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The potential of bamboo and the contribution of bamboo craftsmen to the community's income in Cibadak Village, Bogor City, Indonesia

ZAINAL MUTTAQIN[1,♥], ABDUL RAHMAN RUSLI[1], BAMBANG SUPRIYANTO[2]

[1]Department of Forestry, Universitas Nusa Bangsa. Jl. KH. Sholeh Iskandar, Bogor 16166, West Java, Indonesia. ♥email: muttaqinznl@gmail.com
[2]Directorate General of Social Forestry and Environmental Partnership, Ministry of Environment and Forestry, Building of Manggala Wanabakti. Jl. Jenderal Gatot Subroto, Central Jakarta 10270, Jakarta, Indonesia

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Abstract. *Muttaqin Z, Rusli AR, Supriyanto B. 2023. The potential of bamboo and the contribution of bamboo craftsmen to the community's income in Cibadak Village, Bogor City, Indonesia. Biodiversitas 24: 5796-5807.* Bamboo is a plant of rural communities that can be used for various purposes in people's lives. Cibadak Village is thought to have a substantial number of bamboo potentials, but the exact amount has yet to be discovered. Likewise, the contribution of income obtained from bamboo-cage craftsmen is also unknown, so studies on this issue are essential. This research aimed to determine the potential availability of plants and the contribution of bamboo craftsmen to the income of the people of Cibadak Village, Tanah Sareal Sub-district, Bogor City, West Java Province, Indonesia. The collection of data was conducted through field research and bibliographic research. This research concluded that the potential of bamboo in Cibadak Village was only 6.72 ha or 2.04% of the total area, and the contribution of bamboo craftsmen to the community's income was less significant (27.03%) compared to the average total income of the community. However, the income of bamboo craftsmen more than the other income contribution came from drivers (25.00%), merchants (21.67%), and construction workers (26,30%). Only 20% of respondents consider the revenue of bamboo craftsmen as the main job, and 80% of the revenue is side income to complete revenue from the other job. The species of bamboo were found of *bambu tali* (*Gigantochloa apus*), *bambu betung* (*Dendrocalamus asper*), *bambu ampel hijau* (*Bambusa vulgaris* var. vitata), *bambu ampel kuning* (*Bambusa vulgaris* var. striata), and *bambu andong* (*Gigantochloa pseudoarundinacea*). *Bambu tali* are the most commonly found in Cibadak Village, consisting of 279 clumps (80.87%) and 25,028 culms (90.70%), while other bamboo species were found in small numbers. The bamboo craftsmen use all raw materials of *Bambu tali* (*Gigantochloa apus*), and a few people also utilize bamboo shoots of *Bambu betung* and *Bambu ampel* for self-consumption as complementary food vegetables.

Keywords: *Bambu tali*, clump of bamboo, community's income, contribution, culm of bamboo

Abbreviations: KR: Calculating the potential of clumps per hectare; TP: Total income; TR: Total revenue; TC: total cost

INTRODUCTION

Bamboo is a non-timber forest product (NTFP), which benefits bamboo's environmental and economic potential, specifically in the value chain. The use of bamboo in each region also varies depending on the bamboo species and habits passed down from generation to generation in that community.

The bamboo species worldwide (11%) grow naturally in Indonesia (Charomaini 2014). Bamboo, known as the "green gold grass," is one of the fastest-growing plants on the planet, capable of growing up to 1.2 meters per day. It is beneficial to the environment because it produces more oxygen than equivalent tree strands, reduces the light intensity, protects from ultraviolet rays, is an essential atmospheric land and soil purifier, and its roots can minimize soil erosion by up to 75% (Sharma et al. 2016). There is the superiority of bamboo can archive 12 tons per hectare and produce oxygen 30% more than trees (Basri and Pari 2017). In the bamboo forest at Penglipuran, Bali, Indonesia, the total above-plus below-ground biomass was 87.35 Mg/ha, and carbon storage was 43.67 Mg/ha (Sujarwo 2016). This offers insight into the opportunity for payment for ecosystem services (PES) through emission trading mechanisms. Meanwhile, the value chain of bamboo is one of the marketing practices the community has carried out in several areas within the forest estate and community-owned gardens. Marketing strategies for bamboo products, especially in Cibadak Village in Bogor City, are basic because the marketing scope is limited to the local area. Generally, the value chain will give opportunity of additional income through marketing chain to its actors consisting of farmers/producers, craftsmen, collectors/ middlemen traders as the main actors, and bamboo collector retailers as the minor actors.

As a populist plant, bamboo has a status and social value with deep meaning. Previously, rural communities in Central Java would feel that they were from a lower class or were poor if they had to buy bamboo to make walls or household furniture (Batubara 2002). However, bamboo stands in the agroforestry system and is an important income source for rural villagers worldwide, especially in tropical developing countries (Lee et al. 2021). Indeed, in Indonesia, categorization of major applications of bamboo is given extensively, i.e., harvested bamboo product (HBP), bamboo craft industries, hybrid bamboo, and batik handicraft

as a creative tourism product, woven bamboo crafts and other products; in Cipining village in Bogor, bamboo culms used as a sound tube in angklung gubrag (Maulidyawati 2020; Maulina and Raharja 2018; Pramono et al. 2021; Wartanta 1998; Yuliatiningsih 2005), however, in this study area, bamboo made as bamboo cage craft. Also, according to Shukla and Joshi (2020), improved cultivation, processing, designing, and production of high-quality bamboo products can increase exports and foreign exchange income.

In the bamboo industry, Liu et al. (2012) declared that bamboo is a resource for sustainability and maintaining the ecological balance. It can be a struggle to make the composite basis of bamboo, i.e., plywood, laminated wood, particle board, fiberboard, and, according to Gopar et al. (2018), zephyr bamboo board. Bamboo is also used as the raw material for reinforcing the fiber of primer composite thermosetting and thermoplastic (Kumar et al. 2018). Latha et al. (2016) used those with fiberglass. Also, the liquid smoke of bamboo can be used as raw material for cosmetics, healthy drinks, etc. (Jinhe 2005), and allergy medication (Imamura et al. 2005). The communities have used bamboo for making houses, furniture, crafts, musical instruments, and raw materials for angklung (Setiawati et al. 2017; Rahim and Idrus 2018; Bahtiar et al. 2019; Prasetyo et al. 2020; Ritonga et al. 2020; Maulidyawati et al. 2020; Hanun et al. 2020; Hanun et al. 2023).

