

Design Adaptation of Wooden Furniture through Sustainability Design Strategy (Case Studies: Five Furniture Industries in Central Java, Indonesia)

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Abstract

There is a wide diversity of wood types with high quality in Indonesia. The change in the economic condition until the 21st century has increased the demand of furniture both domestically and internationally. Indirectly, the high demand of furniture has affected the availability of wood. In addition to producing designs that are accepted in the market, the industry and the designers must also consider the environmental aspects. The scarcity of materials has led to various strategies in using wood with the goals to sustain the materials and to use them efficiently. This study will present the models of design strategies used by five wooden furniture industries in maintaining the sustainability of design and the industry itself. Samples of cases were taken from the Central Java region as the center of the wood furniture industry in Indonesia. The result of this study will show the excellence in the sustainability values on Indonesian wooden furniture products, the products which are formed through the advantages of natural resources, the creativity in processing wood and the aesthetic aspects in it.

Keywords: wooden furniture, ecology, strategy, model

1. Introduction

1.1. Wood and Furniture in Indonesia

Furniture has become a commodity in Indonesia since long ago, particularly in Java. Various types of wood materials and superior human resources become the major factors in the development of furniture. Wood has specific properties that cannot be replicated by any other man-made materials. For example, wood is elastic, resilient, resistant to heavy load, and many other properties. The properties are not owned by concrete, steel, or other man-made materials. Tropical wood from Indonesia, such as teak and mahogany, has long been used as a material for furniture. Teak wood (*tectona grandis*) is a type of hardwood that is widely used to make furniture for the domestic market and export. The beauty of the fiber and the strength of teak wood has made it become the main material that was considered so valuable that it is used for furniture, buildings, ships, etc.

According to the Ministry of Industry and Trade of the Republic of Indonesia through the Furnicraft Today magazine, which is published regularly in cooperation with AMKRI, wood is the main material that dominates Indonesian furniture products as much as 67.02%. With so many government policies and regulations that are constantly changing, the industry should be able to survive in competition with large industry and imported products. Effendi and Dwiprabowo (2007) say that the wood raw material is one of the factors that determine the comparative advantages of the furniture industry and also make a major contribution in determining the cost of production. Various challenges that became the obstacles to develop are the government's regulation that is changing frequently; wood legality permits; policy of raw materials export and the system of regional autonomy that gives freedom without limitation in the management of natural resources. The size of the domestic market for furniture products is also characterized by the number of Indonesian population that is increasing and is predicted to keep growing.

Tabel 1.1. The Value of Furniture Export in 2014, based on the Raw Materials

(Source: Furnicraft Today Magazine, 2015)

No	Description	USD	Percentage
1	Wooden furniture	1.259.224.080	67,02%
2	Rattan furniture	172.781.750	9,19%
3	Bamboo furniture	2.129.645	0,11%
4	Metal furniture	45.821.375	2,43%
5	Plastic furniture	62.640.158	3,33%
6	Other	336.185.603	17,89%
	Total	1.878.782.612	100%

From time to time, the high demand of furniture and other wood products, both for export and domestic market, continues to increase. This affects the condition of the environment and the natural forests in Indonesia. According to the report from *Indonesia Forest Watch* in 2013, the degradation and loss of natural forest in a

large scale has begun to occur in Indonesia since the early 1970s, when some companies began to take over the forests and operate there. It is related to the fast economic and industrial growth in the new era that goes beyond the capacity of the natural resources. A decrease in the potential of forests as a producer of wood can be seen through the government policy which is related to the standard of the smallest wood diameter that can be harvested. In 1999, the smallest wood diameter that can be harvested in the areas of the Permanent Production Forest and Conversion Production Forest is 50 cm, while in the Limited Production Forest is 60 cm. In 2009, the smallest wood diameter that can be harvested in the areas of Permanent Production Forest and the Conversion Production Forest is 40 cm, while in the Limited Production Forest is 50 cm (Indonesia Forest Watch, 2013). The scarcity of wood materials has a major impact on the performance of the furniture industry. Therefore, a variety of other materials substitution which is derived from wood begins to develop. The symptoms and problems faced by the wood industry have led to the sustainability of wood material. This means that the environmental factor should be made into consideration. The concept of ecology is very important both from the technical and design aspects.

1.2. Ecological Culture & Sustainable Design

The concept of ecology emerged as a response of the human relationship with the environment. The culture formed occurs as human adaptation to the environment (Steward, 1955). The adaptation process is the core of the ecological culture. It is said that adjustments to the environment will continue to be done by humans in the present and by the next generation. According to Sutton (2010), initially, the emergence of ecological culture began from the study of human ecology that developed empirically. Therefore, the empirical approach, i.e. observation and experience, becomes one of the methods to study the process of adaptation to the environment (Sutton, 2010).

