

DYNAMICS OF SOCIO-ENTROPY FACTORS OF FARMING ACTORS IN A SOCIO-ANTHROPOLOGICAL PERSPECTIVE IN THE AGROECOSYSTEM AREA OF PAGARALAM CITY PROTECTED AREA

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Abstract

This study aims to analyze the dynamics of socio-entropy factors that affect the behavior, adaptation patterns, and socio-economic performance of farming actors in the agroecosystem area of the protected area of Pagaralam City from a socio-anthropological perspective. A qualitative approach with descriptive-analytical strategies is used to understand the meaning of social change and farmers' responses to environmental, economic, and spatial policy pressures. Data were collected through in-depth interviews, participatory observations, and documentation studies, then analyzed using socio-entropy concepts that explain the degradation of social order due to ecological and structural disruptions. The results of the study show an increase in social entropy, which is reflected in the weakening of group solidarity, a shift in the value of cooperation, and a change in economic orientation from the subsistence system to commercialization. However, there has also emerged a process of social negentropy in the form of collective innovation, simple technological adaptation, and the formation of new social networks that function to maintain social and ecological balance. This dynamic marks a change in values and social structures in the farming system that has implications for the sustainability of the agroecosystem of protected areas. Theoretically, this study broadens the understanding of the relationship between social entropy and farming systems, and emphasizes the importance of socio-anthropological approaches in formulating sustainable agricultural policies that are adaptive to environmental changes and the social characteristics of local communities.

Keywords: Agroecosystem, Socio-Entropy, Socio-Anthropological.

INTRODUCTION

Socio-economically, rural communities in South Sumatra are still highly dependent on dryland agriculture and traditional farming systems that are vulnerable to climate fluctuations and changes in spatial policies. According to BPS South Sumatra (2022), more than 56% of the population in rural areas work in the agricultural sector, which shows a high level of dependence on land as a source of livelihood. However, limited access to productive land, both in terms of area, legality, and land quality, is a serious obstacle to improving farmers' welfare. Inequality in land tenure and agrarian conflicts also often occur in this region, which often involves local communities, large corporations, and local governments (Walhi South Sumatra, 2021). This shows the urgency to manage natural resources in a more equitable and sustainable manner, with an approach that considers ecological and social justice aspects.

One of the areas that reflects these dynamics in real terms is Pagaralam City. This city is an administrative area resulting from the expansion of Lahat Regency, which is known as the buffer area of the Bukit Barisan ecosystem and has an important ecological function. Based on Law Number 8 of 2001, the area of Pagaralam reaches 63,666 hectares, of which more than half, which is around 33,364.71 hectares (52.40%), is non-cultivated areas, including protected forests. Meanwhile, only around 47.60% or 30,001.29 hectares are included in the cultivation area. This composition shows the existence of spatial inequality, which has implications for limited public access to legal land for farming and settlement.

This limited land condition has put pressure on the farming community, which is the majority of the population of Pagaralam. When the needs of life and population growth are not commensurate with the availability of land, people are encouraged to open up new land illegally, even in protected forest areas. This activity is further exacerbated by weak supervision, unclear boundaries of forest areas, and a lack of alternative sources of livelihood outside the agricultural sector. This situation illustrates the dynamic pre-life conditions of farmers, who not only face economic challenges but also play a role in driving ecological changes that risk the sustainability of protected

forest areas. Therefore, this study seeks to further examine how the socio-economic dynamics of farmers can affect the existence of protected forest areas, as well as formulate a just, adaptive, and sustainable policy direction. From a land use perspective, the limitations of cultivation areas put pressure on communities that depend on the agricultural sector as their main livelihood. When the available land is insufficient to meet the growing economic needs and population growth, communities are encouraged to expand their cultivated land, often by opening up non-cultivated areas such as protected forests. (Boserup, 1965), This states that population growth will encourage agricultural intensification, and if there is not enough productive land, then people will look for alternatives, including the encroachment of land that should be protected.

Data from the Forest Management Unit of the Dempo X Region of Pagaralam City shows that the area of protected forest areas reaches 26,000 ha, which is equivalent to 2/5 of the total area of Pagaralam. However, another report noted that the area of protected forests reached 28,000 ha, a reduction of 4,000 ha, leaving 24,618 ha. Based on the Decree of the Minister of Forestry Number SK.76/Menhut-11/2010, the area of Pagaralam protected forest reaches 24,618 hectares spread across several sub-districts. From a demographic aspect, data shows that the population of Pagaralam City has increased from 117,386 people in 2001 to 147,071 people in 2022, with an average growth rate of 1.28% per year (BPS, 2022). This growth rate is relatively slow compared to several other areas in South Sumatra Province. If this delay is due to socio-cultural shifts, namely the number of young generations who no longer like to take part in the agricultural sector and then migrate abroad, generally to the island of Java (Sarnubi, B, 2014). In addition, several studies have shown that socio-economic changes, such as increased land needs for housing and infrastructure, are also important factors in land use change (Rudel et al., 2009; Lambin and Meyfroidt, 2011). This is in line with Malthus's theory of population growth, which states that if the population increases faster than the available resources, there will be pressures on the environment, including overexploitation of land (Malthus, 1798).

