Impact of Bamboo-Based Agroforestry Demonstration Plots Based on Farmers' Perceptions

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Abstract. One of the efforts to develop bamboo is to apply agroforestry patterns, including the establishment bamboo-based agroforestry demonstration plots (BAF demplots). This study aims to determine the impact of BAF demplots based on farmers' perceptions. The research was conducted in Sukaharja Village, Rajadesa District, Ciamis Regency, West Java. The respondents in this study were 46 farmers who worked on BAF demplots and 31 farmers who did not work on BAF demplots, so the total number of respondents was 77. Primary data were collected through questionnaires, interviews, and direct observation. The data obtained were then processed and analyzed descriptively. Important Performance Analysis was used to analyse the impact of the BAF demplots based on the farmers' perceptions. The results showed that the BAF demplot had a positive impact on farmers involved in and outside the demplots, in term of social and ecological impacts. However, the economic impact of the BAF demplots is considered to be below farmers' expectations. Therefore, for the demplot to provide more economic benefits, it is necessary to develop potential bamboo-based businesses as part of the demplot development by involving various related stakeholders.

1 Introduction

The value of bamboo, popularly known as "green gold," is increasing in the global economy [1]. Given that it grows more quickly [1,2] and reaches maturity at the earliest [2]. It is a commonly exploited economic resource that can reduce poverty, especially for the tribal community [1]. Bamboo is a widespread plant in Indonesia [3] and is one of the plants essential to people's lives in rural areas [4].

Bamboo is an environmentally friendly, inexpensive, and renewable building material [5]. Bamboo is used to build conventional houses and as fuel in rural areas, which benefits the environment. Moreover, it shields dwellings from the wind [6]. Bamboo can be sustainable if it s harvested selectively rather than by clear cutting [7].

Bamboo-based agroforestry (BAF) hold great promise for the economies of developing countries by increasing productivity, sustainability, and resource conservation [8,9]. For example, the "talun-kebun" bamboo system in West Java combines fast food and timber production cycles and preserves the ecosystem [10].

The bamboo clumps consist of species that have long been cultivated in the community. The community has not yet to cultivated bamboo intensively from planting to harvesting [11]. However, the population of bamboo clumps tends to decrease as the area is used for settlement or replaced by other plant commodities that are considered more profitable [12]. Some of the reason for the the decrease in the number of bamboo clumps include very intensive logging that damage to the bamboo clumps, the conversion of land to other uses, and the conversion of bamboo plants to other plants that are considered more profitable [13]. The demand for bamboo raw materials continues to increase in line with population growth and the development of scientific progress. In the future, this increased demand can only be met by relying on something other than natural bamboo resources. It is therefore necessary to support efforts to plant or cultivate bamboo [12].

One way to support bamboo cultivation and development efforts is to establish a demonstration plot (demplot). Demplots can not only be used for community learning but can also have a social, economic, and ecological impact [14]. Assesing the impact felt by the community can be done through the perception of the community, both directly and indirectly involved. Perception is a process by which a person become aware of an object outside of him or herself [15]. As perception is the starting point for

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developiment attitudes and behaviours, an accurate perception of an object is necessary. It is crucial to understand how the community feels in order apply community empowerment in good agroforestry forest management and to find solutions to any problems that may arise [16]. Research on the public perception of demplots has been done, such as research by [17] on sharecroppers on private land whose crops result of technological development by research institutes. However, research on smallholders' perceptions of BAF developed on village land has never been conducted. The development of bamboo BAF demplots is carried out to maintain the existence of bamboo, become a learning tool for the community and alternative community empowerment activities, and to motivate farmers to cultivate bamboo. This study aims to determine the impact of BAF demplots based on farmers' perceptions.

2 Method

2.1 Research Location

This research was conducted in 2021 in Sukaharja Village, Rajadesa Subdistrict, Ciamis Regency, West Java, Indonesia. This village is the location for a bamboo-based agroforestry (BAF) demplots built in 2015. A map of research locations is presented in Figure 1.

