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# Community Empowerment Through Bamboo Laminate Technology as Part of Disaster Conservation and Mitigation in Wonokerto, Turi, Sleman, Yogyakarta

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**Abstract** Bamboo is included in the classification of grasses, but because of its large size compared to other types of grass, bamboo is also called "giant grass". Bamboo has the ability to grow fast, reaching 30-100 cm per day. The target of this community service is the empowerment of the Daerah Istimewa Yogyakarta (DIY) Search and Rescue (SAR) Team in Wonokerto to become a transfer agent for laminated bamboo technology through the training provided. The approach used in this community service is based on research that has been carried out in universities (research-based community development) by involving potential communities as social agents and potential assets (assessed-based community development) in the community to support Mount Merapi as a National Strategic Area (KSN). In training implementation, the participants showed high contribution in providing training material, attendance, and involvement. Based on the training survey on bamboo laminate technology, 80.59% of respondents know the identification material, stage of preparation material, identification of connection mixture, identification of lamination stage, and quality check of laminated bamboo lumbar. The proposed training or assistance for sustainability community services are marketing, business planning, product design, and quality products.

## 1. INTRODUCTION

Mount Merapi, one of the most active volcanoes in Indonesia and the world, is administratively located in the provinces of Central Java and Yogyakarta. This mountain had a height of about 2,968 meters (before the November 2010 eruption) (Trisnaning & Trianda, 2022). The existence of Mount Merapi has a significant influence on people's lives and the lives of other living things that live around it. Since the beginning of the history of human life on the island of Java, thanks to the soil fertility, the Mount Merapi area has attracted many people to settle and breed. However, living under the slope of Mount Merapi with soil fertility coming from its volcanic activity

The Yogyakarta Institute for Research and Development of Volcanic Technology (BPPTK) released a map of the new Merapi disaster-prone area (KRB) after the major eruption of November 2010. The map of the disaster-prone area has clearly shown the areas that are prone to the primary threat of the eruption of Mount Merapi in the form of pyroclastic flow or the flow of hot clouds in KRB III. Based on the new KRB map, quite drastic changes occurred in two areas: the south side, which includes Gendol River, and the west side, which is in Putih River. In the two rivers that originate at Mount Merapi, the distance of KRB III Merapi is set at 15 kilometers (km) for Gendol River and 12 kilometers for Putih River, while other areas are still the same as on the previous map, with the distance of six to seven kilometers from the summit of Mount Merapi. The Merapi disaster-prone area (KRB) map can be seen in Figure 1.

The eruption of Mount Merapi in November 2010 was a very large eruption, so that it affected not only the Merapi ecosystem but also caused huge losses because it caused many casualties and livestock, which became a source of