In the face of these dynamics, it is imperative that structured and systematic anticipatory actions are carried out through a 4D approach monitored, observed, studied, and controlled to prevent more severe damage and ensure the sustainability of protected forest area functions. The interaction between the people of Pagaralam City and the existing ecosystem and agroecosystem areas needs to be studied comprehensively, including the benefits (positive and negative aspects). This is important considering that the forest area is not only a natural resource (SDA) that supports the livelihood of most people, but also a determinant of the ecological balance and prosperity of the region in the long term. Therefore, if today there is an indication of a decline in the quantity and quality of forest cover, then it is necessary to examine more deeply two main things. First, how much role do community members play in increasing the symptoms of forest encroachment in the protected and conservation area zone in Pagaralam City, and second, the extent to which socio-anthropological factors underlie the lives of residents and migrants can be tamed by their negative influences, for the sake of a sustainable protected ecosystem. In addition, what strategies can be developed to manage protected forest areas in a participatory and sustainable manner to minimize land use conflicts between ecological interests and the economic needs of the community?

MATERIALS AND METHODS

1. Study Area

The location of this research was deliberately (purposively) carried out in the protected forest area and its surroundings, which are in the KPH X area of Pagaralam City (Figure 1) to be carried out from June 2023 to June 2024. Based on the Decree of the Minister of Forestry No.866/Menhut-II/2014 and the results of the administrative boundary overlay of Pagaralam City sourced from the South Sumatra Provincial Bappeda, KPHL Unit XII has an area of 26,064.71 hectares, or more than 40 percent of the area of Pagaralam City is a protected forest. The selection of the Bukit Dingin and Gunung Patah zones as the focus of the research area is based on strategic considerations, both ecologically and socially. These two areas are part of the protected area in Pagaralam City, which has an important role as a water catchment area, microclimate regulator, and conservation area managed by the Dempo Forest Management Unit (KPH). However, on the other hand, this area has also long been a living space and production space for local farming communities. Many of them have used the land for agricultural activities for generations, such as coffee cultivation and horticultural crops.

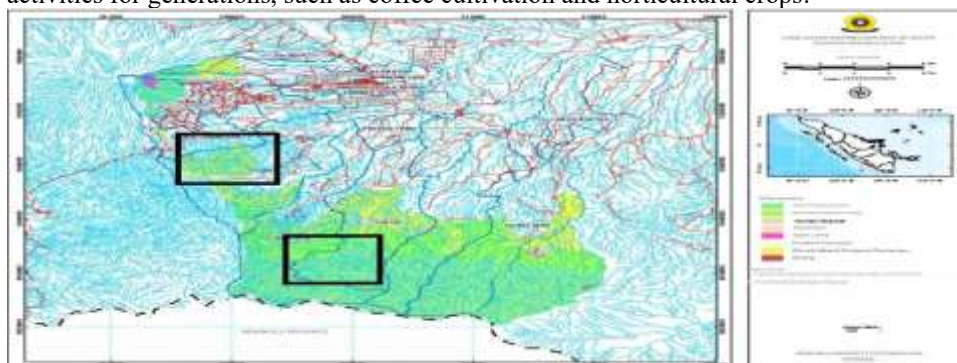


Figure 1. Research Areas

Data Collection

This research is quantitative and qualitative, using a descriptive approach. Quantitative analysis is used to measure performance patterns and work values, such as farmers' income and investment. The data was processed using descriptive statistical techniques and cross-tabulation to see the tendency of relationships between variables. Second, qualitative analysis is used to understand the shift in values and behavior of farmers based on socio-entropy theory, through the interpretation of the narrative results of interviews and direct observations. This approach helps to uncover the socio-economic and socio-ecological dynamics that drive deviations or adaptations in the management of protected areas. In addition, this study also uses SWOT analysis to formulate regional management strategies based on specific strengths, weaknesses, opportunities, and threats in each region. This approach allows research to produce findings that are not only descriptive but also strategic in providing recommendations based on local conditions. The research sample was conducted using observation by first determining the target object that represents, namely, the sample of the area and village determined by intentional (*purposive sampling*). Key informants are determined deliberately (*purposive*), including Forestry Officers, Village Heads, Hamlet Heads, Community Leaders, Religious Leaders, and Youth Leaders related to the research. Meanwhile, the sample of farmers consists of communities around the Bukit Dingin and Gunung Patah forest areas, consisting of local community farmers and migrants. The method used is the accidental sampling technique (Table 1).

