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RESEARCH ARTICLE

Socio-Cultural Factors in Mamar Management Impacting Ecosystem Services

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Abstract. Changes in the earth's landscape is causing significant transformations impacting ecosystem services globally. One notable consequences of these changes is trade-off in ecosystem services, which is caused by human land use activities due to social and cultural perspectives of society. Therefore, this research aimed to understand the influence of socio-cultural factors that impact ecosystem services in *Mamar* management. The experiment was conducted using as qualitative and quantitative survey to identify changes in *Mamar* management through participatory research and land use analysis on Landsat 2013 and 2023. Socio-cultural factors were also identified through an ethnographic method using Smart PLS 3.2.7. The results showed that there was a change in the priority of ecosystem services, as supported by changes in land use and the importance index of *Piper aduncum* L. and *Areca catechu*. Several factors showing significant influence were Socio-Demographic-Economic Conditions (SDE4, SDE5, SDE6), Socio-Economic Vulnerabilities (KR6, KR7, KR8, KR9), and Cultural Resilience (RSB1, RSB2, RSB3) in *Mamar* management (SP1, SP2), which affected the production of ecosystem services. Based on the results, understanding patterns of social influence enabled appropriate mitigation strategies for imbalances in ecosystem services.

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1. Introduction

Mamar is a traditional agroforestry typical of West Timor (Natonis, 2008). Apart from its ecological function as agroforestry, *Mamar* has a social function (Viswanath & Lubina, 2018) and is very closely related to the culture of West Timor people (Manafe, 1990; Openg, 2013). However, agroforestry experienced changes in use as shown by Ngaji et al. (AUK Ngaji et al., 2021, 2023). These changes were caused by humans due to population growth and activities (Hidayah & Suharyo, 2018), which had a significant impact on ecosystem services.

Socio-ecological trade-off is one of the phenomena that occurs in *Mamar* management (AUK Ngaji et al., 2023). Ngaji et al. stated that economic reasons were one of the driving factors that accelerated the changes. In addition, global influences affect the order of social life (Suneki, 2012), contributing to changes in people's behavior and impacting the use of *Mamar*. An overlooked transformation in the culture of West Timorese society is the impact of current economic demands and developments (AUK Ngaji et al., 2022).

One entry point in *Mamar* management is through understanding ecosystem services (Boesing et al., 2020; Locatelli et al., 2014). Generally, changes in ecosystem services are a phenomenon in nature that cannot be avoided over time. This is increased by continuous exploitation (Peng et al., 2023) to promote an increase in one ecosystem service, but leads to a decrease in the capacity of others causing trade-off (Feng et al., 2017). Among several influencing factors, social culture is one of the main domains that affects ecosystem services (Scholte et al., 2015). Human activities in a social and cultural context influence the availability of ecosystem services through management (Febriarta et al., 2020). There are complex interactions in nature between various ecosystem services (Başkent, 2021; Costanza et al., 2014). These changes include exchange between services (Acharya et al., 2019; Feng et al., 2017; Liang et al., 2021) and synergy, namely variation in the same direction (Haase et al., 2012).

Changes in land use types frequently occur due to anthropogenic causes (Cornelio, 2021) which have an impact on the production of ecosystem services including climate change (Rovkin et al., 2013). Fulfilling economic needs is another important factor (Febriarta et al., 2020; Sumadyanti & Zuharnen, 2016). The existence of political policies in the framework of ecological politics or for social development affects the structure and function of ecosystem, which eliminates the balance between services (Müller & Burkhard, 2012; Crossman et al., 2012; Leh et al., 2013; Müller & Burkhard, 2012). Therefore, the strong influence of human becomes the basis for assessing attitudes and perceptions regarding ecosystem services in cultural landscapes (Oteros-Rozas et al., 2018). Similar patterns of transformation and socio-ecological interaction are happening to *Mamar*.

Apart from the push for exchange of ecosystem services in *Mamar*, there is actually still a pull factor in the opposite direction, namely understanding the values and norms existing in society, particularly in relatively old society (> 50 years) (AUK Ngaji et al., 2024). This sense of ownership and perception of *Mamar* as a heritage that require protection have

played a significant role in inhibiting radical changes, thereby showing the need for sustainability (Puspita Sari et al., 2016). Consequently, understanding the strength and driving factors is essential to obtain patterns of influence and a description of socio-economic and ecological conditions that trigger trade-off in the use of *Mamar* in Kupang Regency. In this way, efforts can be made to prevent *Mamar* degradation and maintain the balance of ecosystem services produced through determining appropriate *Mamar* management policies. Therefore, this research aimed to understand and estimate the existing socio-ecological structural trade-off model in West Timor. The data obtained are useful for determining sustainable and balanced *Mamar* management policies.

2. Methods

This research was conducted from June to October 2023 in Silu Village, Fatuleu District and Buraen Village, South Amarasi District, Kupang Regency, as shown in Figure 1.