A broader view to the environment and the concept of ecology grew until the term sustainable design appeared. The development is characterized by the developing character of ecological design concept based on the lifestyle changes and global challenges. Ezio Manzini says that the character transition of ecology concept can be seen in the characters of the 1980s era, i.e., "the normalization of ecological design" to "the new radical view" in the 1990s era (Madge, 1997). One of the figures that talked about sustainable design is Victor Papanek (1971) who published a book titled "Design for the Real World". Until then, the field of sustainable design is recognized as an important study in the early 1990. The approach of reprocessing the materials (recycling), the activity of redesigning a product (reuse) is done with the eco-design approach in the late 1990s. The approach to sustainable design can be done in the use certain materials, such as wood. It is mentioned in the World Summit on Sustainable Development II (2002) that the global consumption of the mineral, wood, plastic and others, increased by 240 percent from 1960 to 1995 (McLennan, 2004). The changes and development of materials can affect the paradigm of design development. In this case, the design of wooden furniture becomes a case study in viewing the sustainable design strategies to face the environmental challenges. Sim Van Der Ryn in his book 'Ecological Design' said that the environmental crisis is a crisis of design (McLennan, 2004).

2. Theoretical Foundation

Based on the viewpoint of philosophy, the study of the design and the environment can be divided into green design, eco design, design for sustainability and sustainability (McLennan, 2004). This study refers to the great theme design for sustainability, where the design process considers the impact on the environment (e.g, the natural resources, the impact in the end of the cycle) and the social impact of the products (e.g., the use, the responsibility after use). According to Victor Papanek (1995), the relationship between ecology and design is built by six macro influences. The first influence is the method that consists of components of the tools, materials and processes. The second influence is the association, which is related to the family environment, education and culture. The third is the aesthetics influence that consists of several components, such as gestalt, perception, eidetic and biosocial "given". The fourth is the effect of necessity that consists of survival, identity and purpose components. The fifth is the effect of the consequences that consists of the ecological-environmental, social, material and energy consumption components. The sixth is the use influence that consists of product functions as a tool, a medium of communication and symbols.

In 2002, William McDonough broke the concept of *cradle to grave* by bringing up the concept of *cradle to cradle*, i.e., increasing the value of unused products. In 2006, UNEP (*United Nations Environment Programme Division of Technology, Industry and Economics*) in collaboration with the Delft University of Technology, issued a set of strategies that became factors in designing products for sustainable purpose. The set of strategies, which is called D4S (Design for Sustainability), consists of seven factors, namely:

- (1) non hazardous materials (low impact material)
- (2) the material use
- (3) the production techniques
- (4) the distribution system

- (5) the impact during use
- (6) the life of the product; related to the time of use and durability of the product (initial life time).
- (7) the end of life system

2.1. Creative Methods in Sustainable Design Strategies

In the designing process, the creativity of designers in making innovation and brainstorming is very important as the initial steps in designing the product. Similarly, the sustainable design strategy also requires creativity. There are many methods that have been done previously for ecological purposes. One creative methods offered by UNEP (2006) is SCAMPER method, which is a common method in the brainstorming process. SCAMPER stands for seven words, which consist of Substitute, Combine, Adapt, Modify, Put to another use, Eliminate and Reverse & Rearrange. This method was first applied by Osborne in 1953, which is originally used as creative methods for students and teachers in solving problems. Then, the method continues to evolve and is used by a wide range of fields including sustainable product design.

Then, Ursula Tischner (2006) emphasizes some creative methods that were intended for the development of sustainable product design, namely:

1. Using renewable energy sources.
2. The efficiency of the product;
 - a. Through reduction of material in products that have the same function.
 - b. Through the usefulness of products which have more than one function.
 - c. Through multifunctional and modular products.
 - d. Efficiency through endurance of the product.
 - e. Efficiency through common use, not owning.
3. Safety;
 - a. Using non toxic materials.
 - b. Using legal wood which comes from well-managed sources
4. The cycle consideration;
 - a. Reusable products (re-using), processed (recycling) and modified (upgrading).
 - b. Designs can be dismantled and disposed of in accordance with the elements and their respective places.
5. The social considerations;
 - a. Designs produced for the lower classes.
 - b. Designs can lead to sustainable behavior.

Based on the method and criteria of Victor Papanek (1995), UNEP (2006) and Tischner (2006), the writer compiled and classified the aspects of sustainable design on a product, in the form of a diagram. This diagram refers to the initial diagram of Papanek which is then developed by the writer by using other sources from the previous studies.

