UPM
UNIVERSITI PUTRA MALAYSIA
BERILMU BERBAKTI

Issue 27. June-Dec 2023
ISSN No. 1985-4951

INTROPica

INSTITUTE OF TROPICAL FORESTRY AND FOREST PRODUCTS

BAMBOO: HARNESSING TECHNOLOGY FOR SUSTAINABLE PRACTICES

Centre of R&D in Tropical Biocomposite and Bioresource Management

Higher Institution Centre of Excellence (HICoE) for Tropical Wood and Fibre

Editorial Board

Table Of Content

HARNESSING GEOSPATIAL TECHNOLOGY FOR BAMBOO CONSERVATION AND SUSTAINABILITY

Norizah Kamarudin[1,2]

[1] Department of Forestry Science and Biodiversity, Faculty of Forestry and Environment, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.
[2] Laboratory of Sustainable Bioresource Management (BIOREM), Institute of Tropical Forestry and Forest Products (INTROP), Universiti Putra Malaysia, 43400 UPM Serdang, Selangor.

Bamboo is one of the forest products classified as non-timber. Bamboo has been known as a substantial industrial resource for rural people in Peninsular Malaysia, as documented by Wahab et al. (1989). Bamboos are a diverse group of plants in a wide range of habitats worldwide, from tropical rainforests to temperate forests and even high-altitude mountain regions. They adapt to the specific conditions of their habitat, including temperature, humidity, and soil type.

The characteristics of bamboo in their habitat depend on the species and the environmental conditions in which they exist. Bamboo is always found in areas with gaps. Irrespective of the size of the gaps created, bamboo is an opportunity to successfully establish in forest gap areas that will outcompete the growth of other successional species. Larpkern et al. (2011) and Tabarelli and Mantovani (2020) describe bamboo as a dominant plant in forest gap areas, thus reducing the diversity and richness of other light-demanding pioneer species.

Bamboos often play a crucial role in their ecosystems, providing food and habitat for various wildlife species. They also help with soil stabilization and erosion control. Efforts to conserve bamboo are substantial because bamboo plays a crucial role in various ecosystems and has economic, cultural, and environmental significance. Conservation efforts for bamboo focus on sustainable management, habitat preservation, and promoting the responsible use of bamboo resources. Below are such efforts to conserve bamboo.

These efforts are designed to ensure that bamboo resources are managed sustainably, biodiversity is protected, and the multiple benefits of bamboo are harnessed without causing harm to the environment or local communities (Griscom and Ashton et al., 2003; Hassan et al., 2022; Hakeem et al., 2015; Nor and Wong et al., 1985).

Bamboo conservation efforts can integrate the application of Geospatial technology, including Geographic Information Systems (GIS) and remote sensing. Such application is,

Habitat Mapping: Geospatial technology allows for the mapping and monitoring bamboo habitats. By creating detailed maps of bamboo stands and their distribution, conservationists can better understand where bamboo resources are located and can identify areas in need of protection or sustainable management.

Bamboo Density and Health Assessment: Remote sensing and GIS can be used to assess the density and health of bamboo stands. Satellite imagery and aerial photographs can provide information on the overall condition of bamboo populations, including their size, health, and distribution.

Threat Assessment: Geospatial technology can help identify threats to bamboo stands, such as deforestation, habitat degradation, and land-use changes. This information can be used to prioritize conservation efforts in areas facing the most significant threats.

Bamboo Species Identification: Bamboo species can be identified and differentiated using remote sensing and GIS techniques. This is valuable for understanding the diversity of bamboo species in a given area, which can aid in targeted conservation efforts.

Land Use and Land Cover Change Analysis: GIS can be used to analyze changes in land use and land cover over time. This can help track shifts in bamboo habitats and their surrounding environments, providing insights into the impact of land use changes on bamboo populations.

Biodiversity Conservation: Geospatial technology can help identify areas where bamboo stands are crucial for supporting wildlife that rely on bamboo for food and habitat. This information can guide conservation efforts to protect these ecosystems.

Sustainable Harvesting: GIS can be used to create sustainable harvesting plans. By mapping bamboo resources and their growth patterns, conservationists can develop strategies to ensure that bamboo is harvested in a way that does not deplete the resource or harm the environment.

Climate Change and Resilience: Geospatial tools can assess how bamboo habitats are affected by climate change. This information can inform adaptation strategies for maintaining bamboo populations in changing climatic conditions.

Ecosystem Services Assessment: Geospatial technology can help quantify the ecosystem services bamboo provides, such as carbon sequestration, soil protection, and water regulation. Understanding these services can support arguments for bamboo conservation.

Policy and Planning: Geospatial data can inform land-use planning and policy development to ensure that bamboo resources are considered in broader conservation and sustainability initiatives

Monitoring and Evaluation: Ongoing monitoring of bamboo populations is essential for assessing the effectiveness of conservation efforts. Geospatial technology allows for the systematic and remote monitoring of bamboo resources over time.

By harnessing geospatial technology, conservationists can make informed decisions and prioritize their efforts to protect and manage bamboo resources effectively. This technology provides the tools to capture, edit, analyze, and visualize data related to bamboo habitats and their surrounding environments, contributing to more sustainable and data-driven bamboo conservation strategies, and ensuring the sustainability of bamboo.

References:

Griscom, B. W., & Ashton, P. M. S. (2003). Bamboo control of forest succession: Guadua sarcocarpa in Southeastern Peru. Forest Ecology and management, 175(1-3), 445-454.

Hakeem, K. R., Ibrahim, S., Ibrahim, F. H., & Tombuloglu, H. (2015). Bamboo biomass: various studies and potential applications for value-added products. Agricultural biomass based potential materials, 231-243.

Hassan, N. H. M., Abdullah, N., Kelana, D. N. A., & Perumal, M. (2022). Early field growth performance of ten selected bamboo taxa: The case study of Sabal bamboo pilot project in Sarawak, Malaysia. Biodiversitas Journal of Biological Diversity, 23(6).

Nor, M. N., & Wong, K. M. (1985). The bamboo resource in Malaysia: Strategies for development. Recent research on bamboos (ed by AN Rao, G. Dhanarajan, and CB Sastry), 45-49.

Wahab, R., Husain, H., & LatifMohmod, A. (1989). Rattan And Bamboo as A Major Industrial Resource for Rural People in Peninsular Malaysia. Multipurpose Tree Species Research for Small Farms: Strategies and Methods, 75.