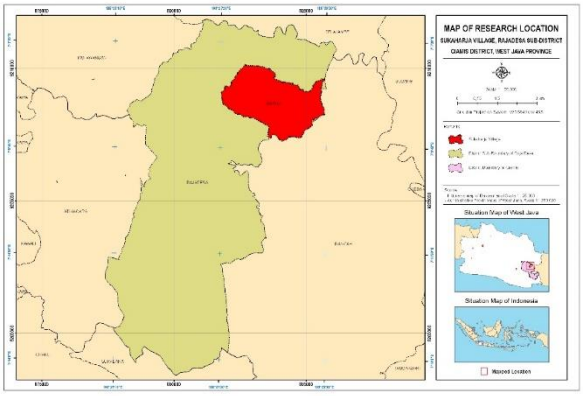


Fig. 1. A map of Research Location

2.2 Data Collection and Analysis

There were 77 respondents in this study, 46 farmers involved in the management of the demplot and 31 farmers not involved in the management of the bamboo-based agroforestry demplot. Primary data were collected through questionnaires, interviews, and direct observation. The questionnaire consisted of 30 questions on the impacts of BAF based on farmers' perceptions, with ten questions each on social, economic and ecological impacts. Measurements were scored using a Likert scale, i.e. 4 for strongly agree, 3 for agree, 2 for neutral, 1 for disagree and 0 for strongly disagree. Next the assessment compares the number of answer scores with the expected (highest) score multiplied by 100%. The results are a percentage of the expected [18]. Furthermore, the percentage value of answers is interpreted in qualitative sentences with references as in Table 2.

Tab 2. Percentage scores and interpretation criteria of perception analysis

Score (%)	Criteria of Interpretation
0 -33,32	Low (Not available, not enough, never, none, very often, hopeless, very influential, and unimportant)
33,33 – 66,66	Medium (Less available, less than enough, less effort, little, often, seldom, less hopeful, less threatened, influential, and less important)
66,67-100	High (Available, sufficient, effort enough, much, seldom, often, hopeful, threatened, less influential, significant, and important)

Source: [18]

Data analysis is presented qualitatively and descriptively through data tabulations and narrative explanations [19]. Data analysis used perception formation analysis [20] to determine farmers' perceptions of bamboo agroforestry adoption.

Importance-Performance Analysis (IPA) was used to determine the impact of the BAF demonstrations. The IPA approach, or quadrant analysis, seeks to quantify the relationship between consumer perceptions and goals for improving product or service quality [21]. Because of its ease of use and its ability to provide analysis results that facilitate suggestions for performance improvement [22], IPA has gained widespread acceptance and use in various academic disciplines. The first step in applying the IPA technique is to identify the attributes that are relevant to the observed decision situation [23]. The list of attributes can be generated by consulting written sources, conducting interviews, and exercising managerial discretion. The attributes compiled include the social, economic, and ecological impacts of the BAF.

3 Result and Discussion

3.1 Development of BAF Demplots

The 'bamboo talun' is one of the traditional agroforestry systems in West Java, Indonesia. *Gigantochloa ater*, *Gigantochloa verticillata*, *Gigantochloa apus*, and *Bambusa vulgaris* are among the dominant species in the 'bamboo talun'. The bamboo clumps are interspersed with *Albizia falcataria, Parkia speciosa, Arenga pinnata* (sugar palm), and a few fruit trees (mango, durian). Perennial trees and bamboo are combined to create a multi-layered canopy structure [24]. In Sukaharja Village in Ciamis Regency,

the most common bamboo species were tali bamboo (*Gigantochloa apus*), betung bamboo (*Dendrocalamus asper*), ater bamboo (*Gigantochloa atter*), gombong bamboo (*Gigantochloa pseudoarundinaceae*), and haur bamboo (*Bambusa vulgaris*) [13].

The bamboo-based agroforestry (BAF) demplots in Sukaharja Village, Ciamis Regency, Indonesia, were established in 2015 and 2018 on six hectares and involved 64 smallholders. In 2015, three types of bamboo were planted, namely black bamboo (*Gigantochloa atroviolacea*), betung bamboo (*Dendrocalamus asper*), and green ampel bamboo (*Bambusa vulgaris* var vitata) were planted at 10 m x 10 m spacing, while in 2018, two types of bamboo were planted, namely yellow ampel bamboo (*Bambusa vulgaris*) and ater bamboo (*Gigantochloa atter*) with a spacing of 10 m x 15 m [25]. The fifth type of bamboo planted in the demplots can be used for house building, handicrafts, and as food ingredient (bamboo shoots).