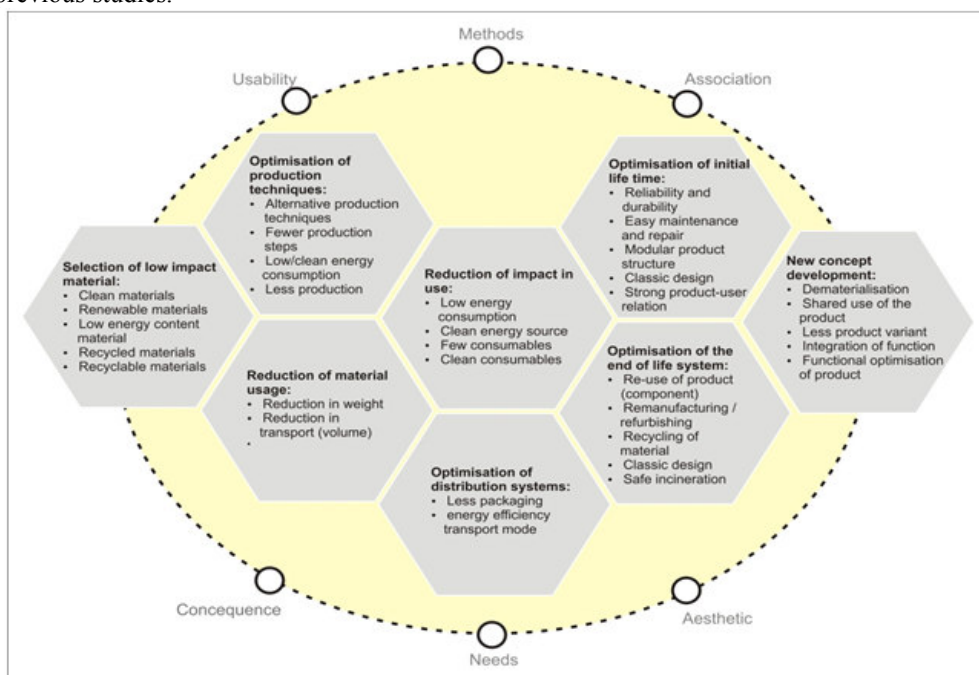


Figure 2. Diagram of sustainable design considerations based on the sustainable design variables (source: The Writer's Analysis)

3. Identification of Industry Criteria

The main keywords of this study are wooden furniture and sustainable design. Based on data from the Association of Furniture in Indonesia (AMKRI), there are 276 furniture industry in Indonesia. From 276 industry listed, the researcher retraced 269 furniture industry in Java and used them as the object of the study. From 269 industry, only 136 of them have complete data including phone number, address, email and website. Particularly, these industry are all material-based industry. From 136 industry, 73 of them focus on the processing of wood materials, 44 of them focus on the processing of rattan material, 17 of them focus on wood and rattan material, and 2 of them focus on bamboo material. From the data above, it can be seen that more than 50% of the listed industry are dominated by the use of wood materials. The main consideration of the industry criteria can be indicated by using the strategy of sustainable design. In addition, the furniture industry should actively participate in various furniture exhibitions, such as the International Furniture Expo in Indonesia and the Indonesia Furniture Pavilion, or at least have received an award from the Government or the Association.

3.1. Method

The initial process conducted is in-depth interviews with the furniture industry regarding their design activities. The interviews were conducted face to face, with questions that are not structured. In addition to conducting the interviews, data is also collected by taking pictures or capturing the data. The data obtained were analyzed through the aspects of sustainable design strategies. The results are presented in two stages. The first stage is the descriptive explanation to the findings of sustainable aspects contained in each industry. The second stage is the mapping visualization of wooden furniture design that refers to the aspects of sustainable design. The mapping will result a comparative picture that shows the magnitude of the environmental impact of each design method. Thus, there are two types of discussion resulted from these two stages, namely the analysis of the industry through sustainable design aspects, which refers to the diagram in Figure 2, and the comparison of design strategies through mapping. The comparison of design methods will be referring to the selection of the type of wood material and production concept, the aesthetic value and the value of the success that followed.

The purpose of this study is not to determine which industry has the best method, because every industry has some methods and each method may be different, or even the same. The goal is to arrange the furniture design strategies based on the selection of materials, with the analysis of the success of each of these methods. Initially, the writer had an obstacle to approach and conduct the research in the industry. However, by referring to the criteria of the previous industry, the writer succeeded to conduct interviews and collect data of the designs from five furniture industry.

3.2. Profile Studies in Five Wood Furniture Industry

Industry 1 - Located in the city of Solo, Central Java. This furniture industry that has established since 1993, has a big market in the international market. The originality of design takes precedence, so the industry has a design committee that has more than 10 designers. The industry is actively participating in international exhibitions, and the owner is also involved in the Association of Indonesian Furniture and Handicraft Industry. The expansion of the local market is done by creating a new product line for the domestic market with a different brand. The products are made by the local artisans from Solo, who do not depend on machines to produce good quality products.

Industry 2 - This industry is still a part of industry 1, but it has a different brand and scope of markets. The furniture is produced for the domestic market, thus it is adapted to the needs of the Indonesian people. Since it was established nearly 10 years ago, the brand that is under the auspices of industry 1, is growing rapidly. It actively participates in the international and national exhibitions.

Industry 3 - This industry was established in 1996. It has customers from the Netherlands, England, Spain, Belgium and the USA. The similarity of this industry with Industry 1 is they both produce wooden furniture. Both of them is also located in the city of Semarang, Central Java. The focus of this industry is using reclaimed-recycled wood from demolished houses. This industry has also received international certificates from the FSC (Forest Stewardship Council) and the national certificate from the Wood Legality Verification System (SLVK Indonesia).

Industry 4 - Since it was established in 2002, this industry is growing rapidly in Central Java, Indonesia. It has the international markets in Europe and Australia. This industry prioritizes traditional technique from the hands of the craftsmen to produce modern designs. The target market refers to a niche market, i.e. consumers with an interest in classic products with natural visual finishing and a vintage value.

Industry 5 - This furniture industry is relatively new, but has gained recognition from the local area as a new industry with an interest in reclaimed-recycled wood material and attention to the environmental preservation, through publications in various media. The industry is located in Yogyakarta. It uses craftsmen from Jepara, which is known as the center of woodcarving craft. So far, the customers of industry 4 still comes from the domestic market .