Table 1. Research Sample Based on Village/Urban Village

No	Forest Area	Village	Population (KK)	Total Sample (KK)
1	Bukit Dingin	Agung Lawangan Burung Dinang	315 126	51
2	Gunung Patah	Joko Candi Jaya	424 121	82
Total			1046	133

Then, after being taken by *accidental sampling*, the samples were divided according to tribal background, namely between immigrants and Basemah, which aimed to dig deeper into the social dynamics and land use patterns in the KPH Dempo protected forest area, Pagaralam City, during the period 2005 to 2024. Of the total 133 Heads of Families (KK) who were made respondents, as many as 54 families came from immigrant tribal groups, while 79 families came from the Basemah tribe, who are indigenous people of the area. The sample is spread across two forest areas, namely Bukit Dingin and Gunung Patah, with compositions that reflect the ethnic diversity and mobility history of the population in the area (Table 2).

Table 2. Research Sample by Tribe

Sample	Immigrant (KK)	Basemah (KK)	Total (KK)
Bukit Dingin	26	25	51
Gunung Patah	28	54	82
Total (KK)	54	79	133

The data collection method used in this study will be carried out by observation or field observation to find out how much of the source of income is received and the allocation of farmers' expenditure at the predetermined research location. In-depth *interview* to find out the social conditions of farmers' society, such as social psychology, socio-ecology, socio-culture, and socio-economy, and what problems are faced by farmers at the research site. Meanwhile, documentation by taking pictures and videos to find out what activities are carried out by farmers at the research site, as well as archival recordings such as location maps, farmer data, villages, and others.

Data Analysis

To understand how farmers' work patterns in managing protected area land, including crop rotation patterns, daily work patterns, and windfall sustenance patterns, are part of their farming strategies. Using indicators measured through the Likert scale, this study also seeks to assess the extent of the performance of the farming produced. The results of this study are expected to provide a comprehensive overview of the dynamics of farming in protected areas and provide recommendations for more sustainable and productive management for farmers in Pagaralam City.

Furthermore, to assess the level of social and ecological stress (socio-entropy) caused by farmers' activities on the environment and social structures in agricultural areas, a scoring approach based on a number of key indicators is used. These indicators are grouped into two main dimensions, namely socio-ecological and socio-economic, each of which consists of three indicators. Each indicator was scored based on five questions, with a score range from 1 (very low) to 5 (very high). The total score per indicator

ranges from 5 to 25, which is then converted into low, medium, or high categories according to the cumulative score.

Furthermore, the analysis method used in the preparation of the management strategy for the Bukit Dingin and Gunung Patah areas is based on the SWOT (Strengths, Weaknesses, Opportunities, Threats) approach combined with quantitative weighting techniques. SWOT analysis is used to systematically identify internal (strengths and weaknesses) and external (opportunities and threats) factors that affect the patterns and values of farmers' performance as well as pressures on the environment, particularly in the context of socio-entropy.

RESULTS AND DISCUSSION

Changes in land cover in the Dempo Forest Management Unit (KPH) protected area, Pagaram City, during the period 2005 to 2024 reflect the increasingly complex dynamics of interaction between human activities and natural ecosystems. This area was initially dominated by primary and secondary forest cover that is still quite intact, serving as an important conservation area to maintain environmental balance, a source of water infiltration, and a habitat for the biodiversity typical of the Bukit Barisan Mountains. However, over time, the pressure on the land increased significantly.

One of the main causes of land cover change is the conversion of forest areas into agricultural land and settlements. Coffee plantations, vegetables, and the expansion of tourism-supporting infrastructure in the foothills of Mount Dempo have led to the degradation and fragmentation of forest cover. Population growth and increasing economic needs of the local community also help accelerate this change process. Unauthorized forest encroachment activities and weak law enforcement have also worsened the condition of the protected area.

In 2024, based on satellite image monitoring and data from the Dempo FMU, it was found that natural forest cover had decreased significantly compared to conditions in 2005. Most areas that were once forested are now turned into scrubland, open land, or intensive farmland. Forest fragmentation causes disruption of ecosystem connectivity and narrows the space for wildlife to move. In addition, the increase in critical land area on steep slopes also increases the risk of ecological disasters such as landslides and floods.

