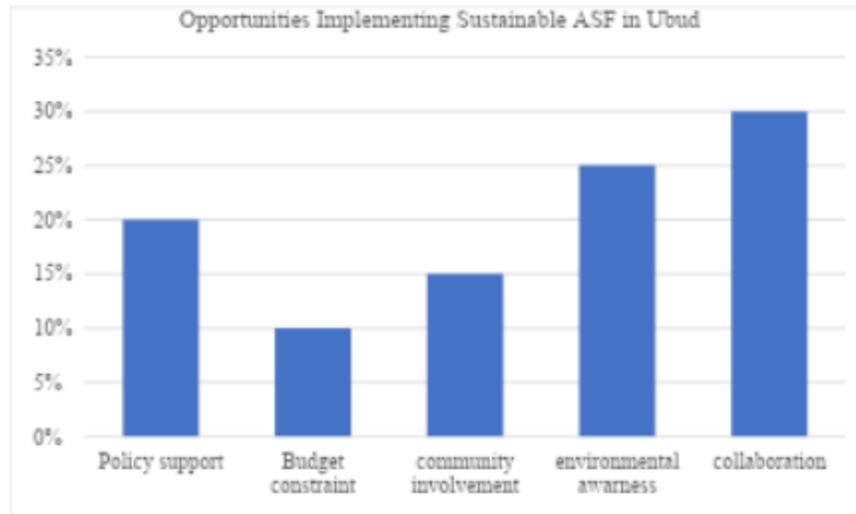
Technology	Environmental Benefits	Implementation
Electricity Energy-Saving	Reduce energy consumption	LED Lighting, Solar panel lighting on the signage media and green space
Rainwater Management System	Improves water absorption and reduces runoff	Absorbability pavement surface and biophory box
Protect Natural Contour & Vegetation	Reduces landscape changes and carbon emission	Keep natural contour and existing trees

The results of interviews with tourism industry stakeholders and local peoples in Ubud show that the active participation of local communities in the ASF planning process has proven to be very effective. Most respondents emphasized that involving indigenous peoples in design decisions ensures that ASF projects align with local cultural values and do not disrupt social balance.

### Challenges and Opportunities of Sustainable ASF Planning in Ubud Tourism

According to the results of interviews with tourists, using local and natural materials in designing ASF in Ubud, Bali, significantly improves the design character and sense of identity for international tourism. These materials reflect Bali's identity and cultural heritage and contribute to environmental sustainability. Balinese architecture is famous for using natural materials such as bamboo, wood, and stone. These materials are not only pleasing to the eye but also sustainable. For example, bamboo buildings in Bali have been around for centuries and are now innovatively integrated into modern design to preserve cultural traditions while adapting to contemporary needs.

Incorporating local materials such as bamboo and wood in ASF in Ubud gives tourists in Bali, especially Ubud, a sense of identity and a sense of place. In addition, the use of local materials reduces dependence on non-renewable resources and minimizes environmental impact. This approach is in line with the principles of sustainable development, which emphasize the importance of preserving the natural environment and cultural heritage. Although the potential for implementing sustainable design in ASF is significant, several challenges exist. One of the main challenges is the lack of incentives support from public policy from relevant stakeholders. Some tourism industry stakeholder stated that policies related to incentives or a reward for environmentally friendly projects are still limited. Meanwhile, the cost of adopting green technologies such as energy-efficient lighting and technological rainwater management systems is still relatively high.



Graph 2. Opportunities in the Implementation of Sustainable ASF in Ubud

Graph 2 shows the challenges and opportunities in implementing sustainable Active Street Frontage (ASF) in the environmental aspects of Ubud. This graph showcases factors such as policy support, budget constraints, community engagement, environmental awareness, and collaboration and their contribution to the successful implementation of sustainable ASF in the region. The graph above shows that collaboration between the government, local peoples, and the tourism industry is the most incredible opportunity to overcome the existing challenges. In addition, increasing environmental awareness among global tourists is also a driver for the development of a more environmentally friendly ASF. The following features a sustainable Active Street Frontage (ASF) design in Ubud, using natural eco-friendly material that create sustainability also uniqueness to ASF Ubud. This image shows the integration of eco-friendly materials in architecture with green spaces to create an environment that supports sustainability.



Figure 5. ASF Ubud that applied eco-friendly material and green spaces creates ASF uniqueness and sustainability

Figure 5 shows how using materials such as bamboo and natural stone has succeeded in creating a visually accessed space that is not only aesthetically pleasing but also environmentally friendly while providing an atmosphere that is in line with the character of Balinese culture. Integrating local and natural materials and green technology in designing

ASF in Ubud, Bali, significantly increases the sense of place for tourists. Although there are challenges related to cultural sensitivity to the application of new technologies and environmental impacts on the excessive exploration of natural materials, these challenges can be overcome through collaborative actions and innovative solutions based on local principles and contexts. By respecting local customs while adapting to modern needs, urban architects and designers can create a sustainable environment in the ASF area that attracts tourists while preserving Bali's cultural heritage.

While the study presents a strong case for sustainable ASF strategic planning in Ubud, some limitations must be acknowledged. Firstly, the research primarily relies on qualitative methods, which may not capture the full scope of the quantitative impacts of ASF design. Secondly, the case study approach, while in-depth, limits the generalizability of the findings to other regions outside Ubud or similar cultural contexts. Moreover, there is a need for a more detailed analysis of the cost implications of the proposed sustainable practices, which could affect their feasibility and adoption.

## 5. CONCLUSION

ASF is a multifaceted concept that integrates sustainable development in all economic, environmental, and social dimensions. Various aspects of ASF design in Ubud support these principles by encouraging pedestrian activities, improving environmental quality, and encouraging community participation. These highlight the importance of integrating sustainability aspects within ASF to create a dynamic, attractive, vital, and sustainable destination. The strategic planning sustainability ASF matrix (Table 1) showed that it is very important to maintain the place quality (aesthetic form, meaning, and activity) in line with three main aspects of sustainability (environmental friendly, social stability, and economic vitality) on Ubud tourism area.

ASF makes a significant contribution to the overall sustainability of tourism destination areas. The use of local materials and eco-friendly technology is the key to the success of sustainable design in Ubud. Implementing these aspects requires collaborative support to achieve sustainable ASF success in the Ubud tourist area. This research successfully answered the formulation of problems related to the integration of sustainability in the design of Active Street Frontage (ASF) in Ubud, Bali. Based on the results and discussion, the conclusions that can be drawn are as follows:

1. Use of eco-friendly materials: Local materials such as bamboo, thatch, palm fibers, and various natural stones have proven effective in creating sustainable ASF designs. This material not only supports environmental sustainability but is also in harmony with the local cultural character of Bali, answering the formulation of problems related to sustainability in the context of Ubud tourism. Using recycled materials and permeable technology in ASF reduces carbon footprint and improves energy efficiency.
2. Creation of green spaces and traditional garden: The study results show that the green spaces integrated in ASF, such as gardens and shade trees, contribute significantly to Ubud's environmental quality. This helps reduce overheating, improve air quality, and create more comfortable public spaces for tourists and local communities. This garden strengthens the concept of Balinese traditional gardens in the street frontage area known as the *telajakan*. In addition, the types of trees in Ubud give a characteristic tourist destination in a tropical climate. This gives a specific impression of the atmosphere of Ubud for tourists who come from non-tropical climate countries.
3. The role of local community participation: The active participation of traditional leaders (*puri*), indigenous communities, and local communities in ASF planning is crucial for successfully implementing sustainable development. The role of indigenous leaders and communities ensures that the concept of ASF in Ubud can be passed on to the next generation using traditional instruments and customary rules. This participation helps to preserve Balinese cultural values and ensures that tourism development does not disrupt the social and artistic balance. It also provides solutions to the challenges faced in the ASF strategic planning process.
4. Application of green and energy-saving technology: Using environmentally friendly technologies such as energy-saving LED lighting systems and rainwater management through permeable paving has been proven

to improve energy efficiency and environmental management in public spaces, especially in the road surface area in Ubud. This shows that sustainable technological innovation can be effectively integrated into ASF design.

