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Opportunities For Utilization of Plywood Waste in Sustainable Interior Industry

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ABSTRACT

The interior industry in Indonesia is experiencing rapid growth, particularly in furniture production using plywood materials. However, this growth has resulted in increased waste, with plywood scraps contributing to environmental degradation and deforestation. Previous studies have addressed sustainable material use in interior design, but most focus on general waste reduction or material selection. A significant gap remains in systematically exploring derivative product development from small plywood scraps (less than 30 cm in width), which constitute 8–10% of furniture production waste. These scraps are often discarded or burned despite their potential for reuse. This research addresses the gap by analyzing the utilization of small plywood pieces as derivative products to enhance material efficiency and support sustainable practices in the interior industry. This study employed a mixed-method approach combining qualitative and quantitative analyses through a case study of a plywood-based kitchen set project. Data were collected through documentation of design plans and material usage, followed by thematic grouping of leftover materials, numerical efficiency calculations, and the development of derivative prototypes. The results demonstrated that optimizing small plywood pieces reduced residual waste from 8.6% to 0.105%. Around 20.7% of leftovers were reusable, and 8.6% were converted

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into derivative products such as shelves and lampshades. These findings highlight that derivative product development can minimize waste, reduce raw wood demand, and lower deforestation risk. The study recommends designing modular components in multiples of 30–60 cm to maximize plywood efficiency and suggests broader adoption of derivative product innovation to strengthen sustainability in the interior industry.

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1. INTRODUCTION

In response to this trend, the interior industry has experienced rapid development, especially in the furniture sector that uses processed wood products such as plywood, blockboard, HMR, MDF, PVC board. This processed wood is one of the materials that are in great demand by the public, considering the economic price that is easily accessible to the public, as well as the abundance of this material in the market so that it is easy to obtain.

Plywood has become a popular choice due to its combination of strength, flexibility, and affordability. However, the production process of multiplex-based furniture and interior elements often results in small leftover pieces that are usually unused and eventually have to be discarded or burned. This is not in line with the concept of sustainability, as it only adds to waste and is not effective in waste management. According to (Basara et al., 2019) and (Burton & Wilson, 2012), regulation on environmentally friendly industrialization is an important issue (Nasir et al., 2015).

The concept of sustainable architecture has gained significant traction in recent years, emphasizing the need for environmentally responsible and resource-efficient practices throughout the life cycle of buildings (Kibert, 2016). A key aspect of sustainable architecture is the efficient use of materials, which directly impacts deforestation rates and the overall environmental footprint of the construction and interior design industries.

With people's awareness of environmental sustainability increasing, the interior industry is constantly looking for innovations in exploiting every part of the material, including leftover small plywood pieces. This way the demand for raw wood can be reduced. This is in line with the principle of sustainable architecture, which aims to minimize the environmental impact of building and design practices. Proper materials management can add value to plywood-based products. For example, plywood waste can be used to make various derivative products such as lampshades, and other creative crafts, thus optimizing the use of materials and reducing environmental impact.

Developing derivative products from small plywood pieces offers a significant opportunity to improve material effectiveness in the interior industry while supporting the goal of sustainable architecture. Not only does the development of these derivative products increase the efficiency of material use, but also for a designer, it is a challenge to think creatively to create a product from leftover materials that is appropriate, useful and economically valuable.

In addition, the focus on developing derivative products from small plywood pieces aligns with the principles of the circular economy, where materials that were previously considered scrap can be utilized to create valuable new products. This approach increases the efficiency of resource use and opens up new opportunities in design and product innovation. More importantly, it contributes to the reduction of demand for raw wood, potentially reducing deforestation rates and supporting sustainable forestry practices (O, 2020). By maximizing the use of existing multiplexes through derivative products, the interiors industry can significantly reduce the demand for new raw materials. This reduced demand can reduce tree cutting, contribute to forest conservation efforts, and align with the goals of sustainable architecture and design (UNEP, 2021).