The materials and tools used in this research were: a) social characteristics questionnaire consisting of vulnerability, socio demography economy, cultural resilience and *Mamar* management strategy for 60 respondents from 2 villages (the indicators shown in Table 1.), b) interview guide for 10 people from each village, c) participatory ecosystem services questionnaire, and d) Focus Group Discussion with 5 people from each village (consisting of 1 traditional figure and 4 people who own land in *Mamar*). Other tools included e). 2013 and 2023 Landsat images, f) camera, g) haga meter, h) measuring tape, and i) GPS.

This research used a survey method with a qualitative and quantitative approach. The data collected were on two main focuses, the first, was identifying changes in *Mamar* consisting of (a) participatory assessment of ecosystem services with the assumption that the community, including traditional leaders, were the parties who directly experienced changes, (b) identification of changes in land use. The second focus was to identify social factors that influenced *Mamar* management strategies.

Participatory assessment of ecosystem services

Participatory assessment of ecosystem services is one way of indirect assessment by including community participation (Vihervaara et al., 2017). In this research, participatory ecosystem services measurements were carried out at two different times (2013 dan 2023) including community members around *Mamar* and traditional leaders, comprising 6 and 5 people in Silu and Buraen, respectively. The classification of ecosystem services used refers to Millennium Ecosystem Assessment, namely provision, regulation, culture, support (La Notte et al., 2017; Millenium Ecosystem Assessment, 2005; Muta'ali, 2019). This is with the consideration that people around *Mamar* directly feels the changes, particularly regarding ecosystem services. Data collection was carried out by consensus using focus group discussion (FGD) method. The results data were analyzed using Analytical Hierarchy Process (AHP) to determine priority rankings (R. W. Saaty, 2016; T. L. Saaty, 2002).