The newly developed bamboo culms are called bamboo shoots. They are used to make a range of traditional and contemporary specialities that can be consumed fresh, dried, shredded, or pickled [26]. Bamboo shoots are also a excelent source of dietary fibre, phytosterols, low fat, high protein, amino acids, and carbohydrates [27,28]. Bamboo shoots are regularly harvested in form of arrangement so that the bamboo clumps are not too dense and the canopy is not too dense.

The arrangement of thebamboo clumps is also done so that farmers can still plant various types of seasonal plants between the bamboo plants. So far, the community's perception is that the presence of bamboo clumps makes it difficult for annual plants to growth. These demplots show how to properly manage bamboo clumps to allow annual crops to continue.

Bamboo is an important l part of agroforestry systems. Proper spacing of bamboo is essential to maximise the combinedperformance of bamboo and associated crops. Although intercrop performance was higher with reduced bamboo cover, the likely reduction in bamboo yield may not be economically beneficial. They developed a trade-off for bamboo-based agroforestry systems to maximise intercrop production without reducinglowering bamboo yields. It is best to use intermediate bamboo plantings, lsuch as eight by nine inches or ten by ten inches [8]. The best bamboo species for intercropping systems may be monopodial ones.

Depending on the species clump size, bamboo can be planted in such intercropping systems at different spacings ranging from 4 m 9 m to 8 m 9 m. Other suitable crops in India include finger millet, cowpea, bottle gourd, turmeric, sesame, and sweet potato [29]. According to [30], the success of any agroforestry systemsdepends on how the woody perennial and assciated elements interact. This interaction can take place above or below ground. Depending on how the components are arranged, how densely they are planted, and how much technical management is applied, competitive and complementary interactions can occur within a bamboo agroforestry system [31,32].

The introduction of agroforestry was facilitated by the diversity matching between species and demands [33]. Based on the suitability of the land and the wishes of the community, several types of annual or undergrowth plants were planted among the bamboo plants in the BAF in Sukaharja Village, including corn (*Zea mays*), peanuts (*Arachis hypogaea*), black potatoes (*Plectranthus rotundifolius*), grass animal feed, and cassava. Meanwhile, the multipurpose tree species (MPTs) developed are based on dog fruit (*Archidendron pauciflorum*), stink bean (*Parkia speciosa*), nutmeg (*Myristica fragrans*), and coffee (*Coffea* sp). Bamboo-peanut-corn agroforestry and bamboo-coffee agroforestry are shows in Figure 2.

(a) (b)

Fig. 2. (a) Bamboo-peanut -corn agroforestry and (b) Bamboo-coffee agroforestry

3.2 The Benefits of BAF Demplots

The adoption of new technology requires time and the appropriate medium. If the new technology increases the utility in terms of benefits and gains over current alternatives, it will adopted ; if not, it will be rejected. Innovations that offer more relative benefits (social, economic, and ecological), compatibility, simplicity, trialability, and observability will be adopted faster than other innovations [34]. Agricultural extension helps rural smallholders adopt new technologies more quickly by providing them with information and guidance [35,36].

Some of the factors that facilitate the adoption of innovations include: higher utility or profitability (usually multipurpose innovations), higher income, or better selling prices [37,38], the existence of related non-financial benefits (ecological conservation), complementarity with current practice (in term of knowledge requred, parctocess, and scale ofproduction), and livelihoods (contribution to risk reduction or food security) [39], a variety of households would be attractive, and was more intensive and appropriate for a wider range of environmental condition [40], matching species and needs [33,41]. However, increased costs of the innovation [38], reducing profitability [42], and the lack of any discernible revenues [37] have reduced the adoption of agroforestry innovations.

Farmers manage bamboo traditionally, such as with less optimal maintenance and no additions to other types of bamboo. This condition causes land productivity not to be optimal, making it less attractive to farmers, and some farmers replace bamboo with other types of plants of high economic value. Therefore,

efforts are needed to introduce innovations in bamboo cultivation with agroforestry patterns through demplots. Demontrations, which are the most popular extension technique, allow for wider adoption by demonstrating viability under farmer-specific conditions [37].