The geographical condition of Cibadak Village, Bogor City, is an agricultural area suitable for bamboo cultivation; however, people need more interest in cultivating bamboo plants. The community mostly takes or harvests existing bamboo, especially for housing construction, i.e., replacing rafters and building fences and chicken or poultry cages. It is suspected that Cibadak Village has enormous potential for bamboo. Hopefully, in the area, people will use resources and variety of bamboo to increase environmental quality, environmental service providers, and livelihood. However, the number of bamboo species and clumps and the contribution of income obtained from bamboo cage craftsmen to the community's income are unknown; therefore, this research is suitable and essential, making this study particularly innovative. Thus, it can provide scientific and practical implications. Subsequently, this research aimed to determine the potential of bamboo availability, bamboo species, and the contribution of bamboo craftsmen to the community's income in Cibadak Village, Tanah Sareal Sub-district, Bogor City.

MATERIALS AND METHODS

Study period and area

This research was conducted through purposive sampling in Cibadak Village, Tanah Sareal Sub-district, Bogor City, Indonesia (Figure 1). The period of this research was from January to July 2022. The research tools used were a GPSMAP 76CSx, plastic rope, a calculator, a camera, and stationery. The materials used included a list of questions (a questionnaire) and other documents related to the research materials.

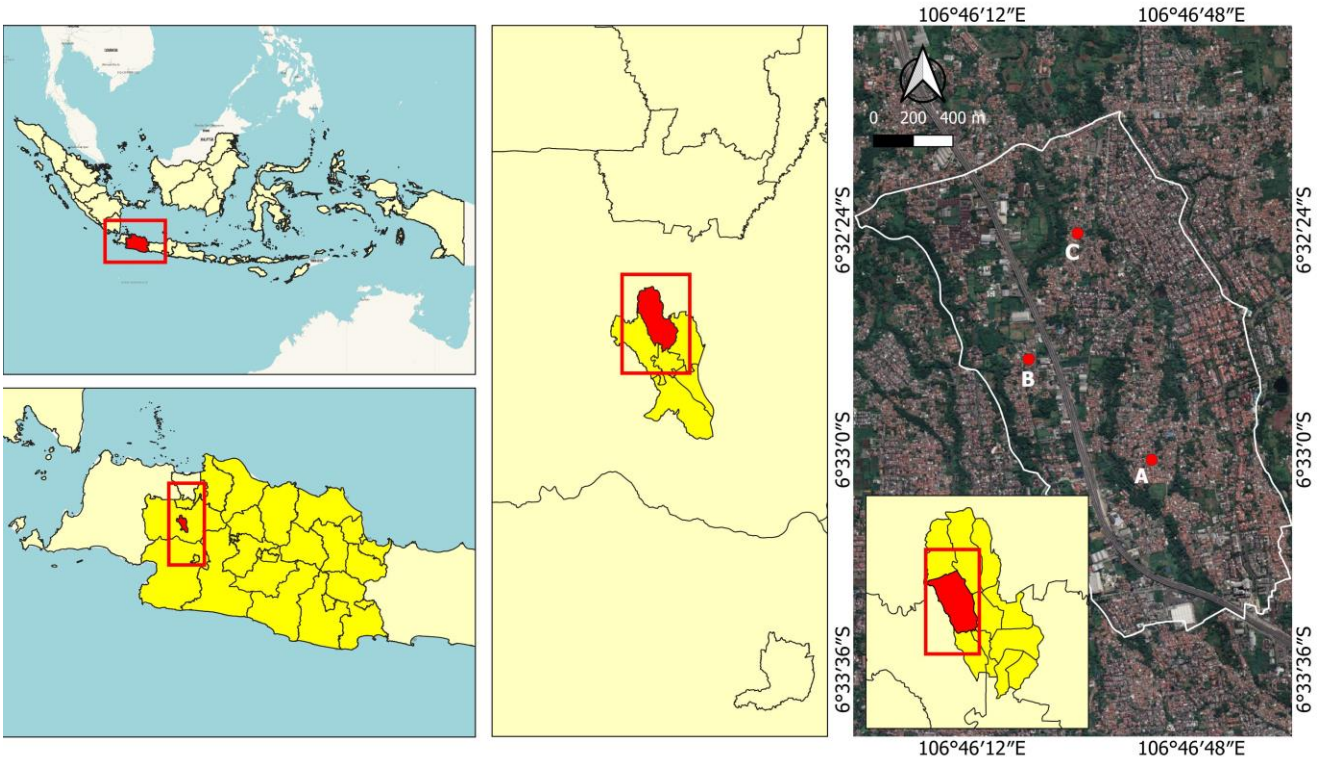

Figure 1. Map of study site in Cibadak Village, Tanah Sareal Sub-district, Bogor City, West Java, Indonesia. This map indicated clumps of bamboo in: A. Kampung Kukupu, B. Kampung Serempet, and C. Kampung Pabuaran

Procedures

Species of data collection

The research data were collected in two ways: i) through field research, i.e., field observations and interviews; ii) through literature study, i.e., searching for data and information following this research contents mainly aspect of ecology data, through publications, and other electronic and internet sources. The data collection technique in the field research was on the potential availability of bamboo in Kampung Kukupu, Kampung Serempet, and Kampung Pabuaran, Cibadak Village, Tanah Sareal Sub-district. Cibadak Village is a rural-urban area in Bogor City and still utilizes local resources, i.e., bamboo. The results of the initial orientation indicated that the locations of bamboo was spread out and not evenly distributed, so a purposive method was used to select the locations where the bamboo clumps were found. Bamboo inventory data covered the bamboo species, the number of clumps, the number of culms for each clump, and the total area. In addition, this research conducted data collection technique with purposive sampling of respondents working as bamboo craftsmen. Socio-economic data on bamboo craftsmen supported 30 respondents. Those data will be with interviews using the open questioner method. The interview was also done with selected RW (citizens association heads) and village officials who know about where the actual bamboo area and value chain and the flow of bamboo marketing.

Thus, this research used primary and secondary data. The primary data collected included bamboo inventory, socio-economic data, management forms, and marketing results. The secondary data collected included the general conditions of the research location and supporting data available at village and district government agencies. The measured quantitative variables included the potential of bamboo and the income contribution to total household income obtained from bamboo handicrafts. The qualitative variables measured covered the bamboo species and handicraft production process.