4. Discussion

Before arranging specific data regarding the sustainable design method and its evaluation on the wooden furniture industry, it is important to know the relationship between the characteristics of sustainable design and its benefits to the industry. It requires an objective view on the ecological vision to establish the appropriate design methods. In general, there are three objective views of the eco-efficiency actions (Bhamra & Lofthouse, 2007), namely:

1. Reduce the consumption of natural resources; minimize the use of energy, materials, water and land; improve recyclability and durability of the product; close the loop of the material.
2. Reduce the impact on nature. Reduce emission, water discharge and the use of hazardous substances.
3. Increase the value of products and services.

The three factors above can become the objectives for both individuals and large industry. To achieve these objectives, further action, which is largely the role of sustainable design, must be arranged. The further action is a method that became a reference for each industry, which then results a different design characteristic in each industry. In order to reach sustained value in the industry, there are several criteria of *Design for Sustainability*, which includes:

- Reduce the environmental impact on their products/process.
- Maximize the use of raw materials and energy use.
- Improve the system of waste management/pollution.
- Generate good design and creativity to innovate.
- Cut the costs.
- To meet the user's needs and exceed their expectations in terms of price, performance and quality.
- Improve the marketing of the products
- Improve the brand of the industry

There are many benefits that can be gained from applying the criteria of design for sustainability, such as; generate new product ideas and services; a new technique as an alternative; increase the workers' participation and satisfaction; and improve the quality and the creativity of workers. Next, the writer will explain the tendencies that lead to the aspects of sustainable design, based on the findings of photo survey and interviews. These various tendencies will become the characteristic, criterion or character in each industry, or one industry can have some of these tendencies.



Figure 3. Situation inside the furniture industry

4.1. Design Tendencies

A. The Use of Material: Changes, Safety and Reduction

Materials and design has a strong connection in generating sustainable product design. This is in line with Ashby and Johnson (2010: 13), who say that the reduction of material can be done through the process of recycling, using new materials, making smaller shapes (miniaturization) and replacing products with services. Ashby (2010: 12) states that the character of the material used in the 20th century is quite large and has three-dimensional shape. On the contrary, the character of the material used in the 21st century has a flat surface, one layer, may consist from one molecule alone and new functions that follow.

The size of the wood diameter, which is getting smaller, encourages the industry to make changes to the production process. However, the design and the standard size of the furniture cannot be changed, because they are associated with comfort and the strength of the furniture. Therefore, the change also affects the production process. As experienced by industry 4, more pieces of wood is needed because the width of the wood is getting smaller. In order to maintain the strength of furniture, a strategy of efficiency is not done to the reduction of wood thickness, but to the amount of wood used. Industry 4 combines wood with iron as the support of the main structure. The benefit is the parts of the wood can be replaced if they are damaged, while the iron structures still last. In addition, the main strategy of industry 4 is to use two types of material; The first is reclaimed-recycled teak wood (expensive material). The second is pines (cheaper material). In terms of visuals, the two types of furniture have similar aesthetic value, but they have different prices.



Figure 4. The comparison of furniture produced by industry 4 industrial with reclaimed-recycled teak wood (left) and new pine wood with rough finishing (right)

With limited and expensive supplies of raw materials, the size of the materials used will be more efficient. This is done to make the price of the products more competitive and also to maintain the availability of the materials. For products which used pines as the raw material, the pines are imported from forests that are managed sustainably. One of the forests comes from Europe (Sweden). From the interviews with the owner of industry 4, it is known that more than 60 percent of the wood becomes the main material of the product. For efficiency, industry 1 and 2 also use alternative types of wood that can be easily obtained from the area around the industry, particularly in Central Java, such as Mahogany and Mindi wood.

Mindi wood is used because it has a lighter weight than teak wood. Lighter volume will make the shipping and the packaging easier. It is also easier to be used by older people, because it can be lifted and moved easily. Mahogany and Mindi wood also have other advantage. They grow in a short period, between 10-15 years. Most of the raw materials is obtained from Central Java, because it is cheaper compared to the wood from East Java and also better than the wood from West Java. For example, teak wood from East Java has better characters. The fiber is denser and the color is darker. Therefore, the price is more expensive than teak from Central Java. This is due to differences in geographical aspects of Central Java and East Java. The soil in East Java areas is more chalky. Efficiency in furniture design is also done through the reduction of wood material. This efficiency is mainly done by industry 2 and 4, for example by reducing one element of the furniture, such as the armrest (Industry 2).

Considerations in designing do not only involve ideas, function and market demand, but also involve choosing the right material. Besides using wood that has a short growing period, the furniture industry also utilize unused parts of the tree, such as twigs, branches and roots. The parts that are used are only 0.62% of the twigs, 11.52% of the branches, 8.64% of the roots and 65.75% of the tree trunks from the whole tree (Sumarno, et.al, 2015). Thus, the supplies of twigs, branches and roots are plenty. The price of twigs, branches and roots are cheaper than the trunk of the tree. Sumarno (2015) says that the price of twigs and branches for furniture is Rp 2.000.000- Rp.4.000.000 / m³. While the price of logs is Rp 4.25 million - Rp 30 million / m³, which is ten times more expensive than the price of twigs and branches. Therefore, the use of twigs and branches can indirectly give more profits for the furniture industry and also cheaper price for the buyers.