BAMBOO AND SMART NURSERY MONITORING SYSTEM

Ruzana Sanusi [1,2], Sheriza Mohd Razali [2], Muhammad Syahmi Hishamuddin [1,2]

[1]Institute of Tropical Forestry and Forest Products, Universiti Putra Malaysia,
43400 UPM Serdang, Selangor
[2] Faculty of Forestry and Environment, Universiti Putra Malaysia,
43400 UPM Serdang, Selangor
email: ruzanasanusi@upm.edu.my

In the continuous need for forest wood supply, forest plantation serves as an alternative to complement the requirement for wood-based products (Borges et al., 2016). Provision of high-quality planting materials is needed to establish a sustainable forest plantation management and ensure high wood production. In Malaysia, Malaysia Timber Industry Board (MTIB) suggested several timber species for forest plantation establishment, including the fast-growing species such as Tectona grandis *Azadirachta excelsa, Paraserianthes falcataria,* Bamboo and *Eucalyptus*.

Fast growing species like Bamboo has gained interest from wood industry in recent years due to its ecological and commercial importance. However, there is a knowledge gap in relation to Bamboo and its water requirements especially during early establishment of Bamboo trees in the nursery. It is crucial that forest plantation make use the innovation and advancement of recent technologies such as through watering automation system and Internet of Things (IoT) in monitoring the water status of Bamboo in the nursery.

Using sensor-based and wireless system, these technologies may be more economical in the long run due to the reduction of the need for human resources. For instance, plant will be watered in the nursery using the automated system where the system will control the water supply without the presence of any irrigator. Moreover, data collected by climate sensors, such as weather conditions, and soil quality can be used to monitor the environmental influence and water status (Figure 1).

Figure 1: Solar radiation sensor is one of the measured environmental parameters.

In addition, when IoT system installed in combination with the sensors, the data can be collected automatically. The collected data will be pushed to cloud storage through a gateway. The information can be obtained from the cloud without being present at the nursery.

This will then be used to guide decision making pertaining to the needs of plant monitoring. Due to reduced time in obtaining required data, monitoring, and response to the watering needs of plants in the nursery can be done faster thus, high quality seedlings can be produced.

At Institute of Tropical Forestry and Forest Products (INTROP), a smart monitoring system using IoT system has been installed. This installation was aimed to look at the potential of digital monitoring of the environment and soil water status in the nursery. This smart monitoring system project was proceeded with three steps as follows:

This smart monitoring system project was proceeded with three steps as follows:

1. Installing the sensors (soil moisture, air temperature, relative humidity, and solar radiation (Figure 2)
2. Linking the set of sensors to the IoT system using a gateway with cellular reception (Figure 3)
3. Reviewing data through a web based application

Figure 2: Installation of the IoT system at the nursery of INTROP

Figure 3: Completed installation of smart monitoring system and ready to be used after the sensors are linked to the IoT system.

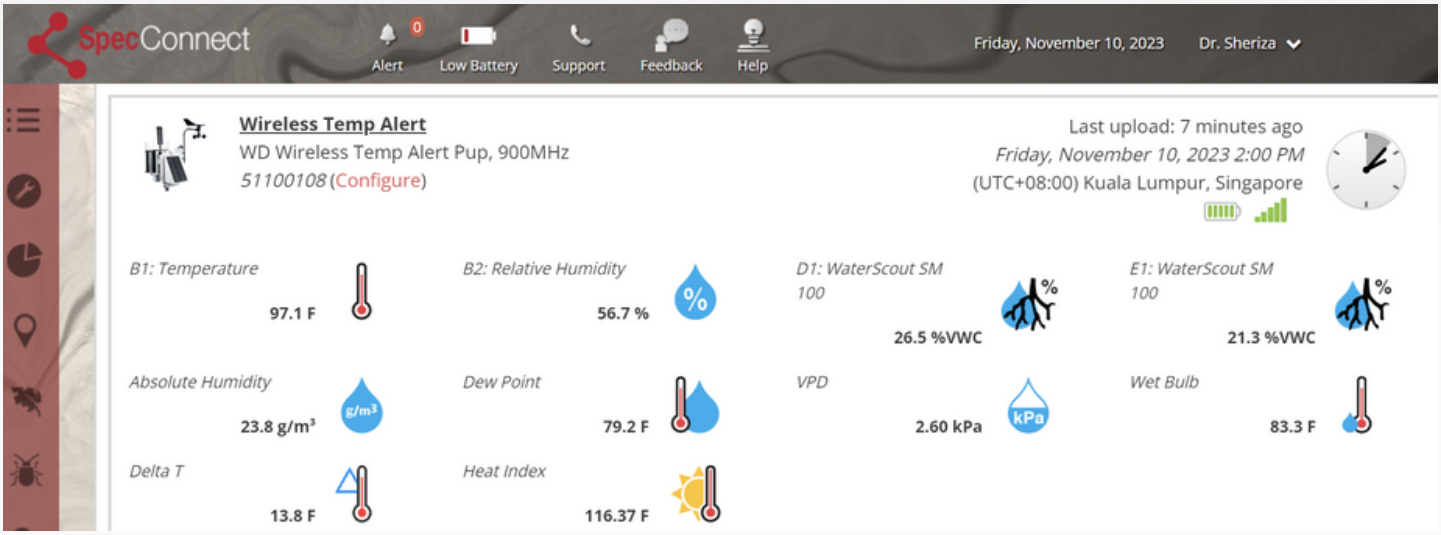

Figure 4: The data from sensors can be viewed from a web based application.

With the applied technology, this can showcase a wireless based monitoring system for the future development of efficient nursery monitoring. The data can be viewed through any digital devices such as handphone and computer. Easy access of information is deemed beneficial to the end users. This can be utilized by related industries in enhancing their nursery management and production quality especially on specific watering regime for species such as Bamboo to support forest plantation program in Malaysia.

References:

Borges, J. G., Diaz-Balteiro, L., McDill, M. E., & Rodriguez, L. C. (2016). Management of Industrial Forest Plantations. Springer.

LiDAR DATA FOR FOREST AND BAMBOO DATA ANALYSIS USING GLOBAL MAPPER SOFTWARE

Sheriza Mohd Razali [1], Mohamad Faizal Mohd Taib [2], Mohd Afifi Mokhtar [2]

[1]Institute of Tropical Forestry and Forest Products, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor
[2] FWF World Solution, 63 Mezzanine Floor, Jalan Negara, Taman Melawati, Ulu Kelang, 53100 Kuala Lumpur

Introduction

Mapping using remote sensing tools has become synonymous with forest management planning. One of the active remote sensing technologies used to measure distances with high accuracy is LiDAR (Kelly and Di Tommaso, 2015). LiDAR, or light detection and ranging, actively emits pulses of light to measure distances to target surfaces. Objects can be precisely found in three-dimensional space by estimating the time it takes for LiDAR pulses to hit a surface and return to the LiDAR sensor. With each pulse, the sensor records several points of contact, and with millions of pulses in a LiDAR acquisition, the result is a dense point cloud that reveals the forest and the ground beneath it (USDA, 2022). LiDAR has several capabilities, for example, estimating canopy height and, subsequently, approximate 50% of the aboveground biomass of an area. The Canopy Height Model (CHM) is one of the most powerful tools available derived from Lidar data.

