Bamboo as sustainable material for furniture design in disaster and remote areas in Indonesia

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Abstract. Bamboo has been known as a sustainable material for architecture, but only used on a small scale for furniture. However, even though it a sustainable resource, many people considered Bamboo as outcast material for furniture because of its appearance. Evidently, the use of bamboo is often used to make simple tools with similar traditional designs for everyday life. The tradition of using bamboo was not further explored with respect to the ongoing development of creative design and function in the era of today's modern technology. In retrospect to the above issues, this study is aimed to introduce the use of bamboo for material furniture in disaster and remote areas in Indonesia to increases their quality of life. It uses a research by a method of collecting data through surveys, literature review, interviews and training to determine the types of bamboo used for material furniture in disaster and remote territories. The results of this study is intended to show that the use of bamboo can be further developed into furniture for disaster and remote territory to create higher values of the products and increase the quality of life.

1. Introduction
For centuries, Indonesian cultures relied on bamboo for tools, shelter, sustenance and as a material for products ranging from furniture to musical instruments. The research found that more than 1250 species of bamboos on earth and spread across several continents. The spread is mostly in Mainland China and Latin America, but 11% of the total species located in Indonesia. These bamboos grown in almost all areas in Indonesia, including 56 species in Sumatra and 60 species in Java. It does not include the bamboo species that grow on the island of Sulawesi, Nusa Tenggara, and Papua [1]. Bamboo also possess several types of advantages including inexpensive, easy to process and offering friendly environment. However, its potential as a material for furniture had not fully optimized by people who live in disaster and remote territories. There is fact file that Bamboo structures treated with preservative have a life expectancy of 40 years, and has been proved robust enough to withstand earthquakes. Bamboo material growth is rapid, growing to the full height of up to 30 m within a year, after which the culm continues to gain strength, reaching the optimal structural properties within 3–5 years, depending on the species. Recently, bamboo has become a shining star of sustainability. It's a durable, versatile and rapidly renewable resource-with aesthetic appeal to boot [3].

The purpose of this study is to develop and increasing the value of bamboo as a material furniture to used in disaster and remote areas in Indonesia. Optimization of material by selecting the appropriate
type of bamboo suitable to the design criteria of furniture that was created and improving the value of bamboo with a functional design under the needs and activities of its users. Users who included in the scope of this research is the people who live in remote territories that have limited access (either in coastal or inland) and areas that are prone to disasters.

The following review explores the application of bamboo material for furniture in the temporary house and aims to provide background on the use of bamboo in the temporary house (studio sized 4.2x3.6 meter) and emerging research on the development of furniture design products.

2. Method.
The research method is a research and development (R & D) product with 4D methods. This type of research used because of the many types of bamboo that can create as a furniture material. While the use of material on a design adapts to the design criteria of each user. The research was undertaken using 4D methods namely Define, Design, Develop, Disseminate. Each phase of method will produce some alternative designs so that at the end of the process, the design can continue to grow with plenty final result.

2.1. Define.
At this stage, the goals are to specify and define the types of bamboo to be used in the design of furniture. Activities were undertaken; first, studying the life of the bamboo plant and what types of the bamboo plant that can be used for furniture. Second, identify the characteristics of bamboo plants based on its type by visiting the bamboo garden and seeing the reference books and journals. Third, studying the processing process of bamboo from the stage of bamboo selection (harvest) to its preservation by attending bamboo training and workshop held in Yogyakarta and Bali. Then, the learning outcomes will give knowledge regarding the advantages and disadvantages of bamboo material. Next step, doing an analysis of the processing process of bamboo and techniques used in both traditional and modern society. The task that must do is to determine the appropriate technique of bamboo that can use in the furniture design. Analysis of the concept of furniture to be made if it can realized with a kind of bamboo that has been determined based on learning outcomes. The determination of form design used is unornamented and multi-function. Then, getting the appropriate types of bamboo in line with the usability/design and balanced with the availability of materials in the community.