Effective interior design solutions for limited spaces, and the material's emphasis on sustainable architectural practices, as well as the development of derivative products from small multiplex pieces offer good opportunities for interior businesses. This not only increases the effectiveness of this material in the interior industry but also contributes to broader sustainability goals. This research aims to explore and analyze the utilization of small pieces

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of multiplex material as derivative products, which can reduce waste and support sustainable architectural practices in waste reduction and create economic added value in the interior industry. This objective supports the principles of sustainable architecture through reducing the demand for wood-based plywood raw materials.

While there has been previous research into the use of materials in interior design, there is still a gap in the exploration of potential derivative products from small pieces of multiplex. This research fills this gap by focusing on design innovations that utilize leftover materials, and their impact on environmental sustainability.

1.1 Problem Statement

1. How can the development of derivative products from small plywood pieces contribute to sustainable architectural practices and reduce the rate of deforestation?
2. What are the potential innovative applications of small plywood scraps in interior design that can improve material efficiency and aesthetic value while supporting the principles of sustainable construction?
3. To what extent can the utilization of small plywood scraps for derivative products reduce the demand for raw wood in the interior and construction industries?

1.2 Research Objectives

This research aims to explore and analyze the utilization of small pieces of multiplex material as derivative products, which can reduce waste and support sustainable architectural practices in waste reduction and create economic added value in the interior industry.

2. LITERATURE REVIEW

2.1 Interior Industry and Enviromental Issues

In the interior industry process, there is a process of ordering from customers, processing materials, and how leftover materials can be used. The life span of a manufactured material has an end, which is when it can no longer fulfill its design function. Usually this situation leads to the accumulation of leftover materials (Elysia, 2014).This accumulated leftover material will only become waste if a designer cannot maximize the function of a material.

Sustainability in interior design focuses on creating spaces that are not only aesthetically pleasing but also environmentally friendly. It involves selecting materials and products that have minimal negative impact on the environment, emphasizing renewable resources, and reducing waste (Green Up Your Space: Eco-Friendly Interior Design Tips for Homes and Workplaces, 2021).

In the development of the field of design, the 'global warming issue' has become a major concern, giving rise to new terms in design studies such as: Green Design, Eco Design, Environmentally Friendly Design, Recycled Design, and so on, the point of which is that design is expected to be a solution to answer these problems (Purnomo, 2019) This is also a consideration for designers in their work.

In the professional ethics competency unit, a designer is required to carry out sustainable environmental preservation, including: respecting and preserving culture, paying attention to the impact of product use on the environment, paying attention to the health of space users, and realizing the limited natural resources used (Himpunan Desainer Interior Indonesia (HDII), 2005). In the National Conference (Munas) XI of the Indonesian Interior Designers Association (HDII) in 2008, Solichin Gunawan as the HDII Code of Ethics Council, reminded in his speech that entering the 21st century, environmental issues have become very important due to the exhaustive exploitation of the environment. This requires the sensitivity of interior

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designers in carrying out their professional services based on their professional commitment and ethics to be responsible for human life and the culture of their era by producing design works that are beneficial to humans and their environment (Himpunan Desain Interior Indonesia (HDII)., 2008).

2.2 Use of Plywood Material

Materials are a very important element in design and affect sustainability in the interior environment (Primadani et al., 2019). To create a sustainable interior design, the use of durable and effective interior materials will help in its effect on the environment.

