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Land Fragmentation of Privately Owned Forest: Impacts and Farmers' Adaptation Strategies in West Java, Indonesia

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ABSTRACT

Population growth requires the use of more land, which increases land fragmentation. This study aims to understand the impacts and adaptation strategies of farmers facing privately owned forest land fragmentation (POF-LF). The research was conducted in Ciamis Regency, West Java, Indonesia. Data were collected through structured questionnaires for a simple random sample of 170 respondents, as well as in-depth interviews. The data obtained were processed by calculating the fragmentation index and descriptive statistical analysis. The results show that POF-LF is present in all the research sites. High levels of fragmentation were found in areas with large landholdings, while areas with small average landholdings had low levels of land fragmentation. POF-LF is dominated by the inheritance process to meet the needs of children or due to children marrying. The most significant impact is the small size of landholdings, which can lead to uneconomical and inefficient management, thereby reducing productivity and income. The most common adaptation strategy of farmers to the decline in land ownership is to change the structure of household income and to change the type and pattern of crops on their land. All information from this study can be used by relevant stakeholders, especially policy makers, to promote the development of POF through policy interventions.

1. INTRODUCTION

The global population has rapidly increased over the last century and will continue to expand in the years to come, although at a lower rate [1]. The population of Indonesia had increased by 1.13% to 275.77 million by the middle of 2022, with a population density of 143.86 people per km^2 [2]. The increase in population has led to an increasing need for natural resources, including land [3]. When population growth is not in direct proportion to the size of the land, land use change and land fragmentation cannot be avoided [3, 4]. The term 'ownership fragmentation' refers to a situation in which agricultural land is divided between several small parcel owners, with the land used as a whole or separately [5].

The phenomenon of agricultural land fragmentation accompanied by land use to meet the need for land in non-agricultural fields has led to the narrowing of farmers' land ownership. Numerous socioeconomic, political, ecological and environmental factors, including population growth, the inheritance system, rising land prices, urbanisation and the development of the transportation system, natural calamities, climatic changes, family size and income, etc., contribute to agricultural land fragmentation [6].

Narrow land ownership is one of the problems faced in land management, and includes land containing privately owned forest (POF). POF development in Indonesia was initially used to rehabilitate degraded land, but now contributes significantly to meeting the daily needs of communities and wood-based enterprises [7]. Ciamis Regency has a fairly large proportion of POF in the West Java region of Indonesia. The area of POF in Ciamis Regency has also increased, whilst farmers' income from POF has not. POF farmers are generally groups of people living in the countryside whose livelihoods depend on the natural resources around them. They are therefore directly affected by land-use changes and land fragmentation. Small and fragmented land parcels make POF management uneconomical and inefficient [8].

Many studies have been conducted on land fragmentation, including the relationship between land fragmentation, land productivity and efficiency at the farm level [9-13], land fragmentation and its influencing factor [4, 14], land fragmentation and welfare [15] and cause and impact of land fragmentation [16-19]. Most of these studies have been conducted in paddy fields or wetlands, while research in POFs

is still limited. Research conducted in POFs includes the efficiency of POF on fragmented land [20] and the relationship between changes in the socio-economic characteristics of POF and forest fragmentation [21].

This study aims to reveal the impact on POF farmers of POF land fragmentation (POF-LF), as well as farmers' adaptation strategies towards these impacts. Through questionnaires and in-depth interviews as well as the calculation of the fragmentation index, the level of POF-LF, the causes, impacts and strategies adopted by POF farmers to deal with the impacts of POF-LF will be known. The study can be used as information and input for relevant stakeholders in POF development and sustainability.

2. METHODS

2.1 Location

This study was conducted in Ciamis Regency, West Java, Indonesia, located between 108°19'-108°43' East longitude and 7°40'30"-7°41'30" South latitude. The established boundaries of the regency are as follows: North: Majalengka and Kuningan; West: Tasikmalaya/Tasikmalaya Municipality; South: Pangandaran; and East: Banjar Municipality and Cilacap. Covering a total area of 1,597.67 km^2, the regency is located 124 km away from the capital of West Java Province, Bandung Municipality. The administrative region is divided into 27 subdistricts and 258 villages [22].