Data processing of bamboo potential

Data on the potential of bamboo covered the areas of bamboo plants, bamboo yields per hectare, and species of bamboo plants. On the other hand, bamboo production covered making bamboo into bamboo handicrafts. The formula for calculating the potential of clumps per hectare is as follows:

$$KR = \frac{\sum_{i=1}^{n} Bi}{\sum_{i=1}^{n} Ri}$$

Where:

Kr : The sum of culms each clump a species of bamboo

Bi : The sum of clumps of a species of bamboo each stripe to-i

Ri : The sum of clumps of a species of bamboo each stripe to-i

Data analysis

The contribution of income to the total household income, according to Soekartawi (1995), is the difference between revenue and all costs. Farmers' income is the multiplication of the production by the selling price, according to the equation:

$$TP = TR - TC$$

Where:

TP : Total income

TR : Total revenue

TC : Total cost

Therefore, to find out the size of the contribution of the bamboo craftsmen business, the calculation was conducted based on the percentage approach:

$$KR = \frac{R}{Pt} x100\%$$

Where:

Kr : Contribution of bamboo craftsmen

R : Income of bamboo craftsmen

Pt : Total income of bamboo craftsmen

All information related to the characteristics of craftsmen and income calculation results was analyzed descriptively/qualitatively and quantitatively. The quantitative analysis uses tabulated data with Microsoft EXCEL 2019 (Excel 17).

RESULTS AND DISCUSSION

Potential of bamboo

The potential of bamboo in Cibadak Village, Tanah Sareal Sub-district, was distributed in Kampung Kukupu, Serempet, and Pabuaran. Bamboo thrives around small rivers. This research identified five species of bamboo in Cibadak Village, i.e., *bambu tali* (*Gigantochloa apus*), *bambu betung* (*Dendrocalamus asper*), *bambu ampel hijau* (*Bambusa vulgaris* var. vitata), *bambu ampel kuning* (*Bambusa vulgaris* var. Striata), and *bambu andong* (*Gigantochloa pseudoarundinacea*). The community's use of these bamboo species was minimal, including building houses in the form of rafters and making poultry and chicken cages. Harvesting was conducted based on small orders. The inventory results obtained purposively in Cibadak Village found bamboo plants in three different villages, as follows: (i) Four species of bamboo, including *bambu tali, bambu ampel hijau, bambu betung,* and *bambu ampel kuning*, were identified in Kampung Kukupu. (ii) Four bamboo species, including *bambu tali, bambu ampel hijau, bambu betung, and bambu andong* were found in Kampung Serempet. (iii) Only two bamboo species, including *bambu tali* and *bambu ampel hijau,* were found in Kampung Serempet. The number of clumps and culms of each bamboo species is displayed in Table 1.

General descriptions of bamboo species

General descriptions of the bamboo species identified in the research locations cover:

Table 1. Species, the sum of clumps and culms of bamboo in Cibadak Village, Bogor City, Indonesia

Local name	Latin name	The sum of clumps		The sum of culms	
		n	%	n	%
Kampung Kukupu					
Bambu tali	*Gigantochloa apus* (Schult. & Schult.f.) Kurz ex Munro	172	80.75	18,187	90.98
Bambu ampel hijau	*Bambusa vulgaris* Scharader ex. Wendland var vitata	31	14.55	1,484	7.42
Bambu betung	*Dendrocalamus asper* (Schult.f.) Backer ex Heyne	3	1.41	154	0.77
Bambu ampel kuning	*Bambusa vulgaris* Schrader ex var. Striata	7	3.29	165	0.83
Total/ ha		45		4,216	
Note:	Area of bamboo = 4.72 ha. *G. apus*, *B. vulgaris*, and *D. asper* have the status of growing wild and native plants				
Kampung Serempet					
Bambu tali	*Gigantochloa apus* (Schult. & Schult.f.) Kurz ex Munro	63	78.75	6,797	90.01
Bambu ampel hijau	*Bambusa vulgaris* Scharader ex. Wendland var vitata	14	17.5	559	7.40
Bambu betung	*Dendrocalamus asper* (Schult.f.) Backer ex Heyne	1	1.25	101	1.34
Bambu andong	*Gigantochloa pseudoarundinacea*	2	2.5	94	1.24
Total/ ha		28		2,649	
Note:	Area of bamboo = 2.85 ha. *G. pseudoarundinacea* have the status of growing wild and native plants.				
Kampung Pabuaran					
Bambu tali	*Gigantochloa apus* (Schult. & Schult.f.) Kurz ex Munro	44	84.6	3,064	87.7
Bambu ampel hijau	*Bambusa vulgaris* Scharader ex. Wendland var vitata	8	15.4	431	12.3
Total/ ha		25		1,705	
Note:	Area of bamboo = 2.05 ha				

Dendrocalamus asper (Schult.) Backer (*bambu betung*)

This species of black bamboo is known as *bambu betung hitam*. It grows well in moist and wet tropical alluvial soils, and it can also grow in dry areas in the lowlands and highlands. This species of bamboo is spread throughout Indonesia and Papua, including Manokwari. *Bambu betung* grows up to 20 m; the culms are upright, have dense clumps with curved ends, and the reed fronds quickly shed (Widjaya 2019). The appearance of clumps, culms, branches, and bamboo shoots is shown in Figure 2. *D. asper* as host plants for epiphytic ferns i.e., *Asplenium nidus*, *Davallia denticulate*, *Microsorum scolopendria* with lifeform of short upright/long creeping, habitual holo epiphytes, aerial roots of basal culm, nodus; *Pyrrosia piloselloides*, *Vittaria ensiformis* with lifeform of short upright/long creeping, habitual holoepiphytes, aerial roots of basal culm, nodus, internodes; *P. lanceolata*, *P. longifolia* with lifeform of long creeping, habitual holoepiphytes, nodus, internodes (Praptosuwiryo et al. 2021).

Bamboo of betung (*Dendrocalamus asper*) has unique characteristics, among them, the carbonization process at a temperature of 500°C, its carbon characteristic is homogenous, and the highest carbon value in the atmosphere of argon is 10,924 cal/g (Wirawan 2019). It has a high strength, so the mechanical properties of bamboo will increase with the increase in the density of sclerenchyma fibers that affect the bamboo's strength (Suriani 2018).