The existence of BAF demplots is also expected to function as a provider of extension materials or information, play a role in the development of extension methods, and become a site for various types of training or application of various technological practices. Farmers often participate in demontrations of result and method offered by local extension and research groups to verify the effectiveness of new technologies [43]. Farmers' participation in training and demplots increased agroforestry adoption [33,44].

3.3 Social, Economic, and Ecology Impact of BAF Demplots

Adoption of agroforestry also involves socio-psychological elements, including the expectations and beliefs of family members' . Socio-psychological aspects (such as preferences) need to be incorporated into development programmes to increase the effectiveness of agroforestry interventions [45]. The development of bamboo-based agroforestry (BAF) demplots in the study involves farmer who joint in bamboo cultivation and farmers outside the demplots. The perceptions of farmers, both demplot farmers and non-demplot farmer, on the impact of the BAF demplot are as follows:

a) Social impact of BAF demplots

The social impact attributes of the BAF demplot consist of 1) increased activities/jobs in the garden, 2) increased knowledge of bamboo cultivation, 3) increased motivation to grow bamboo, 4) dynamic farmer groups, 5) many training opportunities related to BAF, 6) interaction between farmers, 7) related government attention, 8) infrastructure development, 9) farming activities in the garden, and 10) community activities in the village. The social impacts of BAF demplot based on farmers' perceptions are presented in Figure 3. Figure 3 shows that the social impacts of the BAF demplots for importance and performance levels are in the medium and high categories. Socially, the BAF demplots, has generally increased social interaction between fellow farmers and fellow communities in Sukaharja Village, as because the village governmentt often receives visits from various communities/related agencies to see the BAF demplots and learn obout BAF management.

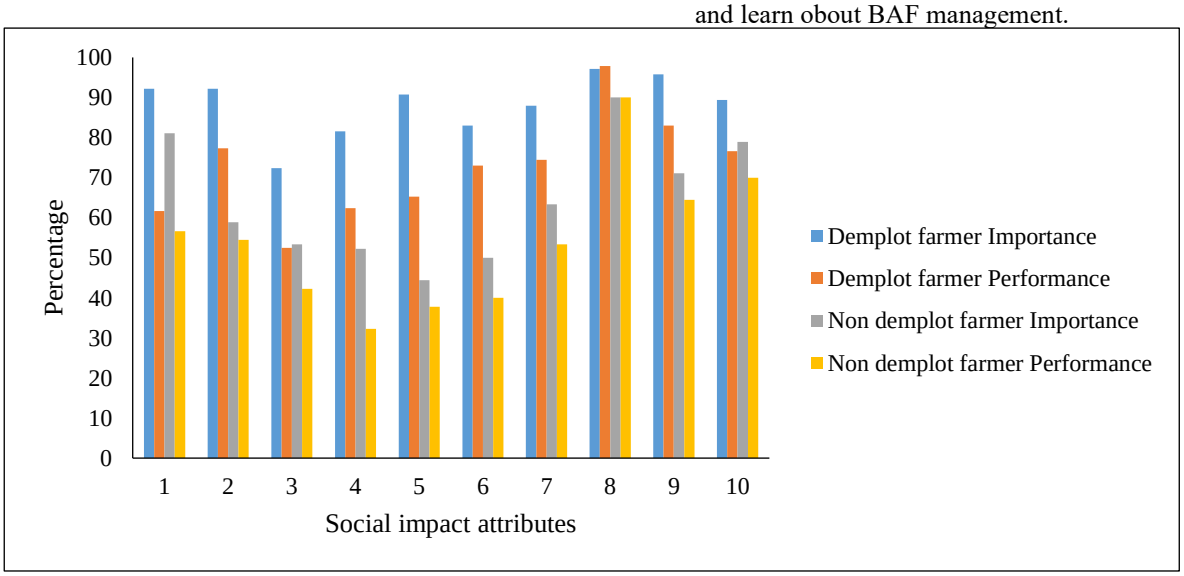
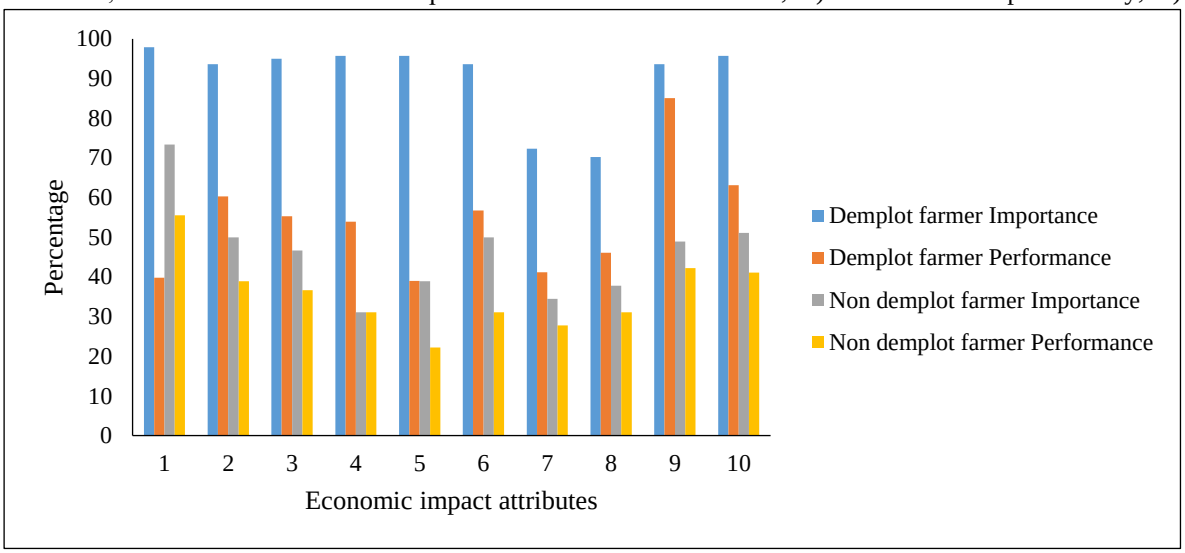