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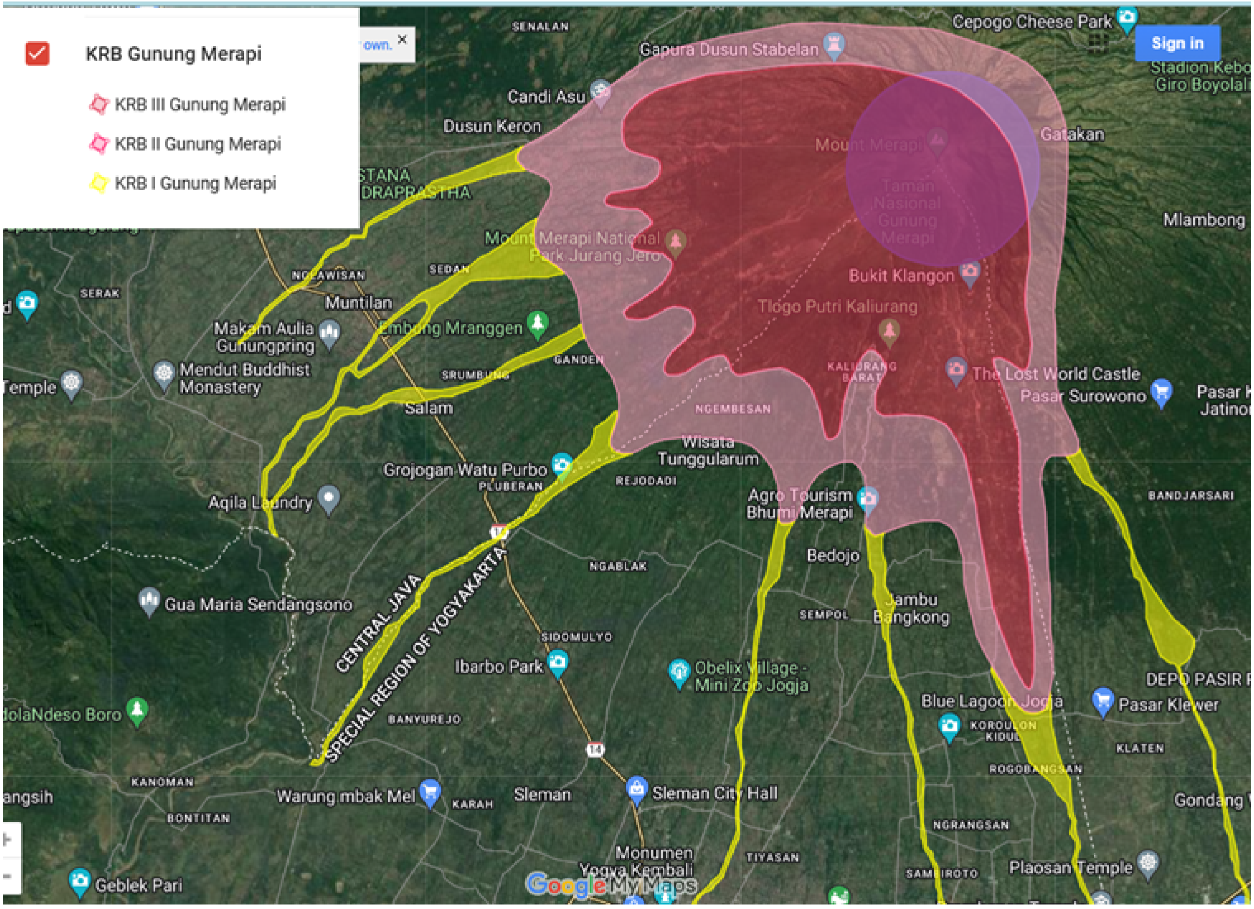


Figure 1 . Map of Mount Merapi disaster-prone areas

of community income, as well as damage to people's plantations. The dangers caused by the eruption of Mount Merapi are not only primary hazards in the form of pyroclastic flows and hot clouds but also secondary hazards in the form of lava.

A National Strategic Area is an area whose spatial planning is prioritized because it has a very important influence nationally on state sovereignty, state defense and security, the economy, society, culture, and/or the environment, including areas that have been designated as world heritage. This area is in Magelang, Boyolali and Klaten Regencies, Central Java Province and Sleman Regency, Yogyakarta Special Region Province, with an area of 6,607.52 ha. It is divided into two national park management sections: Region I oversees areas in Magelang and Sleman, and Region II in Klaten and Boyolali.

UIN Sunan Kalijaga Yogyakarta, one of the PTAIN, which is geographically located on the slopes of Mount Merapi, is trying to contribute to maintaining Mount Merapi as a National Strategic Area. This is manifested in several activities to keep Mount Merapi able to carry out its functions. In ensuring the hydrology of Mount Merapi, UIN Sunan Kalijaga has been involved in reforesting the Merapi area several times as part of saving the Merapi spring. UIN Sunan Kalijaga Yogyakarta's contribution in ensuring Merapi's ecological function is shown by the establishment of the Merapi Incense Rescue and Development Center as an endemic plant of Merapi. Meanwhile, the function of UIN Sunan Kalijaga in disaster mitigation is realized by providing assistance and training for the Merapi SAR.