Based on neonscience.org, LiDAR is a system operated based on light energy. The return of the energy may give multiple reflections that is recorded from one pulse of light (www.neoscience.org). Brief introduction of LiDAR explained by synopsys.com as laser light is sent from a source (transmitter) and reflected from objects in the scene (www.synopsys.com).

Global Mapper is a software that been used for LiDAR data processing. The software module is an optional add-on to the based software that be purchased when needed. The add-on module when purchased can be propagate to the Global Mapper menus. This add-on makes use of Lidar Load Options, Lidar Export support that will first be leveraged to into the software toolbar (bluemarblegeo.com). This article introduced forest application software for LiDAR, focusing on bamboo applications in particular. In the meantime, projects related to LiDAR applications in the institute also presented.

LiDAR projects in Kinabatangan

It's become well-known in forestry application when it was selected application for TRAILS project in Kinabatangan floodplain region of Sabah, Malaysia. LiDAR systems was set-up in Malbumi area for capturing LiDAR image products. The activities were conducted in 2022 with FWF World Solution as specialist in LiDAR operation, image processing and final products derivation. Below presented major components of LiDAR before take-off.

(a) (b)

Figure 1.0: (a) Major components of LiDAR for operation, sensors below the component is completely to take care for avoiding eagle attacks and damaged. (b) Setting up GPS points.

Figure 2.0: LiDAR systems for operation is fully charged and ready to fly.

Figure 3.0: LiDAR flying path is displayed on its monitor and explanation by FWF World Solution staffs to the HUTAN NGO personnel.

Global Mapper software

The software is a trusted software used by GIS professional around the globe by BLUE MARBLE GEOGRAPHICS (www.bluemarblegeo.com).

Figure 4.0: Screen view of the software.

A new version of 24.1 was released. There are nearly 20 tools available which focus on LiDAR data processing, includes:

- Data importing/Exporting
- Access to online data
- Raster data processing
- Digitizing
- Terrain analysis
- Image rectification
- Lidar and image points clouds

The software provides demo, free trials, and online purchase or through licensed vendor in the country reside. Global Mapper screen view shown in the figure below.

Many studies employed Global Mapper software basics version for LiDAR data for data conversion to be use in Catalyst Professional software. For example, from kmz file to Geo tiff file. This is because LiDAR data is saved in kmz format which has to be exported to certain format to be applied in other software.

This list of formats that supported for conversion in Global Mapper is useful to be used in Catalyst Professional software. Table 1.0 showed image data formats in the software.

Table 1.0: KMZ format to some of other format supported in Global Mapper software export tools.

Original format	Converted format
KMZ	GeoTIFF
	JPG, JPG2000, PNG
	Erdas Imagine file
	Idrisi
	PCX
	PDF
	RAW

Data conversion may take around 15-20 minutes for each of KMZ file size 24,000 KB to 29,000 KB data to achieved 100% completed processing.

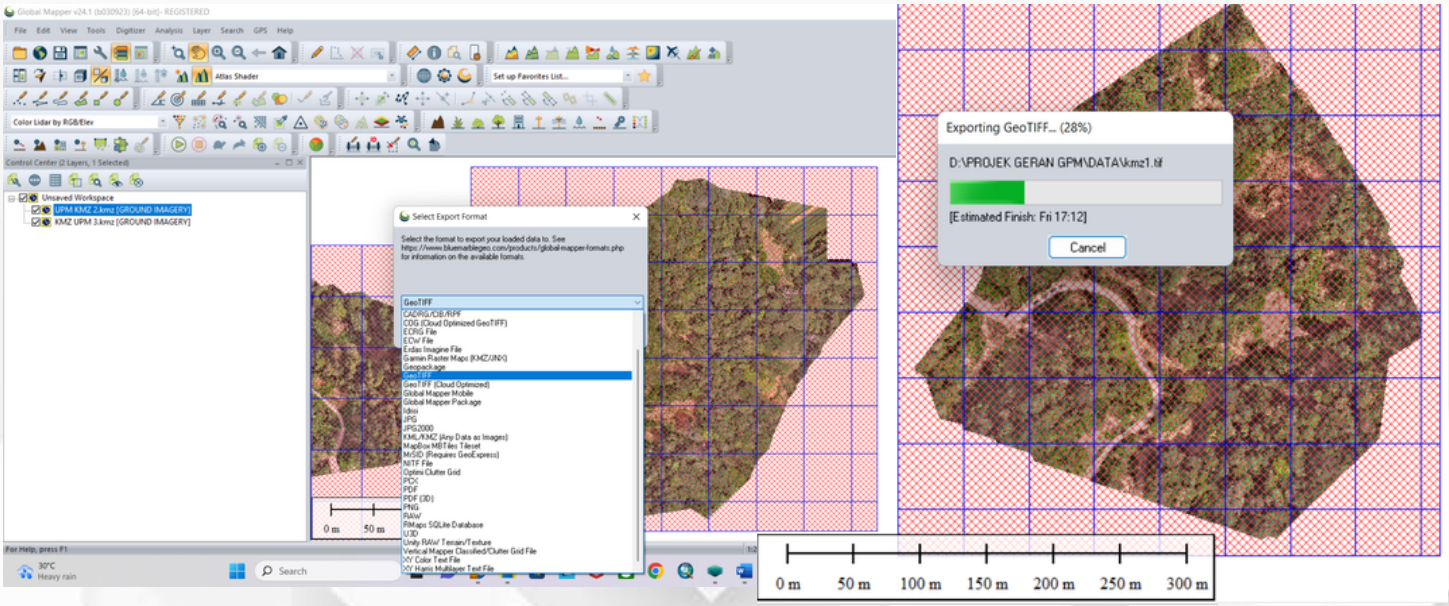

Figure 5.0: Exporting data in the Global Mapper.

LiDAR for bamboo mapping

LiDAR systems is very accurate and precious technology in forestry application. It's applied in various application from assessing tough landscape in the forest and urban area. Urbanization makes use of different types of tree species for landscapes. Bamboo is one of the well-known plants becoming a huge potential in decoration, source of food and it's planted for many benefits for human being.