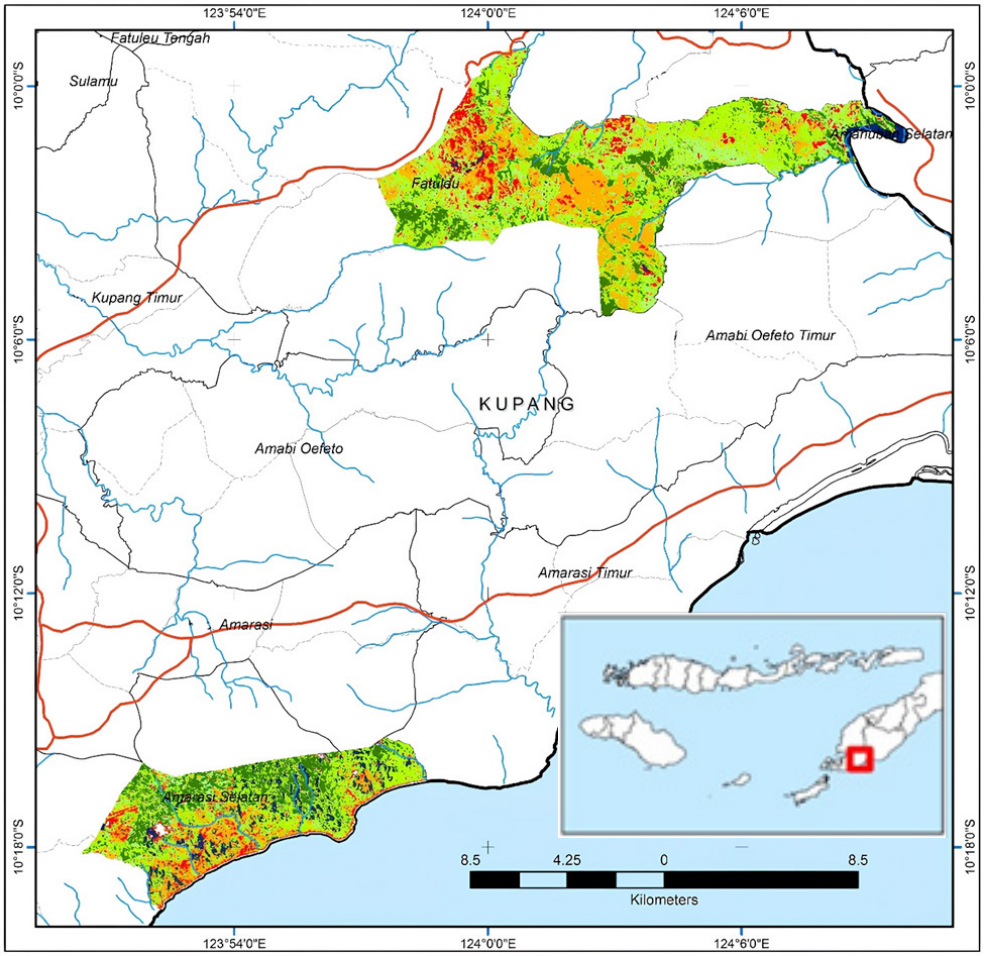

Figure 1. Map of Buraen and Silu as research area

Table 1. Variable and indicator in research

Variable	Notation	Indocator
Vulnerability (KR)	KR1	ownership of residence
	KR2	residential ownership status
	KR3	physical condition of the house
	KR4	consumption expenditure
	KR5	non-consumption expenditure
	KR6	land ownership within the Mamar
	KR7	mamar land ownership status
	KR8	area of agricultural land ownership
	KR9	The results of food crop production in the Mamar area from 5 years ago
	KR10	Production of betel and areca nut plants compared to 5 years ago
Socio Demography Economy (SDE)	SDE1	Head family age
	SDE2	age of spouse
	SDE3	head of family education
	SDE4	couple education
	SDE5	employment
	SDE6	total income
	SDE7	number of family dependents
cultural resilience (RSB)	RSB1	Spiritual and cultural resilience
	RSB2	Mamar for traditional rituals
	RSB3	Mamar is still relied upon for cultural keystone
Mamar Manag Strategy (SP)	SP1	Mamar needs to be maintained
	SP2	do not replace plants in the Mamar
	SP3	Want to change mamar completely

Changes in land use

Land use changes data obtained from the results of satellite image analysis is one way of direct measurement for the purposes of biophysical quantification of ecosystem services (Vihervaara et al., 2017). Interpretation was conducted using ArcGIS 10.8 with the supervised classification method compared to Google Earth imagery as a reference. Accuracy testing was performed with a ground check according to the coordinates obtained during interpretation and resulted in an accuracy of 90%. The area of each land use was measured during interpretation, which included forest, secondary forest, shrub, agricultural land, water body using tools in the ArcGIS program. The calculation results are shown in the form of a graph representing changes as indicated by the differences in the height of the bars on the graph. In this research, Landsat images from 2013 and 2023 were used as follows:

LC08_L1TP_111067_20130828_20200913_02_T1
LC08_L1TP_111067_20230824_20230826_02_T1

Land use comparisons are made by calculating the area of each existing land use, then showing it in graphical form.

Influencing social factors and patterns of influence on *Mamar* management

To determine the relationship between social conditions and biophysical data, an interpretive analysis was carried out. This was supported by Weber's opinion *in* Effendi (2004), where interpretive method was used to explain the causality of social actions regarding various events and their consequences. Furthermore, Effendi stated that there was a circumstantial method to interpretation, namely paying attention to forces that were not visible but had an influence on social behavior.

Analysis of social factors affecting *Mamar* management was conducted using Smart PLS 3.2.7. This analysis was conducted in stages, namely the measurement model evaluation followed by the structural model evaluation.

3. Result and Discussion

Land Use

Figures 2 and 3 show the land use in Buraen and Silu Villages, respectively. Based on the results in Figure 2, significant changes were observed as showing by an increase in forest land area. Apart from that, the area of secondary forest, shrub, and agricultural land decreased, while built-up land and water bodies increased in 2023.

The people admitted that the significant increase in forests was due to the impact of the tropical cyclone SEROJA, leaving a feeling of trauma, with the tendency to allow existing land become forest. On the other hand, the increase in built-up land area occurred due to conversion of secondary forest, shrub, and agricultural land. The rise in water bodies is driven by an increase in the amount of rain over the last 3 years.

In comparison, land use in Silu Village (Figure 3) showed a decrease in land area for forest, secondary forest, and shrub.