Bamboo is a hollow cylinder-shaped material whose diameter diverges towards the bottom with nodes at regular intervals, and the vascular bundles are scattered throughout the span. Based on Sharma et al. (2015), the chemical analysis of various bamboo species shows that its main constituents are hemicellulose, cellulose, lignin, some cold and hot water-soluble, alcohol, pentosans, and sodium hydroxide (NaOH) soluble [70]. Bamboo consists of microfibrils along the length. The elementary fiber is hexagonal, and the presence of the voids shows its hydrophilic nature. Liese proposed the polylamellae structure model for thick-walled crude bamboo fiber and showed that bamboo is a combination of differently oriented fibers (Ln and Nn). Bamboo fiber can be used for several engineering and non-engineering applications such as biofuel production, food and feedstock production, construction, medicinal use, and other commercial uses (Kumar & Mandal, 2022).

Bamboo is included in the classification of grasses, but because of its large size compared to other types of grass, bamboo is also called "giant grass". Bamboo has the ability to grow rapidly, reaching 30–100 cm per day, 15 to 30 m in 3 to 4 years, and has about 400 different species with diverse qualities (Wei et al., 2020). Bamboo grows through vegetative roots with a rhizome system (branching vertically or horizontally). The advantage of bamboo anatomy in reducing the risk of hydrological disasters lies in the bamboo root system. The bamboo root system consists of two systems: (1) monopodial rhizome root system and (2) sympodial rhizome root system. Monopodial roots spread laterally; there are one or two main roots that extend laterally, and their shoots can ascend to become stems. In contrast, the sympodial rhizome root system has a thick and fibrous rhizome. The shoots grow in groups and will grow upwards to become stems. The bamboo root system forms a network of rhizomes that are widely spread up to a radius of approximately 15 meters from the center of the bamboo clump. When the root hairs function to catch water and make the surrounding bamboo clump like a sponge, when the root hairs die and rot, the space left becomes soil pores. The increase in soil pores causes soil friability, which means better soil aeration and drainage so that the soil can retain and store more water.

In addition to roots that play a role in water absorption in the soil, bamboo leaf litter also plays a role in creating a local climate around the bamboo clumps. The body of the bamboo plant produces high mass, so that bamboo also produces high litter. Bamboo leaf litter that falls on the ground affects the local climate in the bamboo growing environment. The surface covered with bamboo leaf litter has high humidity, so that the activity of soil microorganisms is also high. This condition results in high soil pores and good aeration and drainage, which means the ability to absorb water is also high. The advantage of bamboo as a hydrological conservation plant is that Daphe B. Lewis & Miles (2007) suggest that bamboo be planted on relatively steep slopes because bamboo mats can play a role in controlling erosion. Furthermore, bamboo is also recommended to be planted in catchment areas, both in rivers and in upstream watersheds. Planting bamboo in the catchment area, in addition to binding soil particles so that it can resist erosion, can also reduce the level of flood vulnerability in the area below. Some interesting bamboo functions in the Merapi area are described below.

**The ecological function of bamboo**

Bamboo plants are included in the Gramineae family, growing mainly in the tropics and sub-tropics, although there are some found in winter areas such as Japan, China, Chile, and the United States. This family includes 60 genera and around 600-700 species. Approximately 300 species in West Asia are found in the region from India to Southeast Asia, which is considered to be the area of origin. In Indonesia, there are about six bamboo species, generally in the lowlands to the mountains with an altitude between 750 - 3,350 mass, in open places, and free from puddles. The Merapi area is ideal for the growth of several species of bamboo, such as the Gigantochloa Apus Bamboo. At the time of the eruption of Mount Merapi in 2010, some of the bamboo apus in Cangkringan District were destroyed by the eruption of Merapi at the peak of the eruption of Mount Merapi. One of the efforts that have been made to cope with the eruption of Mount Merapi, which destroyed some of the bamboo apus in Cangkringan Sub-district, was in 2011 when the community and BPDAS Serayu Opak Progo (Watershed Management Agency) carried out bamboo replanting in Cangkringan District. Replanting bamboo in Cangkringan, especially the endemic Merapi, is an arboretum (asylum) for bamboo species whose existence in residential areas is starting to become extinct.