Table 1. Comparison of Materials in The Interior Industry

Material Name	Excess	Disadvantages
Plywood	Its resistance to shrinkage makes it less prone to warping and expansion and its length and width are impossible to obtain from solid wood.	The thickness side can potentially absorb water and is sometimes found to lack precision in thickness.
Blockboard	It is cheaper than plywood and is also quite strong as it is made from solid pieces of wood.	Because it is made from pieces of wood that are joined not from one whole solid sheet of wood and even made from soft type wood blockboard is not stronger than plywood and there is even a tendency to break at the wood meeting.
MDF board	The surface is smoother and flatter than Plywood, making the finishing process easier. MDF is also flexible and easy to mold, making it more versatile for making anything.	It is not water and moisture resistant so it has the potential to grow mold and rot. Then screws and nails installed on MDF are likely to loosen faster because MDF is made of fine particles whose density is not too high.
HMR Board	Water and moisture resistant, reducing the potential for mold and other harmful parasites to grow. A solution for furniture in humid areas. The weight is also light and easy to process and the surface is smooth and flat, making the finishing process easier, no need for a lot of sandpaper and putty.	The price is quite expensive, almost on par with plywood. But for moisture and water resistant solutions, it is still much cheaper than PVC board and in terms of strength, it is not as strong as plywood.
HDF board	The pores are tight and smooth, making it easy to finish, especially for painting. Then the layers are stiff and dense so that they can withstand heavy loads and can also hold couplers firmly. HDF is also quite waterproof compared to other types of fiberboard.	It is considered too heavy and also has the potential to break as it is hard and lacks flexibility.

Source: majalahproperti.com/kayu-olahan

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The table below compares materials in terms of strength, durability, and water resistance:

Table 2. Comparison of materials on a scale (1 is the lowest value, and 6 is the highest value)

	Plywood	Blockboard (POLOS)	HDF	HMR	MDF	Particle Board
Kekuatan Beban	6	5	4	3	2	1
Ketahanan Rayap	5	4	3	6	2	1
Ketahanan Air	5	4	3	6	2	1
Harga	6	4	3	5	2	1
Berat material	6	5	4	3	2	1
Ukuran	120X240	120X240	120X240	120X240	120X240	120X240
Ketebalan	3-18mm	15-30mm	6-24mm	3-18mm	3-25mm	9-25mm

Source: majalahproperti.com/kayu-olahan/

3. METHODS

The research method used a qualitative approach with a case study design on a project. This approach explores in depth the use of multiplex materials in interior projects and the analysis of the residual materials generated (Ezzati et al., 2014). The case study was conducted on an interior project using plywood materials, which was selected based on sustainability, design innovation, and relevance to the research objectives (Buchanan, 1992). The sample will be purposively drawn from projects that contain planning drawings and have adequate documentation of material use and scrap management (McDonough & Braungart, 2002).

The data collection technique used was a documentation study. Collecting project-related documents such as design plans and material usage reports. This data collection helps in analyzing the use of materials and the resulting scraps. The processing of data collected from the documentation study will be analyzed using a thematic approach. The research will identify emerging patterns and modules related to the use of plywood materials and the grouping of leftover materials. Numerical data on the amount of material used and the residual material generated will be calculated to provide a quantitative picture of the effectiveness of material use in percentage. The results of the grouping of leftover materials are used for innovative and creative derivative interior processing utilization. Design prototypes will be evaluated to assess the feasibility and creativity in the utilization of leftover materials (Bhamra & Lofthouse, 2016).

The processing of the derived interior results will be calculated thematically to produce unused residual materials after the processing of the main materials. The numerical data on the second processing result is not grouped because the remaining material produced is very small. The results of the qualitative and quantitative analyses will be used to draw conclusions about the effectiveness of using multiplex materials for derived interior products. Provide recommendations for best practices in sustainable interior design (Fletcher, 2013). With this approach, the research is expected to provide an overview of the efficiency that supports the principles of sustainable architecture. The results of this research are expected to contribute significantly to the development of design strategies that are more environmentally friendly and support efforts to conserve natural resources.