5. Challenges and opportunities: The main challenges in implementing sustainable design in ASF in Ubud are strong policy support and high budgets to adopt green technologies. However, significant opportunities are seen in collaboration between the government, indigenous leaders/communities, and tourism industry players, which can encourage the creation of sustainable ASF design. This answers questions related to the obstacles faced in implementing sustainable ASF.

Based on the conclusions of the study, several suggestions can be given to stakeholders to support the sustainable development of ASF in Ubud, namely:

1. Policies that support sustainable principles and have Ubud's natural and cultural identity. Local governments need to strengthen policies supporting sustainable design implementation in developing ASF design guidelines in Ubud. This guideline must emphasize the importance of Ubud's sense of place such as material, landscape, innovative and creative design that suitable socio-cultural aspects. This includes incentivizing developers to use environmentally friendly materials and energy-efficient technologies. Regulatory enforcement is essential to ensure that the control of the development and preservation of the local environment and culture is maintained and represented in the ASF in Ubud.
2. Increased awareness and collaboration: Tourism industry stakeholders, urban planners, and local communities must be more aware of implementing sustainable design in ASF. Collaboration between these parties is essential to ensure the successful implementation of environmentally friendly ASF aligned with social, cultural, and economic needs. The government must also play an active role in facilitating this collaboration through discussion forums and training programs.
3. Priority use of green and natural technology: Green and environmentally friendly technology should be a priority in any ASF development project. Green technology refers to the technology and management system of natural resource developed from locally-handed technology, to enhance tourist experience as Ubud known as cultural tourism destination. Prioritizing the role of nature and local community contribution in providing comfort for tourism. Governments and developers should invest in smart system and green technologies like green building concept, biophilic concept, smart lighting, green mobility, and efficient water management systems like subak system in innovative way. This technology has been proven to reduce environmental impact, small amount of waste and carbon emissions toward smart cities and tourism (Casini, 2017), and most importantly improve the quality of public experience in Ubud.

Furthermore, a study on community participation in ASF planning in Ubud is needed. Research on how local community participation can be more deeply integrated with the ASF planning process in Ubud and other tourism areas, primarily related to increased Indigenous people's involvement in public space design and management decisions, is needed. Future research could benefit from incorporating quantitative methods to complement the qualitative findings, providing a more holistic understanding of the impacts of sustainable ASF planning. Additionally, expanding the study to include comparative analysis with other regions would enhance the generalizability of the results. Exploring the economic feasibility of sustainable practices in ASF design in more depth would also be beneficial, as it would address one of the critical challenges identified in this study. Lastly, further engagement with policymakers could help translate the study's recommendations into actionable policies.

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# Improving the Quality of Book Printing Products through Six Sigma Approach that integrated with Experimental Design

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**Abstract:** This research applies the Six Sigma (DMAIC) approach which is integrated with experimental design at the process improvement stage. The research was conducted at a book printing company. Three dominant defects were found in the book printing process, namely uneven cutting results (44.29%), uneven colors (32.8%) and torn books (23.82%). The sigma value measured at initial conditions is 2.172. The research was carried out by following the Six Sigma DMAIC stages, and in stage I (improvement) experiments were carried out by changing the cutting speed process parameters. The experimental design uses a completely randomized design with the engine speeds to be tested in the experiment being 50 RPM, 60 RPM and 70 RPM. The number of replications in the experiment was 10 times at each level. The number of levels is 3, so the total number of trials is 30 experiments. The treatment stage selected based on the Student Newmann Keuls Test was a level 2 experiment with an independent variable of 60 RPM. The sigma value obtained in the post improvement condition was 2.58  $\sigma$ , an increase in sigma of 0.408 compared to the initial condition. The percentage of post-improvement production defects is 4.62%.

**Keywords:** six sigma, experimental design, cutting speed, completely randomized design.

## 1. INTRODUCTION

Six Sigma method has been proven to be able to identify and eliminate defects, errors or failures in business processes or systems by focusing on process performance characteristics that are very important to customers (Snee, 2004). Six sigma method has been successfully applied in many large companies, but its application in smaller organizations is still less well documented (Jiju et.al, 2005). Various studies examining the application of six sigma in small and medium companies include Scheller et al, (2017), Kandil and Aziz (2017), and Swarnakar, Tiwari and Singh, (2020). Kandil and Aziz's (2017) research focuses on problems related to supply chains in small and medium enterprises in Egypt. The six sigma method is used to explore areas that need improvement and assess the impact of technology in improving company performance. Scheller et.al (2017) shows that Lean and Six Sigma are implemented separately in two different programs. Several aspects required to improve the integration of both approaches have been identified while considering each phase of DMAIC and the actual approach implemented by the company. Although some positive results have been achieved, there are many critical factors and failures that can affect the implementation of both approaches, such as employee training and changes in the organizational environment. Swarnakar, Tiwari and Singh (2020) conducted research with the aim of identifying, evaluating and developing a structured model that measures the interrelationship between critical failure factors (CFF) that influence the sustainable implementation of Lean Six sigma in manufacturing organizations. Six sigma research that uses experimental design at the Improve stage is still very limited. The research conducted examined the company's performance in reducing defective products through a series of DMAIC stages, and specifically carried out process improvements in stage I (improvement) by designing experiments. The research was conducted at PT X, a company engaged in the school textbook printing industry in the city of Bandung. Problems faced by book printing companies include overproduction caused by the unavailability of accurate information about the percentage of defective products in the post-print process. To anticipate the occurrence of defective products, PT X uses a policy of providing production tolerances higher than the demand in the employment contract with consumers. For example, in a particular contract the amount of consumer demand is 3 149 100 copies of books, but produced 3 486 680 copies of books. The disability rate is 7%, or about 244 067 copies of books. Although consumer demand can be met according to the contract, but defective products that are not sold are very high. The sigma value calculated by the six sigma method is still 2.17.