**The hydrological function of bamboo**

Bamboo plants produce 35% more oxygen than other plants in general. One hectare of bamboo plants can absorb up to 12 tons of carbon dioxide from the air, which means it can absorb four times more carbon dioxide than other ordinary plants. In many cases, in many areas, bamboo plants are even capable of giving rise to new springs. The results of a study from the Beijing Academy and Xu Xiaoging showed that bamboo plants planted along watersheds were able to add 240% more groundwater than planting pine. The follow-up study stated that bamboo is recommended as a pioneer plant for critical areas that need reforestation, considering its ability to affect water retention in the topsoil layer, which can significantly increase underground flow. In Colombia, the people believe planting bamboo is the same as planting water. In fact, bamboo is able to absorb up to 90% of rainwater, much higher than the average for other trees, which only absorb 35–40% of the rainwater they receive (Lewis & Miles, 2007).

**Disaster mitigation function of bamboo**

Related to a volcanic eruption in Mount Merapi and Semeru, there is a local belief that a bamboo forest was used as a natural early warning system. The loud sound produced when bamboo culm was burned by pyroclastic flow or hot cloud could be used as an alarm, and bamboo also could be resistant to high temperatures (Aisyah, 2021; Mulyono & Paramitha, 2022; Suryaningsih & Dewi, 2017). During the rehabilitation phase of disaster mitigation, bamboo is usually very useful as a material for temporary shelter for disaster-affected residents.

**The economic function of bamboo**

The community has known bamboo for a long time, and is very familiar to the community. Economically, bamboo has great potential but seems to have lost its prestige to wood. In contrast, bamboo grows 30% faster than wood plants with no less quality. Therefore, it is necessary to introduce to the public bamboo processing technology to increase economic value.

Bamboo lamination technology, like wooden slats or solid wood blocks, is simple to shape. First, cut bamboo into small sheets. Subsequently, arrange and put together using a press or bamboo pen, then press for a specific time. Resin can also be added to the surface of the bamboo to make it glossier. The strength of laminated bamboo is the same as that of solid wood when used as a building structure.

Wonokerto, as a disaster-prone village, has disaster response volunteers in the Search and Rescue (SAR) team under the command of SAR DI Yogyakarta (SAR DIY). Wonokerto village has around 38 active members of DIY SAR with various search and rescue (SAR) skills. During a disaster, this team is very useful and instrumental in handling disasters, especially the Merapi eruption. However, the post-disaster period is usually filled with skills education activities or disaster management counseling for the community, so that at this time, the DIY SAR team practically had much free time. To increase supplies for the SAR team in Wonokerto, this training introduced bamboo lamination technology to make them become pioneers in bamboo processing in Wonokerto. As pioneer agents, the team would encourage and share skills and knowledge about bamboo processing technology with other communities and become an agent to transfer bamboo laminate technology technology to the community.

In terms of vulnerability to disasters, Wonokerto is in Disaster Prone Areas 1, 2, and 3 (KRB 1, 2, and 3), which are prone to geological disasters of Mount Merapi in the form of hot clouds and cold lava. Volcanic eruptions have the potential to not only cause loss of life and property but also damage land and the environment. The consequence of this disaster is that the arrangement of land use and utilization of natural resources must be regulated in such a way as to the rules of disaster management to minimize risks in pre-emergency response and post-disaster. The economic condition of Wonokerto Village is divided into several sectors, with the main sectors being agriculture, plantations, fisheries, and animal husbandry. Most villagers are related to the agricultural sector (snake fruit both on-farm and off-farm). However, the agricultural sector has not been exploited optimally, especially after the 2010 eruption of Merapi, which caused irrigation canals to be damaged. This non-optimal agricultural sector has consequences for the structure of the community according to their level of welfare, which pre-prosperous families and below still dominate.

In terms of socio-culture, the population of Wonokerto Village is dominated by people with a productive age level (21–49 years). However, there is still much unemployment, especially unseen unemployment. The cultural character of the community is an agrarian culture with a social system with solid ties between the residents. It is manifested daily in cooperation activities or various kinds of routine meetings. This village also still preserves traditional customs, arts, and culture. These conditions show that some of the basic things needed for the development of Wonokerto Village in the future are:

1. Land use and natural resource utilization must be directed in such a way that the ecological role of this village is not diminished, either for the internal village or for the larger ecosystem (watershed areas), particularly the role of preserving water and soil resources.