In Peninsular India and the same genus, *D. stocksii* is well suited for agroforestry systems. It has favorable morphological characteristics like a feathery compact canopy, a self-pruning nature, and a profuse root system. The funding that most roots (>95%) belong to less than 2 mm diameter class provides a fine mesh for soil binding. Its roots were significantly higher in 5m x 5m spacing than 9m x 9m in 0-30 cm depth. The spacing between bamboo clumps plays a significant role in the development of correct root architecture patterns for main crops and intercrops, which will encourage optimum production from intercrops of the agroforestry system (Lubina et al. 2020). Jihad et al. (2021) showed the result that there is no effect ($P>0.05$) of elevational variation to *D. asper* growth and development, while the intra-clump spacing showed a significant result ($P<0.05$) on the culm DBH. It suggests a wider intra-clump spacing (0.4-0.6 m^2) is better than a narrow intra-clump spacing for optimal culm diameter growth. Therefore, improving the productivity of *D. asper* was by maintaining the plantation, i.e., fertilizing, managing spacing among clump bamboo, and regular harvesting cyclically every 3-4 years to achieve sustainable development of the bamboo plantation. Moreover, according to Lubina et al. (2019), *D. stocksii* is considered the most economically viable option in per-humid regions. It is considered more effective for managing land degradation and carbon sequestration, particularly in the semi-arid and sub-humid zones.

Gigantochloa apus (Schult.) Kurz (*bambu tali*)

Tali bamboo has two varieties, i.e., black and yellow lines. It grows well on sites that are compatible with betung bamboo. However, the culms become smaller and thicker if they grow in dry areas. This bamboo species is grown throughout Java, Bali, and Lombok and is also found in several locations in Sumatra and Sulawesi. This research found that tali bamboo grew up to 22 m, straight and upright, in tight clumps, and the reed fronds did not easily shed, so they remained attached to the old culms. It has a growth rate of 29.75 cm/day (Bahtiar 2015). The appearance of clumps, branches, leaves, fronds, bamboo shoots, and ropes can be seen in Figure 3**.**

Gigantochloa asper as host plants for epiphytic ferns i.e. *Asplenium nidus, Davallia denticulate, Goniophlebium percussum, P. lanceolata* with lifeform of short upright/ long creeping, habitual holo epiphytes, aerial roots of basal culm, nodus, internodes; *Nephrolepis biserrata* with lifeform of long creeping, primary hemiepiphytes as a plant that spends part of its life cycle as an epiphyte, aerial roots of basal culm, nodus (Praptosuwiryo et al. 2021).

Bambusa vulgaris Schrad (*bambu ampel*)

Ampel bamboo has varieties of green, yellow, and convex reeds. This research found the varieties of *B. vulgaris var. vulgaris* (green) and *B. vulgaris var. striata* (yellow). Moreover, ampel bamboo grows in dry, humid areas and can grow in waterlogged areas for 2-3 months. This bamboo species grows throughout Indonesia, although, in general, the yellow and convex reed varieties are more commonly planted. At the research location, green varieties were also found. The growth of this bamboo reached 20 m, was upright or notched, and the clumps were not too tight. It has a growth rate of 21.32 cm/day (Bahtiar 2015). The appearance of clumps, branches, shoots, and fronds is shown in Figures 4.A, 4.B, and 4.C.

Based on the review of the ecology aspect, the three species of bamboo in the research area consist of *D. asper* (*bambu petung*), *G. apus* (*bambu tali*), and *B. vulgaris* (*bambu ampel*), sustainable planted in dry land. *Bambu ampel* also can be planted in moist land or frequent flooding or marginal soil. Generally, environmental conditions suitable for bamboo planting are the climatic types according to Schmidt dan Ferguson of A and B types, and it's C and D types, and marginal soil with frequent flooding, so it should be planted by species of *bambu ampel kuning, bambu ampel hijau,* and *bambu ori*. Moreover, to arrange cutting to get stem quality, coeval, and sustainability, it is necessary to arrange the structure and composition of stem in clumps. The wetter the climatic type (A and B), the more the stem of the age generation class must be made than of climatic type (C, D). Generally, bamboo industry allotment is planted in a moist area of the climatic type A (very moist) for bamboo of the lamina, play bamboo, toothpick, skewers, chopsticks, incense sticks, and charcoal, so bamboo must be arranged in one clump consisting of five generation ages of the stem, i.e., 1, 2, 3, 4 and 5 year. Also, bamboo planted in climatic type B (moist) must be arranged in one clump consisting of four stems of age generation structure, i.e., 1, 2, 3, and 4 years (Sutiyono 2014).

Vegetative propagation in bamboo is the only way to produce propagules on a large scale because the seed availability is uncertain due to its irregular flowering but less viability. The present findings (Yadav et al. 2022) showed that the Indole butyric acid (IBA) hormone contributes to the effective propagation of *Bambusa vulgaris* branch cuttings. It is suggested that the one-node cuttings can multiply more propagules than those two and three nodes. According to Mensah et al. (2021), based on bamboo properties, the basic density of the matured culm was significantly higher and had better morphological and physical properties than that of the juvenile *Bambusa vulgaris*. It is considered matured culm for the production of engineering composite products rather than that of the juvenile. According to (Praptosuwiryo et al. 2021), *B. vulgaris* is a host plant for epiphytic ferns, i.e., *A. nidus, D. denticulate, P. piloselloides* with lifeform of short upright/ long creeping, habitual holo epiphytes, aerial roots of basal culm, nodus, internodes.

The study assessed the carbon stock of ~ 60-year-old *B. vulgaris* stands in a regenerating secondary forest in Ile-Ife, Nigeria. The finding of the means above-ground biomass was 257.82 t ha-1, with culm (210.75 t ha-1) significantly higher than twigs (35.59 t ha-1) and leaves (11.47 t ha-1). The mean carbon stored was 237.94 t C ha-1, of which 138.70 t C ha-1 were stored in the above-ground biomass, 32.72 t C ha-1 in the below-ground biomass, and 66.52 t C ha-1 in the soil. It sequestered ~32.22 t C ha-1 yr-1 and stored carbon higher than some dominant tree species in the secondary forest, agroforestry systems in Africa, and most bamboo species in tropical and subtropical countries (Borisade et al. 2018).

The other bamboo species

On *Guadua angustifolia*, Nolke et al. (2016) state the hypothesis that young culms may exhibit lower surface temperatures than old ones. The culm surface temperature was small but constant differences between the three age classes of 1, 2, and 3 years. It indicates that surface temperature may be applied as an additional indicator to support the maturity determination of *guadua* culms besides the visual assessment. On *Phyllostachys edulis*, Zhang et al. (2019) have revealed that at the intraspecific level, it can adjust its leaf NRE (nitrogen resorption efficiency), NRP (proficiency), and leaf-level NUE (nitrogen use efficiency) in concert with culm development of the current-, 3rd-, and 5th year under extensive management. Understanding NRE and NUE of *P. edulis* can help decision-makers design appropriate deforestation strategies and achieve precise N fertilization for sustainable bamboo forest management.