Fig. 3. Social impact of BAF demplot based on farmers' perception

Social factors play an important role in any tree planting programme. In short, the tree's survival rate shows that the community accepting the program well and that there is no conflict, and long-term (>5 years) community monitoring of the plants will affect the sustainability of the programme [46]. The existence of social demplots impacts the attention of various parties. The Sukaharja Village government responded to the existence of the BAF demplot by building several infrastructure facilities such as road repairs, mosque construction, meeting houses, and circuit tourist sites. This infrastructure will support the development of BAF, facilitate extension and training activities, hold smallholder farmer meetings;etc.. This condition is verydifferent from the land before the BAF programme.

It is important because the era of modernisation threatening the development of bamboo, where bamboo is beginning to be abandoned, especially by industry. This is because bamboo has an asymmetrical shape that most industry players find unattractive. There is a perception that bamboo material is only used for traditional communities or those from Indonesia, from low or poor economic background [47]. Socially, people have abandoned bamboo as a support in their daily lives. Plastic materials have now replaced bamboo due to the effects of modernisation [48].

Bamboo is an essential part of human life. In Indonesia, the cultivation of bamboo plantations still



still largely a community effort. Thus, the availability of bamboo to meet current needs still depends on forest products or farms. Moreover, bamboo applications are mostly limited to traditional uses.

b) Economic impact of BAF demplot based on farmers' perception

The attributes of the economic impact of the BAF demplots consist of 1) land resources, 2) encouraging other economic businesses, 3) increasing farming, 4) increasing income, 5) increasing the economic value of bamboo, 6) increase farm productivity, 7) acces to agricultural capital, 8) the availability of wage labour, 9) the availability of family labour, and 10) the sustainability of farming.

The attributes of the economic impact of the BAF demplots consist of the economic impact of the BAF demplot based on farmers' perceptions is presented in Figure 4.

Fig. 4. The economic impact of BAF demplot based on farmers' perception

Figure 4 shows that the economic impact of the BAF demplots based on farmers' perceptions of importance and performance levels are in the medium and high categories. The demplot farmers feel that the BAF demplots have started to have a positive impact on increasing their income. However, this is not yet significant. [13] mentioned that agroforestry development this is not yet significantly improved their economy. Bamboo is a source of income for farmers, although the selling value still needs to be higher. The use of bamboo can generate and increase new income for the community, which will support the improvement of community welfare [46, 47]. However, the community is not yet fullfocused entirely on agroforestry, so there is a need to intensify agroforestry practices and improve agroforestry land management [51].

c) Ecology impact of BAF demplot based on farmers' perception

The ecological impact attributes of the agroforestry demplots consist of 1) reducing the potential for drought, 2) maintaining the sustainability of the planting period, 3) reducing the impact of drought, 4) improving land cover, 5) maintaining springs; 6) reducing forest pest disturbance, 7) improving air conditions, 8) increasing the growth of other plants, 9) increasing plant biodiversity, and 10) increasing animal biodiversity .