The impact of these changes is not only ecological, but also social and economic. Forest destruction causes a decrease in environmental quality, a decrease in the availability of clean water, and an increased risk of disasters that threaten communities around the region. In addition, this change also has an impact on the loss of cultural and spiritual values that have been attached to forest areas for indigenous or local peoples.

Changes in land cover also occurred in the Bukit Dingin (North Dempo District) and Mount Patah (South Dempo District) areas. Data from the Ministry of Environment and Forestry (MoEF, 2024) shows that the area of primary forests in Bukit Dingin has decreased by 7.8% in the last five years, mainly due to an increase in open areas used for agricultural activities and forest encroachment. A report from the Geospatial Information Agency (BIG, 2024) confirms that there is a decline in natural vegetation that correlates with an increase in land use for horticultural commodities and small-scale plantations. A study conducted by Indrawati et al. (2023) on land use dynamics in South Sumatra revealed that economic factors are the main driver for communities to open up new land in conservation areas, especially due to the limited productive land available outside protected areas.

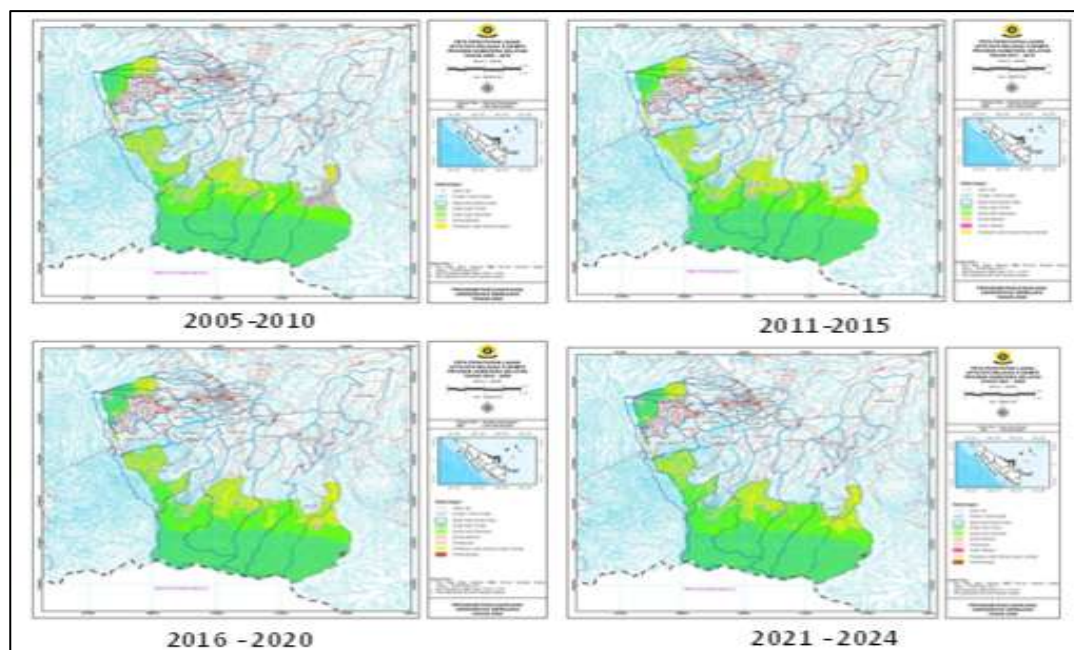


Figure 1. Land Cover Changes in Protected Areas KPH Dempo Pagaram City 2005 - 2024

On the other hand, the Mount Patah area is still dominated by forest cover, but analysis of Landsat 8 (2024) satellite imagery data released by the LAPAN Remote Sensing Center shows indications of new land clearing for agriculture. Areas previously covered by secondary forests are beginning to show signs of change, with increased light reflectance in some areas indicating logging and land clearing activities. A study from Wijayanto et al. (2022) also noted that deforestation trends in this region tend to increase during the planting season period, as the number of farmers relying on farming systems shifts.

These changes can impact the balance of local ecosystems and increase the risk of environmental disasters. Research from Margono et al. (2021) shows that the conversion of primary forests to agricultural land in the Sumatra region increases the risk of soil erosion by up to 35% and causes degradation of soil fertility due to the loss of the humus layer. In addition, research conducted by the *World Resources Institute* (WRI, 2023) highlights that forest fragmentation in the Bukit Barisan Selatan area, including in Pagaralam, can threaten biodiversity and accelerate the effects of regional climate change.

The ecological impact of this land clearing is also seen in the increase in disaster potential. Data from the National Disaster Management Agency (BNPB, 2024) noted that the North Dempo and South Dempo regions experienced an increase in landslide incidents by 20% compared to the previous year, which correlated with increased land clearing activities in hilly areas. In addition, rainfall analysis from BMKG (2024) shows that changes in land cover have affected local hydrological patterns, increasing the potential for flash floods in downstream areas.