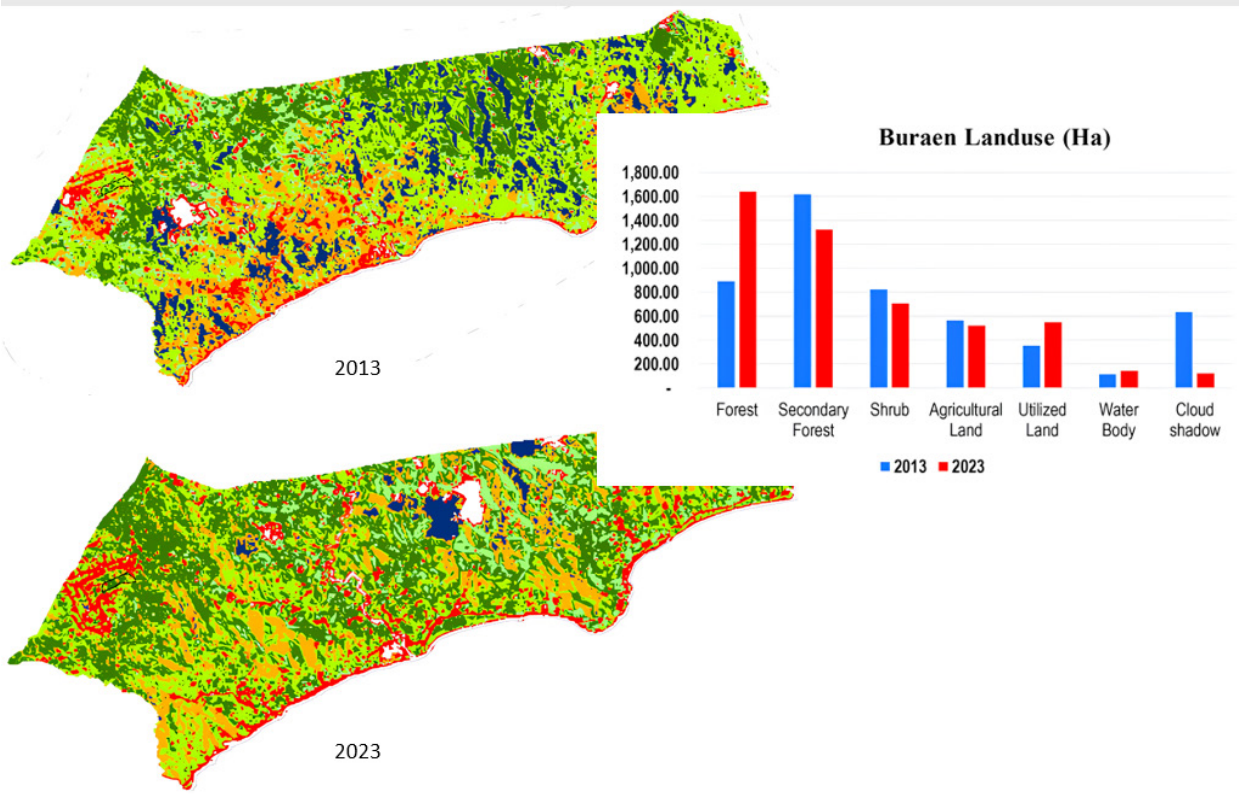

Figure 2. Map and graphic of land use changes in Buraen in 2013 and 2023

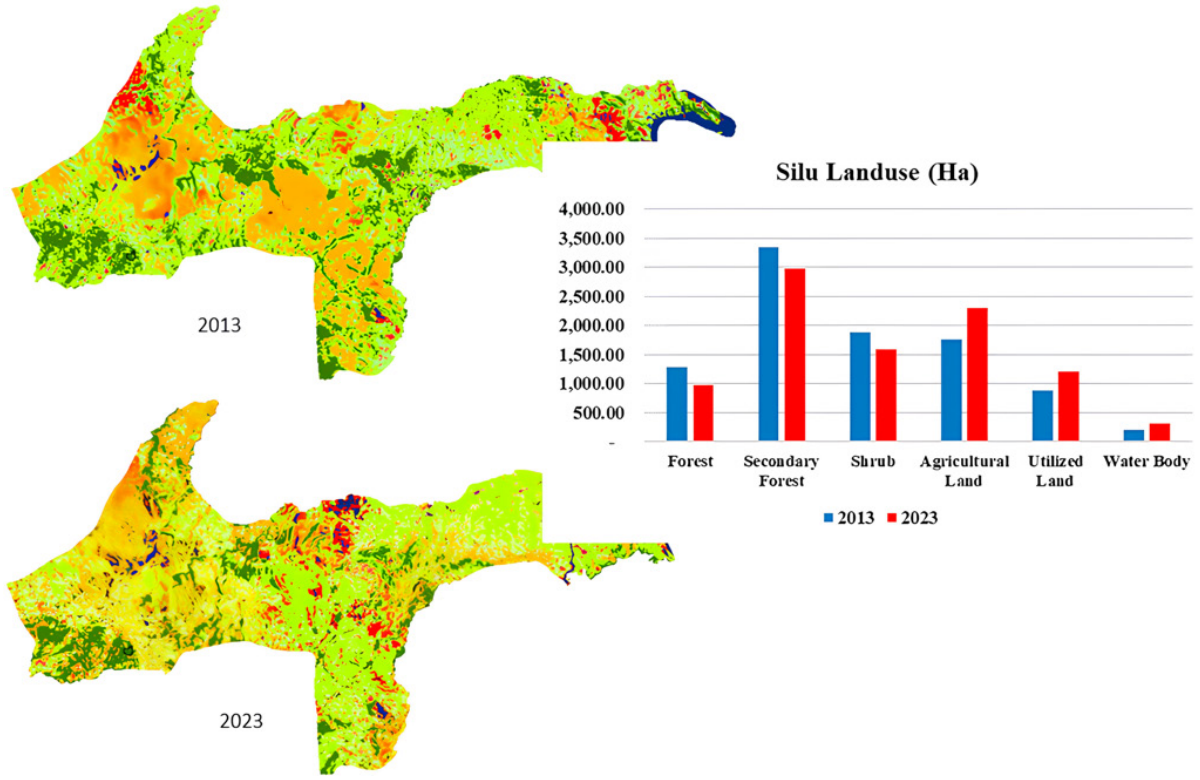

Figure 3. Map of land use changes in Silu in 2013 and 2023

Meanwhile, agricultural land, used land, and water bodies showed an increase in area in 2023 compared to 2013.