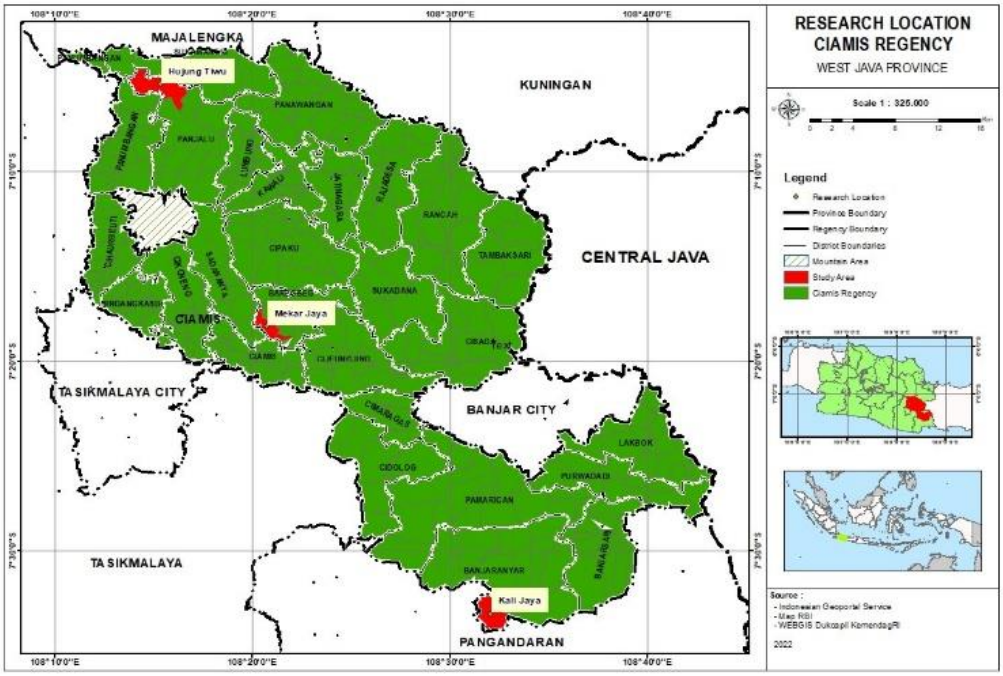

Figure 1. Map of study location

Three villages were used as the sample locations: Kalijaya village, Banjaranyar Subdistrict, in the south; Mekarjaya village, Baregbeg Subdistrict, in the central area; and Hujungtiwu village, Panjalu Subdistrict, in the north. A map of the study locations is presented in Figure 1.

2.2 Data collection

Data were collected using structured interviews and in-depth interviews. Structured interviews were conducted with 170 respondents (55 in Hujungtiwu village, 55 in Mekarjaya village and 60 in Kalijaya village). Respondents were identified based on preliminary information from secondary data, village officials, extension workers and POF farmer group leaders, and then selected using simple random sampling. This number is considered to be sufficiently saturated [23-25]. In-depth interviews were conducted with respondents who were able to answer the questions, as their ability to do so was fundamental to the study [26], as well as key informants such as extension workers (3), village officials (3) and farmer group leaders (3). The primary data collected were data on land fragmentation, area of POF ownership, number of POF plots and area of each plot, impacts of land fragmentation and farmers' adaptation strategies in dealing with the impacts of land fragmentation.

In addition to the primary data, secondary data such as general conditions of POF and socio-demographic conditions of the population were collected to supplement information from Central Bureau of Statistics, Forestry Service Branch VII West Java and village governments.

