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Community preferences for agroforestry patterns in supporting future forestry development

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Abstract. Through the selecting cropping patterns can be used as a strategy to regulate the success rate of land management it can contribute to deciding the level of the earth's temperature through the selection of plant species. The high level of the earth's temperature causes various impacts such as an increase in drought, which affects the agricultural industry, changes in weather that affect the success of planting, to the foodcrisis. Therefore, the selection of plant species must be done correctly and in accordance with the preferences of farmers. The choice of plant types that are by following the wishes of farmers can increase the motivation of farmers to maintain and caring for plants so that the success rate of planting will be higher. Therefore, it is essential to research farmers' preferences in choosing crop types and agroforestry cropping patterns (simple agroforestry and complex agroforestry) because the amount of carbon stored by plants will depend on farmers' preferences. The purpose of this study is to determine the preferences of farmers in choosing types of crops and agroforestry cropping patterns by using decision-making analysis methods. The study was conducted from December 2020 to February 2021 at the Batutegi Forest Management Unit, Tanggamus Regency, and Lampung Province. Research results show that the aspects considered by farmers are the aspects considered by farmers in choosing plant types and cropping patterns were production orientation (100%), time and labor (95.65%), biophysical conditions (80.43%), knowledge (80.43%) and the ability to invest in plants (36.96%). The reasons for farmers choosing crop types and cropping patterns are income (100%), productivity (88.89%), production speed (82.22%), and ease of harvesting (37.78%). As many as 73% of farmers who choose complex agroforestry cropping patterns have a more significant role in minimizing the impact of global warming. This happens because complex agroforestry cropping patterns are able to minimize the effects of global warming more optimally with larger stored carbon stocks of 765.61 tons/ha when compared to simple agroforestry planting patterns with carbon stocks of 356.21 tons/ha.

1. Introduction

Selection of cropping patterns is one of the strategies for regulating the success rate of land management. Cropping patterns are land management techniques that control the layout and sequence of plants [1]. In addition to playing a role in the success rate of planting, another role in the selection

of plant species that make up the cropping pattern is that it can affect the conditions and levels of the earth's temperature. This occurs because all plants have the capacity to absorb carbon dioxide (CO_2), so the presence of plants will play a role in determining the earth's temperature level in the present and the future [2]. The process of CO_2 absorption by plants occurs during the photosynthesis process, where plants absorb CO_2 and water with the help of sunlight and then convert it into glucose and oxygen [3];[4].

Each type of plant has a role in minimizing global warming, but plants with the tree phase have the most significant role in absorbing carbon. According to the findings of [5]'s research, which states that trees are the most oversized carbon sinks in plants. This statement is also strengthened by the results of study conducted by [6], which said that plants in the tree phase had a more excellent stored carbon stock than plants in the litter and seedling/plant material phases. Plant carbon stock at each stage based on the research was 99.67 tons/ha for trees, 0.47 tons/ha for litter, and 1.69 tons/ha for seedlings. Although plants other than the tree phase have a smaller stored carbon stock than the tree phase, they still play a role in lowering the earth's temperature level to minimize the effects of global warming [7].

The high level of the earth's temperature can cause various adverse effects the earth's life in the present and future. Some of the impacts caused by the phenomenon of an increase in the earth's temperature are sea level rise, drought, which also has an effect on the agricultural industry, erratic weather changes that affect the success of planting, to the food crisis [8]; [9]; [10]. Looking at the impacts that occur due to the increasing temperature of the earth, it can be concluded that an increase in the earth's temperature can disrupt all activities and life on ground [11]. Therefore, the selection of plant species must be carried out correctly according to the preferences of farmers because farmers are the holder of the most significant role in forest management so that they contribute to the condition of the earth, the progress and success of planting, and minimize the impact of global temperature increases [12]. By choosing the types of plants that are in accordance with the wishes of the farmers, the motivation of farmers in maintaining and caring for each plant will be higher so that the success rate of planting will also be higher [7]. Matters related to the selection of plant species can also be a solution in supporting the government's efforts to emphasize the rate of land deforestation through forest management with the concept of social forestry in the Forest Management Unit [13]. Therefore, it is essential to research farmer preferences in selecting crop types and agroforestry cropping patterns especially simple agroforestry and complex agroforestry because the amount of carbon stored by plants will depend on farmers' preferences. The research was conducted with the aim of determining the preferences of farmers in choosing plant types and agroforestry cropping patterns in the Forest Management Unit (KPH) Batutegi, Tanggamus Regency, Lampung Province, so that farmers' reasons for choosing plant types can be seen, so that it is related to climate change mitigation.