The technology was reported in a study by Lin et al., (2019) employed in Yushan Forest, China located within subtropical monsoon climatic zone of southeast Jiang province, at 120°42′9.4″E, 31°40′4.1″N.

The bamboo forest LiDAR data was using for mapping, delineated and prediction bamboo management class for the areas (i.e extensively managed).

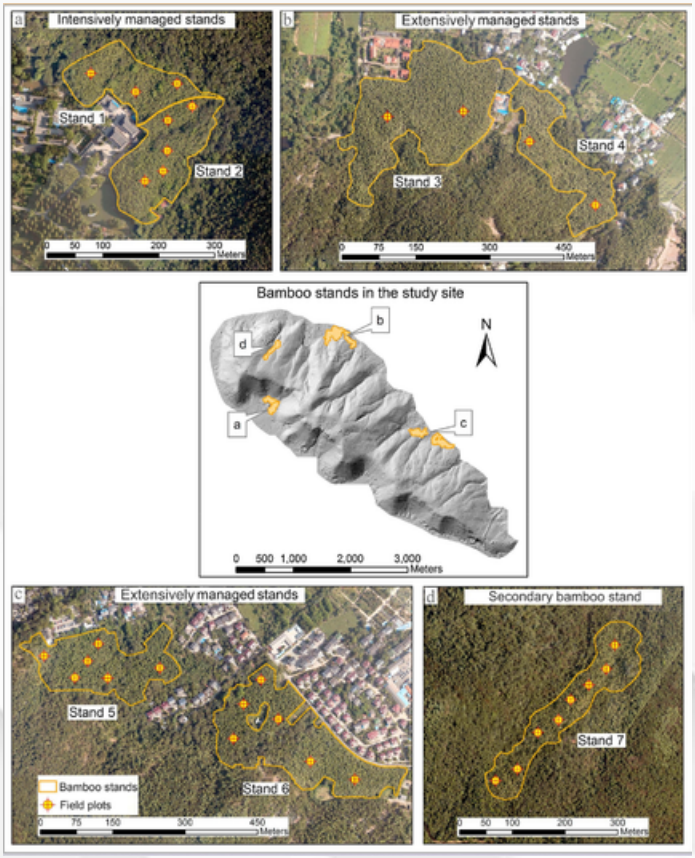

Figure 6.0: Bamboo LiDAR data captured for mapping, delineation, and prediction of bamboo management area in China (Lin et al., 2019).

LiDAR systems is becoming a requirement for efficient forest management. It's a potential core tools for forest inventory in the future. Handling big data is a solution through GIS application, but LiDAR is a solution for capturing data for hypothesis and theory.

References:

Kelly, M., & Di Tommaso, S. (2015). Mapping Forests with Lidar Provides Flexible, Accurate Data with Many Uses. California Agriculture, 69(1), 14–20. Doi:10.3733/Ca.V069n01p14.

BLUE MARBLE GEOGRAPHICS. 2003.Global Mapper. www.Bluemarblegeo.Com. Accessed On 7 September 2023.

Neoscience. 2023. www.Neoscience.Org. Accessed On 6 September 2023.

Synopsys.2023. www.Synopsys.Com. Accessed On 6 September 2023.

Lin Cao, Nicholas C. Coops, Yuan Sun, Honghua Ruan, Guibin Wang, Jinsong Dai, Guanghui She, 2019. Estimating Canopy Structure and Biomass in Bamboo Forests Using Airborne Lidar Data, ISPRS Journal of Photogrammetry And Remote Sensing, Volume 148, 2019, Pages 114-129, ISSN 0924-2716, Https://Doi.Org/10.1016/J.Isprsjprs.2018.12.006.

CULTIVATING BAMBOO: ORCHESTRATING GROWTH THROUGH DIGITAL NURSERY OVERSIGHT WITH IoT

Muhammad Syahmi Hishamuddin[1,2], **Ruzana Sanusi**[1,2]

[1] Laboratory of Sustainable Bioresource Management (BIOREM), Institute of Tropical Forestry and Forest Products (INTROP), Universiti Putra Malaysia, 43400 UPM Serdang, Selangor
[2] Faculty of Forestry and Environment, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor

Introduction

The incorporation of Internet of Things (IoT) technology has fundamentally transformed the way we cultivate and oversee crops in the field of modern agriculture. This shift in paradigm encompasses not only conventional crops, but also encompasses the fragile yet durable bamboo. Utilizing IoT technology in bamboo nurseries has significant promise for improving monitoring and management methods, guaranteeing optimal growth and long-term viability.

Understanding Bamboo Significance

Bamboo is a highly esteemed plant that has been venerated for countless years in numerous cultures across the globe. Renowned for its adaptability, robustness, and ecological soundness. Bamboo finds several applications, ranging from building and textiles to environmental conservation. Due to its rapid growth rate and resilience, it is very suitable for sustainable agroforestry and reforestation projects. Bamboo is seen as a symbol of resilience, adaptability, and progress in Eastern civilizations. It serves multiple functions, such as crafting tools, instruments, furniture, and other items. Bamboo is regarded as a remarkable plant, carrying a profound spiritual significance within the cultural beliefs of the Far East. The composition of bamboo exemplifies the enigmatic concepts of emptiness and shape, while its flexibility and durability evoke admiration from both humans and animals.

Bamboo holds significant economic and cultural importance in South Asia, Southeast Asia, and East Asia. Bamboo is utilized in the construction industry, serves as a dietary staple, and is employed as a primary material. Additionally, it frequently features in artistic representations, such as bamboo paintings and bamboo craftsmanship.

Challenges In Bamboo Nursery Management

Nurturing bamboo from a young seedling to a mature plant necessitates meticulous and diligent care and vigilance. Conventional methods for monitoring and maintaining bamboo nurseries sometimes face challenges in terms of accuracy, effectiveness, and real-time data collection. The growth and progress of bamboo are greatly impacted by a range of elements, such as climatic variations, pest invasions, and soil conditions. Consequently, the growth of bamboo necessitates consistent monitoring and flexible management strategies.

Role of IoT in Nursery Monitoring

The integration of IoT devices in bamboo nurseries provides growers with immediate and precise information and authority over essential environmental factors. Soil-embedded sensors can monitor moisture levels, ensuring optimal irrigation,

while climate sensors track temperature and humidity for ideal growth conditions. Additionally, IoT-powered surveillance systems enable early identification of pests or diseases, facilitating prompt intervention to prevent extensive harm.