## 2. METHOD

The research was conducted in the school textbook printing industry using the Six Sigma approach, Pyzdek & Keller (2010), which includes the stages of define, measure, analyze, improve, and control. At the define stage, observation of the production process, analysis of production data and identification of types of defects that may occur in book printing products are carried out. The measure stage measures the number of defective products and the achievement of sigma values in conditions when research is carried out. The analyze phase identifies the root cause of the problem using pareto diagram tools, fishbone diagrams and failure mode effect analysis. At the improve stage, process improvement is carried out by conducting experiments through determining parameter settings on the cutting machine. The study used two types of data, namely primary data and secondary data. Primary data were obtained from interviews and observations of the Company's stakeholders, which include president directors, production directors, production supervisors and production operators. Observation is carried out by active observation where this research is carried out based on field conditions and researchers participate in the production process. The experimental design used to improve the cutting process is an experimental design with the Complete Randomized Design (RAL) method. Experiments were conducted to obtain an optimal parameter set up in reducing product defects in the 3-sided cutting section (treemar) in the TSK Binding Inline Machine.

## 3. RESULT AND DISCUSSION

### 3.1 Define

*Define* is the initial stage carried out in the DMAIC approach. At this stage, define and select the problems to be solved. Figure 1 is the process flow that occurs at PT. X, starting from the supplier to the hands of consumers using the SIPOC diagram (*supplier, input, process, output, customer*).

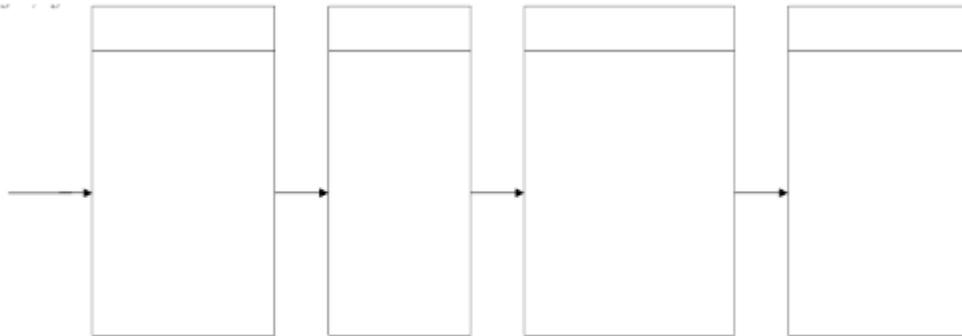


Figure 1. Diagram Supplier-Input-Process-Output-Control

PT. X has approximately 83 suppliers, ranging from suppliers of paper rolls, paper sheets, ink and others. At this stage explain the symptoms of problems observed at PT. X by using a cause effect diagram. The cause effect diagram can be seen in figure 2.

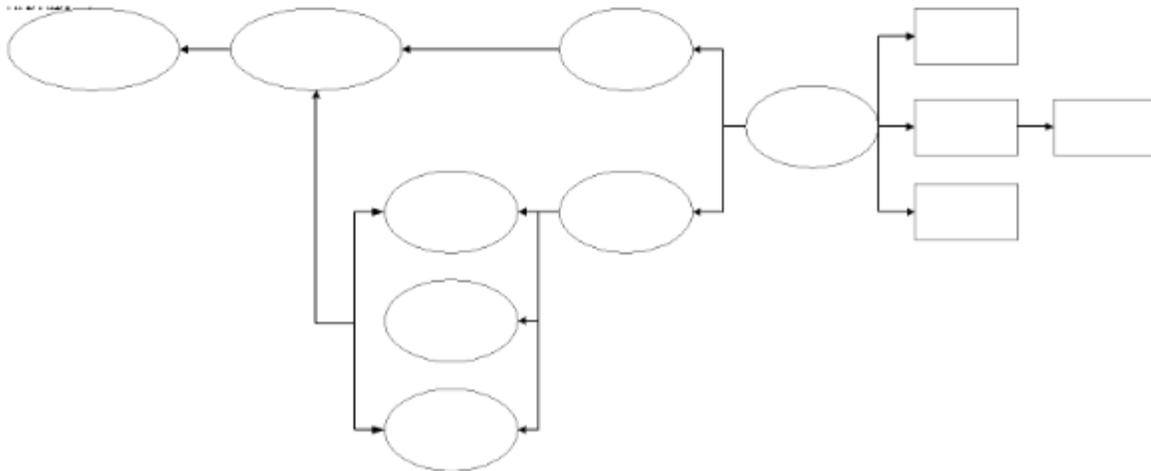


Figure 2. Cause effect diagram

### 3.2 Measure

*Measure* is the stage of measurement of problems that have been defined to be solved. At this stage, various data are measured, measuring process characteristics and capabilities. The data are presented in Table 1 to Table 5.

Table 1. Type and Quantity of Production

No.	Level	Class Level	Book Title	Oplagh Quantity (Units)
1	SD	1	Tema 1 - 8	423000
2	SD	2	Tema 1 - 8	420000
3	SD	3	Tema 1 - 8	642100
4	SD	4	Tema 1 - 8	548000
5	SD	5	Tema 1 - 8	471000
6	SD	6	Tema 1 - 8	645000
Total				3149100

PT. X initially experienced the phenomenon of overproduction, one of which was caused by the post-print process. The following are the production results for thematic books at the elementary school (SD) level for a certain year period.

Table 2. Thematic Book Production Results

No.	Level	Class Level	Book Title	Oplagh
				Quantity (Units)
1	SD	1	Tema 1-8	484912
2	SD	2	Tema 1-8	474872
3	SD	3	Tema 1-8	697596
4	SD	4	Tema 1-8	596387
5	SD	5	Tema 1-8	531266
6	SD	6	Tema 1-8	701649
Total				3486680

Table 3. Production-demand deviation

Level	Class Level	Book Title	Oplagh
			Quantity (Production Yield - Demand)
SD	1	Tema 1-8	61912
SD	2	Tema 1-8	54872
SD	3	Tema 1-8	55496
SD	4	Tema 1-8	48387
SD	5	Tema 1-8	60266
SD	6	Tema 1-8	55647
Total			337580

The difference in products is inventory produced by the company which will be stored in the warehouse and then sold at retail. The company suffered losses caused by the inventory. Estimated losses due to overproduction can be seen in table 4.

Table 4. Estimated Company Loss

Level	Class Level	Book Title	Difference (Eksemplar)	HET/Product	Total (Rupiah)
				ZONA 1	
SD	1	TEMA1- TEMA 8	61912	Rp 12,400.00	Rp 767,708,800.00
SD	2	TEMA1- TEMA 8	54872	Rp12,400.00	Rp 680,412,800.00
SD	3	TEMA1- TEMA 8	55496	Rp12,400.00	Rp 688,150,500.00
SD	4	TEMA1- TEMA 8	48387	Rp 12,400.00	Rp 599,998,800.00
SD	5	TEMA1- TEMA 8	60266	Rp 12,400.00	Rp 747,298,400.00
SD	6	TEMA1- TEMA 8	55647	Rp 12,400.00	Rp 692,502,800.00
Total					Rp 4,176,072,000.00

Besides inventory, there is a major problem experienced by the Inline *TSK Binding Machine* , namely production defects. Table 5 describes the number of defective products of thematic book production for the Primary School (SD) level in Theme 1 – Theme 8 in the *TSK Inline Binding Machine*.