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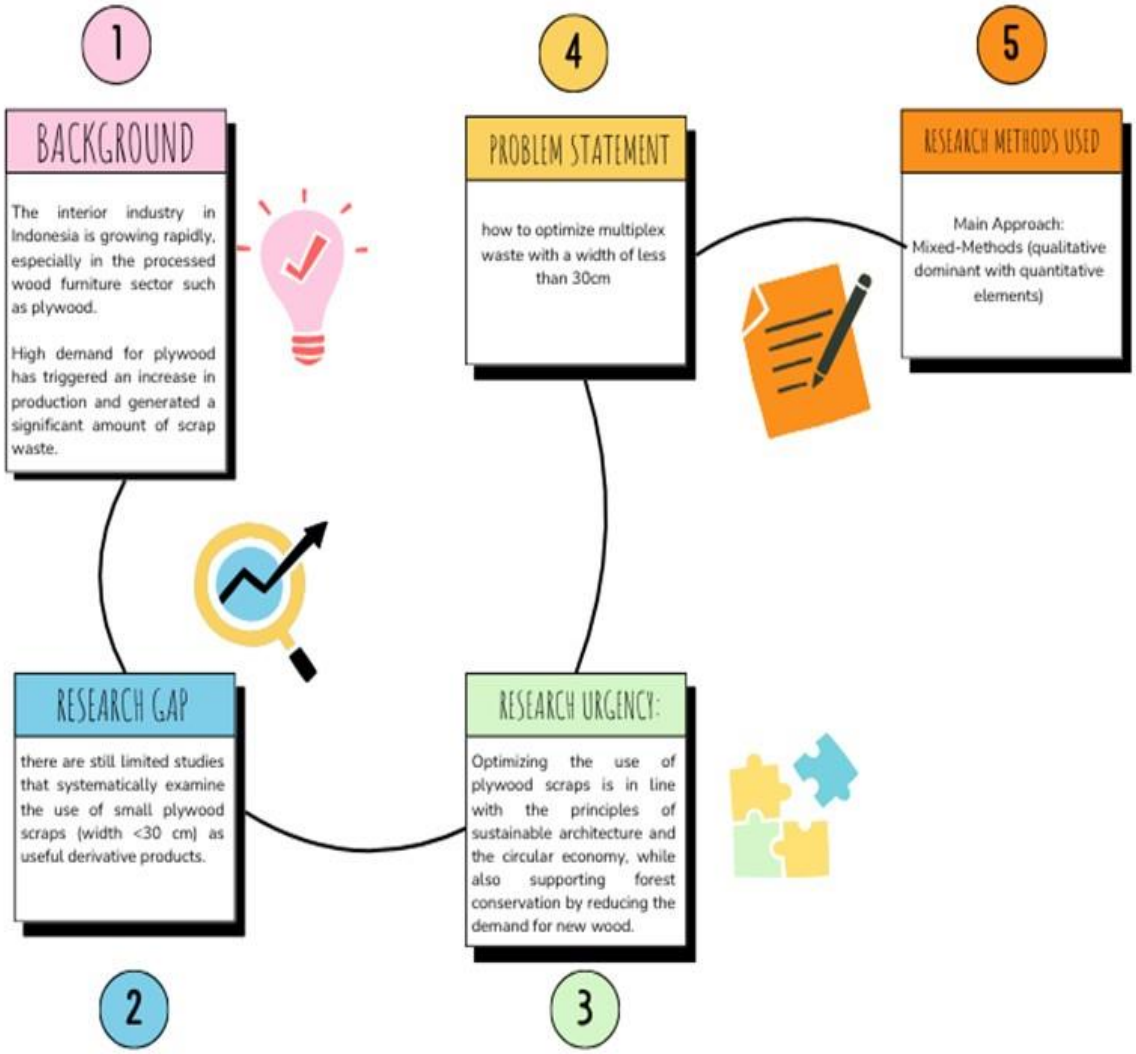

Graphic 1. Research Stages
(Source: Author, 2024)

The figure below shows the research flow using a mixed method approach, which combines qualitative and quantitative methods. This approach is used to obtain a comprehensive understanding of the utilization of plywood waste, from the data collection and analysis stage to the development of derivative products, prototype evaluation, and analysis of results and recommendations.