IoT Implementation for Bamboo Management

Implementing IoT infrastructure requires a methodical and customised approach that specifically addresses the distinct requirements of bamboo nurseries. Data from strategically positioned Sensor Networks in the nursery is transmitted to a centralised platform. Subsequently, these data are scrutinised with sophisticated algorithms and machine learning techniques to extract practical and applicable insights. Real-time soil moisture data can be used to activate automated irrigation systems, optimising water usage and maintaining optimal growing conditions.

Benefits of IoT-Driven Bamboo Management

1. **Accuracy and effectiveness.**
   The accuracy provided by IoT devices enables producers to accurately adjust ambient conditions to meet the specific needs of bamboo species. This level of precision not only promotes more robust growth but also maximizes the efficiency of resource usage, hence minimizing water and energy wastage.

2. **Timely identification and proactive measures.**
   IoT-enabled surveillance enables the rapid detection of possible dangers such as insect infestations or diseases, facilitating timely intervention. By adopting a proactive strategy, the dangers are reduced and the negative effects on the health of bamboo are minimized, so ensuring the entire productivity of the nursery is preserved.

3. **Utilizing data to inform decision-making processes.**
   The abundance of data produced by IoT devices enables producers to make well-informed decisions. Examining past patterns and current data assists in forecasting growth trends, enhancing farming methods, and adjusting approaches for the sustainable management of bamboo.

Prospects for the future and the ability to maintain sustainability.

Adopting IoT technology in the management of bamboo nurseries not only improves existing methods but also establishes a foundation for sustainable agriculture practices. The fusion of technology and agriculture facilitates the development of inventive approaches to tackle the issues of environmental sustainability, biodiversity preservation, and food security.

Conclusion

The integration of IoT technology and bamboo nursery management signifies the advent of a novel era characterized by meticulousness, effectiveness, and environmental consciousness in the field of agriculture. By closely monitoring and analyzing data, producers may make informed decisions and take proactive measures to maximize growth conditions and maintain the natural resilience of bamboo. Adopting IoT is not just a progress in farming techniques, but a dedication to the responsible and enduring management of this priceless asset.

BAMBOO INDUSTRY DEVELOPMENT STRATEGY IN MALAYSIA

Paiman Bawon [1]

[1] Department of Wood and Fiber Industries, Faculty of Forestry and Environment, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor

Introduction

Bamboo industries in Malaysia play a vital role in meeting the growing demand for forest-based materials and energy production. With a large cultivation area and relatively cost-effective production, Malaysia has the potential to become a major player in the bamboo industry. These bamboo species have multiple uses in construction, transportation, and cultural activities, making bamboo a valuable source of income for communities across the country. This abundance of bamboo resources provides a strong foundation for the development of the industry and the generation of income (Ameram et al., 2018).

In our country, the total bamboo species is about 59, of which 36 species consist of local types while the other 25 types come from abroad. The genera in Malaysia are *Bambusa, Dendrocalamus, Dinochloa, Gigantochloa, Racemobambos, Schizostachyum, Thyrsostachys, Chusqua, Phyllostachys* and *Yushania*. The distribution of wild bamboo trees in this country is quite limited to one area. The estimated total area grown with bamboo plants for a period of 20 years is 329,600 hectares. Bamboo that grows in the forest is mostly found to be thriving, especially in areas with high rainfall and sustainable water sources, (Azmy & Norhazaedawati, 2015). Based on the information on the chemical and mechanical properties of several types of bamboo in Table 1 and Table 2 below, the chemical compositions of bamboo are similar to those of hardwoods compared to the other wood species, except for the higher ash content. A comparison of the mechanical properties of bamboo to those of other wood species that are used as raw material for wood composite manufacture such as Douglas-fir, Red pine, Yellow poplar, American aspen, and Rubberwood (USDA Forest Service, 1999), in general, bamboo is stronger than wood in bending strength, compression strength parallel to grain and is similar in shear strength parallel to grain.

Table 1. The chemical composition of some bamboo species

Bamboo species	Chemical compositions (% w/w)						
	Holocellulose	Lignin	Ash	Cold-water solubility	Hot-water solubility	1% NaOH solubility	Alcohol-benzene solubility
Dendrocalamus asper [1]	74.0	28.5	1.5	6.4	9.2	24.7	5.5
Phyllostachys heterocycla [2]	76.8	26.1	1.3	-	-	-	4.6
Phyllostachy nigra [2]	66.4	23.8	2.0	-	-	-	3.4
Phyllostachy reticulate [2]	51.8	25.3	1.9	-	-	-	3.4
Phyllostachy makinoi [3]	79.9	25.5	-	-	-	-	2.6
Phyllostachy pubescens [4]	71.7	23.6	1.4	-	-	-	4.6
Gigantochloa scortechinii [5]	67.4	26.4	1.3	4.8	5.9	19.4	3.4
Bambusa clumeana [6]	69.2	21.6	-	4.3	7.3	23.3	3.8
Schizostachyum zollingeri [6]	71.6	21.4	-	4.1	5.1	24.3	2.5

Sources: 1 Kamthai (2003) 2 Higuchi (1957) 3 Fengel and Shao (1984) 4 Li, Shupe, Peter, Hse and Eberhardt (2007) 5 Jamaludin, Abd. Jalil, Ashari and Abd. Latif (1992) 6 Nor Azah and Azmy (1991).

Table 2. The mechanical properties of some bamboo species

Bamboo species	Modulus of rupture (MPa)	Modulus of elasticity (MPa)	Shear strength parallel to grain (MPa)	Compression strength parallel to grain (MPa)
Bambusa blumeana	99.8	4,100	4.5	24.0
Bambusa vulgaris	62.3	6,100	4.0	25.3
Dendrocalamus asper	85.7	6,300	5.4	31.5
Gigantochloa scortechinii	52.4	4,800	4.3	27.0
Gigantochloa levis	78.5	5,100	4.8	40.0
Balanocarpus hemii	122.0	1,800	13.7	69.0
Koompasia malaccensis	100.0	1,700	10.0	54.7

Source: Liese (1985).

Bamboo Development Strategies

Based on the large cultivation area and the bamboo properties, to capitalize on the potential in this industry, a comprehensive development strategy should focus on the following key areas:

1. **Enhancing the processing technology:**
   Investing in research and development to improve processing technology will enable the production of high-quality bamboo fibers that can be used in a wide range of applications such as the fabrication of composites. Therefore, the level of quality and capacity of the existing factory needs to be improved to encourage the growth of bamboo-based products, especially those aimed at production for export purposes. Some of the things that need to be considered include machine selection, training requirements, exposure to new products, and product quality improvement.