Changes of *Mamar* land use in Buraen and Silu are shown in Figures 4 and 5. In detail, the changes in land use are described through graphs.

The increase in forest area in Buraen correlates with changes at the sub-district scale, showing that the treatment of *Mamar* is not special. Furthermore, from the results of previous research, the general public's understanding of *Mamar* has experienced a shift. This is shown by the results of interviews using incidental sampling methods with the people, where 7 out of 8 respondents does not understand *Mamar*'s philosophy. In this context, majority considers *Mamar* a mixed garden with an irregular layout.

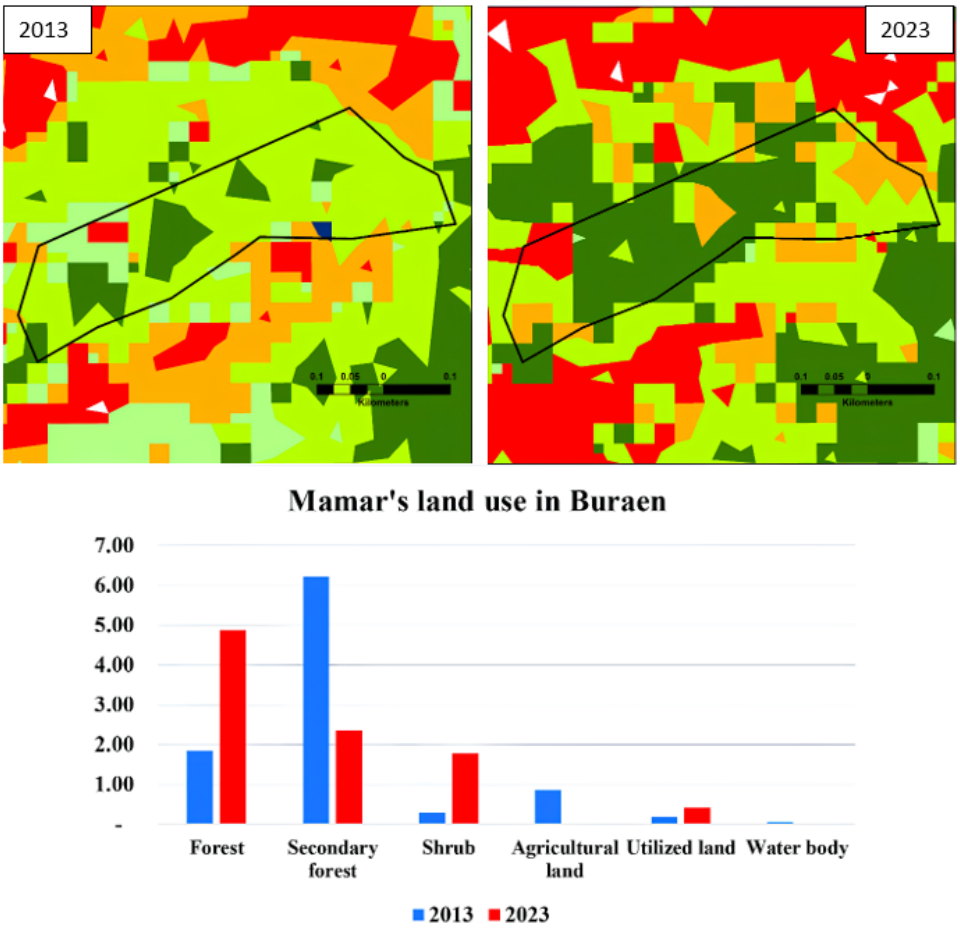

Figure 4. *Mamar*'s land use in Buraen

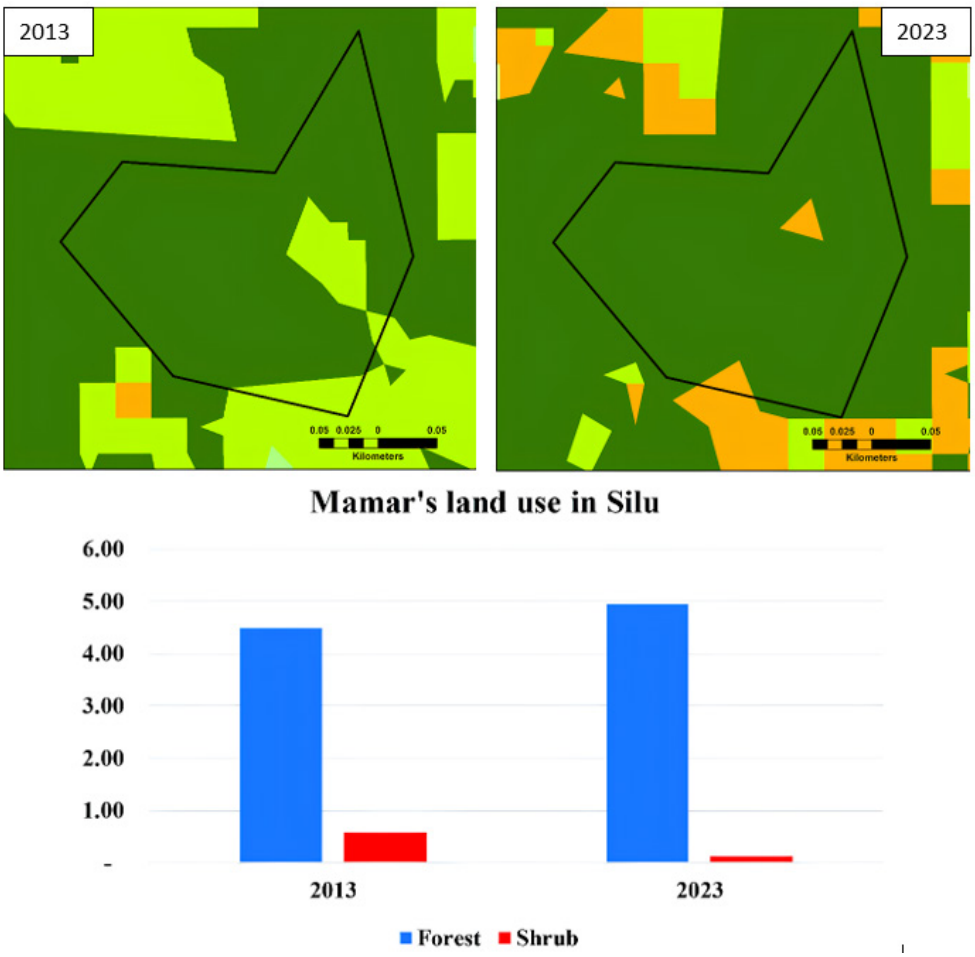

Figure 4. *Mamar*'s land use in Silu

The increase in forest area (dense vegetation) in both areas was caused by several factors. These included neglect for cultural reasons (as a heritage that should not be changed) and the hope that *Mamar* could be a balancing factor for the environment in order to reduce disasters due to storms. Additionally, in several places, there was visible planting of plants with high economic value.

Land use that changes initial conditions such as forest area due to conversion causes ecosystem services including food and clean water produced in the forest to be lost or reduced. Similarly, regulatory services will be reduced or even lost such as landslide protection services, air quality regulation. Additionally, cultural identity and social relations will not have the appropriate space. Despite the significant contribution to support services, biodiversity and habitat will be disrupted.