2.2. Design.
At this stage, the purpose to be achieved is designing furniture in conformity with bamboo processing technology and applying the appropriate system i.e. the knockdown system. Activities undertook; first, the merger between the phases of defining with the design stage is to adjust the character of bamboo material used in the design being made so that the technique used can be functional which is using the knockdown system as a connection of bamboo material. Second, media selection for designs and drawings using AutoCAD program for the image of the working and laminated bamboo material for prototype material. Thirs, the selection of format referred to is the option of a simple design and a simple bamboo processing technology. The last, make sketches and picture of working by taking into account the basic needs of inhabitants with proper facilities and multifunction. Also paying attention to the knockdown systems that are used in the bamboo material.

2.3. Develop.
At this stage, the design is made in the form of a prototype to get an evaluation from various parties, and therefore can be modified regarding design, engineering, and systems used to obtain maximum results. Activities undertook; the prototype of furniture produced which will be evaluated by the experts or internal parties by feedback regarding materials, techniques, and designs to obtain maximum and quality results. Then, testing of prototype furniture to the community is done in a limited scale to test the strength of the materials and systems used as well as testing the response towards a design created.
2.4. Disseminate.
At this stage, the furniture has been in the final production stage and showing a positive consistency in the final design and material quality. Activities undertook; first, designs that have been through the stage of developments and design revisions will tested to the people who will be using the furniture to obtain measurable results. Then, the stage of furniture packaging is held to facilitate furniture delivery to the remote territories and as part of the branding image of bamboo to the community. And last, packaging furniture received by the consumer can be easily installed by gradually following the assembly instructions that are inserted in the packaging. Instructions made in the Indonesian language competed with pictures to make ease.

3. Results and Discussions
The results and discussions will be discussed in 3 subsection, they are interior and furniture design concept, the concept of knockdown system and bamboo joint system.

3.1. Interior and Furniture Design Concept.
To produce a furniture design by using the bamboo material, the existing furniture design needs to assess. Hence it can be used as reference material for the design to be made. In the early stages, the design process will created for the layout design of a studio-sized temporary house that can comfortably occupied for a maximum of 6 months due to the nature of the building which is not permanent. Therefore the bathroom is located outside the house as a facility to be used jointly. The layout made by taking into account the residents comfort with a maximum capacity of 2 adults or 1 adult with two children. Activities carried out in this room including sleeping, sitting, learning, cooking, eating and storage of everyday utensils. To complement the needs of users in the interior of the bamboo house, interior products created which can facilitate activities inside the house. Due to limited space, the design of furniture products made multifunction and practical so that the design can be used by all residents and supporting activities in the house (Figure 1.)

![Figure 1. The Layout Design of Residence (studio type)](image)

Indonesia is an archipelago state that has many plenty remote areas which are difficult to reach. Therefore the life of people in the region needs to be considered how they can fulfilled through a practical and efficient design, but also compact to facilitate the packing and delivery to inaccessible and remote areas. To overcome this matter, a design that adopts the concept of knock down needs to make so that the furniture and interior products created can be dismantled during shipping and can be installed whenever required. As such, the problem to be overcome is how to design interior products that are functional and practical which are easy to use and can be detachable (knock down) by using the appropriate bamboo material.
3.2. The Concept of Knockdown System

The notion of interior product using bamboo material made based on the criteria and characteristics of users located in the areas that have limited access or disaster-prone areas, by creating products that easy to make (simple) by using simple technology, products made of materials that easily found around neighborhood residents, products made of environmentally friendly materials, products easy in dismantling (knock down) and they are also easy in packing, lightweight and sturdy, and products suitably placed in a modest house with limited size.

The knockdown system that widely used in residential furniture, originally conducted by a Swedish furniture designer namely Gillis Lundgren. She brought home a removable table in which the table leg can stored in his car. And upon arrival at his house, the table legs can be reassembled. This idea is then realized by IKEA in 1950 and was followed by other furniture companies.

The use of the design concept with the knockdown system in this modest house based on the criteria of; foldable, moveable, stackable furniture and foldable, storable room/screen dividers and small scale, rolled storage [4]. By having several advantages that can be packed quickly, saving storage space and reduce the cost of delivery, the knockdown system also has other strong point for the user such as easy for self-assembling following the instructions provided (Figure 2.)