The shift in livelihood patterns from traditional agriculture to more intensive agricultural practices can increase pressure on natural resources and magnify potential conflicts between conservation interests and the economic needs of communities. Thus, changes in land cover in Bukit Dingin and Gunung Patah are not just a local phenomenon, but also part of a broader trend regarding the dynamics of protected area utilization in Indonesia.

In the dynamics of the use of protected areas by farming communities, there are various forms of interaction between economic activities and ecological conditions involving social, cultural, and environmental aspects. One of the approaches used to understand this phenomenon is the concept of socio-entropy, which highlights the various forms of social deviation due to structural and ecological pressures experienced by society. In this context, socio-entropy not only shows a form of violation of rules or spatial planning, but also reveals changes in people's behaviors and values that can have an impact on environmental sustainability.

These shifts in values and behavior can be identified through two main indicators, namely socio-ecological indicators and socio-economic indicators. Socio-ecological indicators include patterns such as spatial planning violations, overexploitation of land fertility, and threats to biodiversity. Meanwhile, socio-economic indicators include the tendency of farmers to ignore the proportionate use of inputs, limited access to business capital, and low income variability that reinforces the economy's dependence on one main source. To provide a more structured understanding, the following presents a comparison table between the Bukit Dingin and Gunung Patah regions, which illustrates the degree of socio-anthropological shift based on relevant socio-entropy indicators. This table serves as a basis for assessing the level of threats and opportunities for policy interventions that are contextual and locally-based.

From the perspective of the socio-entropy concept, the shift in socio-anthropological factors in farmers in the Bukit Dingin and Gunung Patah areas shows differences, both from socio-ecological and socio-economic aspects, which affect the intensity of threats to protected areas. Socio-entropy explains that the higher the level of social deviation from the environmental and economic governance system, the greater the potential threat to the sustainability of forest areas. In this case, the Mount Patah area shows a higher level of entropy than Bukit Dingin. For more details, see Table 3.

Table 3 Socio-Anthropological Factors Based on Socio-Ecological and Socio-Economic Indicators in the Socio-Entropy Perspective

Socio-Entropy Indicator	Cold Hill		Broken Mountain	
	Immigrants	Basemah	Immigrants	Basemah
Social-Ecology				
Violating Spatial Planning	3.0	2.0	5.0	4.0
Depleting Land Fertility	4.0	3.0	5.0	4.0
Destroying Biodiversity	3.0	2.0	5.0	4.0
Socio-Ecological Subtotals	10.0 (Medium)	7.0 (Medium)	15.0 (Tinggi)	12.0 (Medium)
Socio-Economic				
Ignoring Proportional Input	4.0	3.0	5.0	4.0
Lack of Capital Support	4.0	3.0	5.0	5.0
Minimal Income Variation	2.0	2.0	4.0	5.0
Socio-Economic Subtotals	10.0 (Medium)	8.0 (Medium)	14.0 (Tinggi)	14.0 (Tinggi)
Total Socio-Entropy	20.0 (Medium)	15.0 (Medium)	29.0 (Tinggi)	26.0 (Tinggi)

From a socio-ecological perspective, farmers in Gunung Patah tend to violate spatial planning provisions more often because most of their farming activities take place within the core block, which, regulatively should only be intended for conservation functions. Land clearing activities in this area are often carried out without consideration for sustainability, such as selective logging practices, land burning, and clearing coffee plantations on steep slopes.

This leads to a gradual decline in soil fertility and accelerates the rate of erosion. In addition, because the Gunung Patah area still has primary forest areas, encroachment by farmers also contributes to the loss of biodiversity, both flora and fauna.

In contrast, Bukit Dingin shows a lower level of socio-ecological entropy because it is entirely within the utilization block, which is indeed designed for limited use by the community. Although there are still agricultural practices that are not environmentally friendly, such as the uncontrolled use of chemical fertilizers or land clearing with little conservation, the damage to biodiversity and spatial planning violations are relatively smaller. The land in Bukit Dingin is predominantly used for coffee plantations and local crops, with a relatively regular rotation.

In the socio-economic aspect, farmers in Gunung Patah face heavier obstacles. The lack of capital support and access to empowerment programs causes farmers to tend to ignore the proportional use of inputs. For example, in one season they use fertilizer excessively, while in the next season they use fertilizer at all due to cost limitations. This has a direct impact on decreased yields and productivity instability. The lack of income variation also worsens the socio-economic conditions of farmers. Dependence on one commodity (coffee) and forest products such as honey, rattan, or agarwood makes their income unstable and seasonal.