Table 5. Number of defective products

No.	SD	Class Level	Book Title	Defective Products
				Total Amount
1	SD	1	TEMA 1 - TEMA 8	49,261
2	SD	2	TEMA 1 - TEMA 8	52,129
3	SD	3	TEMA 1 - TEMA 8	47,862
4	SD	4	TEMA 1 - TEMA 8	48,271
5	SD	5	TEMA 1 - TEMA 8	43,411
6	SD	6	TEMA 1 - TEMA 8	50,377
Total				291,311

Defective products are products produced in the production process with specifications that are not in accordance with the quality standards set by the company. The Company experiences losses caused by product defects so that if calculated losses based on defective products can be seen in table 6.

Tabel 6. Estimasi Kerugian Karena Produk Cacat

No.	Tingkat	Jenjang Kelas	Judul Buku	Produksi Cacat	HET/Produk	Total (Rupiah)
					ZONA 1	
1	SD	1	TEMA1- TEMA 8	49261	Rp 12,400.00	Rp 610,836,400.00
2	SD	2	TEMA1- TEMA 8	52129	Rp 12,400.00	Rp 646,399,600.00
3	SD	3	TEMA1- TEMA 8	47862	Rp 12,400.00	Rp 593,488,800.00
4	SD	4	TEMA1- TEMA 8	48271	Rp 12,400.00	Rp 598,560,400.00
5	SD	5	TEMA1- TEMA 8	43411	Rp 12,400.00	Rp 538,296,400.00
6	SD	6	TEMA1- TEMA 8	50377	Rp 12,400.00	Rp 624,674,800.00
Total						Rp 3,612,256,400.00

### 3.3 Analyze

The analysis stage is the stage to find a solution that can solve the problem based on the root cause that has been identified. The different types of manufacturing defects in PT X are described in Figure 3.

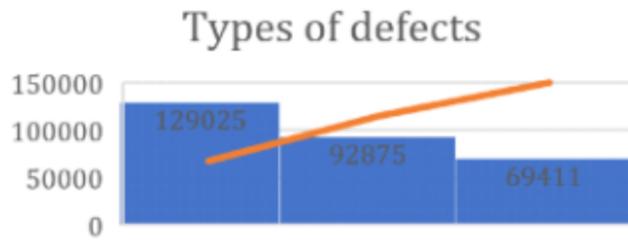


Figure 3. Different Types of Production Defects

Each type of defect is caused by various factors, which include human factors, *inline tsk binding machine* factors, 3-sided cutting method factors and environmental factors. The data stating the cause of the occurrence of manufacturing defects when sorted from the largest percentage of product defects is shown in Figure 3.

The deduction does not correspond to the percentage of disability of 44.291%

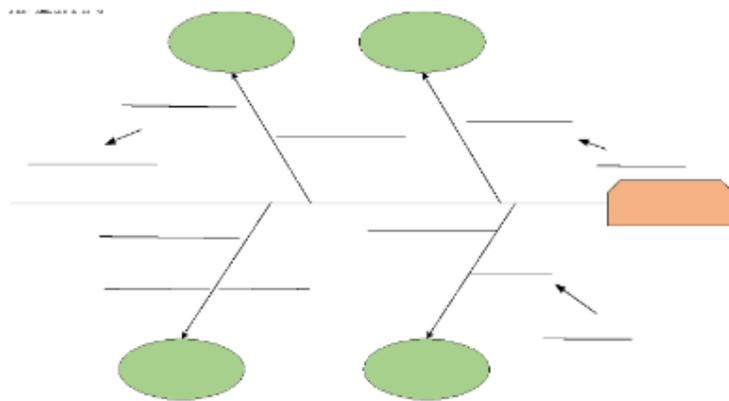


Figure 4. Product defects due to inappropriate cutting size

Inappropriate colors or uneven colors with a defect percentage of 31.884%

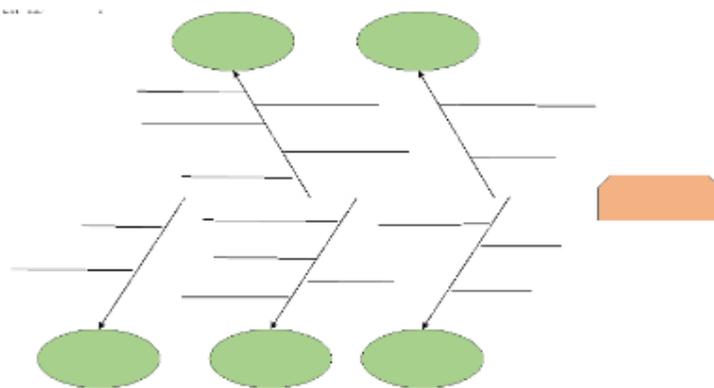


Figure 5. Product defects due to uneven color

Tearing with a manufacturing defect percentage of 23.827%

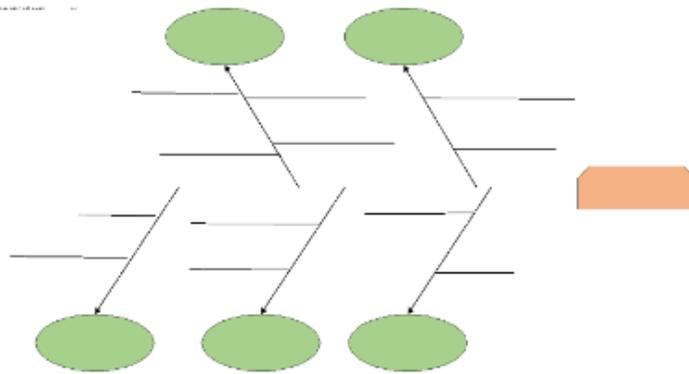


Figure 6. Product defects due to tearing

The measurement results show that the most dominant product defects are caused by *the Inline TSK Binding Machine* on the *treemar* (3-sided cutting). The dominant defect is thought to be caused by the engine speed (RPM) used is not optimal. The alleged cause of the dominant factor of disability is supported by the FMEA (*Failure Mode Effect Analysis*) diagram which shows this.

### 3.4 Improve

The *improvement* stage was carried out by designing experiments using the Complete Random Design (RAL) method on the *TSK Inline Binding Machine* of the *treemar* section (3-sided cutting). Factors to consider are engine speed (RPM) and the stack of books to be cut to minimize defective products. Settings to determine cutting parameters are obtained through primary data, both from the manual *book*, operator experience and policies from PT. X. In the *existing* state, the company uses three measures of engine speed (RPM), namely 55 RPM, 60 RPM, and 65 RPM. The stack of books will be cut in a *setting* of 4 – 7 books, depending on the thickness of the book. The small or large number of stacks of books is done based on the stack capacity required by the *inline binding TSK Machine*, which is 70 mm – 75 mm high. In this study, experiments were carried out by *setting a stack of 5* books. Observations inform that the high speed of the machine will cause disruption to the *gathering* process for book filling, so that the book filling will be folded and when cut on 3 sides will experience product defects. The engine speed (RPM) is too slow will result in disruption of the queue when the cutting process is carried out on 3 sides of the *treemar*. The phenomenon that occurs in a low RPM state is the friction between 1 book and another book which causes the stack of books to become misaligned (experience a shift in books), so that the 3-sided cutting process becomes asymmetrical. Therefore, it is necessary to choose the right speed to minimize product defects. The engine speeds to be tested in the experiment are 50 RPM, 60 RPM and 70 RPM. The number of replications in an experiment is 10 experiments at each level. The number of levels is 3, so the total number of trials is 30 trials. The experimental results are shown in Table 7.