It is also important to consider the security in the process of the finishing, particularly for industries that export their products. Some countries impose strict regulations on the use of chemicals for furniture finishing. Therefore, many furniture industries do not coat the furniture in the final finishing so that it will qualify the selection process. The process of final finishing can be done by the company that purchased the furniture products based on the standard of the buyers. There are some terms and characteristics that must be considered in choosing the type of wood for furniture. The considerations in the selection are the availability potential of wood (the wood can be obtained easily) and the good properties of wood. In general, the types of wood for furniture and craft must meet the following requirements (Kasmudjo, 2012):




1. Wood has hardness and strength from middle to upper (strong class I -III).
2. Wood is in the medium class of natural durability (durable class I - III).
3. Wood can be drained easily.
4. Wood with minimum (low) risk to be cracked or broken
5. Wood with minimum content of resin.
6. Wood has the texture of rather smooth until smooth.
7. Wood that can easily have finishing process with a good result.

In addition to the requirements above, according Kasmudjo (2012), there are characteristics of wood that must be considered in each kind of wood for furniture and crafts. They are the physics and the physical properties, the mechanical or strength properties, the processing, sticking, drying and durability properties. Based on the results of interviews and analysis, there are four main types of wood used by the furniture industry.

The first is new local logs and new imported logs (consisting of two types of age, wood that is above 30 years old and wood with the growing period of 10-15 years). The second is reclaimed-recycled wood that comes from demolished houses, boats, trucks and railway sleepers. The third is unused tree parts such as twigs, branches and roots. The fourth is local and imported wood, either as the main structure, decoration or furniture inner layer.

Table 2. The type of wood used by furniture industry in Central Java, Indonesia.

TYPE OF WOOD	Condition	Opportunities & Problems
SOLID WOOD		
<p>New wood with growing period > 30 years</p>  <p>Macassar Ebony (<i>Diospyros celebica</i>) Red Amboyna (<i>Pterocarpus indicus</i>) Rosewood (<i>Dalbergia latifolia</i>) Teak (<i>Tectona grandis</i>)</p>	<ul style="list-style-type: none"> Comes from natural forests, Forest Plantation and <i>Perhutani</i>. Comes from a strong class: I-II. Has beautiful fiber. The color of the wood tends to be dark. High price. 	<ul style="list-style-type: none"> Wood with growing period of > 30 years has excellent level of strength and durability. Wood with growing period of > 30 years is rarely found. Even if it is available, it is very expensive.
<p>New wood with growing period 10-15 years</p>  <p>Pine (<i>Pinus Merkusii</i>) Acasia (<i>Akacia mangium</i>) Young teak (<i>Gmelina arborea</i>) Mahogany (<i>Swietenia spp.</i>) Sungkai (<i>Peronema canescens Jack</i>) Mindi (<i>Melia azedarach</i>)</p>	<ul style="list-style-type: none"> Comes from Forest Plantation and <i>Perhutani</i> Competes with imported wood from Europe (spruce wood, oak, and white ash). Comes from a strong class: II-III. The color of the wood tends to light (pale-yellowish). Fiber varies from straight, mixed to wavy. The price varies from Rp. 4,250,000/m³ –Rp. 30,000,000 /m³. 	<ul style="list-style-type: none"> There are many other wood alternatives in Indonesia, such as sapedilla wood, rubber, jackfruit and durians. The weakness of HTR local wood is after going through the process of shaping and finishing. From one board, only 50% of it is used. While for the imported wood (spruce and white ash), up to 90% of it is used.
UNUSED PARTS OF THE TREE/ WASTE		
 <p>Twig Branch Root</p>	<ul style="list-style-type: none"> From a tree, only 0.62% of the twigs, 11.52% of the stems and 8.64% of the roots. Does not prioritize the beauty of the wood fiber. Has an affordable price, starting from Rp 2,000,000 to Rp 4,000,000/m³. 	<ul style="list-style-type: none"> Availability of materials is very high. Requires the right design to match the strength of the wood, which is not a part of the tree trunk (main part of the tree). Has sustainable value. Cannot use a modular system.
RECLAIMED-RECYCLED WOOD		
 <p>Remnant of house Remnant of wood cest Remnant of ship Remnant of bearing rail</p>	<ul style="list-style-type: none"> The price of reclaimed-recycled wood is quite high, around Rp 3,000,000/trunk The shapes are boards or beams. The size of the beam is around 16 cm², 14 cm², 12 cm². Requires the selection of the wood color grading. 	<ul style="list-style-type: none"> There is high demand of furniture using reclaimed-recycled wood in the international markets. Supplies of reclaimed-recycled wood are limited. The design depends on the size of the wood obtained. The condition is not smooth. There are nail marks /nuts.
PROCESSED WOOD		
<p>Plywood and Multiplex</p> 	<ul style="list-style-type: none"> Thickness variations: 3 mm, 4 mm, 9 mm and 18 mm. The standard size is 120 cm x 240 cm There is melamine type, which has a waterproof coating. Texture and fibers can be made similar. Patterns are symmetrical. 	<ul style="list-style-type: none"> More stable dimension and wider areas. Will not be broken if the edges are nailed. Can be processed with bending technique. It is not as durable as solid wood.