Total area of bamboo plants and distribution of bamboo plants

The total area of bamboo plants found in Cibadak Village, Tanah Sareal Sub-district, was 9.62 ha, or around 2.07% of the total 464.73 ha. The most expansive area of bamboo plants was found in Kampung Kukupu, at 4.72 ha, or 49.1%, followed by Kampung Serempet at 2.85 ha, or 29.6%, and Kampung Pabuaran at 2.05 ha, or 21.3%. The distribution map of bamboo plants in Cibadak Village is presented in Figure 1. Overall, in Cibadak Village, bamboo planting is not an important land use, but only in Kampung Kukupu, Serempet, and Pabuaran are enough forest bamboo.

In the study area, bamboo stands grow naturally, and youth spread. Initially young stem (rebung) appears on the clump's base and gradually grows into a mature bamboo stem, while it is from rhizome roots. Bambu tali were found here, also called *bambu apus, awi tali,* or *pring tali* followed by *bambu ampel hijau, bambu betung, bambu ampel kuning* and *bambu andong*. Bamboo craftsmen use raw material most *bambu tali* because it has high flexibility and elasticity, so it is not easy to break and is tenacious. Moreover, bambu tali have mechanical characteristics better with not bamboo books than those that have them.

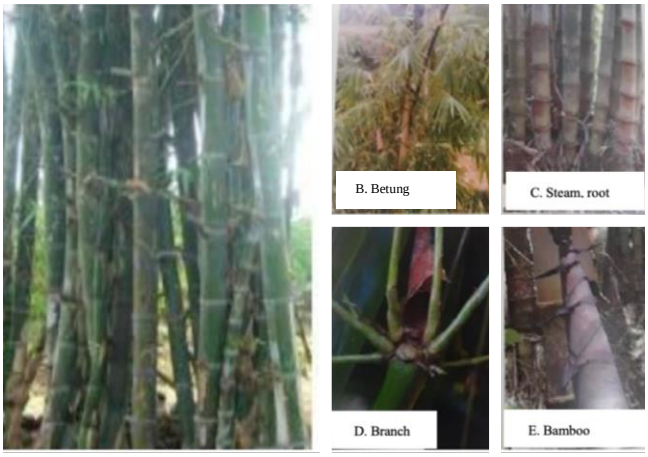

Photo: This study Photo: Wijaya (1987, 1997, 2019)

Figure 2. *Dendrocalamus asper* (bambu betung)

Photo: This study Photo: Wijaya (1987, 1997, 2019)

Figure 3. *Gigantochloa apus* (bambu tali)

Photo: This study Photo: Wijaya (1987, 1997, 2019)

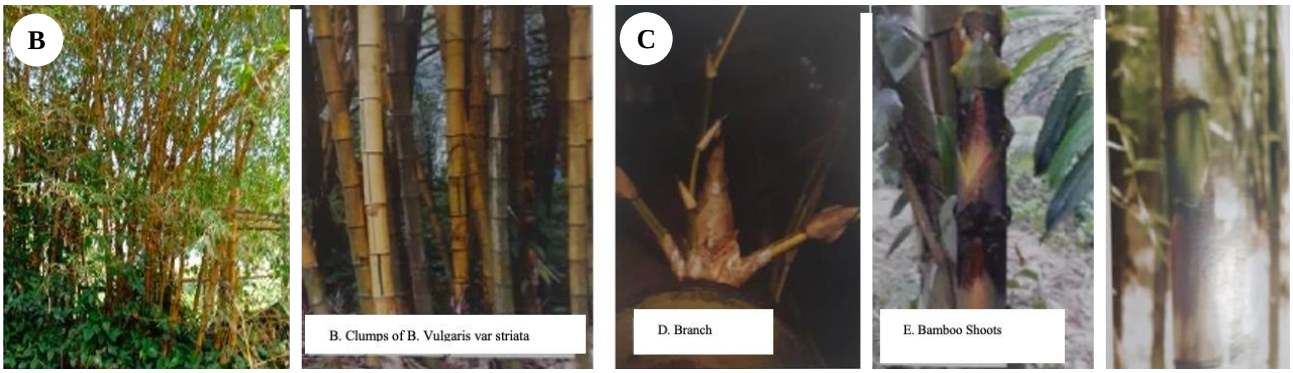

Photo: This study Photo: Wijaya (1987, 1997, 2019)

Figure 4. A. *Bambusa vulgaris* var vulgaris (variety of green). B. *Bambusa vulgaris* var Striata (variety of yellow). C. *Bambusa vulgaris* (Widjaya; 1987, 1997, 2019)

Characteristics of the bamboo craftsmen community

Bamboo craftsmen in Cibadak Village reside in Kampung Kukupu. Based on the interview with the village officials, there are currently ±50 bamboo craftsmen in the area; however, this indicates a decline from the previous 150 bamboo craftsmen. The decreased number of craftsmen aligns with the increased variety of job opportunities today, and people's education levels are increasing. Hence, they get other jobs with higher incomes. The notable characteristics of the bamboo craftsman community are described in Table 2.

Even though this work as bamboo cage craftsmen was not the primary or less significant but an alternative or side job if there was no other work, so that the income from these bamboo cage craftsmen was important for the household economy. The community's income in Cibadak Village was mainly obtained from the bamboo craftsman business and other business sectors, including drivers, traders, and construction workers. The study revealed from 30 respondents that 21 people as bamboo craftsmen (70,0%), 3 people (10,0%) had side jobs as drivers, 4 as traders (13.3%), and 2 as construction workers (6,7%). Moreover, 21 bamboo craftsmen consist of 6 only craftsmen and 15 bamboo craftsmen as drivers, traders, and construction workers.

Table 2. Characteristics of the bamboo craftsmen in Cibadak Village, Bogor City, Indonesia

Characteristics	Percentage (%)
The age category (years)	
<35	10.00
35-45	20.00
45-55	56.67
>55	13.33
The education level	
Elementary school	83.30
Junior high school	16.70
Senior high school and above	0
The married status	100.00
The gender category (male)	100.00

Discussion

Potential of bamboo

Bambu tali is the most common bamboo species found in Cibadak Village, consisting of 279 clumps (80.87%) and 25,028 culms (90.70%), followed by *bambu ampel hijau* species with 53 clumps (15.36%) and 2,051 culms (7.40%). In comparison, other bamboo species were found in small numbers of clumps and culms, as presented in Table 3.