2. Land use and natural resource utilization involve risk management and potential disasters. Risk management principles based on land use and utilization of natural resources for reducing the risk of potential disasters (Merapi eruption) and preventing other disasters that may arise, both those related and unrelated to eruption.

3. Land use and natural resource utilization should be designed to increase self-reliance, particularly economic independence. In pre-disaster, occurring, or in the recovery phase.

4. Land use and natural resource utilization should be directed toward building social capital as a critical factor in disaster mitigation success.

## 2. METHOD

The bamboo preservation technology training, as the focus of this service, is one of a series of stages of community service and assistance to the Wonokerto community in the use of bamboo as a laminate material. The training utilized Morisco's bamboo lamination manual (Nugraha, 2014). Morisco introduced connections used in laminated bamboo lumbar from mortar or cement mixture to form rectangular boards like lumber. Besides that, steel plates with cement and sand were used to upgrade connection strength (Suriani, 2017).

As the first stage of preparation, Focus Group Discussion (FGD) was carried out to identify the type of training needed, natural resources owned by the community, and design for furniture products. After that, the team made material identification and sources for training such as bamboo, cutting tool (saw), sharpening knife, camps for pressing bamboo blades, wooden block as a clamp holder for the press, bamboo blades, and meter sandpaper for smoothing bamboo blade surface.

The next stage was continued with training to make laminated bamboo lumbar. The production of furniture is one result or critical success of the training as the final stage. Besides that, surveys were also conducted to investigate participants' understanding of the lamination process, the possible training knowledge for entrepreneurship, and as a basis for enhancing the sustainability of community services.

## 3. RESULT AND DISCUSSION

FGD Design: FGD of operational design for the use of bamboo was conducted on September 3, 2021 in Wonokerto Village by involving the community, village officials, and community leaders. The FGD was attended by resource people and members of the SAR team as active participants in the training. Evidence of FGD activities can be seen in Figure 2.

In this FGD, the type of training needed by the community and the natural resources owned by the community were identified. On average, the people of Wonokerto village are salt farmers who are highly dependent on the price of snake fruit. Therefore, there is a need for an approach for new insight using other sources that can lift the village economy due to the low price of snake fruit.

Figure 2 . Focus Group Discussion of the SAR team

The results of identification and field observations showed that in the upper slope landform unit, 33,380 bamboo clumps were found with two springs flowing 74 liters/second, the volcanic slope foot landform found 21,259 clumps with 18 springs flowing 3,752.5 liters/second, while in the plains landforms at the foot of the volcano, there were 8,718 bamboo clumps with 15 springs with a discharge of 879 liters per second. The landform at the foot of the volcanic slopes is often found in springs with large discharges influenced by the catchment function above it, the volcano's upper slopes. The abundance of bamboo on the upper slopes of the Merapi volcano directly affects the number and discharge of the springs beneath it. The Merapi Bamboo Plant can be seen in Figure 3.

Figure 3 . The Merapi bamboo plant

The use of bamboo on the slopes of Merapi has been realized by providing petung bamboo/ Dendrocalamus Asper as the primary material for training. In that training, the team provided insight into how the initial treatment should be carried out on bamboo plants before processing and the criteria for bamboo plants that are worthy of further processing.

**Dendrocalamus Asper Characteristics**

Based Sutiyono et al. (2015), Dendrocalamus Asper found in some areas in Indonesia with different name such as: trieng betong (Aceh), oloh otong (Gayo), bulu botung (Batak), lewuo guru (Nias), bambu batueng (Minangkabau), pering betung, (Lampung) awi bitung (Sunda), pring petung, deling petung, jajang petung (Jawa), pereng petong (Madura), tiing petung (Bali), au petung (Solor), bulo patung (Sangihe). Dendrocalamus Asper has a large trunk with a base diameter of the stem reaching 26 cm and a height of > 25 meters, prominent root circles at segment nodes 1-11, wide leaves, and prominent branches at segment nodes 8-10. There are three types of Dendrocalamus Asper in Indonesia: brown, green, and yellow (Nugraha, 2014).