The ecological impacts of BAF demplot based on farmers' perceptions are shows in Figure 4. Figure 4 shows that the ecological impact of the BAF demplots for importance and performance levels are in the medium and high categories. People still believe that bamboo is good for protecting springs and farmers' land from erosion and landslides, so people still maintain the existence of bamboo plants [13]. Brazilian communities cultivate bamboo species such as *Bambusa blumeana* and *Phyllostachys pubescens* to control soil erosion, prevent loss of soil nutrients, and improve soil structure [52].

Bamboo has an extensive fibrous root system, systematically connected rhizome roots, and relatively thick bamboo leaves that can protect against rain. Bamboo produces new stems from underground rhizomes that can be harvested without disturbing the soil.

In addition, bamboo serves ecological purposes such as preventing soil erosion, conserving water, rehabilitating land, and sequestering carbon [53,54]. Other benefits to farmers include the availability of clean water and the appearance of several animals (monkeys, birds, and bees) that make community forests their habitat.

The important and the interests of the existence of demplots is medium and high categories on social, economic, and ecology. For demplots farmers, the existence of BAF demplots can fulfil some of the farmers' social, economic, and ecological expectations (their interests). The difference in perception between demplot farmers and non-demplot farmers is possible because the intensity of farmer involvement in demplots

is greater than that of non-demplot farmers. The perception of non-demplot farmers is lower in term of importance and availability but is still in the moderate category. For non-demplot farmers, demplots strongly support efforts to increase motivation for farmers/communities to plant bamboo on their land and cultivated areas.

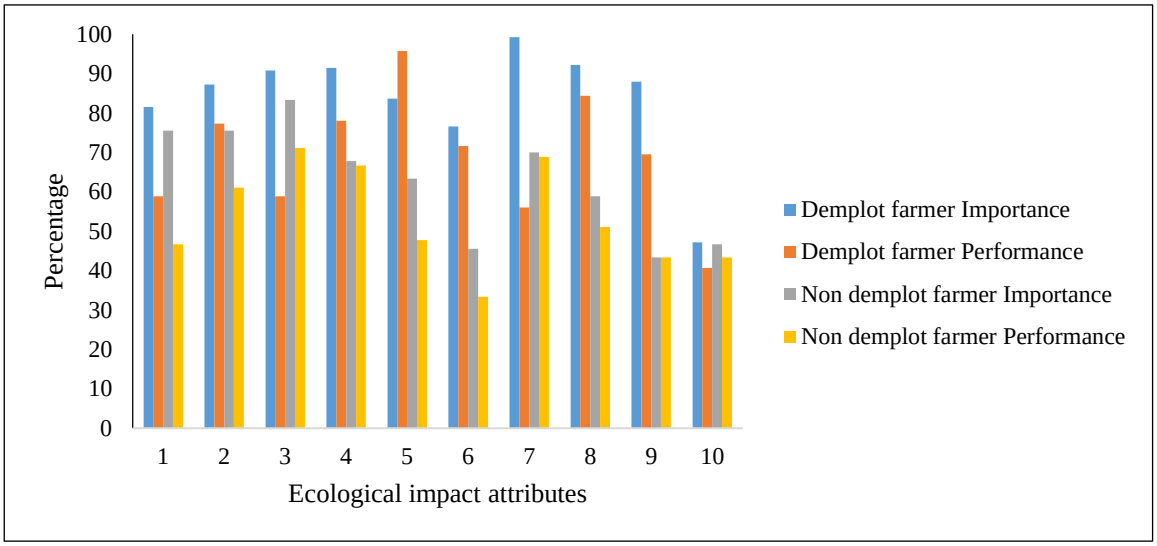
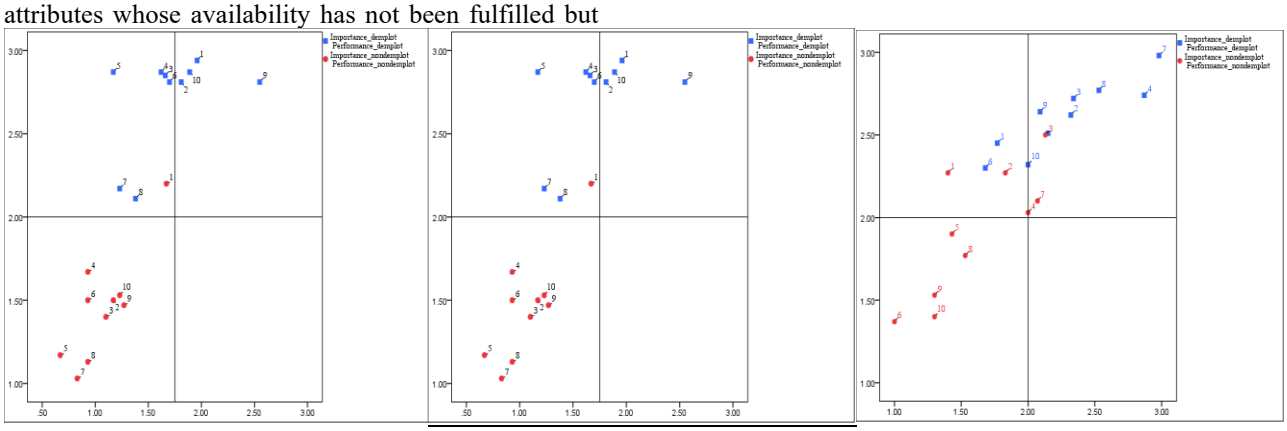