Ecosystem services resulting from participatory assessment

The results of weighting using AHP on data from consensus and traditional leaders comprising 5 people each in Buraen and in Silu are shown in Table 2. Ecosystem services grouping refers to Millennium Ecosystem Assessment (MEA) which is adjusted to the area conditions. The provisions of ecosystem services include the role of *Mamar* in providing food, clean water, fiber, fuel, genetic sources, and medicinal materials. Meanwhile, regulatory services include climate, water management, disaster protection, water and waste treatment, and air quality maintenance. Cultural services include Cultural identity and heritage values, Spiritual and religious, Science and education, social relations, supporting services include Soil formation and fertility, Nutrient cycles, Biodiversity, Habitat.

Table 2. Weighting results of ecosystem service production in the two observation areas in 2013 (Buraen 1 and Silu 1) and 2023 (Buraen 2 and Silu 2) using AHP

	Buraen 1	Rank	Buraen 2	Rank	Silu 1	Rank	Silu 2	Rank
Provision	0.230813644	3	0.2003003	3	0.307559069	2	0.280630631	2
Regulating	0.307559069	2	0.39984985	1	0.076745425	4	0.410960961	1
Culture	0.076745425	4	0.099774775	4	0.230813644	3	0.102552553	4
Supporting	0.384881862	1	0.300075075	2	0.384881862	1	0.205855856	3