2. **Promoting sustainable cultivation and management:**
   Establishing measures for the sustainable cultivation and management of bamboo resources is very important. This can include implementing policies and regulations to prevent over-harvesting, promoting reforestation efforts, and encouraging the adoption of sustainable cultivation practices. We cannot rely on bamboo resources from the forest only because the species that grow together do not have the same thickness, type, and age, causing the bamboo sticks produced to be of poor quality. Most of the ex-logged forest areas that have commercial bamboo trunk resources do not have an organized management system. Silvicultural management systems are very important in improving the quality and quantity of commercial bamboo found in ex-logged forest areas.
   An alternative to overcome the lack of bamboo supply from the forest is to plant or establish large-scale commercial bamboo plantations. This way can supply raw bamboo materials continuously.

3. **Strengthening industry collaboration and networking:**
   To foster growth and innovation in the bamboo industry, we should encourage collaboration between different stakeholders, including researchers, government agencies, bamboo farmers, and industry players. By establishing strong networks and partnerships, knowledge sharing, and technology transfer can take place, enabling the industry to benefit from the expertise of various stakeholders. This can include conducting research on new and improved bamboo species, developing innovative processing techniques, and exploring new applications for bamboo in various industries.

4. **Investing in research and development:**
   Further research for bamboo composite development, property improvement and the enhancement of knowledge are necessary for assessing its suitability for bamboo composites and to decide the approximate methods, technology, and equipment suitable for bamboo processing. The following recommendations research should consider including the study about the ownership structure, tenure system, plantation area and annual production as a raw material for wood industries, three development and studies with a view to improving bamboo plantation management, the highly efficient methods and equipment for bamboo processing, the effect of bamboo-based products on tool wear during machining, and an efficiency process reducing the starch content or increasing the resistance to

the insect and fungi, (Febrianto et al., 2010; Rowell & Norimoto, 1987). Three national policies have highlighted the need to develop the bamboo industry as a source of non-timber forest products. The National Timber Industry Policy (2006 to 2020) emphasizes bamboo being utilized as raw material for the development of the downstream timber sector (Maguigad 2020). The National Forest Policy, 1987 (revised in 1992) underlines the need to increase the non-timber forest resources using scientific and sustainable approaches (Moktshim 2020).

5. Expanding market opportunities:

To fully capitalize on the potential of the bamboo industry, we should explore and expand its market opportunities. This can involve promoting the use of bamboo products domestically and internationally, identifying new industries and sectors where bamboo can be utilized, and developing marketing strategies to highlight the unique qualities and benefits of bamboo products. Several steps need to be identified to make bamboo products get an effective market. Every bamboo product that is produced needs to consider customer taste, product design, product quality, new product market research, comparing product price with neighbouring countries, and handicraft product entrepreneurs need to have a preservation process and the moisture content of each raw material according to standards before being exported to foreign countries.

Overall, the development strategy in the bamboo industry in Malaysia should focus on enhancing processing technology, promoting sustainable cultivation and management, strengthening collaboration and networking, investing in research and development, and expanding market opportunities. By implementing these strategies, Malaysia can unlock the full potential of its bamboo resources and establish itself as a leader in the bamboo industry, both domestically and internationally.

References

Azmy, M and Norhazaedawati, B. 2015. Penanaman Buluh Komersial di Malaysia. Malaysian Timber Industry Board (MTIB. Kuala Lumpur.

Ameram, Nadiah & Agoh, Muhammad & W Idris, Wan & Arlina, Ali. (2018). Chemical characterization of bamboo leaves (Gigantochloa albociliata and Dracaena surculosa) by sodium hydroxide treatment. F1000Research. 7. 1024.10.12688/f1000research .15036.1.

Febrianto, F., Sahroni, Hidayat, W., Bakar, E. S., Know, G. J. Know, J. H., Hong, S., & Kim, N. H. (2012).

Fengel, D., & Shao, X. (1984). A chemical and ultrastructural study of the bamboo species Phyllostachys makinoi Hay. Wood Science and Technology, 18, 103-112.

Higuchi, H. (1957). Biochemical studies of lignin formation, III. Physiologia Plantarum, 10, 633-648. http://dx.doi.org/10.1111/j.1399-3054.1957.tb06971.x

Jamaludin, K., Abd. Jalil, H. A., Ashari, A. J., & Abd. Latif, M. (1992). Variation in specific gravity of 1-, 2- and 3 year old Gigantochloa scortechinii (Buluh Semantan). In W. M. Wan Razali & M. Aminuddin (Eds.). Proceeding First National Bamboo Seminar (pp. 182-185). Forest Research Institute Malaysia, Kuala Lumpur, Malaysia.

Kamthai, S. (2003). Alkaline sulfite pulping and ECF- bleaching of sweet bamboo (Dendrocalamus asper Backer, M.S. Thesis). Kasetsart University, Thailand.

Li, X. B., Shupe, T. F., Peter, G. F., Hse, C. Y., & Eberhardt, T. L. (2007). Chemical changes with maturation of the bamboo species Phyllostachys pubescens. Journal of Tropical Forest Science, 19(1), 6-12.

Liese, W. (1985). Bamboos-biology, silvics, properties, utilization. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Eschborn, Germany.

Maguigad, E. (2020). Assessment of Policies on Non-timber Forest Products, Swiss Agency for Development and Cooperation SDC, Bern, Switzerland.

Moktshim, N. (2020). "Forest management in Malaysia: The strategies undertaken towards achieving Sustainable Development Goals," IOP Conference Series: Earth and Environmental Science 561, Article ID 012041. DOI: 10.1088/1755- 1315/561/1/012041.

Nor Aziha, M. A., & Azmy, H. M. (1991). Preliminary study on the four Malaysian commercial bamboo species. India Bulletin, 1(2), 6-10.

Rowell, R. M., & Norimoto, M. (1987). Acetylation of bamboo fiber. Mokuzai Gakkaishi, 33(11), 907-910.

USDA Forest Service. (1999). Wood Handbook: Wood as an Engineering Material. USDA gen. Tech. Rept. FPL-GTR-133.

BAMBOO: A REVIEW OF FUNCTIONAL PROPERTIES AND APPLICATION VERSATILITY

Nurul Izzati Abdullah Zawawi [1], Zaiton Samdin [1,2*], Norzanalia Saadun [1,3], and Norfaryanti Kamaruddin [1]

[1] Laboratory of Sustainable Bioresource Management, Institute of Tropical Forestry and Forest Product, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

[2] School of Business and Economics, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

[3] Faculty of Forestry and Environment, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

*Corresponding author's e-mail: zaisa@upm.edu.my

Introduction

Bamboo, revered for its inherent strength and rapid growth, has emerged as a versatile and sustainable resource across various industries. Amidst the growing environmental concerns and dwindling natural resources, the global quest for sustainable alternatives has intensified. Among the rising stars, bamboo has captivated the attention of researchers and consumers alike. Renowned for its inherent strength and resilience, bamboo matures within 3-5 years, solidifying its position as a readily available and renewable resource (Han et al., 2021). Bamboo's exceptional characteristics and inherent eco-friendliness make it a highly valuable material suitable for diverse applications.