2.3 Data processing and analysis

The survey data obtained were coded, tabulated and graphed using Microsoft Excel. The level of POF-LF was calculated using the fragmentation index formula [27, 28], as follows:

$$FI = \frac{\sum_{i=1}^{n} a_i^2}{A^2} \quad (1)$$

where, *FI*: fragmentation index
n: number of plots in the garden
a: land/parcel area
A: total area of respondents.

The value of the fragmentation index is between 0 and 1. A

value of 1 indicates that there is no land fragmentation (land consolidation), whereas a fragmentation index value closer to 0 indicates that the land is highly fragmented. The land fragmentation is divided into three categories: 0-0.49 (high), 0.5-0.99 (low) and 1 (no fragmentation). This formula is used because it is simple enough to take into account the number of fragments, the area of land compared to the whole, but it is enough to explain whether there is fragmentation of land or not. Spearman correlation analysis was used to find the determinants of POF-LF using IBM SPPS Statistics 27 software. All processed data were interpreted and analysed descriptively.

3. RESULTS AND DISCUSSION

3.1 Socio-demographic conditions of farmers

In all three locations, the farmers were mostly male. Their average level of education was primary school completion. Farming was the preferred occupation for those with a low level of education in the area. Most of the respondents were married and had about two dependent families. Family size can increase expenses [29] and motivate farmers to increase their income. As the farmers had been living in the villages for a long time, with an average age of more than 50 years, the average farming experience was also long. Only the farmers in Hujungtiwu had less experience, as many of them had worked in other sectors outside the village when they were young.

Table 1. Socio-demographic data of respondents

Description	Villages		
	Kalijaya	Mekarjaya	Hujungtiwu
	Gender (%)		
Male	81.67	80	89.1
Female	18.33	20	10.9
Average age (years)	53.8	62.6	55
Average education (years)	7.2	8.0	7.3
Average number of dependent family members (person)	2.0	1.5	2.1
Average length of stay (years)	50.2	58.8	50.4
Average farming experience (years)	31.7	34.5	21.1
Average size of POF (ha)	1.81	0.39	0.58

Table 1 shows the socio-demographic information for the farmers at the three research sites.

The most common land use type at the third research site was dryland or POF, with the dominant pattern of POF being mixed or agroforestry between woody plants, multipurpose tree species (MPTs), understorey and annual plants. The type and pattern of management depended on the owners' preferences. The average area of POF was 1.81 ha in Kalijaya, 0.39 ha in Mekarjaya and 0.58 ha in Hujungtiwu. These average areas were larger than the average area of POF in Java, which is only 0.25 ha [30]. However, from the perspective of individual farmers, there were many farmers with less than 0.25 ha of land. Some POF land was controlled by 'several co-owners' [31].

3.2 Land fragmentation and its causes

Indications of land fragmentation can be seen from the number of parcels of narrow size and spread. According to the study [32], land fragmentation is measured by an average area per landowner. It can also take into account the number and size of the fields, as well as the distance from the farmer's home [33]. The number of POF parcels at the three study locations predominantly ranged between one and four parcels, as shown in Figure 2. The level of land fragmentation is shown in Table 2.

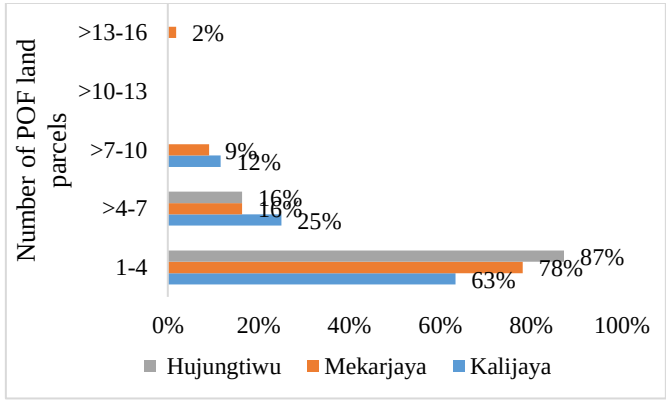

Figure 2. Number of POF land parcels

Table 2. Land fragmentation level

Land Fragmentation Level / Index Score	Percentage of POF Farmers (%)		
	Kalijaya	Mekarjaya	Hujungtiwu
High (0-0.49)	70	41.82	21.82
Low (0.5-0.99)	21.67	14.55	47.27
No land fragmentation (1)	8.33	43.64	30.91