On the other hand, farmers in Bukit Dingin have a more diverse economic pattern. In addition to relying on coffee farming, most of them also have a side income from seasonal activities, such as small trading or working in the local informal sector. Although still facing limited capital, access to agricultural programs and local markets is slightly better than in Gunung Patah. Thus, the shift in socio-anthropological factors in these two regions shows that the socio-entropy level in Mount Patah is higher, so it has the potential to pose a more serious threat to the preservation of protected areas.

Social Ecological Conditions of Farmers in Protected Areas

Based on Table 4, the *Socio-Ecological* conditions from the perspective of Socio-Entropy are presented in two research locations, namely Bukit Dingin and Mount Patah, by comparing the two main groups of actors: immigrants and the Basemah community (indigenous people). The analysis was carried out based on three main indicators, namely violations of spatial planning, depletion of land fertility, and destruction of biodiversity. Scores are given in a range of 1.0–5.0 per indicator, which is then summed up into subtotals and classified into three categories of pressure levels: low, medium, and high.

Table 4 Socio-Ecological Conditions in the Perspective of Socio-Entropy

Indicator	Cold Hill		Broken Mountain	
	Immigrants	Basemah	Immigrants	Basemah
Violating Spatial Planning	3.0	2.0	5.0	4.0
Depleting Land Fertility	4.0	3.0	5.0	4.0
Destroying Biodiversity	3.0	2.0	5.0	4.0
Socio-Ecological Subtotals	10.0 (Medium)	7.0 (Medium)	15.0 (Tinggi)	12.0 (Medium)

In the Bukit Dingin area, the immigrant group obtained a total score of 10.0, which is classified as a medium category. This shows that despite the intensive practice of land use, there are still efforts to maintain the use in the permitted blocks, although it is not yet fully formally legal. Meanwhile, the Basemah group in Bukit Dingin obtained a total score of 7.0, also in the medium category, but with lower environmental pressure. They tend to practice farming practices that are more conservative and in accordance with local knowledge, and are relatively non-destructive to biodiversity.

On the other hand, in the Gunung Patah area, the immigrant group showed the highest score of 15.0, which is classified as high. This shows that the pressure on the environment is enormous. They encroached heavily on primary forest areas, cleared land on a moving basis, and implemented monoculture systems that caused soil degradation and loss of natural vegetation. In contrast, the Basemah group in Gunung Patah obtained a score of 12.0, which is still in the medium category, but still shows an increase in ecological pressure compared to the Basemah group in Bukit Dingin.

This data shows that the immigrant group on Mount Patah is the actor with the highest contribution to socio-ecological degradation. This can be influenced by weak spatial controls, unestablished land ownership, and short-term economic orientation. Meanwhile, the Basemah group, both in Bukit Dingin and Gunung Patah, showed relatively lower pressures, reflecting that local knowledge and attachment to the region may play a role in maintaining ecological balance. These findings are important as a basis for formulating region-based policies that are more sensitive to the social structure and adaptation strategies of each group.

If it is related to the issue of forest encroachment, the results of the analysis in Table 4.10 show that higher levels of socio-ecological pressure tend to come from immigrant groups, especially in the Gunung Patah area, which obtained a maximum score of 15.0 and was included in the high category. This reflects the intensity of activities that go beyond legal and ecological boundaries, such as land clearing in core blocks of forest areas that should be protected, shifting cultivation systems that deplete soil fertility, and biodiversity decline due to the conversion of forests into monoculture gardens.

Thus, forest encroachment is closely related to socio-entropy patterns, especially when high socio-economic pressures are met with weak spatial surveillance and a lack of alternative livelihoods. Policy approaches to tackling forest encroachment cannot simply emphasize prohibition and law enforcement, but must also strengthen the economic base of farmers, especially vulnerable groups such as migrants, through legal access to land, income diversification, and strengthening local institutions. This is important to reduce pressure on forest areas while promoting socio-ecological sustainability in areas prone to encroachment.

Socio-Economic Conditions of Farmers in Protected Areas

The socio-economic conditions from a socio-entropy perspective in the Bukit Dingin and Mount Patah areas show significant economic pressure, especially in the Mount Patah area. This is reflected in the relatively high indicator scores, especially in the immigrant group and the Basemah community, which each recorded a score of 14.0 and were included in the high category. Three main indicators are decisive: disproportionate use of inputs, lack of capital support, and low variation in income sources. The unbalanced use of agricultural inputs such as fertilizers and pesticides reflects low efficiency and understanding of sustainable farming practices. Meanwhile, limited access to capital, either through bank credit, government assistance, or local cooperatives, makes it difficult for farmers to increase production intensively.