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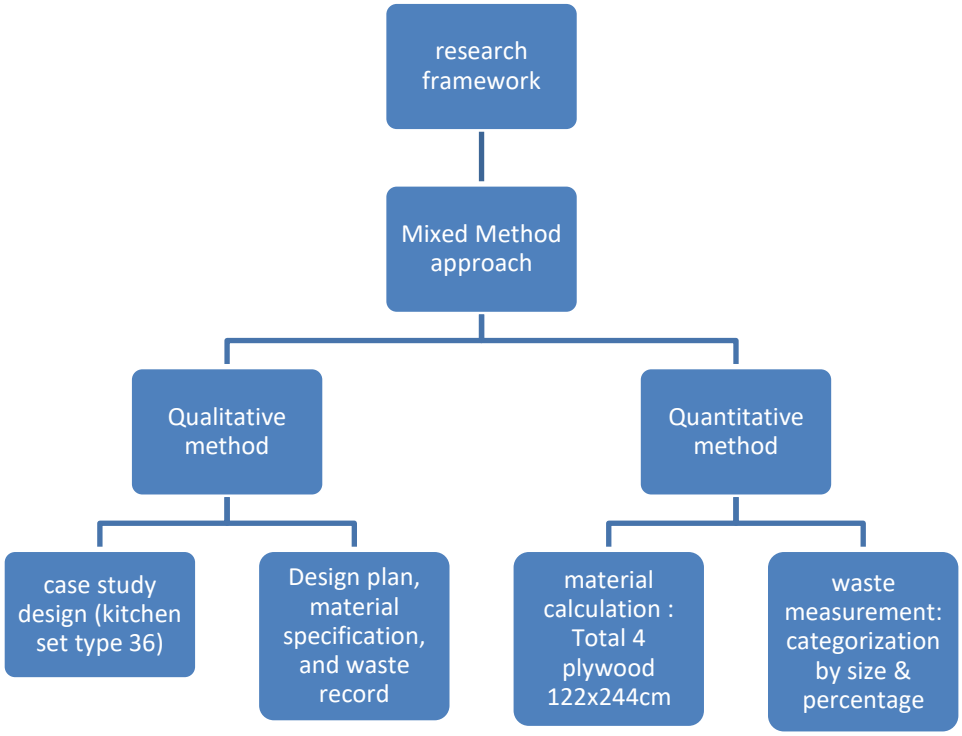

Graphic 2. Research graph
(Source: Author, 2024)

4. RESULTS AND DISCUSSION

In general, furniture materials that support sustainable development are environmentally friendly, including materials that are low in waste, meaning that they can be reused, and easily recycled or upcycled (Putri & Fivanda, 2022). Meanwhile, when looking at the “Greenship Rating Tools for Indoor Spaces” ” (Green Building Council Indonesia, 2012)

1. Purchasing Policy,
2. Waste Management Policy,
3. Use of Refrigerant without ODP,
4. Preserving Used Materials
5. Certified Wood,
6. Low Environmental Impact Materials,
7. Eco-friendly Cleaning Materials,
8. Waste Management Practices,
9. Purchasing Practices.

Some of the various processed wood materials that are in demand by the interior industry in Indonesia are plywood or multiplex and wood fiber boards with various densities. Multiplek is a board composed of several layers that are glued together and compressed with high pressure. Its utilization produces less waste or residual material than wood, if the design process has considered material conservation (Paryoko & Rachman, 2023). Leftover interior projects, such as plywood and high pressure laminate (HPL) can also be managed into derivative furniture products (Asmoro & Widagdo, 2021).

The simulation sample is a kitchen set in a type 36 house. The following are the specifications of the simulated furniture design kitchen set with size:

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- Top cabinet : 180cm long, 35cm wide, and 80 cm high.
- Bottom cabinet : 100 cm long, 70 cm wide, and 63 cm high.