This review delves into bamboo's transformative journey, highlighting its significant role in developing sustainable materials. From house construction and flooring to handicrafts, art, and furniture, bamboo demonstrates remarkable adaptability and durability. This brief review highlights the wide-ranging applications of bamboo, encouraging continued research for eco-friendly solutions and promoting sustainability across diverse fields.

Domestic Uses

Guadie et al. (2019) underscore that bamboo's distinctive properties extend far beyond its environmental benefits, offering exceptional adaptability in numerous domestic uses. From house construction to flooring and indoor utensils, bamboo's versatility shines through. Its inherent strength and durability make it suitable for wall construction, scaffolding, and even flooring. The hardness and natural beauty of bamboo further enhance its appeal for flooring, while its flexibility allows for its use in creating aesthetically pleasing furniture and utensils (Dlamini et al., 2022).

Handicrafts and Art

Boissière et al. (2020) further highlight the artistic and artisanal aspects, showcasing its versatility. Skilled artisans utilize the natural flexibility of bamboo to create intricate carvings, delicate fans, captivating paintings, and exquisite jewellery. Beyond traditional crafts, bamboo is finding innovative applications in contemporary designs, adorning computer cases, keyboards, car interiors, and even textiles (Huang, 2021).

Construction Material

The construction industry is increasingly recognizing the potential of bamboo as an environmentally friendly and efficient alternative to traditional materials. Its strength and adaptability make it suitable for various applications, including roofing, structural frameworks, and flooring (Yadav & Mathur, 2021). Furthermore, the natural elasticity of bamboo contributes significantly to the construction of earthquake-resistant structures, as demonstrated in the study by Shiwani and Thangamani (2023).

Furniture and Fiber Composites

As indicated by Deng et al. (2023), the popularity of bamboo furniture is a testament to its exceptional characteristics. Its adaptability and durability make it a preferred choice for both urban and rural areas. Additionally, the ease with which bamboo can be molded and its compatibility with local carpenters contribute to its widespread usage. Beyond furniture, bamboo's applications extend to construction materials and innovative bamboo-plastic composites (BPCs). These BPCs incorporate bamboo fibers to enhance their mechanical properties, further showcasing the versatility of this remarkable resource (Żelaziński et al., 2019).

Pulp and Paper

According to Bajpai (2021), beyond tangible products, bamboo is also making its mark in the pulp and paper industry. Recognized for its sustainability, high-quality fibers, and economic benefits, bamboo is steadily gaining traction as a viable alternative to wood-based paper. Although challenges related to its high silicon content exist, technological advancements are addressing silicon retention and removal, paving the way for the broader adoption of bamboo paper. The quality of bamboo paper is comparable to wood-based paper, making it suitable for various applications (Nisha et al., 2022).

Conclusion

The transformative journey of bamboo, from its humble origins in the forest to its diverse functional applications, underscores its potential as a sustainable and high-quality resource. Its adaptability, rapid growth, eco-friendliness, and inherent strength contribute significantly to its growing popularity across various industries. This review serves as a testament to the vast potential of bamboo, encouraging continued research and development for innovative and eco-friendly solutions. As the world navigates the ever-pressing challenges of environmental sustainability, bamboo emerges as a beacon of hope, offering a path toward a greener and more sustainable future.

References

Bajpai, P. (2021). Nonwood Plant Fibers for Pulp and Paper. Elsevier.

Boissière, M., Atmadja, S., Benmakhlouf, S., Beyessa, M., Kassa, H., Hunde, T., & Assefa, F. (2020). Developing small-scale bamboo enterprises for livelihoods and environmental restoration in Benishangul-Gumuz Regional State, Ethiopia. International Forestry Review, 22(3), 306–322. https://doi.org/10.1505/146554820830405618

Deng, W., Lin, H., & Jiang, M. (2023). Research on Bamboo Furniture Design Based on D4S (Design for Sustainability). Sustainability, 15(11), Article 11.https://doi.org/10.3390/su15118832

Dlamini, L. C., Fakudze, S., Makombe, G. G., Muse, S., & Zhu, J. (2022). Bamboo as a valuable resource and its utilization in historical and modern-day China.

BioResources, 17(1), 1926–1938. https://doi.org/10.15376/biores.17.1.Dlamini

Ge Han, Rongrong Li, & Chuangui Wang. (2021). Effects of Three-layer Structure and Age on Mechanical Properties of Moso Bamboo. BioResources, 16(2), 2406–2415. https://doi.org/10.15376/biores.16.2.2406-2415

Guadie, Y. W., Feyssa, D. H., & Jiru, D. B. (2019). Socio-economic importance of highland bamboo (Yushania alpina K. Schum) and challenges for its expansion in Bibugn District, East Gojjam, Ethiopia. Journal of Horticulture and Forestry, 11(2), 32–41. https://doi.org/10.5897/JHF2018.0564

Huang, Z. (2021). Element Analysis of Bamboo Construction-Related Resource. In Z. Huang (Ed.), Resource-Driven Sustainable Bamboo Construction in Asia-Pacific Bamboo Areas (pp. 41–85). Springer International Publishing. https://doi.org/10.1007/978-3-030-73535-7_2

Nisha, Singh, R., & Singh, K. (2022). Handmade Paper Industry: A Green and Sustainable Enterprise and Its Challenges. In S. Arora, A. Kumar, S. Ogita, & Y.-Y. Yau (Eds.), Biotechnological Innovations for Environmental Bioremediation (pp. 171–188). Springer Nature. https://doi.org/10.1007/978-981-16-9001-3_7

Shiwani, & Thangamani, K. (2023). Evaluating the potential of bamboo: A sustainable alternative for building construction. AIP Conference Proceedings, 2766(1), 020094. https://doi.org/10.1063/5.0146103

Yadav, M., & Mathur, A. (2021). Bamboo as a sustainable material in the construction industry: An overview. Materials Today: Proceedings, 43, 2872–2876. https://doi.org/10.1016/j.matpr.2021.01.125

Żelaziński, T., Ekielski, A., Tulska, E., Vladut, N.-V., & Durczak, K. (2019). Wood Dust Application For Improvement Of Selected Properties Of Thermoplastic Starch / Wykorzystanie Pyłu Drzewnego Do Poprawy Wybranych Właściwości Skrobi Termoplastycznej. 58, 37–44. Https://Doi.Org/10.35633/Inmateh-58-04

BULAKSALAK BAMBOO VILLAGE, YOGYAKARTA, INDONESIA

Mohd Muhaizi Mat Daud [1], Intan Suraya Ibrahim [1], Adela Mat Arof [1]

[1]Laboratory of Sustainable Bioresources Management,
Institute of Tropical Forestry and Forest Product (INTROP), Universiti Putra Malaysia,
43400 UPM SERDANG, Selangor Darul Ehsan.