This situation is exacerbated by the high dependence on one type of commodity, such as coffee, in the absence of diversification into other economic ventures. When yields are insufficient or coffee prices fall in the market, farmers tend to open up new land as a survival strategy. It is in this context that forest encroachment is often a rational choice for farmers who are under economic pressure. They see forest areas as 'reserves' of fertile land that can be accessed without large costs. However, these actions negatively impact environmental sustainability and accelerate the degradation of protected forests and production forests.

Table 5 Socio-Economic Conditions in the Socio-Entropy Perspective

Socio-Entropy Indicator	Cold Hill		Cold Hill	
	Immigrants	Basemah	Immigrants	Basemah
Ignoring Proportional Input	4.0	3.0	5.0	4.0
Lack of Capital Support	4.0	3.0	5.0	5.0
Minimal Income Variation	2.0	2.0	4.0	5.0
Socio-Economic Subtotals	10.0 (Medium)	8.0 (Medium)	14.0 (Tinggi)	14.0 (Tinggi)

Theoretically, this condition can be explained through the *agrarian frontier* approach and *push-pull factors*, which state that structural poverty and limited economic resources encourage communities to expand into forest areas. Within the framework of *sustainable livelihoods* developed by Chambers and Conway, this situation shows inequality in asset ownership, especially financial and physical assets, which leads to unsustainable exploitation of natural assets (forests). In *the social theory of entropy*, this condition reflects a social system that experiences an imbalance between production capacity and the needs of life, thus triggering a pattern of destructive interaction with the environment. The development of farmers' lives from the perspective of local wisdom in protected areas can be seen in Table 6.

From the perspective of local wisdom, Gunung Patah farmers can be seen through the use of natural protective plants, such as lamtoro, dadap, and palm, to shade coffee plants. This practice not only helps to maintain soil moisture and prevent erosion, but it also becomes part of the local eco-based farming system. In addition, there is a cultural value that develops not to clear land by burning, because it is believed to damage the "spirit of the forest" or the spirit of nature that is traditionally maintained. Although it has not yet become the collective consciousness of all farmers, this practice is a form of ecological protection born from local traditions that respect nature.

In contrast to Gunung Patah, the people in Bukit Dingin show a stronger form of local wisdom in the aspects of communitarianism and socio-economic collectivity. This system creates solidarity between farmers, especially for those who do not own their own land, as they remain involved in the production process and get a share of the produce. In addition, economic diversification is an important strategy in dealing with agricultural risks. Farmers not only depend on coffee for their livelihood, but also on vegetable gardening, raising livestock, and running small businesses. This wisdom shows the ability to manage economic risks and create family income resilience.

Table 6 The Development of Farmers' Lives Seen from the Perspective of Local Wisdom in the Protected Area

Indicators of Local Wisdom	Broken Mountain		Cold Hill	
	2005	2025	2005	2025
Socio-Economic				
Work Systems and Social Networks	Still, the dominance of the nuclear family	Formation of cross-regional working groups (strategic & adaptive)	Very strong family and neighbor based	Stay sustainable, the work system is still carried out

Indicators of Local Wisdom	Broken Mountain		Cold Hill	
	2005	2025	2005	2025
Coffee Farming Patterns	Managed simply, not optimal from an economic point of view	Considered an economic heritage, efficiently managed & strategic	Traditional and family-based gardens	Managed collectively with a fair share of results
Economic Strategy	Just rely on coffee; it depends on the season	There are efforts to vary with non-timber forest products	Focus on coffee	Diversification into vegetables, livestock, and small trade
Gotong Royong	Only in times of emergency or customary events	Starting to grow again in the Basemah group	Very powerful	Increasingly established and institutionalized in farming activities
Social Ecology				
Eco-friendly planting patterns	Coffee monoculture in the open field	Use natural shade trees (lamtoro, dadap)	A mixture of coffee and protective trees, but not yet structured	Simple agroforestry systems are becoming more stable
Natural Resources Conservation	Land clearing by burning is still common	The value of the burning taboo appeared, and began to be obeyed	Springs are not all protected	Springs are guarded together, considered sacred
Ecological Awareness	Still low, forests are considered open source	Grows due to interaction with primary forests	It has begun to grow in the village deliberations	Becoming a collective customary value in resource governance

From a socio-ecological perspective, the people of Bukit Dingin naturally apply a traditional agroforestry system by planting coffee under tree stands or on the sidelines of other forest vegetation. This practice indirectly protects the ecological structure of the garden and maintains the balance of the microclimate. In addition, they also uphold the tradition of maintaining water sources in a traditional way. Some springs are considered "sacred" and are maintained collectively by the community, with unwritten rules prohibiting destruction of surrounding vegetation or water pollution. This reflects a tangible form of ecological wisdom that is able to protect natural resources for the survival of the community.