Figure 1 Interior Design Kitchen
(Source: Author, 2024)

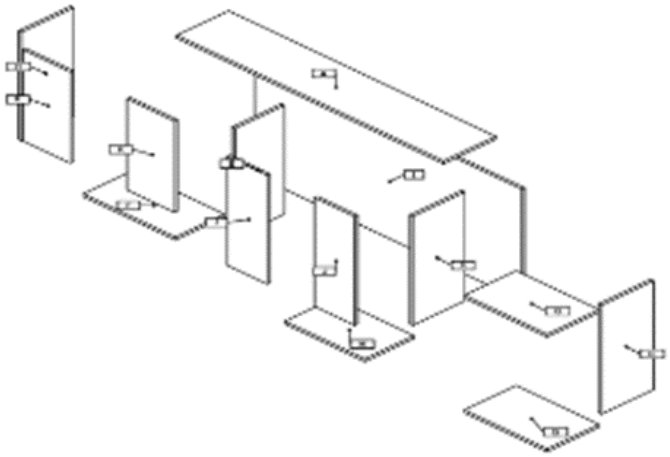

Figure 2 Explode Top Cabinet
(Source: Author, 2024)

From the top cabinet module, we need 2 pieces of 18mm plywood, and can be cut into modules as below.

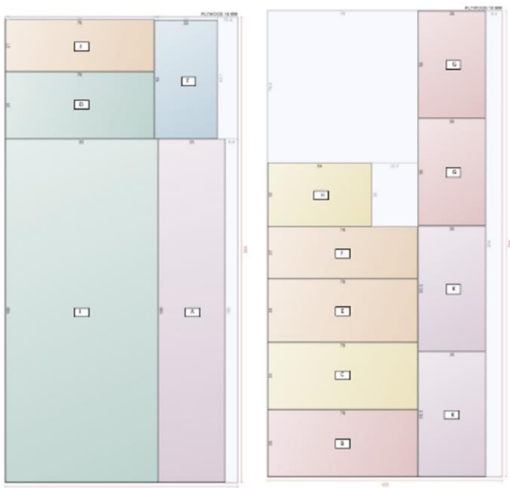

Figure 3 Moduler Eksploda Top Cabinet
(Source: Analysis, 2024)

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Based on the image above, the size needed to make the Upper Cabinet Explosion is in the table below:

Table 3 Material Requirement table of the upper cabinet

Panel	Label	Qty
35x78	D	1
180x35	A	1
62x33	F	1
180x80	I	1
27x78	J	1

Panel	Label	Qty
35x78	B	1
35x78	C	1
33x78	E	1
56x35	G	2
33x54	H	1
27x78	J	1
65.5x35	K	2

(Source: Analysis, 2024)

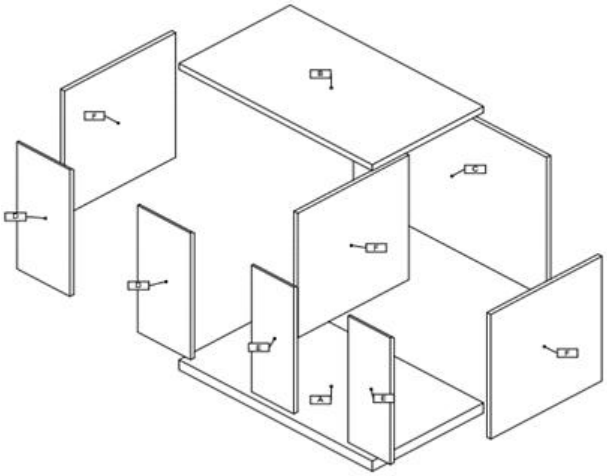

Figure 4 Bottom Cabinet Explodes
(Source: Analysis, 2024)