As a comparison, in Rumpin village of an owned forest, Bogor district, Kurniawati (2023) reported 5 species of bamboo in one genus, i.e., *bambu tali* (*Gigantochloa apus*) (81 clumps and 1,760 culms), *bambu mayan* (*G. robusta*) (57 clumps and 1,369 culms), *bambu andong* (*G. pseudoarundinacea*) (18 clumps and 599 culms), *bambu hitam* (*G. atroviolacea*) (12 clumps and 419 culms), *bambu atter* (*G. atter*) (7 clumps and 193 culms), so total of 175 clumps and 4,340 culms; this finding is lower than in Cibadak Village (the research). In the Cibadak Village of this research, *bambu tali* (*G. apus*) dominated, shown by the greatest value of the sum of clumps and culms. Meanwhile, the 5 bamboo species in Cibadak Village are spreading and do not agglomerate. This result is the same as reported by Kurniawati (2023) in Rumpin village. Meanwhile, in Cibadak Village, the clump and culm densities were 36 and 2,868/ha, respectively; this value is lower than in the bamboo forest in Penglipuran traditional village with the clump and culm densities were 339 and 7190/ha, respectively (Sujarwo 2016). Also, its culm is lower than in other areas of Indonesia (*G. ater* and *G. verticillata*, 6,820/ ha), in area of India (*B. vulgaris, B. cacharensis, B. bambos, D. strictus*; 4,800-27,000/ ha), but this study is still greater than India (*B. balcooa*) of 20 clumps/ha (Borthakur et al. 2021). This study has a lower result than in the area of Taiwan (*Pyllostachys makinoi*, 21,191/ha), Taiwan (*P. pubescens*, 3,968/ha), Bolivia (*Guadua angustifolia*, 4,500/ha), Japan (*P. bambusoides*, 12,040/ha) (Quiroga et al. 2013; Zhang et al. 2014; Yuen et al. 2017). In addition, it compares bamboo forest carbon projects by stand types and baseline conditions. In China, Suichang has a target density of 3,600-3,900 culms/ha with 6-8 years of adjustment; Anji has a target density of 4,100-4,200 culms/ha with 6 years of adjustment (Gu et al. 2019).

Setiawati et al. (2017), found that there are 13 species of bamboo in Karangwangi Village, district Cianjur, namely *haur gereng* (*Bambusa blumeana* JA & J.H. Schult), *haur geulis* (*Bambusa* sp.), *Haur Koneng* (*Bambusa vulgaris* var. Striata), *haur seah* (*Bambusa vulgaris* Schrad Ex. var vittata), *awi tali* (*Gigantochloa apus*), *awi hideung* (*Gigantochloa atroviolacea* Widjadja), *awi gombong/awi surat* (*Gigantochloa pseudoarundinacea* (Steud.) Widjadja), *awi temen* (*Gigantochola atter* (Hassk.) Kurz.), *awi lengka* (*Gigantochloa hasskarliana* (Kurz.) Backer ex Heyne), *awi tamiyang* (*Schizostachyum iraten* Steud.), *awi gembong* (*Schizostachyum* sp.), *awi hias* (*Bambusa glaucophylla* Widjadja), and *cangkoreh* (*Dinochloa scandens* (Blume ex Neese) Kuntze). Those are used for various purposes, such as building materials, handicrafts, furniture, food, medicine, and poison fish.

According to Ritonga et al. (2023), there are 8 bamboo species on Weh Island, Aceh province, i.e., *Bambusa multiplex* (Lour.) Raeusch. ex Schult.f., *Bambusa spinosa* Roxb., *Bambusa tuldoides* Munro, *Bambusa vulgaris* Schrad. ex J.C.Wendl., *Dendrocalamus asper* (Schult.f.) Backer, *Schizostachyum brachycladum* (Kurz ex Munro) Kurz, *Schizostachyum silicatum* Widjaja, and *Thyrsostachys siamensis* Gamble. *B. vulgaris* is the most abundant and widespread on Weh Island. Ervianti et al. (2019) inventory of the bamboo diversity in Sulawesi showed that there are 39 species of 12 genera in Sulawesi, i.e., *Bambusa blumeana, B. glaucophylla, B. maculata, B. multiplex, B. tuldoides, B. vulgaris, Chloothamnus sp., Dendrocalamus asper, Dinochloa albociliata, D. aopaensis, D. barbata D. cordata, D. erecta, D. hirsuta, D. morowaliensis, D. petasiensis, D. pubiramea*, and *D. truncata.* Their study also found some new species were identified, i.e., *Dinochloa* sp.1, *Dinochloa* sp.2, *Dinochloa* sp.3, *Dinochloa* sp.4, *Dinochloa* sp.5, *Dinochloa* sp.6, *Dinochloa* sp.7, *Dinochlo*a sp.8, *Dinochloa* sp.9, *Fimbribambusa* sp., *Gigantochloa apus, G. atroviolacea, G. atter, Neololeba atra, Phyllostachys aurea, S. latifolium, S. lima, Racemobambos celebica, Schizostachyum brachycladum, Sphaerobambos subtilis*, and *Thyrsostachys siamensis*.

Table 3. Species of bamboo, clumps, and the culms bamboo di Cibadak Village, Bogor City, Indonesia

Local name	The clumps	%	The culms	%
Bambu tali (*Gigantochloa apus*)	279	80.87	25,028	90.7
Bambu ampel hijau (*Bambusa vulgaris* var vitata)	53	15.36	2,051	7.4
Bambu betung (*Dendrocalamus asper*)	4	1.16	255	0.9
Bambu ampel kuning (*Bambusa vulgaris* var. Striata)	7	2.03	165	0.6
Bambu andong (*Gigantochloa pseudoarundinacea*)	2	0.58	94	0.3
Total/ ha	36		2,868	

Note: Area of bamboo in Cibadak Village = 9.62 ha

Therefore, from the aspect of ecology, one factor influencing bamboo growth was the environment related to the growing conditions for bamboo plants. The crucial environmental factors were climatic conditions and soil parameters, soil types, soil compositions, etc. The environmental component was the air temperature suitable for bamboo plants, around 8.8-36°C. The air temperature was also affected by altitude.

Bamboo plants could be found from the lowlands to the highlands at 0 to 2,000 masl. Nonetheless, not all species of bamboo can grow well at all altitudes. The rainfall requirement for bamboo plant growth was a minimum of 1,020 mm per year, and the desired humidity was at least 80% (Berlian and Estu 1995). On the other hand, the hills in India's north-eastern part of Karbi-Anglong district were dominated by *Dendrocalamus hamiltonii*, *Melocanna baccifera*, and *Schizostachyum dullooa*, in addition to bambusa of tulda and bambusa of balcooa in the lowlands (Borthakur et al. 2021). Actually, in this study, Kampung Kukupu and Kampung Serempet in Cibadak Village (Tables 1 and 2) also grow *Dendrocalamus asper* in the lowlands at below 300 masl.