2. Research methods

2.1. Research sites
Research location is in Sinar Harapan Group Association (gapoktan) at the Batutegi Forest Management Unit, Tanggamus Regency, Lampung Province, from December 2020 - February 2022.

2.2. Research objects and tools
The research object is the Sinar Harapan Gapoktan who use agroforestry cropping patterns, especially simple agroforestry and complex agroforestry. The tools used are a camera, questionnaire sheet, and recorder.

2.3. Determination of respondents
The respondent determination method used is the Snowball method. The snowball method is used for alternately taking samples from one respondent to another, with respondents closely related to the

research criteria that have been set [14]. This method was used because the population of Sinar Harapan Gapoktan farmers who use simple and complex agroforestry patterns has not been calculated. The primary respondents used were the heads of the Gapoktan, then the secondary respondents used were farmers recommended by the leadera of the Gapoktan.

2.4. Data type

The study's data are divided into two categories: secondary data and primary data primary data consists of data related to farmer preferences, while secondary data in this study is data pertaining to farmer preferences in the selection of plant types and cropping patterns, as well as other supporting data such topographic maps and an overview of the research location. Data were collected using direct interview techniques with respondents.

2.5. Data analysis

The analytical method used on the data that has been collected is the decision-making analysis method by Gladwin (1980). Decision-making analysis is carried out through two stages namely; the first stage is the elimination of all unwanted alternatives with various aspects of consideration. In the first stage, the sub-digest from the elimination process was obtained, then the sub-digest was analyzed in the second stage. The second stage is the stage where the farmer must choose the remaining alternative options from stageone by considering the aspects that have been determined. In the second stage, several elements that havethe same value are reduced to simplify the decision-making process so that farmers' preferences are obtained in the selection of plant types and cropping patterns used. The results of the analysis related tofarmer preferences were then analyzed further using a descriptive method with a qualitative approach.

3. Results and discussion

Farmers have made various changes to crop types for multiple reasons and influential aspects to produce decisions related to the selection of plant species and cropping patterns that exist and are developed to date. The causes and factors that influence the farmers' decisions are then analyzed using the decision-making analysis method by Gladwin (1980) through two decision-making stage.

The first stage is the initial stage of decision-making. At this stage, the farmer eliminates alternativetypes of plants that exist with consideration of the reasons or minimum requirements that have been setbased on the order of the farmer's decisions. The order of these minimum requirements is presented in Table 1.

Table 1. Minimum requirements have been set based on farmers' decisions.

Minimum requirements	Respondent (person)	Decision rating	Percentage (%)
Production orientation (Rp/kg)	45	1	100,00
Time and labor (day/week)	43	2	95,65
Biophysical conditions of the land	35	3	80,43
Knowledge	35	4	80,43
Plant investment ability (Rp/year)	17	5	36,96

The decisions of farmers in order from highest, as follows : production orientation (100%), time and labor (95.65%), knowledge (80.43%), biophysical conditions (80.43%), and the ability to invest in tree crops (36, 96%). The decisions of various farmers are based on differences in age, education, farming area, and social and economic environment of the community [15]. Decision made by farmers is generally carried out based on the needs and desires of farmers [16]. Most of the decision-making is done by the head of thefamily, namely the father [17].

Production orientation is an aspect that shows how farmers choose plant varieties by considering theyield of products with commercial value to fulfill their subsistence needs [18]. The farmers of the Batutegi forest management unit, especially the Sinar Harapan Gapoktan, select plant species that

have high commercial value such as coffee plants. The selection of plant species based on these aspects is carried out with the aim of meeting the needs of farmers. Types of plants that have high commercial value are believed to be able to increase farmers' income significantly [19]. This type of coffee plant is chosen by farmers because it has a high commercial value, so it is believed to be able to help farmers in meeting their daily needs. The average selling price of robusta coffee (*Coffea robusta*) is Rp. 18,500/kg in the form of dry coffee beans.

Types of coffee plants are used by farmers as the main crop, while the types of secondary plants that are developed are mostly Multi-Purpose Tree Species (MPTs). The types of MPTs include dog fruit (*Archidendron pauciflorum*), stink bean (*Parkia speciosa*), cloves (*Syzygium aromaticum*), avocado (*Persea americana*), candlenut (*Aleurites moluccana*), durian (*Durio zibethinus*), and nutmeg (*Myristica fragrans*). All types of secondary plants can be utilized by non-timber forest products produced by each type of plant. Based on this, the farmers of the Sinar Harapan Gapoktan select plant types based on the production orientation of the plant. Production orientation is a variable that shows how farmers determine plant varieties based on non-timber forest products (NTFPs) that can be sold to meet their daily needs [19].