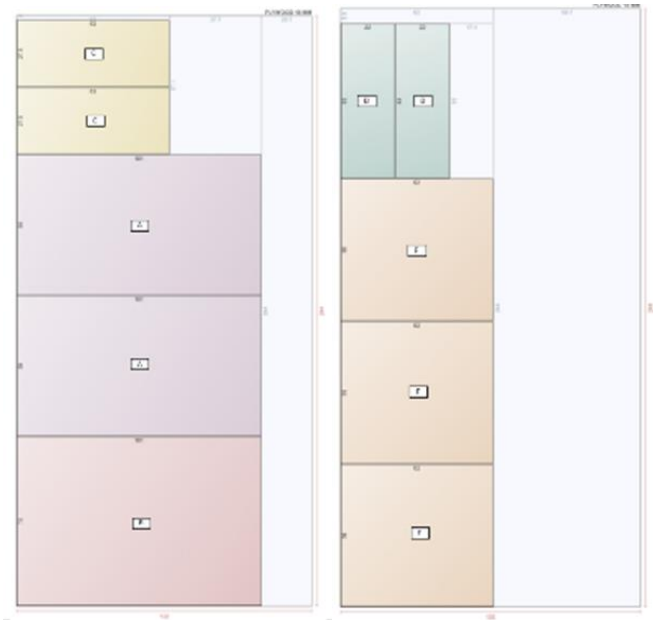

Figure 5 Moduler Explodes Bottom Cabinet
(Source: Analysis, 2024)

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Table 4 Material Requirement table of the lower cabinet

Panel	Label	Qty
70x101	B	1
27.5x63	C	2
58x101	A	2

Panel	Label	Qty
63x22	D	2
58x62	E	3

(Source: Analysis, 2024)

From the case study in type A, it is found that from the existing modular interior industry requires 4 plywoods for 1 kitchen set type A. The remaining materials of each plywood are as follows:

Table 5 Residual Material Analysis Table

Remaining material 1 (in cm)	Remaining material 2 (in cm)	Remaining material 3 (in cm)	Remaining material 4 (in cm)
10.4 x 63.7	23.7 x 33	57.1 x 58.4	5.8 x 44
6.4 x 180	78 x 79.5	20.7 x 186.9	17,4 x 68.8
1.5 x 109.6	8.4 x 244	3 x 63	59.7 x 244

(Source: Author, 2024)

Table 6 Analysis of Needs and Leftover Materials

	Residual size (in cm)	Area (in cm^2)	Percent (%)
Total plywood	4x 29.280	117.120	100 %
Remaining plywood with a width above 30cm	78 x 79,5 57,1 x 58,4 59,7 x 244	24.102,44	20.7 %
Leftover plywood with a width of 10-30 cm	10,4 x 63,7 23,7 x 33 20,7 x 186,9 17,4 x 68,8	6.510,53	5,5 %
Leftover plywood with a width of 3-10 cm	6,4 x 180 8,4 x 244 5,8 x 44 3 x 63	3.645,8	3.1 %
Remaining plywood under 3 cm	1,5 x 109,6	164.4	0.1 %

(Source: Analysis, 2024)

Keterangan :

Unusable scraps

Leftover materials that can still be used for the next project

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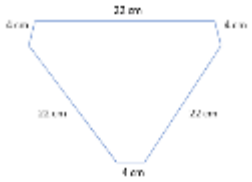
From the table above, we can see that 20.7% of the material can still be utilized for small modules in the next project, while 0.1% is waste that cannot be processed. In the remaining 8.6% of these pieces, if not reprocessed for a derivative product, then this residual material will eventually only become industrial waste that ends up being disposed of or burned.

The following products are derived from the remaining material, which is from the width above 3cm - 30cm.