Moreover, because of the favorable soil or geographic conditions, tali bamboo is the most common species in Cibadak Village. Meanwhile, *bambu ampel hijau* is found along small rivers, but the amount of *bambu betung*, *bambu ampel kuning*, and *bambu andong* are small. The small number of bamboo species is due to the absence of planting, maintenance, and re-cultivation after the bamboo is harvested. Generally, bamboo regeneration depends on growing coppice from bamboo cutting that leaves stumps. Recently, there has been no enrichment planting with bamboo seedlings by semi-rural villagers in bamboo stand areas with a fever for bamboo rejuvenation. In addition, *bambu betung* has a large and sturdy diameter for poles and house construction. Apart from being used for buildings, this bamboo species is often split to make roof battens and *bambu betung* shoots can be made into tasty vegetables. Perceived from the wide-area ratio of Cibadak Village, the potential of bamboo in this area is in a small category at only 9.62 ha, or 2.07%, or below 200 clumps per ha, so it can be classified as having low or no potential.

Contribution of bamboo craftsmen to the community's income

The average income calculation revealed that the contribution of bamboo craftsmen to the community's income in Cibadak Village was less significant than the community's increasing costs. This situation forced some bamboo craftsmen to find other jobs to support their economy, as presented in Table 4.

The contribution of bamboo craftsmen to the total income of craftsmen in Cibadak Village was 27.03% (Table 3), which means that the community's needs could not be fulfilled merely by the bamboo craftsmen's business activities. Instead, other sources of additional income were needed, such as drivers (25.00%), merchants (21.67%), and construction workers (26.30%). In other words, the contribution of income of craftsmen from bamboo craftsmen is 27,03% (small), while other incomes for craftsmen, consist of drivers, merchants, and construction workers, is 72,97% (big). Therefore, most of the craftsmen in Cibadak Village had a side job than their main job as bamboo craftsmen. From 30 respondents, every head of household has income ranges 1,250,000-3,250,000 IDR/month. This income value is still under the minimum basic income (UMR) in Bogor City for 4,639,429 IDR/month. Therefore, it needs to increase the quantity and quality of bamboo craftsmen products, variety, and marketing reach to raise its income. As for, the contribution of income of bamboo craftmen to a community's income in Cibadak Village is 12.46%, and the contribution of income of other work types to that community's income, presented in Figure 5.

According to Yuliatiningsih (2005), in Selang village, Wonosari sub-district, Gunungkidul district, the odd job of craftsmen contributed to a farmer income of 43,5% (big enough) of the total revenue. Wartanta (1998) explained craftsman businesses in the Minggir district, Sleman Regency, can increase farmer income and distribution income to reduce the rural social gap. Widiyanto et al. (2021) reported that the Covid-19 pandemic positively impacted the income of bamboo craftsmen in Mandalagiri village with an average income increase of 2% due to several factors: higher demand, availability of raw materials, and ease in seeking public loans with low interest. Next, the loan money is used to develop the number and quantity of products of bamboo craftsmen.

Table 4. The average income of the bamboo craftsmen community in Cibadak Village, Bogor City, Indonesia

Type of work	The average income (IDR/month)	Percentage (%)
Bamboo craftsmen	1,135,000	27.03
Drivers	1,050,000	25.00
Merchants	910,000	21.67
Construction workers	1,104,545	26.30
Amount	4,199,545	100

Note: income includes salaries, wages, and other payments that received

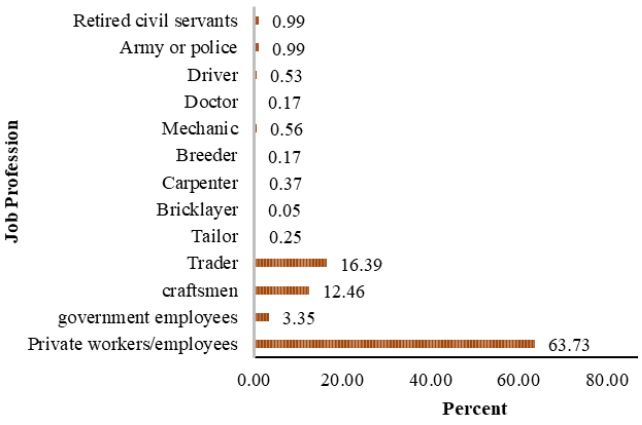

Figure 5. Contribution of income of bamboo craftsmen and the other work to the community's income in Cibadak Village, Bogor City, Indonesia

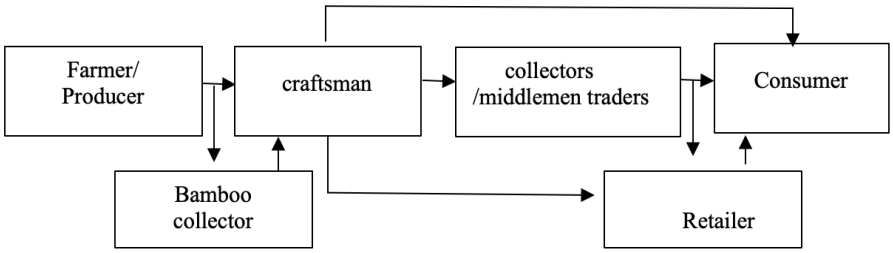

Figure 6. The flow of bamboo marketing in Cibadak Village, Bogor City, Indonesia

In this study, the average time to complete one large product of bamboo cage craft was one day; hence, the average monthly production was ±30 bamboo cages. The net profit of each cage was Rp.50,000 after deducting the average manufacturing cost of Rp 5,000. There was no issue in the marketing aspect of bamboo handicrafts because collectors were already buying bamboo craftsmen. Thus, this study has a simple value chain of bamboo (Figure 6).

According to Figure 6, the bamboo marketing flow might be long or short chains. Marketing flows with extended chains demonstrate a growing number of stakeholders/actors involved. When compared to other business commodities, each commodity has unique marketing flows. Craftsmen obtain their raw materials from bamboo farmers or also from bamboo collectors. Craftsmen then sell their products to collectors and finally to consumers. Craftsmen sell their bamboo to consumers or go through retailers and then directly to consumers. Bamboo craftsmen are still limited to caged crafts, and the market has few customers. The actors who play a role in bamboo marketing in Cibadak Village, Bogor City, are limited to bamboo farmers, bamboo collectors, bamboo processors/craftsmen, middleman/broker traders, retailers, and consumers. There is no direct role for the government as an actor in marketing products produced by bamboo craftsmen. However, it is known that the government's role is important in its policies that will influence the sustainability of bamboo craftsmen's businesses.