The next aspect is time and labor. The factor that shows the ability of farmers to set aside time and energy for crop management is the aspect of the availability of time and energy in the selection of plant species [20]. Farmers in the Sinar Harapan Gapoktan who use agroforestry cropping patterns often use plant species that do not require complex management techniques and do not take a long time. This happens to obtain optimal production results and efficient management. Labor a considerable influence on production results, and efficient use of labor can produce an optimal amount of production [21].

The types of plants chosen by Sinar Harapan Gapoktan farmers have a suitable place for growing plants. This is evidenced by the level of rainfall on the land, which is 2000 – 3000 mm/year, with an average temperature of 22°C. The level of rainfall and the average temperature is an ideal number for planting with this type of coffee plant. This is reinforced by the results of the research by [22]; [23], which states that Robusta coffee grows and develops well on land that has rainfall levels between 2000 - 3000 mm / year with an average temperature of around 21°C - 24°C. The level of rainfall and the average temperature in the Sinar Harapan Gapoktan land is also by the needs of existing secondary plant species, such as durian (Durio zibethinus), which will grow well on land that has an average temperature of 20oC-30oC and minimum rainfall of 1500-3000 mm/year [24].

The next aspect that is considered by farmers is knowledge. Knowledge relates to the ability of farmers to manage land and the ability of farmers to learn and develop [25]. The knowledge aspect can affect the success of farmers in cultivating plants, so farmers must have broad knowledge aspects to achieve success in managing plants [26]. The knowledge possessed by farmers is obtained from fellow farmers and extension activities held by farmer groups. The same thing is also seen in the results of research conducted by [27], which states that farmers gain knowledge in managing land as a result of learning experiences from both fellow farmers and outsiders. Farmer knowledge is related to decision-making in setting and achieving goals correctly so that it can be related to forest sustainability [28].

The final aspect that farmers consider when deciding which types of crops to plant is the ability of every kind of crop to invest in crops. The ability to invest in crops refers to the capacity of farmers to meet their daily needs while waiting for the annual harvest to produce [29]; [20]. Meeting the needs of farmers while waiting for the central plants to produce, is obtained from the types of secondary plants that exist. Sinar Harapan Gapoktan farmers apply agroforestry cropping patterns so that land use can be carried out optimally and the results obtained can be carried out continuously or alternately between plants. Agroforestry cropping patterns can increase the economic value of the community through optimal land use [30]. In addition, farmers also earn income while waiting for the main crop to produce by way of lending money to collectors and doing side jobs. Side jobs carried out by farmers are farm laborers, motorcycle taxis, construction workers, traders, coffee mills, and casual daily laborers. Labor, motorcycle taxis, trade, and brick businesses are sources of income for non-agricultural farmers [31]. Farmers can borrow money from collectors with an agreement that the harvests to be obtained,

especially from the main types of crops, will be sold with the collectors. The same thing also happened to other farmers, as seen in the results of research conducted by [20]; [32], which stated that farmers have non-formal agreements in the form ofcapital loans with collector traders.

The plants that pass in stage one are coffee, pepper, stink bean, betel nut, cloves, avocado, candlenuts, durian, and nutmeg. Alternative types of plants that pass in stage one are then analyzed furtherin stage two. The second stage is the stage that reveals the farmers' reasons for choosing each type of plant and the cropping pattern developed. The reasons are then sorted based on the farmer's decision. This is done to know more about the reasons why farmers choose plant species. The reasons for farmers selecting the types of plants sorted by farmers' decisions are presented in table 2.

Table 2. Minimum requirements have been set based on farmers' decisions.

Aspect	Respondent (person)	Decision rating	Percentage (%)
Income (money)	45	1	100,00
Ease of marketing	43	2	95,56
Productivity	40	3	88,89
Production speed	37	4	82,22
Ease of maintenance	35	5	77,78
Ease of postharvest processing	20	6	44,44
Easy harvesting	17	7	37,78
Price stability	12	8	26,67

Aspects that have been sorted are then simplified by eliminating aspects with the same value. Elimination is done by comparing the two main types of plants in each aspect, namely the types of coffee and pepper. Aspects that have the same value are ease of marketing, ease of maintenance, post-harvest processing, and price stability so these aspects are eliminated. Income (money), productivity, speed of production, and ease of marketing are aspects that are not destroyed. In addition to determining the aspects that are not destroyed, farmers also specify the minimum conditions of obstacles that must be faced. The minimum requirements are the availability of labor related to the ease of harvesting, and the ability of plants to be planted with other plants. The availability of labor and the power of plantsto be planted with different types of plants influence the amount of production that will be obtained [33].