Source: primary data processing

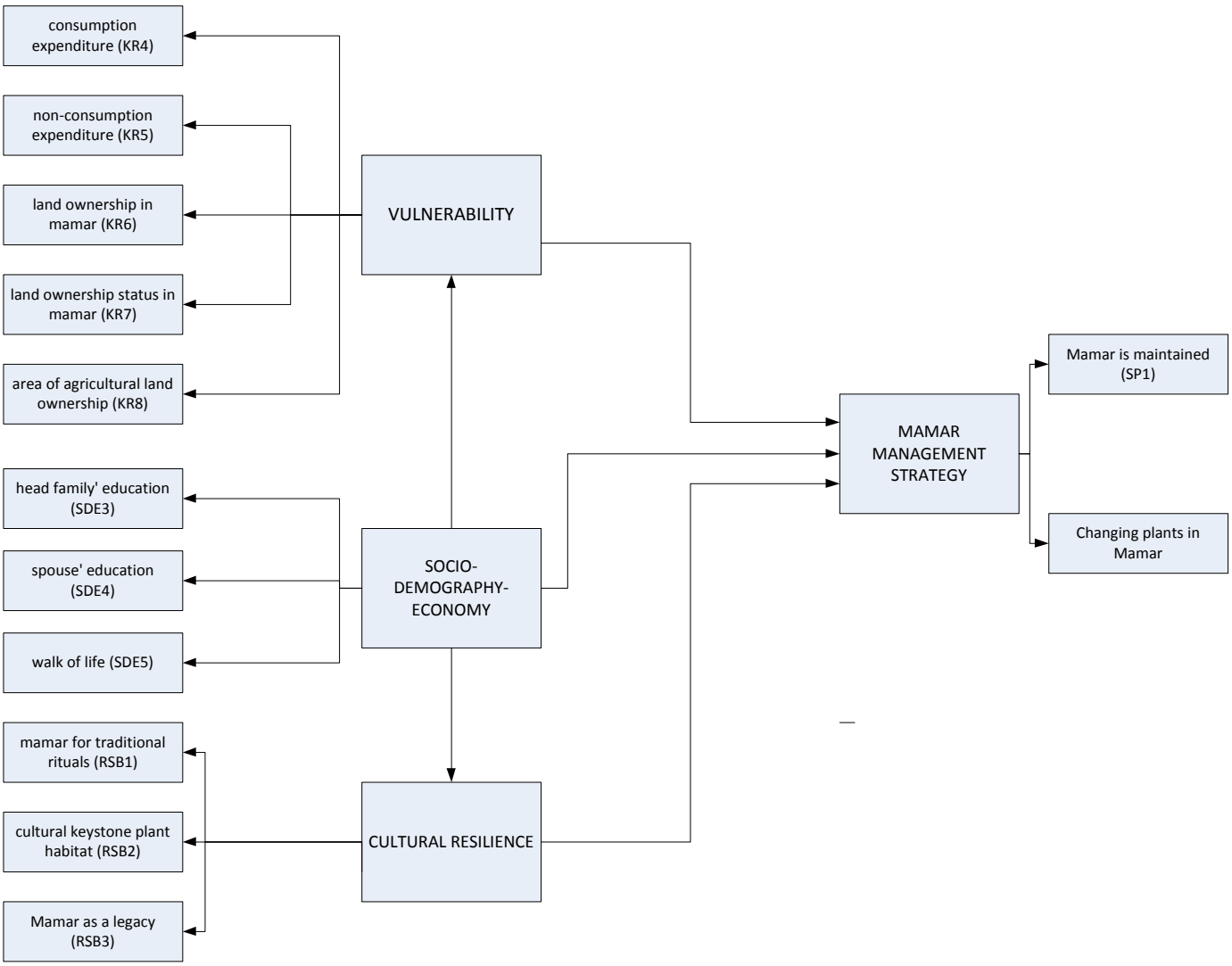

Figure 6. Pattern of social-cultural influence on *Mamar* management in Buraen and Silu

From Table 2, there is a change in the priority order of ecosystem services that occurred in 2023 compared to 2013 as observed in Buraen village. If in 2013, supporting ecosystem services were in first place and regulating was in second place, then in 2023, the opposite will happen. In Silu Village, changes include three ecosystem services, namely regulating, culture, and supporting. Based on the results, significant changes are observed in regulating and supporting, while provisioning services have not changed. This condition shows that there are similar orientations in the two areas, prioritizing regulatory services in current conditions (based on Table 1, where the rank of regulating ecosystem services is 1 in both areas in 2023 compared to 2013). This is also confirmed by the results of interviews and FGD, which acknowledge the impact of tropical storm SEROJA on the reasons why people change their priorities for ecosystem services. Additionally, cultural ecosystem services occupy the last position in the priority order for people in both areas. The result suggests a degradation of the orientation of cultural functions in the use of *Mamar*.

1.3. Identify influential social factors and patterns of influence on *Mamar* management

Analysis of social factors that influence *Mamar* management was carried out using Smart PLS 3.2.7 (Cheah et al., 2021; Memon et al., 2021). This analysis was performed stages, namely evaluation of the measurement model followed by structural model (Fan et al., 2021). Therefore, the relationship model of factors that are thought to be influential is shown in the form of a structural model, as presented in Figure 6.

In Figure 6, the vulnerability variable is explained by indicators of consumption expenditure, non-consumption expenditure, land ownership in *Mamar*, status, and area of agricultural land ownership. Socio-demographic economic variables are explained by indicators of head of family education, spouse education, and walk of life. For the cultural resilience variable, it is explained by indicators of *Mamar* for traditional rituals, cultural plant habitat, and *Mamar* as a heritage. Meanwhile, the management strategy variable is described by indicators of *Mamar*, including maintenance and changes in plants. Socio-demographic economic variables also affect cultural vulnerability and resilience, and management strategy which has an impact on changes in ecosystem services. This suggests a strong influence of socio-demographic and economic conditions on the occurrence of cultural vulnerability and resilience, which affects the *Mamar* management strategy by people. From the results, people that owns *Mamar* has two different opinions, namely maintenance and changing the types of plants.