Table 7. Experimental data

Operating Parameters	Speed		
	Level 1	Level 2	Level 3
	50 RPM	60 RPM	70 RPM
Production Defects (in book copies)	1177	933	1284
	1199	1047	1259
	1303	1004	1357
	1259	1068	1308
	1314	1045	1368
	1259	938	1307
	1154	937	1526
	1307	936	1088
	1264	981	1303
	1283	1173	1324
Sum	12519	10062	13124
Many Observations	10	10	10
Average	1251.09.0 0	1006.02.0 0	1312.04.0 0

### 3.5 Control

The purpose of the control stage is to standardize, control and maintain the improved process. The control stage is carried out by compiling standard operating procedures / SOPs with a machine speed of 60 RPM.

## 4. CONCLUSION

1. Based on research conducted on the post-print process at PT. X, The independent variable in the form of engine speed (RPM) used at the time of the experiment consisted of 3 levels, namely 50 RPM, 60 RPM and 70 RPM with a stack of 5 copies of books.
2. The treatment stage selected based on the Newmann Keuls Student Test is a level 2 experiment with a free variable of 60 RPM.
3. The sigma value obtained in post-improvisation conditions is  $2.58 \sigma$ , there is an increase in sigma of 0.408 compared to the initial state.
4. The percentage of post-improvement production defects is 4.62%.

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# Increasing Electric Vehicle Acceptance, an Insights into Reducing Range Anxiety

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**Abstract:** Given the increasing worldwide focus on sustainability, electric vehicles (EVs) have become important in the efforts to decrease carbon emissions and address climate change. Nevertheless, the broad acceptance of electric vehicles (EVs), especially in Indonesia, encounters substantial barriers, with range anxiety being one of the main issues. This article explores the complex nature of range anxiety, specifically examining its technological aspects and the important function of customer support in reducing the effects. This study uses Structural Equation Modeling (SEM) with a Partial Least Squares (PLS) approach to analyze the relationships among Charging Infrastructure, Customer Support, Perceived Technological Sophistication, and Range Anxiety. The data collected from 146 individuals aware regarding EV technology is analyzed. The findings suggest that customer service and perceived technological sophistication have a substantial effect on lowering range anxiety. However, the presence of charging infrastructure does not have a statistically significant influence on alleviating range anxiety. This discrepancy indicates a requirement for focused approaches that tackle both physical and psychological obstacles to electric vehicle (EV) adoption.

**Keywords:** Electric Vehicles (EVs), Charging Infrastructure, Perceived Technological Sophistication, Range Anxiety, Customer Support.

## 1. INTRODUCTION

Electric vehicle (EVs) are leading the way in reducing carbon emissions and tackling climate change, offering a possible replacement to traditional gasoline-powered vehicles [1]. EVs provide numerous environmental and operational advantages, such as reduced operating expenses and no emissions from the exhaust pipe. Still, their acceptance, especially in Indonesia, has been limited by range anxiety, a major concern about the driving distance EVs can cover and the availability of charging stations. This research investigates the complex nature of range anxiety, analyzing not only the technology side but also the customer support. This study suggests a comprehensive method to reducing range anxiety, which is crucial to accelerating the adoption of electric vehicles (EVs), by incorporating these factors. The Indonesia Electric Vehicle Outlook 2023 reveals a notable surge of 60% in worldwide electric vehicle sales, reaching an all-time high 10.6 million units in 2022. This surge is a result of Indonesia's initiatives to reduce carbon emissions in its transportation sector and fulfill its commitments under the Paris Agreement's Nationally Determined Contributions (NDC) targets. The nation's ambitious strategy involves raising the number of electric motorcycles and cars by 2025 and 2030, respectively. The increase in the adoption of electric vehicles (EVs) has been additionally stimulated by a cut in value-added tax (VAT) from 11% to 1% for electric cars that have a minimum of 40% locally sourced components. This has resulted in a substantial rise in sales for models such as Hyundai's IONIQ 5 and Wuling's Air EV, thanks to tax incentives offered by the government [2], [3]. While there has been a significant increase in the sales of electric vehicles (EVs), as indicated by the Indonesia Electric Vehicle Outlook 2023, the rate at which EVs are being adopted has not yet reached its full potential, primarily because of concerns about the limited driving range of these vehicles, often known as range anxiety. Range anxiety, which refers to the concern that an electric vehicle (EV) may not have enough charge to reach its destination, continues to be an important challenge. This fear eclipses the advantages of reduced carbon emissions and is in line with worldwide environmental goals. This concern restricts the wider acceptance of consumers and decelerates the shift towards a transportation system that is more sustainable and free from fossil fuels, despite the implementation of substantial tax incentives and government regulations intended to accelerate the adoption of electric vehicles.

Range anxiety has a substantial impact on users of battery electric vehicles (BEVs), acting as a psychological barrier to their general acceptance. This anxiety stems from anxieties about the battery running out of power before reaching a destination or a place to charge, and also includes worries about the amount of time it takes to charge. These concerns impact users' charging habits and travel plans, taking consideration the availability and duration of charging at infrastructure points. The combination of worries connected to distance and time not only affects the decisions made about everyday vehicle usage, but also discourages potential purchasers who compare the convenience of traditional vehicles with the limitations of electric mobility [4]. A number of important factors affect consumer willingness to buy battery electric vehicles. One of the many issues that arises is range anxiety, which is caused by the battery's limited driving range. [5]. The adoption of electric vehicle (EV) technology leads to a substantial decrease in emissions and reduces dependency on fossil fuels, representing a pivotal advancement towards achieving environmental sustainability and ensuring energy security. Nevertheless, the restricted distance that electric cars (EVs) can go in comparison to conventional gasoline vehicles is a significant factor in causing users to experience range anxiety. The worry about the possibility of not having enough battery power to reach a destination or a place to charge the electric vehicle is still a significant obstacle to the widespread acceptance of EVs, despite the advantages of this technology in reducing pollution and promoting a transition away from non-renewable energy sources. [6].

The adoption of electric vehicles (EVs) is an essential and unavoidable step in the pursuit of sustainable transportation, motivated by the pressing requirement to decrease carbon emissions and address climate change. Nevertheless, the fear of running out of battery power, known as range anxiety, poses a significant barrier to the widespread adoption of electric vehicles. Despite the environmental and economic advantages, it impedes customer confidence and readiness to adopt EV technology. Conquering this barrier is crucial for expediting the acceptance of electric automobiles. [7]. The primary obstacle to the widespread adoption of electric vehicles (EVs) in Indonesia is mostly due to range anxiety experienced by users, which is caused by the limited availability of charging or battery swapping infrastructure. Furthermore, there is a continuous discussion regarding the supremacy of charging stations compared to battery swap stations, which requires a thorough examination that takes into account demographic, geographic, cultural, and socio-economic viewpoints. [8]. Range anxiety is a significant obstacle that is preventing the broad acceptance of battery electric vehicles (BEVs). Range anxiety, caused by the dread of running out of battery power before reaching a destination or charging point, has a substantial impact on both daily car usage and the consumer market's desire to adopt electric mobility. The restricted range of electric vehicles, in comparison to conventional gasoline-powered vehicles, worsens these problems, impacting customers' charging routines and travel arrangements. Although EV technology provides significant environmental and economic benefits, including as huge reductions in emissions and reduced dependence on fossil fuels, the fear of running out of battery power, known as range anxiety, continues to be a significant obstacle. This barrier not only impacts individual choices but also presents a difficulty to the overall market expansion of electric vehicles (EVs).