Introduction

Bamboo is one of the biomaterials available in the world and is still not optimally used. Bamboo is capable of having added value up to tens of times if processed into more attractive shapes. Even bamboo trees can become an object of bamboo forest ecotourism if properly managed. Bulaksalak Bamboo Village is one of the tourist destinations based on bamboo plant resources and bamboo products naturally.

The location of the area (Figure 1) is in Kampung Wukirsari Kapanewon Cangkringan, Yogjakarta, Indonesia. Kampung Bulaksalak is now also known as a tourist attraction based on bamboo resources including food and the local community. This is because there is a natural bamboo forest on the ground of Merapi volcano, even in the area there is a bamboo market where every week Kliwon, (Figure 2). The locals will be held a market that sells a variety of agricultural products of the population, the typical cuisine of the villagers and so on. Every market is also usually crowded because sellers and buyers meet in the middle of a clean and comfortable bamboo forest.

In addition to the bamboo market, in the same location is also an education forest that emphasizes the problem of bamboo for the centre of learning to cultivate bamboo ranging from breeding to utilization of bamboo, both for construction, and crafts. It also serves traditional snacks, bamboo arboretum tracking, out bond and camping ground.

Map Location

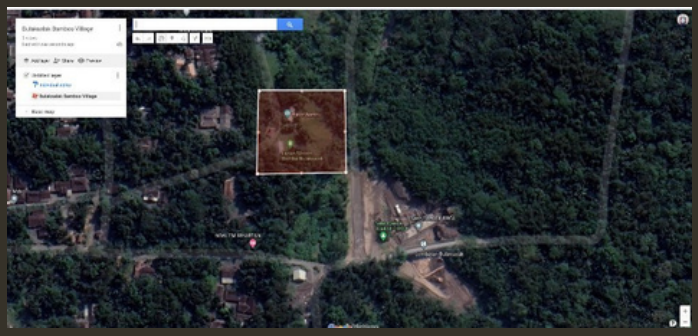

Figure 1: Location of Bulaksalak Bamboo Village from Google Map

Bulaksalak bamboo forest is an abandoned sand mining area of Mount Merapi. Since 1997, the former mine land has been planted with bamboo trees by the local community and until now almost 1.8 hectares have been planted with bamboo and has 35 types of bamboo species. The existence of Bulaksalak bamboo forest has changed the ecological situation in the area from highlighted land to areas for planting. The existence of bamboo trees along the river located upstream of the Opak River also causes the river to not experience drought even though drought occurs.

Figure 2: Location of a Bulaksalak bamboo market at every week of Kliwon

This location is also often used as a place for surrounding universities, especially universities in Indonesia. The author himself had the opportunity to visit the place during a Training of Trainer (TOT) session organized by the Stiper Agricultural Institute (INSTIPER) in September 2023 (Figure 3). Realizing the great potential of bamboo to be developed in Southeast Asia, INSTIPER Yogyakarta is trusted to carry out the Training of trainers Bamboo Village Sustainable Landscape. The tot Bamboo Village Sustainable Landscape Batch 1 activity was held for 5 days on September 18-22, 2023. This ToT activity was not only held at INSTIPER Yogyakarta campus but also held at Bulaksalak Bamboo Forest, Cangkringan.

Figure 3: Training of Trainers (TOT) program in Bulaksalak Bamboo Village

Training of trainers Bamboo Village Sustainable Landscape followed by participants from 3 countries namely Indonesia, Malaysia, and the Philippines. A total of 26 participants consisting of 18 participants from Indonesia, 6 participants from INTROP UPM Malaysia, and 2 participants from UPLB Philippines. Participants from Indonesia come from various agencies such as Universitas Mulawarman, uns Solo, University of Muhammadiyah Malang, INSTIPER Yogyakarta, NGOs, Trainers, and entrepreneurs.

There are also bamboo-based products produced in the area by villagers as well as local entrepreneurs such as furniture products chairs and tables (Figure 4), as well as the structure of the building itself is made of bamboo (Figure 5). Similarly, there are several sculptures built using bamboo embedded elements of culture and beliefs of the local population. This sculpture has become an attraction for visitors to take pictures or record videos that become current trend on social media (Figure 6).

Figure 4: Furniture products chairs and tables from local communities.

Figure 5: Bamboo structure that will be used as the roof of the building.

Figure 6: Several sculptures built using bamboo.

Conclusion

This bamboo village area is seen to have a lot of potential for development in the future. With the involvement of local universities in Indonesia, it is seen to be able to expand the products from the area which are not only physical bamboo products but other products that also involve sectors such as ecotourism and ecosystem services.

The advantage of this place is the cooperation and involvement of the local population itself which in terms of bamboo treatment itself is carried out by residents in their respective homes where bamboo products offered are semi - finished bamboo which of course has a higher price. All the knowledge practiced in this place can be applied in Malaysia in developing the local bamboo community involving the government, universities, local entrepreneurs, and community residents such as the existing communities Koperasi Kareah Masjid Kampung Hulu Kundur (KOMASKU) and the Clarity Crest Sdn. Bhd. Bamboo Plantation Sungai Jerneh.

References

Information System Kalurahan Wukirsari Kapanewon Cangkringan (2021) retrieved by Website https://wukirsari.id/artikel/2021/11/11/pasar-bambu-bulaksalak.

INSTIPER (2023) Instiper Yogyakarta Sukses Selenggarakan Tot Bamboo Village Sustainable Landscape retrieved by https://home.instiperjogja.ac.id/berita/instiper-yogyakarta-sukses-selenggarakan-tot-bamboo-village-sustainable-landscape-1

UPM
UNIVERSITI PUTRA MALAYSIA
BERILMU BERBAKTI

INTROPica

INSTITUTE OF TROPICAL FORESTRY AND FOREST PRODUCTS

BAMBOO:
HARNESSING TECHNOLOGY FOR SUSTAINABLE PRACTICES

Published by:
Institute of Tropical Forestry and Forest Products (INTROP),
Universiti Putra Malaysia (UPM)
43000 UPM Serdang,
Selangor Darul Ehsan.
Phone: +03 9769 1880 / 1881
www.introp.upm.edu.my