According to Lee et al. (2021), a new income model should encourage local villagers to increase their value chain by selling more local value-added bamboo products. Furthermore, villagers could build their capacities to make and sell local bamboo products, without middlemen/broker or collectors. For example, the study in Yogyakarta (Pramono et al. 2021) revealed hybrid bamboo and batik handicraft items have potential and are in demand by the market. Furthermore, the market research analysis shows that most respondents like those products, and according to a market research review of odd groupings, women like this bamboo batik craft product. Design, material, product quality, function/usage, and pricing are the most important considerations when purchasing a handcrafted item. In addition, Ekawati et al. (2022) also stated drivers, barriers, and strategies in the community-based supply of bamboo for industrial-scale utilization in Ngada Regency, East Nusa Tenggara, Indonesia.

Moreover, the study concluded that income must be increased and achieved by appropriate strategies. Cidhy et al. (2016) stated that the probability of developing a business model focusing on bamboo with its tangible and intangible products is very potential to be developed. According to Maulina and Raharja (2018), who presented the case of Virage Awi in Bandung City, the bamboo craft industry is an SMEs (Small Medium Enterprises)-level performance that has been well-managed to reach the international market. In Indonesia, the criteria to measure SMEs are their assets and turnovers.

Moreover, Roostika (2019) reported that areas of expertise that have been achieved on SMEs, covering Kajigelem Bantul, Yogyakarta, include the bamboo hand fan made up 56% of the sample of respondents *bigger than* Kasongan pottery cluster made up 19%; Lemah Dadi with wooden batik made up 13%; and Gendeng with leather puppet at 12%. Many crafts SMEs in that location continue the conventional models to represent the origin and authentic models. However, SMEs in some degree have developed new designs and innovate their products according to new demands and skills they have acquired from trainings given by government/education institutions. Also, according to Chan et al. (2019), Saung Angklung Udjo marketing its products internationally through overseas agents (such as in Korea) and direct sales to consumers.

The advantage of bamboo cultivation is the value of bamboo products and its secondary products. In this study, the bamboo craftsmen use all raw materials of *bambu tali* (*Gigantochloa apus*), and a few people also utilize *bambu betung* and *bambu ampel rebungs* for self-consumption as complementary food vegetables. Another example, usually in the cultivation of *bambu betung*, *surat*, *serit*, *ampel hijau*, *ampel kuning*, and *ori*, is secondary potential revenue from the sale of bamboo shoots at the thinning stages. During the rainy season, young bamboo or bamboo shoots' culms, namely rebung, grow greatly depending on soil fertility and rainfall; not all bamboo shoots (rebung) can grow well, even dead. Generally, the growth of *rebung* to maturity needs lots of nutrients, whereas soil nutrients

are in limited availability. Many *rebungs* would compete to grow to the mature culm, but on the contrary, many would die naturally. Therefore, before they die naturally, they can be harvested in the thinning stages to arrange their structure and clump compositions. For example in bamboo of betung, suppose each clump can be thinned for 6 cut *rebung* pieces as a secondary product, reaching 10,000 m^2 : 64 m^2 (planting distance) = 152 clumps, and 152 x 6 cut rebung/clumps = 936 cut *rebungs* per ha per year. In the traditional market, the *rebung* price is IDR 3.000/kg. Therefore, bamboo cultivation revenue from *rebungs* would get a secondary income IDR 7.488.000,-/ha/year (Sutiyono 2014).

According to Kalanzi et al. (2017), the average total income from selling bamboo products in Southwestern Uganda was UGX 125,902 or USD 33,62 or IDR 532,871.96 with a gross margin of 51.6%. According to Subbanna and Viswanath (2018), in the Konkan belt of Maharashtra, India, *Bambusa balcooa* Roxb. and *Dendrocalamus stocksii* Munro.), have competitive market, especially in the furniture industry. Based on a report by Dwivedi et al. (2019), farmers can earn up to USD 800 or IDR 12,679,880 per hectare annually by selling raw bamboo from their degraded land. Additionally, under-employed farmers can work like skilled workers in the bamboo handicraft industry. They can earn up to USD 2,700 or IDR 42,794,595 annually, significantly higher than current farmers' average income (USD 1,750 or IDR 27,737,237.50/annum).

Khotimah and Sutiono (2014) conclude the analysis of the financial feasibility of bamboo cultivation in a certain bamboo plantation company in Lampung Province, NPV value IDR 36,644,364.08 > 0, Net B/C $\left|-2{,}56\right|>1$, and IRR 11% > DR 6%. This result signifies that bamboo cultivation potentially changes economically to get profit. Generally, the return on venture capital can be achieved in the 9th year of the growth cycle. In comparison, the research of Sutiyono (2014) revealed that the revenue of bamboo cultivation comes from the sale of clumps in the 7th year. The research of Prasetyo et al. (2021) used Market Analysis and Development (MA&D) and financial analysis on cultivation of *bambu petung* with 6 m x 6 m spacing, resulting in the biggest advantage of NPV value amounting to IDR 330,329,538.00; BCR 29,10 and IRR 25,18% is more worthy than sengon (*Paraserianthes falcataria*) agroforestry and other bamboo species different planting patterns. However, after a review of the community, the agroforestry pattern of a mixture of bamboo and sengon is probably applied in the field to ensure sustainability and continuity for farmer revenue.

The study concluded that the potential of bamboo in Cibadak Village was only 9.62 hectares or 2.07% of the village's total area of 464.73 ha. The bamboo species found include *bambu tali* (*Gigantochloa apus*), *bambu betung* (*Dendrocalamus asper*), *bambu ampel hijau* (*Bambusa vulgaris* var vitata), *bambu ampel kuning* (*Bambusa vulgaris* var. Striata), and *bambu andong (Gigantochloa pseudoarundinacea). Bambu tali* was mostly found, grows, and spread in this study area. *Bambu tali* was used as raw material for the bamboo cage craftsmen, contributing to their income. In addition, *Bambu betung* and *bambu ampel* used their *rebungs* as complementary food vegetables and *bambu andong* as a building material. Actually, the contribution of bamboo cage craftsmen to the community's income was considered less significant (27.03%) compared to the average total income of the craftsmen, while other incomes for craftsmen, consist of drivers, merchants, and construction workers, is 72,97%. In additionally, the contribution of income of bamboo craftmen to a community's income in Cibadak Village is 12.46%,

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