Table 2 shows that as many as 70% of farmers in Kalijaya village had POF with a high degree of fragmentation, while Mekarjaya and Hujungtiwu villages had fewer such farmers. Compact POFs with sufficient area are usually found among farmers who own land of above-average area on marginal land as well as on slopes [34]. But in Java today, farmers with vast lands are largely scattered. POF-LF was quite common in Kalijaya village, because the average land ownership there was larger than in the other two villages, making it possible to fragment the land. The level of fragmentation in Mekarjaya and Hujungtiwu villages was low because the average POF area was only 0.39 ha in Mekarjaya and 0.58 ha in Hujungtiwu. About 43.64% of farmers in Mekarjaya and 30.91% of farmers in Hujungtiwu had one parcel of POF land (unfragmented).

A low level of POF-LF does not imply ownership of large areas of land; rather, it indicates that land ownership already occurs on very small parcels of land, making it impossible for farmers to physically (spatially) fragment the land or its usage. Based on the results of the statistical analysis (Table 3), it was found that the size of POF land had a strong positive correlation with the level of land fragmentation, while other respondent characteristics did not show a strong correlation. With a correlation coefficient of 0.595**, it showed that the larger the area of POF land, the higher the level of POF-LF. This is in line with Susanti et al. [35], who mentioned that land fragmentation is prevalent among farmers with large land sizes.

Table 3. The determinants of POF-LF

Spearman's Rho Correlations		POF-LF
Gender	Correlation Coefficient	0.143
	Sig. (2-tailed)	0.062
	N	170
Age	Correlation Coefficient	-0.053
	Sig. (2-tailed)	0.491
	N	170
Education	Correlation Coefficient	-0.121
	Sig. (2-tailed)	0.118
	N	170
Number of dependent family members	Correlation Coefficient	-0.038
	Sig. (2-tailed)	0.622
	N	170
Length of stay	Correlation Coefficient	-0.067
	Sig. (2-tailed)	0.388
	N	170
Farming experience	Correlation Coefficient	0.062
	Sig. (2-tailed)	0.426
	N	169
POF land area	Correlation Coefficient	0.595**
	Sig. (2-tailed)	0.000
	N	170

Notes: 1. *. Correlation is significant at the 0.05 level (2-tailed);
2. **. Correlation is significant at the 0.01 level (2-tailed).

The links between holding size and forest owner traits have substantial consequences for many of forestry's most pressing issues. These difficulties are fluid, as is family forest ownership. As owners' demands and views evolve and as forests are purchased and sold, opportunities will exist for holdings to be subdivided and consolidated, and for related qualities to alter [36].

POF-LF can be caused by temporary or permanent fragmentation [15]. Permanent fragmentation generally occurs due to the institution of inheritance and the buying and selling of agricultural land in the community, while temporary fragmentation generally occurs due to land leasing activities, pawn systems and profit-sharing systems carried out by landowning farmers and cultivator maps. In the study area, POF-LF was mostly permanent, while temporary POF-LF was rarely carried out by farmers.

In addition to land inheritance and land sales, there are also practices of partial or complete land use change that cause land fragmentation. The inheritance process was the most dominant cause of POF-LF in all study sites except Hujungtiwu village, which was dominated by the land sale process, as shown in Figure 3.