### 3.1 Bamboo lamination product technology training

At the implementation stage, training on bamboo product lamination technology was carried out by direct introduction and training on how to laminate bamboo lumber to become furniture products. The bamboo lamination technology training was held on Wednesday, September 25, 2021. The training was conducted by involving members of the DIY SAR team, resource people, and community leaders. The furniture result of this training can be seen in Figure 4.

Figure 4 . Furniture product

Another measurement of the success of bamboo lamination technology training is measured by distributing posttests on understanding of the lamination process and the possibility of training knowledge for community entrepreneurship. The surveys were filled out by 34 members of the DIY SAR TEAM, with 34 members answering validly all the posttest items (11 questions).

Descriptive statistics are statistics that describe or provide an overview of the object under study through sample or population data as it is, without analyzing and making conclusions that apply in general. The descriptive analysis of respondents based on gender is male, comprising 97.06%, and female 2.94%.

The assessment of the questionnaire is expressed in two statistical measures: mean and standard deviation data. Questionnaire Part 1 consists of questions in technical training: material, connection mixture, stage preparation, stage lamination, and quality. The average rating questionnaire part 1 can be seen in Figure 5.

Based on Figure 5, it can be seen that the highest percentage is identification material (88.23%) or thirty participants, and the stage of preparation material with

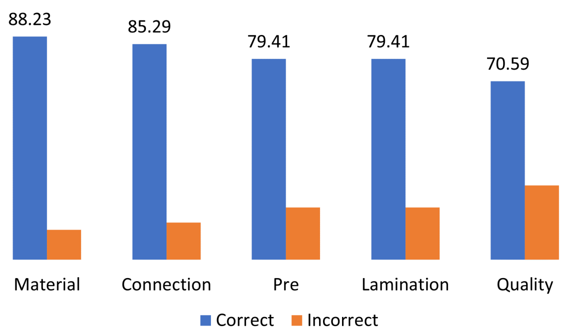


Figure 5 . Lamination technique

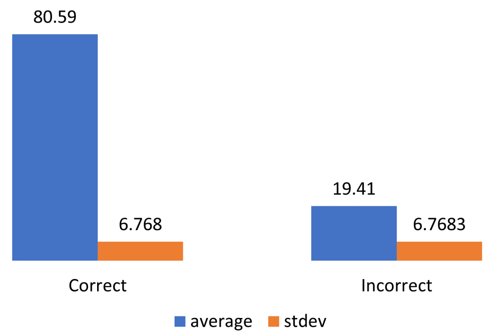


Figure 6 . Overall answer precision

twenty-nine participants (85.29%), twenty-seven participants for identification of connection mixture and identification of lamination stage (79.41%) and twenty-four participants correctly answer in quality check of laminated bamboo lumbar (70.59%). The average and standard deviation for the overall question in Part 1 of the questionnaire can be seen in Figure 6.

Based on Figure 6, it can be stated that an average of 80.59% of the respondents (twenty-seven participants) were able to answer the posttest questions correctly. In comparison, 19.41% of the respondents (seven participants) need more explanation. Respondents gave some reasons for their unfamiliarity with manual equipment in bamboo lamination, including quality concept, connection mixture, bamboo type, and supporting material. Part two of the questionnaire focuses on the benefit of training to motivate and encourage participants to become entrepreneurs. This questionnaire used a Likert scale (1-5). The result of part II, the benefit of training to motivate and encourage participants to become entrepreneurs, can be seen in Figure 7.

Based on Figure 7, it can be seen that the highest percentage of laminate bamboo as a source of business ideas is 91.18% (31 participants), and training was able to motivate become entrepreneurs with 88.24% (30 participants), access to supporting material and easy of laminate bamboo processing technique is 79.41% (27 participants), availability access bamboo as the primary material to run a business (82.35%, 28 participants), followed by questions about the availability of manual equipment (73.53%, 25 participants). The questions that have a value below 50% are questions regarding modification of goods (32.53%, 11 participants), marketing (38.24%, 13 participants), basis of business planning (29.41%, 10 participants), sustainability quality product (41.18%, 14 participants), and access for capital (35.29%, 12 participants). All questions with a value below 50% are questions in the form of a negative correlation using the word "except". From these surveys, proposed training or assistance for sustainability community services are marketing, business planning, product design, and quality products.