<p>Particle board</p>  <p>(Chipboard standard, Chipboard veneer & OSB (oriented strand board))</p>	<ul style="list-style-type: none"> • It consists of a mixture of coarse sawdust and special chemicals. • OSB has uniqueness in the wood pattern. 	<ul style="list-style-type: none"> • Can use a modular design. • Lightweight. • It is not durable. • Can change the shape when in contact with water or when it carries heavy weight too long.
<p>Medium Density Board (MDF)</p> 	<ul style="list-style-type: none"> • It consists of a mixture of wood pulp and special chemicals. • The thickness variation is from 2mm - 32,8mm. 	<ul style="list-style-type: none"> • The surface is smooth and poreless, making it easier to do the finishing. • Can use a modular design. • Lightweight. • Non waterproof and it is not durable to moistness. • The price is relatively more expensive .
<p>Block Board</p> 	<ul style="list-style-type: none"> • Consists of 4x5 cm wooden beam, which is compacted with the thickness of 15 mm and 18 mm. 	<ul style="list-style-type: none"> • The blockboard that is widely used is teak block, with teak wood as the outer layer and softwood as the inner layer. The value that is sold, is the impression that the furniture looks like it is made of teak wood. • Heavier than plywood, particle board, and MDF.

B. Design for Energy Efficiency

In the production process, the effectiveness of energy is required so that the process and the cost of production can be maintained. Industry 1 and Industry 2 built their production centers in the city that are also spread around several close regions. The distance between each center is only 25-27 km (Kepoh Region - Daleman Region - Boyolali City). The material used is a local material that comes from the same island, namely Central Java. Thus, energy efficiency can be done by both industry 1 and industry 2 on the logistical aspect.

Energy efficiency is also applied in the production process, i.e. in the QC (Quality Control) stage. This is implemented by Industry 1 and Industry 2, which implemented the QC system in each stage of production. This will reduce the possibility of production failure. Aside from the production process, efficiency can also be done in the design. Industry 1 and Industry 2 also apply efficiency through design that minimizes the number of materials used. This is also associated with the needs of furniture in the current lifestyle. The size of houses is getting smaller and the number of apartments is growing. So, it takes certain furniture designs that can meet the criteria of the current residence dimension, i.e. the size of the furniture is getting smaller; it can be transported easily and it is multifunctional. The example is the furniture design of Industry 2 below. The design management is also an important concern because it is related to the efficiency of material, energy, and cost. More design variations will need more material, energy and costs.

The modular system is not a new system for furniture design. The difference is only the material used. Based on the interview with Industry 5, it is known that reclaimed-recycled teak wood is also stronger than other wood alternatives (examples: Mindi, Mahogany, Mango, Sungkai, etc.). Old teak wood is also assumed to be cut after a period of growth of more than 20 years. The following is the excerpts of an interview with industry 5:

"Theoretically, reclaimed-recycled teak wood also has the right and natural maximum dryness. So, it is very effective for producing good quality design. Although it is not very efficient because it requires an extra charge (the price is getting higher). It also requires extra time and effort to select, cut and process the teak wood. With proper quality control, reclaimed – recycled teak wood is a guarantee for the quality of the product".

C. Design for Longevity

Another character found was a tendency to produce furniture with classic design. A case study in Industry 3 shows that the industry can maintain their classic design as a high demand design that continues to be ordered by clients. Previously, the main material used is a new teak wood with a diameter that is quite large. However, it is getting difficult to find teak wood with large diameter. Therefore, Industry 3 uses an alternative material, i.e. recycled teak wood. The recycled teak wood used comes from demolished houses, usually from the main pillars of houses. The standard size of teak wood used is beams with the size of 16 cm², 14 cm² and 12 cm² and the price of one trunk is Rp.3000.000. In the past, a beam with the size of 20 cm²- 40 cm² can be obtained easily, but now it is difficult to find. Even if it is found, it is very expensive. The grading standard of the wood color is used to determine the age of the wood. It is better to choose wood which only has one color and is not mixed with white color.



Figure 5. The material of recycled teak wood (left) and the result of furniture made of recycled teak wood (right) (Arianti Ayu Puspita, 2015)

The strength and durability of recycled wood are different from new wood. Therefore, many furniture designs combine recycled teak wood with other types of materials. One of them is iron. The combination of wood and iron is adopted by Industry 4. The primary structures, such as the legs of chairs, tables or cabinets, use iron. While the cushion and tabletops use recycled wood. In addition to the factor of material strength, iron is also used because it can give a longer life to the product (durable).

D. Rethinking the Structure

The reduced size of the width of the wood affects the structural pattern of the furniture. If the structure used previously came from one plank of wood with a large width, now the industry should be able to figure out how to use wood with a small width. The smaller size of wood can still be used, but the strength of the furniture must be retained in accordance with the standards for comfort. The strategy used is to multiply the number of wooden boards with similar form of design. Therefore, the smaller the width of the wood, more pieces of wood used are needed on the furniture dimension that does not change (according to the standard of comfort).

The use of recycled teak wood also affects the aesthetic aspect of the furniture. Industry 5 uses recycled teak wood and secondhand furniture as the main materials. The challenge in using recycled teak wood is it needs proper selection on the age and the size of the wood. The industry does not know the age of the wood when it is cut and they have to receive any size of wood because the wood is limited (cannot choose the size freely). Thus, the color of the wood selected should be similar. It cannot be too different. Smaller size will make the designers think about the structure. As performed by Industry 5, they made a wooden floor mat with a unique pattern from recycled wood.