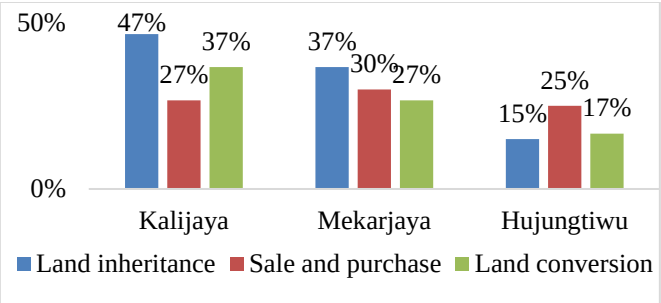

Figure 3. Distribution of respondents based on land fragmentation process

3.2.1 Land inheritance

Land inheritance or land grants were common in Kalijaya village, where many parents who were still alive gave land or land cultivation rights to their married children. The aim of such land inheritance is to build a house or give land in the form of POF as capital for their children. In the other two villages, Hujungtiwu and Mekarjaya, land inheritance or granting was less common because the average amount of land ownership was small.

Land inheritance is one of the causes of POF-LF. Narrow POFs are the result of land fragmentation customs that have long been practised. However, it is not always possible to obtain information on the granting/inheritance process or even the sale and purchase of land from the certificate, as the new owners do not always separate the Land and Building Tax certificates.

The inheritance system in a community is related to the kinship system adopted by the community. In Java, three types of kinship patterns are known in customary law, namely patrilineal (paternal), matrilineal (maternal) and parental/bilateral (both/father-mother) [37]. In addition, other variations are a combination of the three systems, namely aged patrilineal and double unilateral. Communities in Java, including West Java, are more likely to use the parental/bilateral pattern or Islamic inheritance law if they are Muslim. In Islamic inheritance law, the division of inheritance has its own rules wherein women and men have different rights in the inheritance system [37].

Population growth is the primary driver of land fragmentation because it is linked to all other causes, such as growing nuclear family size and agricultural output or food security [16]. The causes of land fragmentation can be divided into the following four categories: socio-cultural (e.g. farmers' technical decisions), economic (e.g., rational agricultural reasons, urbanisation, land use change), physical (e.g. natural conditions) and irrational agricultural reasons [19].

The respondents' reasons for inheriting or gifting land are shown in Figure 4. The dominant reason for inheritance in Kalijaya and Mekarjaya villages was to fulfil the needs of children, while in Hujungtiwu inheritance was mainly given to married children.

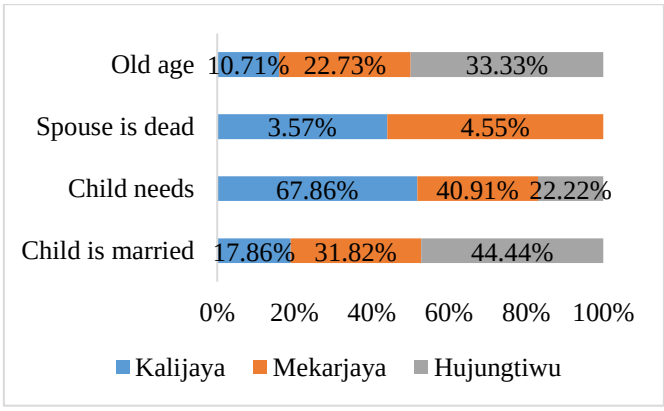

Figure 4. The respondents' reasons for inheriting

Some farmers with small plots of land did not give their land to their children outright, but instead farmed it together or handed over the management to their children and enjoyed the results together. Some farmers did not divide their land but bought land from their relatives (Sundanese: nyusukan). This occurred in scenarios where the land was so small that it was

impossible for farmers to subdivide it further, where one of the heirs could not manage POF land, or where the children did not plan to live in the village in future, or were more interested in other business types.