In order to successfully alleviate concerns about limited driving range among individuals considering or already using electric vehicles (EVs), a comprehensive strategy is required. This strategy should primarily prioritize the advancement of technological complexity, namely in the field of battery technology. Cutting-edge battery technologies that provide extended driving ranges, accelerated charging times, and enhanced durability are essential for effectively tackling the root cause of range anxiety. This technological advancement holds the potential to increase the range of electric cars (EVs) on a single charge, so making them more convenient to use and comparable to traditional vehicles. Nevertheless, technological progress alone is unable to completely solve the problem of range anxiety. The development of charging infrastructure is equally crucial. Increasing the number of charging stations, particularly those that offer fast-charging capabilities, in various locations such as cities, rural areas, and important transportation routes, guarantees drivers a dependable and uninterrupted access to charging facilities. This network development alleviates concerns about depleting battery power at a significant distance from a charging station, hence improving the convenience of using electric vehicles for both long trips and regular commuting.

In addition to technical and infrastructural progress, support systems such as customer support are crucial. Superior customer service that offers expert advice, knowledge, and support for electric vehicle (EV) consumers. Customized customer assistance that specifically answers the concerns and inquiries of electric vehicle (EV) consumers has the potential to clarify the technology, hence enhancing its accessibility and reducing its perceived complexity. This kind of assistance not only alleviates concerns about the limited distance an electric vehicle can travel without recharging, but also promotes a favorable overall experience with electric transportation. Therefore, this article goes beyond solely analyzing the technological aspects of electric vehicle (EV) adoption. It explores the equally important function of customer service. The report emphasizes the importance of considering and solving both the physical and psychological obstacles to electric vehicle (EV) adoption by incorporating several comprehensive strategies. Given the complex strategy for reducing concerns about limited driving range in the deployment of electric vehicles (EVs), we put up the following hypothesis:

- Technological sophistication, significantly decreases range anxiety among potential and current EV users.
- The expansion and strategic distribution of EV charging infrastructure significantly decreases range anxiety among potential and current EV users.
- Enhanced customer support for EV users significantly decreases range anxiety among potential and current EV users.

## **2. LITERATURE REVIEW**

Range anxiety is a psychological condition that affects both consumers and vehicle operators. It is caused by worries about the restricted distance that electric cars (EVs) can go without needing to be recharged. It includes the concern felt by consumers regarding the ability of electric vehicles (EVs) to go the necessary distances without depleting their energy supply, as well as the operator's anxiety about the vehicle running out of power during a voyage. The anxiety surrounding the vehicle's durability and the accessibility of charging infrastructure is recognized as a crucial barrier to the broader acceptance and adoption of electric mobility. This emphasizes the need of comprehending customer behavior towards electric vehicles. [9], [10], [11]. Perceived Technological Sophistication in this study refers to the degree to which persons see electric cars (EVs) as progressive, inventive, and modern products within the automobile industry. This construct incorporates the perception of electric vehicles (EVs) as symbols of advanced technology, showcasing modernity through their form and functionality, and symbolizing the most recent technological progress in the industry. This survey measures the opinions of the participants regarding the level of sophistication and innovation present in electric vehicles. It evaluates their perspectives on the technological advancements that electric vehicles represent in the automotive industry. [12], [13], [14], [15]. Previous study indicates that perceived ease of use in technology can accelerate the adoption rate of new technology in society [16], [17] and technology also one of competitive advantages for businesses to keep inline with the environment [18].

Technological advancement is essential in overcoming range anxiety, a major obstacle to the general acceptance of electric cars (EVs). Electric vehicle (EV) owners frequently misunderstand how well the battery capacities of available EVs align with their transportation requirements, which results in a desire for extended battery ranges and a hesitancy to embrace EVs. In order to reduce concerns about the limited range of electric vehicles, several solutions have been suggested. These include creating efficient charging management systems for EVs that can be charged while driving, incorporating intelligent human-machine interfaces (HMIs) that offer accurate strategies for dealing with range limitations, and addressing both user perception and actual factors that impact the range of EVs. These technological developments have the objective of enhancing the assurance of electric vehicle (EV) consumers, mitigating concerns about limited driving range, and fostering the acceptance and implementation of EV technology. [6], [19], [20], [21]. The exploration of technology solutions aimed at decreasing range anxiety reveals a notable relationship between technological sophistication and range anxiety. A charging station is a facility designed to supply electric power for charging electric vehicles (EVs) [22]. Charging stations play a crucial role in promoting the widespread use of electric vehicles (EVs) and the transition to a sustainable transportation system. The presence and ease of use of charging

infrastructure play a crucial role in motivating potential customers to switch from conventional to electric vehicles, thereby eliminating a major obstacle to the widespread adoption of EVs.

The density of charging stations is directly correlated with the level of range anxiety experienced by individuals when considering the adoption of electric vehicles. (EVs) [23], [24]. Increasing the number of charging stations might mitigate range anxiety, which is the apprehension of running out of battery power while traveling. [25]. The presence of charging stations offers reassurance to electric vehicle (EV) customers, ensuring that they can conveniently locate a charging port when necessary, so alleviating worries about depleting their battery charge. [26]. Consequently, this can enhance the inclination to embrace electric vehicles (EVs) by tackling one of the primary obstacles to their extensive use. [27]. Moreover, the effectiveness of charging stations is influenced by their proximity to densely populated regions and the presence of existing charging stations. In general, the existence and ease of access to charging stations are extremely important in reducing concerns about the limited range of electric vehicles and encouraging their widespread use. Customer support represents the communication and assistance provided by a corporation to customers following their purchase of a product. The role include responding to customer inquiries, resolving technical issues, diagnosing and rectifying product defects, and delivering comprehensive assistance to improve the client's satisfaction. [28]. Customer support is necessary for guaranteeing consumer satisfaction and cultivating lasting relationships with customers. The initial interaction with customers is frequently the primary point of contact and has the potential to greatly influence their image of the firm. [29], [30].

This study aims to explore the correlation between customer support and range anxiety by analyzing the overall connection between customer support and customer anxiety in general. Due to the lack of extensive research on the direct impact of customer support on range anxiety in the electric vehicle (EV) industry, this technique enables us to deduce the possible effect of customer support in reducing range anxiety. Recent study in different fields highlights the crucial importance of customer support and services in reducing consumer anxiety. This research reveals a complex connection that covers multiple aspects such as Web 2.0, omnichannel platforms, social anxiety, and e-commerce environments. Research indicates that increased customer involvement and support through Web 2.0 can enhance the quality of e-services. Additionally, studies on omnichannel customer experiences reveal that anxiety plays a role in moderating the relationship between consumer psychology factors and loyalty. This suggests that implementing effective customer service strategies can help alleviate anxiety in these circumstances. Moreover, those who experience social anxiety have a preference for particular online customer care channels. This highlights the importance of adapting customer support to meet the various demands of consumers. Relational marketing strategies that focus on mental benefits, trust, and hedonic value can help alleviate anxiety in e-commerce transactions. This highlights the importance of customer support in reducing consumer anxiety and promoting a positive relationship between the business and its customers. [31], [32], [32], [33].