E. Design for Local Market

Today, the furniture industry in Indonesia began to think about the importance of the local market towards the business continuity. Although there is still export market, it is important for the industry to master the local market in their own country, i.e. in Indonesia, a country which has a big population. A large number of the population in Indonesia is also dominated by the number of productive people aged 15-55 years (60%). This factor affect the consumers' taste for local furniture products and therefore create a new market. The large number of the population in Indonesia also becomes a big opportunity for a new market in the country, so the orientation of furniture export market can slowly shift and enter the local or domestic market.

One important factor in the sustainability of the industry is branding and design. Branding on the design is also important because when a design is original and has a characteristic, then the industry do not need to follow trends. They will have a more regular production flow (Puspita, et.al., 2015). Industry 1 and Industry 2 have already started to pay attention to the local market since 2008, and they have grown from industry with the OEM (Original Equipment Manufacturing) status into the ODM (Original Design Manufacturing) status and now the OBM (Original Brand Manufacturing) status. The following is the excerpts from interviews with Industry 1 & Industry 2:

"Now there is a positive response from the local market. The local market saved our company in 2008. From 2014 to 2015, we began to receive many projects from the local market such as apartments, hotels, offices, and restaurants. Since then, we do OBM for the local market. We also continue to receive orders from the export market and the response is always good".

4.2. Sustainability Critical Strategies as the Main Objective

Previously, it has been explained about the tendency of design that illustrates the human response in utilizing the available natural resources. The limited wood materials encourages people to look for an alternative to use other types of wood, and to develop new designs and techniques. Unconsciously, humans do activities in order to sustain the wood material. One of them is by producing furniture. The effort in maintaining the sustainability of wood material is done through the process of exploration and innovation that led to designs. The design activities are applied in almost all types of wood: solid wood, recycled wood, and processed wood. Various techniques are

applied in order to utilize the wood optimally and efficiently. The vision of the five industries in using various design methods is to apply sustainable design to wooden furniture. The design methods are closely related to sustainable design diagram that was identified by the writer (Figure 2), so that we can find out the purpose or the main benefits gained from using the methods. The main benefit of these methods is classified as a form of critical strategies that need to be applied to the wooden furniture industry. It consists of limitation, regeneration, innovation, stewardship and safety. The relationship between the five major strategies, design methods and the design characters produced can be seen in Table 2 below.

Table 3. Critical strategies categories, sustainable design method and characters of wooden furniture design

Critical Strategies	Sustainable Design Method	Characters of wooden furniture
Limitation	Reduction of material usage	Smaller design, mass production, saving space
	Reduction in weight	Lightweight, movable, mass production
	Energy efficiency transport mode	Smaller design, knockdown system, lightweight, local source (human & material).
Regeneration	Wood from plantation	From sustainable source, using V-Legal sign on product, secure for export.
	Fast growing wood	Affordable, easily obtained material, mass production, standard of durability & strength between II-III grade, indoor use.
	Upcycling	Waste material, from useless product, reduce waste, environment value, rough surface, playful color, combined with other material or other wood (mozaic), wood thickness variation
	Reliability & durability	Reliability: modest design, common structure, secure for next production Durability: strong structure, possible for upcycle,
	Easy maintenance	Modest design, indoor use, chemical finishing,
	Modular product structure	Geometrical shape, new mechanism, (can be easily distributed), mass production, simplicity
	Classic design	Nostalgic, symbolic value, natural object (carving), natural color, natural material, strong structure, heavier, bigger.
	Re-use of product component	Reduce waste, historical value, unique
Innovation	Alternative production techniques	Unique, playful, creative concept, reverse concept
	Rethinking the structure	Unique shape, playful, new concept
	Fewer production step	Simplicity, affordable
	Less type of product	Save material and production cost
	Functional optimization	Longevity, shared use, movable
Stewardship	Utilization of unused part of tree	Unique, natural form, (decoration product)
	Legal certification	Secure for export (the good name of the country of origin), qualify the standard
	Original design	Bring the good name of the country of origin, improve the product branding, can be produced periodically
Safety	Clean consumables	Secure for export, environment value

Limitation

The first critical strategy undertaken by the industry is Limitation. The goals of this strategy are efficiency, savings, and dividing the materials. The three design methods used are reduction of material usage, weight reduction and energy efficiency in transport mode. Each of the design method has a design character that does not directly benefit the industry and the users. By reducing the use of wood in furniture, the design will be smaller and it will save more space. Reduction can also be done by removing one element of furniture, for example armrest. Besides saving space, this can also reduce the weight, making it lighter and movable. The third method is the efficiency of the transport system, usually can be achieved through a design that uses local wood and the artisans from the same location or nearby. The designs that use smaller dimensions or knockdown system can also save transportation costs because they can be carried in greater numbers.