In practice, the division of land is carried out by parents during their lifetime, or described as grants, to avoid conflicts between heirs when the parents have died. The share of land received depends on the amount and size of land owned by the parents and is adjusted to the condition of the land they own. Many land grants are also made when the farmers' children marry. In such cases, the children have not actually inherited the land; instead, the parents have transferred its management to their children [38]. The division of inheritance has caused the ownership of land from one generation to the next to become narrower [39]. Up to a certain extent, small-scale farmers tend to sell their crops because the income earned from the land does not meet their household needs. Land transactions involving land addition and release are dominated by small-scale land parcels, both in villages such as Java and beyond Java, where land transactions on a land scale of <0.50 ha are more dominant [40].

3.2.2 Selling land

Selling POF land also causes land fragmentation, and does so permanently. In our study, farmers gave several reasons for selling POF. The dominant reason that drove farmers to sell land was to meet the daily needs of their families, reaching 56% of respondents, as shown in Figure 5. In addition, some farmers believed that the sale of POF would not have a major impact on the structure of their household income because POF made a low contribution to household income.

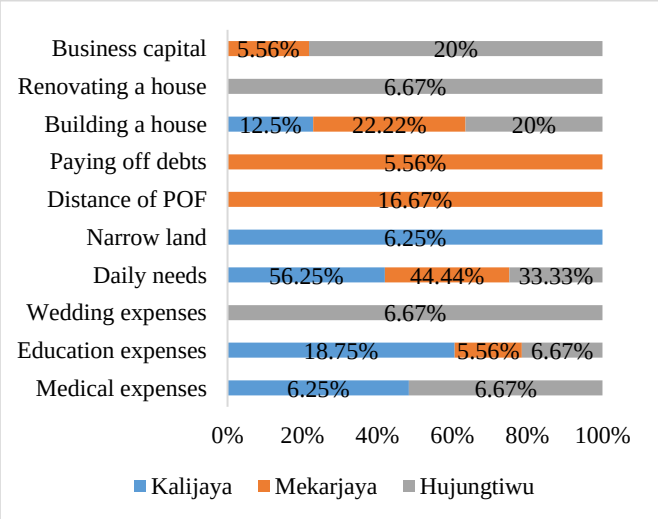

Figure 5. The respondents' reasons for land sales

It is not uncommon for land to be sold to relatives or neighbours, but the farmers are still given the opportunity to manage it. A lot of land sale transactions are common in Java. The high number of land sale transactions on a small scale is due to the inefficiency of agricultural activities, the ease of conducting land sale transactions and the high sale price of lands [40]. However, land sale transactions on a large scale are rare because only a few households in rural areas own land on a large scale, the selling value of land makes it more profitable to sell on a small scale and the purchase of large land parcels requires large capital from buyers [40]. Empirically, these conditions have led to the accumulation of land tenure, indicating that farmers are forced to give up land due to land division through inheritance patterns and unavoidable urgent needs.

3.2.3 Land conversion

Land conversion is defined as the process of changing from one land use to another either permanently or temporarily [41]. The reduction or increase in agricultural land, including POF, is due to land conversion carried out by the owner. POF land conversion to other land uses was not widely undertaken by farmers. In addition to limited land, POF has unique biophysical characteristics, so not all POF land can be converted to other uses. The dominant land conversion was from paddy fields to POF or vice versa in Kalijaya, from POF to house in Mekarjaya, and from POF to fishponds in Hujungtiwu.

The reduction of POF area in Mekarjaya village was also due to the land conversion from POF to settlements, either for private houses, building complexes or boarding houses. The location of the village, which is quite close to the regency town and the local university campus, attracts entrepreneurs from outside the village to build housing complexes or student dormitories. On the other hand, POF owners were interested in selling their land to outsiders because of the high purchase price of land, and because they benefitted from other business types more than by cultivating the limited land.