The types of questions that cannot be answered correctly are negative questions or those that use the word "except." Another measure used in testing the accuracy of this posttest is standard deviation data. The standard deviation is a measure of the spread of the data from the average. The size of the data spread can be seen in Figure 8.

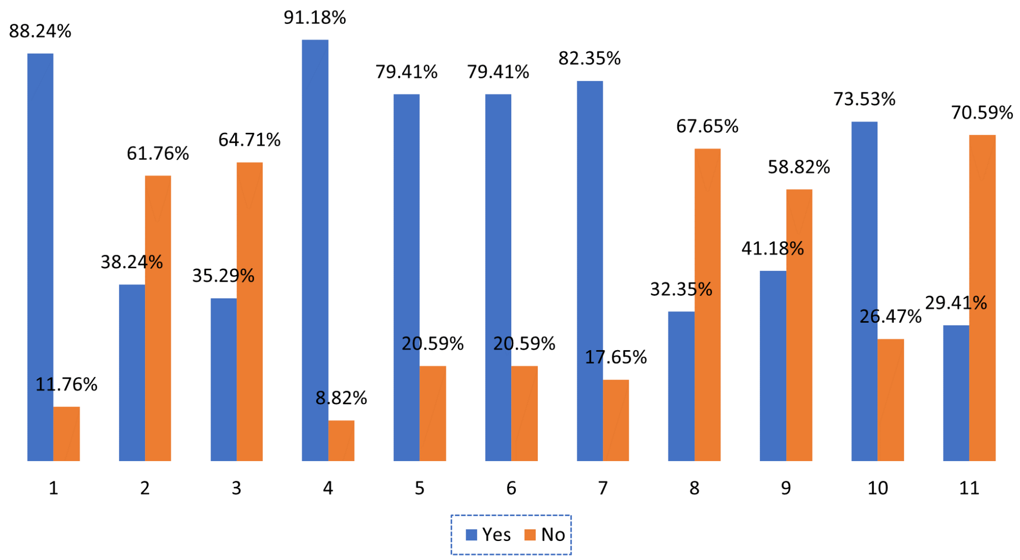


Figure 7 . Benefit of training

Based on Figure 8, it can be stated that the data spread is below 0.5. The highest data distribution value is in easy access to capital loan at 0.5, followed by familiarity of manual lamination equipment at 0.495, where this value is the same as Laminated Bamboo Lumbar (LBL) as the source of the idea of making a business and maintaining sustainability quality product. Two other questions with the same distribution value of 0.48 benefit from this training as a basis for planning a business, product modification, and marketing. The two questions that have the lowest spread are 0.18 for access to bamboo as the main material and 0.33 for access to supporting material.

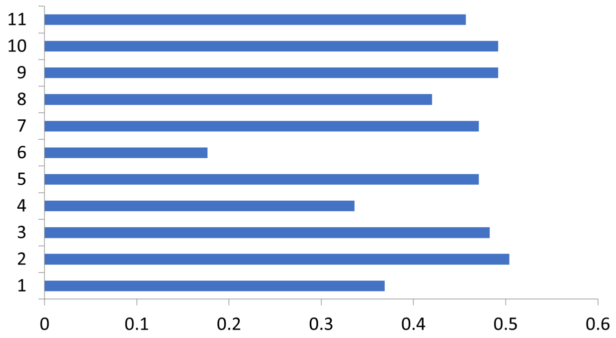


Figure 8 . Standard deviation posttest

## 4. CONCLUSION

Action research conducted in Wonokerto Village, Turi District, and Sleman Regency, which was carried out by discussing with community leaders, farmers, and village officials, can be said to have been carried out well. This success can be proven by the implementation of training on the use of bamboo and bamboo lamination technology, along with a training success survey. Based on the training survey on bamboo laminate technology, 80.59% of respondents have knowledge of identification material, stage of preparation material, identification of connection mixture, identification of lamination stage, and quality check of laminated bamboo lumbar. The proposed training or assistance for sustainability community services are marketing, business planning, product design, and quality products.

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