Thus, Based on the above literature review, the hypothesis for this study is as follows:

- Hypothesis 1 (H1): Higher perceived technological sophistication among consumers is inversely related to the intensity of range anxiety.
- Hypothesis 2 (H2): The density and strategic location of charging stations are directly related to the alleviation of range anxiety
- Hypothesis 3 (H3): customer support plays a critical role in reducing range anxiety in the context of electric vehicle (EV).

### **3. METHOD**

The purpose of empirical testing is to assess the correlation between perceived technological sophistication, charging station density, customer assistance, and range anxiety in the context of electric vehicle (EV) adoption. This study especially targets respondents in Indonesia who possess expertise in electric vehicles (EVs), so ensuring that the data collected accurately represents the perspectives of individuals who are

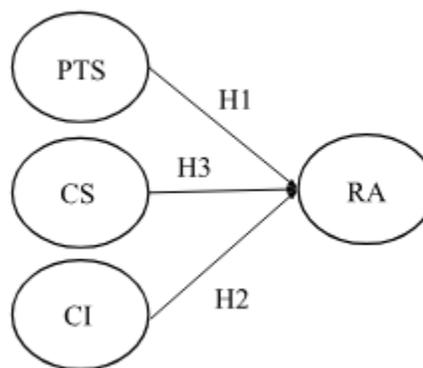
already well-versed in EV technology. The minimum sample size needed to obtain a confidence level of 95% and a margin of error of 10% has been determined to be 97 respondents. The study will utilize a non-probability sampling technique, namely convenience sampling, to collect data. The survey will be disseminated in Bandung to individuals who have exhibited expertise in electric vehicles, with the objective of gathering a diverse array of perspectives and experiences pertaining to EV utilization.

Before distributing the survey, the variables will be operationalized to match the defined concepts in the study context. The operationalization process entails defining indicators for each variable to ensure that the survey items effectively capture the core aspects of perceived technological sophistication, charging station density, customer support, and their impact on range anxiety among potential and current electric vehicle (EV) users.

**Table 1. Variables Operationalization**

Variables	Indicators
Range Anxiety (RA)	Concern about the mileage of electric vehicles (EVs)
	Mileage concerns on decision-making regarding electric vehicles.
Perception of Technological Sophistication (PTS)	Electric vehicles as highly sophisticated and innovative products.
	The technology behind electric vehicles conveys modernity.
Customer Support (CS)	Satisfaction with customer support for electric vehicle owners
Charging Infrastructure (CI)	The availability and convenience of electric vehicle (EV) charging stations.
	Adequacy of the charging infrastructure in Indonesia for daily use

Table 1 presents the operationalization of the main factors examined in this study, namely Range Anxiety, Perception of Technological Sophistication, Customer Support, and Charging Infrastructure. The measurement items for this study will be designed to reflect the defined indicators for each variable, in accordance with the operationalization.



**Fig 1. Research Model**

Figure 1 depicts the research model that illustrates the hypothesized connections among the main variables in the study: Perception of Technological Sophistication (PTS), Customer Support (CS), Charging Infrastructure (CI), and Range Anxiety (RA). Hypothesis 1 (H1) states that Perception of Technological Sophistication (PTS) has a direct impact on Range Anxiety (RA). Hypothesis 2 (H2) suggests that Charging Infrastructure (CI) directly affects Range

Anxiety (RA). Hypothesis 3 (H3) posits that Customer Support (CS) has a direct impact on Range Anxiety (RA). This research will apply Structural Equation Modeling (SEM) with a Partial Least Squares (PLS) approach, using the SmartPLS software, to investigate the given hypotheses.

#### 4. RESULT AND DISCUSSION

A sample of 146 respondents was analyzed to investigate the hypothesized relationships between perceived technological sophistication, charging station density, customer support, and range anxiety, within the context of electric vehicle (EV) adoption in Indonesia. The acquired data from the sample was analyzed using Structural Equation Modeling (SEM) using the Partial Least Squares (PLS) approach through the utilization of the SmartPLS software.

**Table 2. Construct Reliability and Validity Result**

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
CI	0.678	13.834	0.769	0.644
CS	0.887	1.052	0.943	0.893
PTS	0.767	1.162	0.882	0.79
RA	0.836	0.994	0.92	0.852

Table 2 presents the reliability and validity statistics for the constructs evaluated in the study. The constructs of Customer Support (CS) and Range Anxiety (RA) demonstrate strong internal consistency and validity across all metrics. Furthermore, the construct of Perceived Technological Sophistication suggests high reliability and convergent validity. The reliability of the Charging Infrastructure (CI) is a bit below the appropriate threshold as shown by Cronbach's Alpha. Nevertheless, it is still within acceptable bounds. The abnormal rho\_A result shows that recalibration or further study may be necessary. All constructs demonstrate high composite reliability and excellent Average Variance Extracted (AVE), showing that the survey items properly represent their respective constructs.

**Table 3. Discriminant Analysis Result**

	CI	CS	PTS	RA
CI	0.803			
CS	-0.029	0.945		
PTS	0.01	-0.089	0.889	
RA	0.199	-0.174	-0.202	0.923

Table 3 provides the results of the discriminant analysis using the Fornell-Larcker criterion. The matrix shows that all constructs have necessary discriminant validity. This is demonstrated by the fact that the square root of the Average Variance Extracted (AVE) for each construct (diagonal values) exceeds than its highest correlation with any other construct (off-diagonal values). The AVE square roots for Charging Infrastructure, Customer Support, Perceived Technological Sophistication, and Range Anxiety are 0.803, 0.945, 0.889, and 0.923 respectively. These values suggest the correlations between these factors are lower than their individual AVE square roots. These findings indicate that each construct is unique and encompasses occurrences that are not covered by the other constructs in the study.

**Table 4. Model Fit Result**

	Saturated Model	Estimated Model
SRMR	0.067	0.067
d_ULS	0.163	0.163
d_G	0.163	0.163
Chi-Square	166.571	166.571
NFI	0.635	0.635

Table 4 exhibits the model fit indices for both the saturated and estimated models in the study. The SRMR (Standardized Root Mean Square Residual), d\_ULS (Unweighted Least Squares Discrepancy), and d\_G (Geodesic Discrepancy) all show the same values for both models. The SRMR value of 0.067 is below the commonly accepted threshold of 0.08, indicating a satisfactory fit. Furthermore, the d\_ULS and d\_G values demonstrate equality in both models, demonstrating that there is no apparent disparity in the satisfactory level of fit between the saturated and estimated models. The Chi-Square statistic reveals a significantly high value. Nevertheless, it is important to consider that this statistic is influenced by the size of the sample, which may mitigate any potential concerns. The Normed Fit Index (NFI) has a value of 0.635, which falls below the intended threshold of 0.9. This indicates that there is room for improvement in the fit of the model. Overall, whereas certain indices such as SRMR show a satisfactory fit, others such as NFI imply that the model's ability to explain may be improved with more adjustments.