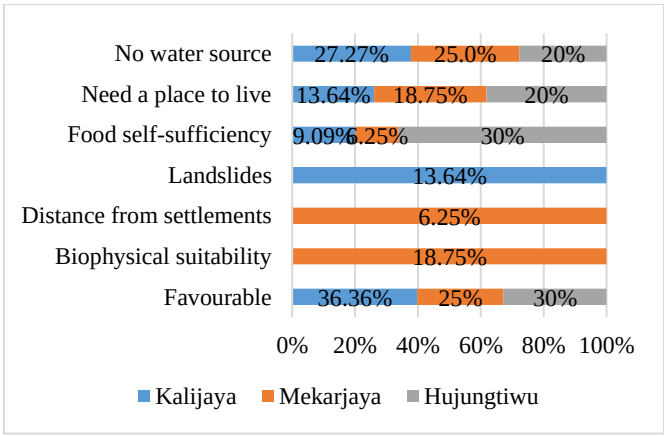

Figure 6. The respondents' reasons for land conversion

The decrease or increase of POF land was caused by many factors. Some of the factors driving of land conersion are political, economic, demographic and cultural [42]. The factors causing land conversion in the study area are shown in Figure 6. The dominant reason for land conversion from POF to other land use or vice versa was that it was favourable. For example, when paddy fields are unproductive for biophysical reasons, namely frequent disasters that bury or overshade paddy fields, or limit their water sources, the farmer will change to POF. On the other hand, farmers convert POF to paddy fields or fishponds when POF are unproductive, water sources are available and farmers want to meet their own food needs (rice).

3.3 Impact of POF land fragmentation

POF-LF is an unavoidable reality and has both negative and positive impacts. Land fragmentation has a negative impact on the reduction of POF land and its constriction. This situation leads to reduced employment opportunities and increased

unemployment in the villages. Land fragmentation increases the supply of non-agricultural labour while reducing the marginal productivity of agricultural labour [43]. These conditions ultimately drive changes in the social structure of farming communities and increase migration. Faced with more remunerative non-agricultural work opportunities, it is expected that many farmers will decide to leave fragmented 'high cost, low income' farmland [17].

When land is fragmented and small, yields and incomes are also lower. POF is often considered ineffective and inefficient because of the small land areas involved [8]. Even when capital and labour inputs are added, the results do not increase and in fact have a negative impact on POF productivity and income. POF-LF, mainly through land conversion, causes ecological changes. Fragmentation of landscapes has several and opposite direct effects on biodiversity [44, 45], decreasing the diversity of plant species and their structure [46]. It has the potential to lead to the overuse of agrochemicals, which is detrimental to the conservation and maintenance of agricultural ecosystems [47]. Ecosystem changes can occur because as land is fragmented, farmers make adjustments to their management of it, particularly in the type and pattern of crops. This can lead to changes in wildlife habitat.

Although it has more negative impacts, land fragmentation also has positive impacts, especially as most fragmentation activities undertaken by farmers are self-directed. Land fragmentation in rural areas is quite common and has both direct and indirect negative and positive impacts, depending on a combination of locally specific external circumstances ranging from biophysical, social, economic, political and technical to agro-ecological in nature [48-51].

Tenure distribution, rural development, vulnerable populations and collective action are social issues associated with land fragmentation [52]. However, POF-LF has a positive impact on meeting individual land needs, especially for housing, and reducing social conflict. Inheritance or gifting of land to children helps to meet the basic needs of children who are already married, thereby reducing the problem of landlessness. In some cases, land fragmentation through the conversion of land to more appropriate uses also reduces social conflict with neighbours who own adjacent land, especially in community forests with woody plants whose shade inhibits plant growth on neighbouring land.

Economically, changing the use of POF land to other functions can increase income from other sources. Meanwhile, land fragmentation has encouraged farmers to focus more on more highly productive species, cropping patterns and management systems when the land is close to their homes and has good fertility. For example, narrow-land farmers can focus more on managing the land by planting seasonal or understorey crops to produce quick yields [53].

3.4 Farmers' adaptation strategies in response to the impacts of POF-LF

Depending on the level of fragmentation and certain natural and social variables, land fragmentation can have either good or harmful impacts [49, 54]. Farmers' practice of land fragmentation occurs naturally as a consequence of population pressure on land [3, 55]. Simple measurements cannot be used to alleviate the landscape fragmentation problem; instead, strong economic policies and modifications to social mechanisms are necessary to address the issue at its core [56]. The impact of these activities encourages farmers to adopt strategies or adaptations in various aspects, as shown in Figure 7.