Discussion

The role of human in changing ecosystem services is very important (Su et al., 2023), as supported by human life and lifestyle (Christiawan & Lai Nguyen, 2024). However, these changes can cause environmental degradation which impacts small farmers (Buyinza et al., 2022). Buyinza also stated that limited access to other resources was the cause of small farmers' vulnerability, showing the need to increase biodiversity on farmers' land (Iiyama et al., 2017).

From the research results, changes in ecosystem services in *Mamar* in 2023 compared to 2013 can be observed, as shown in Table 1. Apart from human factors as the main cause, natural disasters are also a driver of human activities. In 2021, the Seroja tropical cyclone disaster changed the people's perspective and focus on managing *Mamar*. Therefore, regulatory ecosystem services are higher in 2023 compared to 2013. In Silu, regulatory ecosystem services are higher in 2023 compared to 2013, indicating the occurrence of trade-off (Zhang et al., 2023). Cultural services vary from position 3 to 4, while supporting services ranges between position 1 and 3.

The differences between Buraen and Silu are mainly due to variation in land use levels. In Silu, land use is more intensive, while in Buraen, it is slower to enable the environmental recovery process. The decline in forest area, secondary forest, and shrubs is driven by efforts to use land by people to meet their living needs. Moreover, increase in the agricultural area and land use shows compensation (Emmerson et al., 2016) for the decline in the three previous forms of land use.

The tendency of *Mamar* to change is more desired by economically disadvantaged people. The demands of the times and the desire to have more pushed *Mamar* to change. Replacing vegetation types is the dominant option with the aim of maintaining the ecological function of *Mamar* but producing higher profits from changing vegetation types.

People who suffer losses tend to defend *Mamar*, as education level and length of services are factors that influence management strategy. With relatively low levels of education, resistance is promoted which is also strengthened by a conservative mindset in the context of cultural values and norms. On the other hand, people who have jobs other than farming tend to keep *Mamar* due to several factors such as maintaining hereditary norms. Other contributing factors include relying on non-*Mamar* agricultural products for livelihood and time used for businesses. In this context, there are strong social considerations (Rodríguez-Piñeros et al., 2022). *Mamar* with irregular plant spacing can theoretically only be changed by thinning and succession of vegetation, which requires several effort and time. Therefore, the presence of *Mamar* can only be exploited, with tendency to decrease because of competition for nutrients and sunlight. These ecosystem services would also be dominated by regulatory and supporting services. Cultural ecosystem services would decrease along with the development of existing civilization, which tends to eliminate cultural rituals in *Mamar*.

Several indicators in the vulnerability variable show an influence on *Mamar* management strategy in Buraen and Silu. Expenditures for consumption and non-consumption are a logical reason to create ideas for increasing income to offset expenses or maintain the amount of income. However, this level of expenditure tends to only go to the extent of replacing plants in *Mamar* and not converting *Mamar* as a whole.

Apart from that, land ownership, status, and non-*Mamar* agricultural land ownership are indicators that influence management. Due to ownership status, people can show tendency to change the way *Mamar* is maintained through joint decision from various parties. Meanwhile, ownership of non-*Mamar* agricultural land will influence intentions and actions.

The understanding of some people that *Mamar* is only a mixed garden and not a cultural heritage, has led to unintentional changes. This is related to missed transformation between generations, causing degradation of the understanding. With respondents, some of people were >50 years old, with the assumption that they were still undergoing a process of cultural transformation, this resulted in the discovery of

cultural resilience (Bolton et al., 2016) in this research. The existence of *Mamar* is considered to still function as a place for carrying out traditional rituals, particularly in Silu (the definition of traditional rituals is divided into two, namely (a) prayer and (b) giving signs accompanied by sacred words such as "bunuk", which is actually more personal). Apart from that, *Mamar* is still considered a place for planting betel and areca nut (according to philosophy), and an ancestral heritage that must be maintained. These factors are responsible for *Mamar* management, as well as being a balancing factor. However, changes can still occur due to natural processes.

From both research areas, respondents generally agreed that they did not want to change *Mamar* land completely, but selected management strategy. This can be observed from the structural model based on PLS (Partial Least Square) analysis which showed the selection of SP1 (management strategy to maintain *Mamar*) with an indicator value of 0.943 and SP2 (limited change) at 0.902. SP3 option (management strategy to completely change *Mamar* land) had an indicator value <0.7 (invalid).

4. Conclusion

In conclusion, this research showed the efforts to promote an increase in the capacity of one ecosystem service, causing a corresponding decrease in the potential of others. The results showed that socio-demographic economic variables, socio-economic vulnerability, and cultural resilience influenced the management strategy of *Mamar* in Buraen and Silu which had an impact on the production of ecosystem services. Therefore, environmentally aware development planning in areas where *Mamar* was located needs to pay special attention to these variables.

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