Sinar Harapan Gapoktan farmers generally choose the type of plant with a high price. Income is the main reason for farmers in choosing the type of crop. The same thing is also seen in the research conducted by [34], showing that the income aspect is the reason for farmers choosing plant types and cropping patterns. Farmers choose types of plants that have the ability to provide high income for farmers, such as incomeobtained from coffee plants. The average income of farmers from coffee is Rp. 21.500.000/ha/year. Theincome value is much greater when compared to other types of plants, namely pepper, with an average income of Rp. 6.000.000/year/ha. The existence of coffee plantations can contribute to improving the welfare of farmers [35].

The selection of plant types, especially the main crop (coffee), is also carried out by farmers becausethey can produce continuously. The coffee plant is an annual plant with a long life span of 20-25 years [36]. Therefore, the aspect of plant productivity becomes one aspect in the selection of plant types by farmers. Productivity is an aspect that shows the tendency of farmers to choose varieties of plants based on the level of production continuously [20]. This aspect is also considered necessary by farmers because it is closely related to meeting the needs of farmers' life [37]. In addition to coffee plants, othertypes of plants selected by farmers also have the ability to produce continuously, such as durian, avocado,candlenut, stink bean, dog fruit, and pepper. Farmers plant every kind of plant on the same piece of ground to create an agroforestry cropping pattern. Agroforestry cropping patterns can help farmers increase theirincomes and welfare through the benefits of various types of crops [38].

Sinar Harapan Gapoktan farmers in the Batutegi Forest Management Unit tend to choose plant types not based on production speed. It can be seen in the farmers' decisions in choosing plant types that cannot be produced in a fast time, namely the type of coffee plant as the main crop and the type of

secondary plant, which is mostly forest plant species with a long production period. Coffee will be produced in the third to fourth year, while pepper can produce in a faster time, namely one year [39]. Farmers focus more on marketing aspects of crop production, especially price, compared to other aspects. Marketing and prices influence farmers' decisions in choosing plant types [40]. In addition, farmers also select varieties of plants that have proven successful, the success rate can be seen from other farmers who have been successful and based on recommendations from experienced fellow farmers [40]; [41].

The last aspect that is considered by farmers in choosing plant types is the ease of harvesting relatedto production inputs and can be planted with others which indicates the level of plant resistance if prrroduced together with other kinds of plants [20]; [29]. Crops that have the ability to be produce simultaneously with other crops can provide additional income for farmers [42]; [43]. Farmers can obtain continuous production with a high level of productivity [44].

Alternative types of plants that pass in the second stage are a combination of coffee with candlenut, avocados, beans, dog fruit, durian, and nutmeg. As many as 100% of farmers in the Sinar Harapan Gapoktan chose coffee as the primary type of plant. This is because coffee has a high potential to increase farmers' income due to the productivity of coffee cherries, as well as easy access to sales and relatively stable prices. Similar research results were also found in research conducted by [45]; [46]; [35], which states that farmers chooseplants for various reasons, including the potential to market their harvests, daily needs, the need to savefor their children's school fees, and processing crops that do not take long time.

Alternative types of plants that pass in stage two are then categorized into groups of complex agroforestry and simple agroforestry cropping patterns. 73% of farmers chose complex agroforestry cropping patterns with coffee, candlenut, avocado, stink bean, dog fruit, durian, and nutmeg; while 27% of farmers chose a simple agroforestry cropping pattern with a combination of coffee, stink bean, dog fruit, and candlenut. Farmers who decide complex agroforestry cropping patterns have a more significant role inminimizing the effects of global warming. This is supported by the results of research conducted by [9],which states that the value of carbon stored in complex agroforestry planting patterns is greater than that of simple agroforestry, with carbon stock numbers of 765.61 tons/ha and 356.21 tons/ha. The higher thecarbon stock stored in an area, the more it will play a role in climate change mitigation efforts [47]. Therefore, farmers' preferences in choosing the types of plants to be managed to form cropping patterns are very important and affect the value of carbon stored by plants.

4. Conclusion

Sinar Harapan Gapoktan farmers in the Batutegi Forest Management Unit choose plant types with the aspects considered in the form of production orientation, time and labor, biophysical conditions, knowledge, and plant investment capabilities. The reasons behind farmers choosing types of crops are income, productivity, speed of production, ease of harvesting, availability of labor, and the plant resistance level when planted together with other types of crops. Farmers who choose complex agroforestry cropping patterns have a more significant role in minimizing the effects of global warming. Therefore, farmers' preferencesin determining the planting to be managed are important and affect the value of the stored carbonof plants.

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