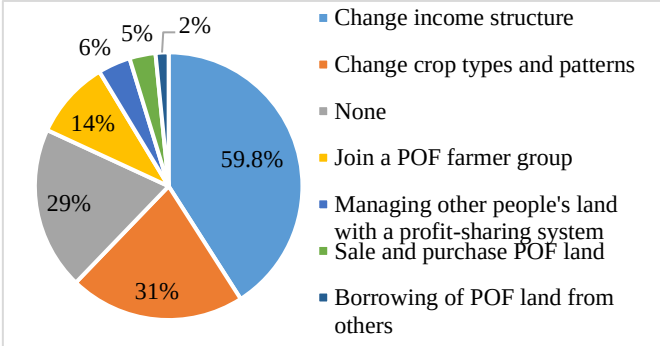

Figure 7. The farmers' adaptation strategies in response to the impacts of POF-LF

Pro-poor growth must go beyond agriculture, incorporating both rural and urban areas, and must promote both the creation of jobs and the diversification of sources of income [57]. The most common adaptive strategy of farmers when POF land becomes scarce was for most to change their income structure by looking for work or new sources of income, or to focus on other work they had been doing both within and outside the village. In Hujungtiwu, many farming family members chose to work or do business outside the village by migrating either permanently or temporarily. The people of Hujungtiwu had long been used to migrating. A large number of people in Mekarjaya also work in the non-agricultural sector, outside the village but still within the district. When farmers relied on non-agricultural income, their POF was usually planted with makeshift timber without maintenance, or the small land was farmed by other family members living in the village.

Unlike the other two villages, most farmers in Kalijaya village continued to farm their land, but were changing the type and planting pattern of POF with agroforestry patterns. Through mechanisms of plant diversification, fragmentation can be addressed [58]. The agroforestry pattern developed involves reducing the number of timber plants and replacing them with understorey plants, MPTs, or annual plants that can be consumed and have high economic value. This pattern was considered by farmers to be able to meet their subsistence needs, and the farmed food could also be sold.

However, 28.74% of farmers did not do anything with their land and did not conduct other activities that could replace the income from the land. They only adjusted the fulfilment of household needs with the income earned. Another adaptation strategy, adopted by about 14% of the farmers, was membership of Unit Manajemen Hutan Rakyat (UMHR) or Private Forest Management Unit (FMU), which makes POF management cost-effective despite the limited land area. The existence of FMU in the forest is necessary to help the community cope with the effects of the economic crisis [59]. All levels of government should think about implementing various policies to better resolve land fragmentation, encourage rural development and support plans for rural rehabilitation [60].

4. CONCLUSIONS

This study shows that land fragmentation also occurs in POF. High levels of POF-LF were found in areas with large

landholdings, while areas with small average landholdings had low levels of land fragmentation. This was because land ownership was already too small, and the number of parcels was so small that it was not possible to fragment the land further. The main cause of POF-LF was the practice of inheriting land to meet the needs of children or due to children marrying. POF-LF results in a smaller land area, and small and scattered land has negative impacts such as uneconomical and inefficient management, resulting in lower productivity and income, reduced employment opportunities and changes in social structure, as well as changes in animal habitat. However, POF-LF land also has positive impacts, such as meeting the need for land for other uses and allowing farmers to manage POF land in a more focused way, land use that is better suited to biophysical conditions, reduced disaster risk, crop diversity and increased land cover. Faced with these impacts, farmers' most common adaptation strategies were to change the structure of their household income and to change the type and pattern of crops on their land. Land fragmentation is inevitable in POFs. It's therefore necessary to find ways to keep farmers managing POFs on their limited land, or to find alternative ways of employing people so that POFs can be maintained.

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