Fig. 5. Ecological impact of BAF demplot based on farmers' perception

d). Importance Performance Analysis (IPA) of BAF demplots impact

The Cartesian graph of the IPA of BAF demplots impact is shows in Figure 6. Figure 6 (a) shows that the IPA attributes are distributed in quadrants I, II, and III. Demplot farmers have a higher interest than non-demplot farmers. According to the perception of non-demplot farmers, socially, demplots provide something in the interests of farmers. However, there are two attributes whose availability has not been fulfilled but which are very important, so that the BAF demplot manager must pay priority attention to them, namely: for demplot farmers, how the BAF demplot can increase the opportunity to work on the plantation (attribute 1) and for non-demplot farmers, how the existence of the demplot motivates farmers to plant, maintain, and sustainably use bamboo (attribute 3).



(a) (b) c)

Fig. 6. IPA of the social (a), economy (b) and ecology (c) impacts of BAF demplots

Figure 6 (b) shows that the demplots have yet to fully meet the farmers' economic expectations . The farmers' interest in developing bamboo through the production of BAF demplots is very high but has yet to be fulfilled by the demplots. In the economic aspect, many things need be considered, namely attributes 1, 3, 4, 5, 6, 7, and 8. In order to provide economic benefits to demplot farmers, it is necessary to strengthen the farming community in marketing bamboo and other agroforestry products because farmers are still face problems-barriers to marketing bamboo in small quantities. Planting trees can increase social cohesion [55] so that the community can share economic benefits and increase group cooperation.

Farmers around the demplot feel the ecological impact of the bamboo demplot (Figure 6 c). Non-demplot farmers also perceived some of the attributes. The attributes that need to be considered because they are very important but did not meet farmers' expectations are attributes 1, 2, and 6, namely optimising BAF to reduce the impact of drought in the

dry season, keeping the planting period from decreasing, and how BAF reduces pests.

4 Conclusion

Bamboo-based agroforestry (BAF) is one of the interesting models in bamboo development efforts. The BAF demplot is an important tool that can be a medium for transferring cultivation bamboo knowledge and technology to farmers and the wider community. BAF demplots are also have an impact on farmers within the demplots and outside the demplot. The existence of demplots is more felt more by farmers who are directly involved in the development of demplots than by farmers who are not involved in demplots. The existence of BAFs has had a positive impact on farmers, particularly in term social and ecological impacts. However, the economic impact of the BAF demplots is considered to be below farmers' expectations. Farmers hope that in addition to bamboo development, they can also learn to process bamboo into products that have economic value and increase their income.

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