![Figure 2. Knock-down System Furniture](image)

3.3. Bamboo Joint System

There are many techniques and ways that can do in making a connection in bamboo from the traditional to modern method. Each type of connection has a different purpose and strength. The bamboo joint system for this furniture adapted from Oscar Hidalgo Lopez techniques for bamboo pole [2]. The type of joints for knockdown system is more difficult because of making a hole on bamboo poles can cause cracking and splitting. However, the appearance of the joints looked clean and easily combined with plug-in (bolt connection) techniques. This type of fitting bamboo connections are widely used in tradisional bamboo buildings and other products like bamboo ladders and furniture.

Techniques and safety of joinery system were significant for bamboo furniture because it was self constructed furniture (knock down). Various bamboo joint system can be used but only some of them required specific tools and skills of expert craftsmen. Therefore, the model and techniques was designed to be simple and efficient. To specify the form of connection that is suitable for the design created, a study of this relation that widely used is performed (Figure 3.)
The design of the bed is two units single bed size with the stack placement of a pull out system when needed. Also, the bed is bendable which adjusted according to its tilt in line with the human's ergonomic. Hence it can be used as a sofa or couch if needed. The type of bamboo used is a round bamboo for the main construction and lamina slab bamboo for the slab (Figure 4.)

The model of the multifunction table designed to accommodate two adults to sit side by side or one adult and two children sitting alongside. The table leg can be removed easily and are flat packed and stored in a versatile closet when not in use. This table designed with a convenient height to used for sitting at the table for working or eating. The type of bamboo used is a type of slab laminated bamboo, beam board shaped (Figure 5.)
This versatile closet designed for the storage of daily needs such as clothes, TV rack, books, bicycle storage and other goods. These cabinets are designed with a modular system and can be adjusted both height and width as needed. Using this kind of lamina slab board and half round bamboo board (Figure 6.)

4. Conclusion
The final process of research and development of the design producing furniture prototypes made in the scale of 1: 2.5 as study materials purposed and a scale of 1:1 as final result. These prototypes will examined and expected on the public test (exhibition) to gain feedback in form of questionnaires given to public who are keen to try the interior products created and give evaluation for improvements in both design and construction used in bamboo. The use of bamboo as a furniture material needs to continuously done, since bamboo is a plant that is sustainable, vulnerable for captive breeding, have a relatively short term of planting, effortless processed with simple equipment, has become the cultural roots of Indonesian society. Moreover, Indonesia has various types of bamboo that scattered in almost all regions. The government should encourage the use of bamboo in construction such as low income housing scheme and furniture making because of its benefits for disaster and remote areas. Numerous
potential of bamboo plants can be utilized by the community to improve their quality of life because it's easy to install and offer solutions at reasonable price. Through the design of furniture products made of the bamboo material, it is expected that people no longer underestimate the value of bamboo and can see the potential of bamboo plants.

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References
[1] Sonjaya J A 2014 Kumpulan Materi Pelatihan Bambu. Pusat Studi Asia Pasifik UGM dan Bambubos (Yogjakarta: Bambobos) pp 9-24
[2] Lopez O H 2003 Bamboo The Gift of the Gods (Columbia: Oscar Hidalgo-Lopez) p 228
[3] Liese W and Weiner G 1996 Ageing of bamboo culms: A review Wood Science and Technology 30 (2) p 77-78
[4] Parihk A 1994 Making the Most of Small Spaces (New York: Rizzoli International Publications).
[5] Nurdiah E A 2016 The Potential of Bamboo as Building Material in Organic Shaped Buildings Social and Behavioral Sciences 216 p 30-38
[6] Sharma B et al 2015 Engineered bamboo: state of the art Construction Materials 168(CM2) p 57-67
[7] Baldawi M T 2015 Application of Smart Materials in the Interior Design of Smart Houses Civil and Environmental Research 7 (2) p 1-15