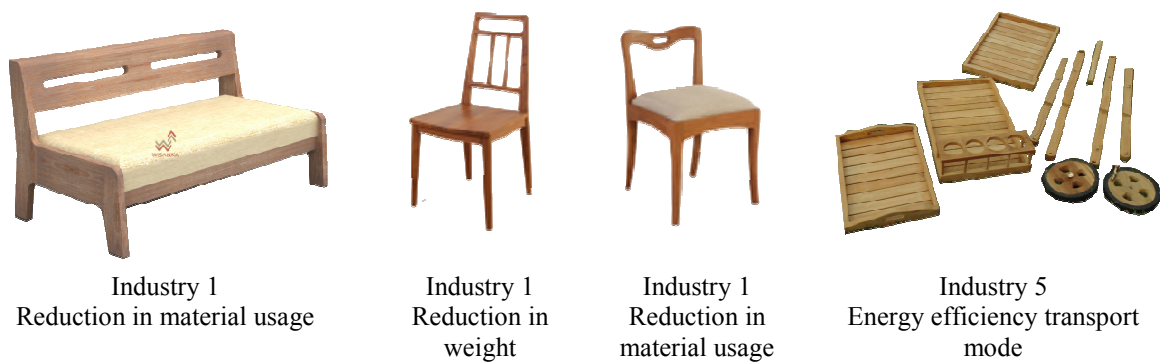


Figure 6. Examples of industrial products using the Limitation Strategy

Regeneration

Wood is a natural resource that is widely used, but it also needs to be preserved. Slowly along with the development of industry, the rate of cutting trees faster than the rate of tree growth. Therefore, conservation simply cannot be done only by planting trees. Designers, as the main actor in the furniture industry, play an important role in producing effective designs in accordance with the availability of the materials. Some methods that can be done with the purpose of regeneration is to use wood from official plantations; using wood with short period of harvest; do the upcycling ; create a design that is easily produced and durable; make designs that are easy to maintain; make products with modular mechanism, classic design , and reuse of unused furniture components. Upcycling is a design process that uses waste material or unused products to be recycled so that new products that are different and have better value can be produced.



Figure 7. Examples of industrial products using the Regeneration Strategy

Innovation

Innovation is needed to face any obstacle in meeting future changes. Most of the wood used by the furniture industry today is the fast-growing wood (with a period 10-15 years), it is the young wood fibers with an active fiber movement, which are more active than old wood (growing period of 30-50 years). Therefore, the industry also make adjustments in the production process and assembling furniture. Adjustment is one act of anticipation, as a form of innovation. One such anticipatory actions was to replace the old furniture key system with a floating lockdown system. Floating system provides a wide hole in the lockdown, so that the wood can still move freely. In addition to the wooden furniture, floating system is also applied to the combination of wood and iron furniture.

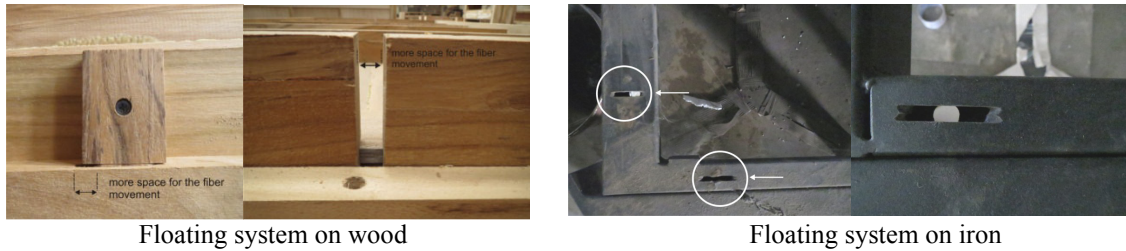


Figure 8. Floating system on wood and steel

Stewardship

Twigs and branches of trees is the remainder of the logging process. Most of twigs and branches waste used for fuel. Now the industry used it as raw material for furniture. Uniqueness, authenticity and natural impression become selling value of twigs and branches. It is regarded as a tribute to the wood, that each section should be utilized as much as possible after felling. Original design become supporting factors in sustainable system, because it affects the effectiveness of the production phase and improve the reputation of the country through design.



Industry 1

Utilization of unused part

Industry 2

Original design

Figure 9. Examples of industrial products using the Stewardship Strategy

Safety

Attention to the sustainability of the wood showed by the involvement of environmental organizations in the dissemination of the Wood Legality Verification System (SVLK). The institutions included the WWF Indonesia, the Global Forest & Trade Network Indonesia, Perhutani (State Owned Enterprises in Indonesia), ASMINDO (Association of Indonesian Furniture and Handicraft Industry), and others. There are some benefits obtained by the company when it acquired the certificate of timber legality, such as; to save time and costs for the issuance of V-legal documents with is not required for the inspection, increase the confidence of the buyer against the legality of the products are exported, a form of compliance with government regulations, and may use a V-Legal at product.

5. CONCLUSION

There are five main strategies to be the goal of sustainable wood furniture design; namely limitation, regeneration, innovation, stewardship and safety. In each of the five major strategies, there is a design method to achieve the goal. The fifth strategy also has an influence on the aesthetic value and the character forms of furniture. Thus, there is a close relationship between the benefits of sustainable design strategies with aesthetic value that can be generated by furniture industry in Indonesia. Changes in the wooden furniture design at this time tend to exhibit the aesthetic value of new environmentally sound. Environment issue can not be solved only through the design, but it is important to abide by the rules and policies. Government and industry have an important role in caring for the sustainability of the wood, so it needs good cooperation between the government and furniture industry.

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Interview

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2. Piguno Furniture, Solo City, Central Java Province, Indonesia (26 April 2015).
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