Cold Hill "Comer"				
KM	KM	KM	KM	
PA	S ₁	S ₂	S ₃	
PA	"damai"	"vain"	"strategic"	
PA	S ₄	S ₅	S ₆	
PA	"skeptical"	"static"	"strategic"	
PA	S ₇	S ₈	S ₉	
PA	"voluntary"	"merry"	"like dream"	

Cold Hill "Basemah"				
KM	KM	KM	KM	
PA	S ₁	S ₂	S ₃	
PA	"damai"	"vain"	"strategic"	
PA	S ₄	S ₅	S ₆	
PA	"skeptical"	"static"	"strategic"	
PA	S ₇	S ₈	S ₉	
PA	"voluntary"	"merry"	"like dream"	

Broken Mountain "Newcomer"				
KM	KM	KM	KM	
PA	S ₁	S ₂	S ₃	
PA	"damai"	"vain"	"strategic"	
PA	S ₄	S ₅	S ₆	
PA	"skeptical"	"static"	"strategic"	
PA	S ₇	S ₈	S ₉	
PA	"voluntary"	"merry"	"like dream"	

Broken Mountain "Basemah"				
KM	KM	KM	KM	
PA	S ₁	S ₂	S ₃	
PA	"damai"	"vain"	"strategic"	
PA	S ₄	S ₅	S ₆	
PA	"skeptical"	"static"	"strategic"	
PA	S ₇	S ₈	S ₉	
PA	"voluntary"	"merry"	"like dream"	

Figure 2 Relationship of Socio-Ecological and Socio-Economic Interactions in the Protected Area of Pagaralam City

In the Bukit Dingin area, both the migrants and the Basemah community show a pattern of socio-economic and environmental interaction that is classified as static (S5), where the change in the natural environment is relatively small and there is no significant change in the community's wealth. This can be seen from the socio-ecological and socio-economic scores that are in the medium category, showing stable conditions without severe environmental damage or a significant increase in income. For example, farmers in Bukit Dingin still manage land traditionally with limited use and without major expansion into protected forest areas, so that the impact on the environment can be controlled. Their income tends to be stable, although it has not seen a significant increase. Meanwhile, in Gunung Patah, the pattern of interaction is different between the migrants and the Basemah community. Migrants on Mount Patah fall into the "damn" pattern (S1), which is characterized by a significant increase in community income accompanied by a very high level of environmental damage. This is reflected in the socio-ecological and socio-economic scores that are in the high category. Migrants are encroaching on forests on a large scale and clearing new land without paying attention to conservation aspects, causing deforestation, soil degradation, and biodiversity loss. However, in the short term, they gain economic benefits from the expansion of the land.

Meanwhile, the Basemah community in Mount Patah shows a pattern of "vain" (S2), where there is a real increase in community wealth, but it is still accompanied by significant environmental damage, even though it is not as severe as the migrants. They began to abandon traditional utilization patterns and intensify land use, including the expansion of monoculture crops and non-timber forest products, thus leading to the degradation of local ecosystems. This condition illustrates the imbalance between economic growth and environmental sustainability. The analysis of these patterns is supported by socio-ecological theories that state that society and the environment dynamically influence each other. The S1 and S2 patterns in Mount Patah show the phase of exploitation of the socio-ecological system that risks causing a "tragedy of the commons," namely, the destruction of natural resources due to utilization without sustainable management. Therefore, regional management efforts need to be directed so that the community can transition to a more sustainable pattern of interaction, such as the strategic pattern (S6) or the like-dream (S9), which balances improving welfare with environmental conservation. This approach can be done through land legalization, sustainable agriculture assistance, as well as increasing access to capital and diversifying sources of income.

CONCLUSION

Changes in land cover in the protected area of Pagaralam City show increasing socio-economic pressure on the environment, which triggers an increase in socio-entropy levels in the form of weakening social order, ecological degradation, and shifting the value of cooperative cooperation of the farming community. The Gunung Patah area shows high socio-ecological entropy due to forest encroachment and intensive agricultural practices by immigrant farmers, while Bukit Dingin is relatively more stable because it still maintains the local wisdom of the Basemah community in maintaining the balance of nature. However, there are also forms of negentropy, such as social innovation, simple technological adaptation, and collective networks, that are important social capital to withstand ecological and social disruption. Overall, this dynamic confirms that the sustainability of protected areas can only be achieved through strengthening local values, diversifying the farmer economy, and culturally-based governance that can reduce the rate of socio-entropy in the Pagaralam farming system.

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