**Table 5 Path Coefficient Result**

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics ( O /STDEV)	P Values
Charging Infrastructure -> Range Anxiety	0.196	0.18	0.119	1.647	0.1
Customer Support -> Range Anxiety	-0.188	-0.185	0.078	2.4	0.017
Perceived Technological Sophistication -> Range Anxiety	-0.22	-0.224	0.078	2.832	0.005

The path coefficients presented in Table 5 provide a clear indication of the degree of correlation and statistical significance of the correlations between Charging Infrastructure, Customer Support, Perceived Technological Sophistication, and Range Anxiety. The examination of the path coefficients shows numerous levels of significance for the connections between the components. The relationship between Perceived Technological Sophistication (PTS) and Range Anxiety is statistically significant, with a p-value of 0.005, which is lower than the standard significance level of 0.05. The correlation between Customer support (CS) and Range Anxiety is statistically significant, as indicated by a p-value of 0.017. This finding reinforces the importance of customer support when measuring Range Anxiety.

However, the relationship between Charging Infrastructure (CI) and Range Anxiety, however it has a p-value of 0.100, does not meet the standard threshold for statistical significance. Within the parameters of this study, the impact of Charging Infrastructure on Range Anxiety is not statistically apparent. Further research is needed to fully understand its significance in relation to the adoption of electric vehicles. The absence of statistical significance in the correlation between Charging Infrastructure (CI) and Range Anxiety, specifically in the Indonesian context, can be attributed to various factors closely associated with the particular characteristics of the respondents and the current type of electric vehicles (EVs) in use.

**Table 6. Path Coefficient Result**

	CI	CS	PTS	RA
CI				0.196
CS				-0.188
PTS				-0.22
RA				

The examination of the path coefficients in Table 6 offers useful information into the effect of Charging Infrastructure, Customer Support, and Perceived Technological Sophistication on Range Anxiety among electric vehicle (EV) customers. The strong inverse correlation between Customer Support and Range Anxiety underscores the crucial role of high-quality customer service in addressing concerns related to the use of electric vehicles. Professional customer service that provides dependable aid and knowledge on electric vehicle maintenance and charging can significantly reduce users' anxieties. Moreover, the strong inverse correlation between Perceived Technological Sophistication and Range Anxiety highlights the influence of customers' beliefs regarding electric vehicle (EV) technology. An essential approach for reducing range anxiety and promoting wider adoption of electric vehicles (EVs) is to educate both future and present EV users about the sophisticated technology that powers EVs and its capability to meet their transportation requirements. These findings indicate that a comprehensive approach is needed to tackle range anxiety, with a focus on customer assistance and technology education in addition to infrastructure improvement.

The absence of statistical significance between Charging Infrastructure (CI) and Range Anxiety could be attributed to the particular characteristics of the study's respondent pool and the unique nature of the EV market in Indonesia. Firstly, the survey participants, who are mainly individuals aware about EV technology but not necessarily owners, may create their opinions about CI based on theoretical knowledge or information from others, rather than their own firsthand experience with EV charging. The lack of direct experience with charging infrastructure may lead to a diminished understanding of how it affects range anxiety. This is because their evaluations of the sufficiency of the infrastructure are not influenced by the daily need for charging. Furthermore, the prevalence of electric motorbikes in the Indonesian electric vehicle industry may influence the perception of the sufficiency of charging infrastructure. Considering the lower power requirements and more charging flexibility of motorcycles compared to electric cars, respondents may perceive the current charging infrastructure as adequate for their current needs, especially for motorcycle users. This viewpoint may underestimate the importance of a comprehensive public charging infrastructure, consequently impacting the perceived connection between electric vehicle charging infrastructure and the fear of running out of battery power, particularly in a market where motorcycles are widely used for transportation.

After analyzing the path coefficients and gaining a detailed understanding of how Charging Infrastructure, Customer Support, and Perceived Technological Sophistication impact Range Anxiety, several recommendations for EV adoption namely:

- To improve customer support, it is essential for electric vehicle (EV) manufacturers and service providers to invest in enhancing the quality of customer assistance, as there is a strong negative correlation between customer support and range anxiety. This may entail instructing personnel to offer specialized guidance on electric vehicle maintenance and charging, creating extensive web materials, and guaranteeing prompt and supportive customer care channels. It is essential to prioritize the accessibility and informativeness of customer service, specifically focusing on answering often encountered problems and queries regarding the utilization of electric vehicles (EVs).
- Emphasize Technology Education: The strong inverse correlation between Perceived Technological Sophistication and Range Anxiety indicates that educating the general population about the technological progress in electric vehicles (EVs) is crucial for reducing range anxiety. Possible measures could encompass public seminars, informational campaigns, and partnerships with educational institutions to emphasize the efficacy, dependability, and advantages of electric vehicle technology. The objective of these initiatives

should be to clarify the technology behind electric vehicles (EVs), highlighting how it fulfills the transportation requirements of customers and underscoring its ongoing progress.

- Tailoring Communication for Various EV Types: To effectively engage with the Indonesian EV market, particularly electric bikes, it is crucial to customize communication and marketing approaches to cater to the unique needs and preferences of motorcycle consumers. This may entail emphasizing the convenience and adaptability of charging alternatives for motorcycles and using specific strategies to instill trust and assurance among this particular group of users.

By implementing a comprehensive strategy that encompasses customer assistance, advanced technological education, and customized charging infrastructure development to cater to the specific requirements of the Indonesian market, stakeholders may successfully mitigate range anxiety and encourage greater acceptance of electric vehicles.

## 5. CONCLUSION

The analysis performed in this research presents compelling data concerning the hypothesized relationships that impact Range Anxiety among electric vehicle (EV) customers in Indonesia. The observed inverse correlation between Customer support and Range Anxiety reinforces the idea that proficient customer assistance plays a vital role in mitigating concerns over the use of electric vehicles, underscoring the need of dependable and informed customer care. The presence of a strong negative correlation between Perceived Technological Sophistication and Range Anxiety confirms the hypothesis that consumers' perceptions of the technological advancement of electric vehicles (EVs) are crucial in alleviating concerns about limited driving range. This emphasizes the need to educate consumers about EV technology. Nevertheless, the idea that the presence of Charging Infrastructure would have a substantial effect on Range Anxiety was not corroborated, as this correlation did not demonstrate statistical significance. The limitation of this research arises from the relatively small sample size of 146 respondents, as well as the fact that not all participants definitely had an electric vehicle (EV). Notwithstanding this constraint, the study provides significant perspectives on potential approaches to alleviate range anxiety among a wider demographic. It emphasizes the need of improving customer assistance and utilizing technological education as crucial methods for overcoming a major obstacle to the adoption of electric vehicles. Further investigation utilizing a more extensive and heterogeneous sample, which includes individuals who currently possess electric vehicles, might be advantageous in corroborating and broadening the scope of these discoveries.

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