Table 7 Derived Product Table

	Produk turunan yang dapat dihasilkan dari sisa material diatas	
Leftover plywood with a width of 10-30 cm	**Ambalan A (1 piece)** Size 10 x 60 cm **Ambalan B (1 piece)** Size 20 x 30 cm **Ambalan C (3 piece)** Size 20 x 60 cm **Ambalan D (1 piece)** Size 15 x 60 cm	
Leftover plywood with a width of 3-10 cm	**Square type lampshade** Size 20x20x5cm (2 piece) **Triangular type lampshade** Size 22cm,width 5cm (3piece)  **Rectangular lampshade** size 12x30x width 3cm (1piece)	  

(Source: Author, 2024)

Table 8 Residual material usage table

	Size of material used (in cm)	Unused waste (in cm)	All remaining materials (in %)
Ambalan A (1buah)	10,4 x 63,7 (A)	0,4 x 3,7 = 1,48 cm^2	
Ukuran 10 x 60 cm	23,7 x 33 (B)	0,7 x 3 = 2,1 cm^2	
Ambalan B (1buah)	20,7 x 186,9 (C)	0,7 x 6,9 = 4,83 cm^2	0.025%
Ukuran 20 x 30 cm	17,4 x 68,8 (D)	2,4 x 8,8 = 21,12 cm^2	
Ambalan C (3buah)			
Ukuran 20 x 60 cm		Total 29,53 cm^2	
Ambalan D (1buah)			
Ukuran 15 x 60 cm			
Kap lampu tipe persegi	6,4 x 180	1,4 x 20 cm^2	
Ukuran 20x20xlebar 5cm	8,4 x 244	3,4 x 10 cm^2	**0.08%**
(2buah)	5,8 x 44	2,8 x 14 cm^2	
Kap lampu tipe segitiga	3 x 63	0,3 x 1 cm^2	
Ukuran sisi 22cm, lebar 5cm (3buah)		Total 101,5 cm^2	

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	Size of material used (in cm)	Unused waste (in cm)	All remaining materials (in %)
Rectangular lampshade Size 12x30x wide 3cm (1 piece)			

(Source: Author, 2024)

The result of this study show that the development of derivative products from small pieces of plywood not only contributes to improving the effectiveness of material use in the interior industry, but also has a significant impact on environmental sustainability and reducing deforestation. By optimizing the use of the small pieces, this study recorded a reduction in residual waste material from 8.6% to 0.105%, reflecting efficiency in waste management. This is in line with the principles of sustainable architecture that emphasize the efficient use of natural resources and can significantly reduce the demand for raw wood, which in turn has the potential to reduce deforestation rates. This approach not only reduces the negative impact on the environment but also promotes awareness of the importance of effective waste management among designers and manufacturers.

5. CONCLUSIONS

The conclusion of this study confirms that the development of derivative products from small pieces of plywood can significantly improve material efficiency in the interior design industry and support sustainable architectural practices. By optimizing the use of such small pieces, this study shows a reduction in scrap material from 8.6% to 0.105%, which not only reduces waste but also contributes to the reduction of raw wood requirements. This has the potential to reduce deforestation rates and support forest conservation efforts. This research provides important insights into how innovation in waste management can create economically valuable products, encouraging the interior industry to be more committed to sustainability. A suggestion from the researcher is to design more efficient dimensions of furniture components by using multiples of 30cm, 40 cm and 60 cm so that the remaining pieces of one sheet of plywood can be maximally utilized for other furniture components.

Recommendations for future research include developing comprehensive waste management strategies for various types of materials. Life cycle assessment studies are needed to measure environmental benefits compared to traditional disposal methods, while market feasibility studies should analyze consumer acceptance and willingness to pay for derivative products. Technology integration studies exploring digital fabrication (CNC, laser cutting) and automated sorting systems can streamline the manufacturing process. Scalability assessments across various business scales, long-term economic analyses tracking financial impacts, and comparative case studies across different project types (living rooms, bedrooms, commercial interiors) will validate findings more broadly and support industry-wide adoption of sustainable practices.

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