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Socioeconomic Development of the Local Community and Causes of Land Use Change in Belaga, Sarawak, Malaysia

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Abstract

The state of Sarawak in Malaysia has witnessed a surge in demand for its valuable land resources, primarily driven by major commodity investors establishing plantations. These land concessions have further exacerbated land scarcity and the depletion of crucial forest areas, which are essential for the livelihoods of indigenous communities. The indigenous community in Sarawak, heavily dependent on forests, faces significant challenges due to land use changes. This study aims to identify the drivers of land use change and assess the socioeconomic impact on the local community in Murum, Belaga, Sarawak. The research was conducted in December 2020, utilizing a combination of quantitative and qualitative approaches. Questionnaires, in-depth interviews, and site observations were employed to collect data, involving 511 household heads and ten key informants. Statistical analysis using SPSS software was performed on the collected data. The findings highlight that the primary cause of land use change in the study area was the hydroelectric dam project, followed by the establishment of oil palm plantations, logging activities, forest plantation development, government policies, and agricultural activities. Regarding infrastructure satisfaction levels, respondents ranked sport/recreational facilities as the most important, followed by electricity supply, house/accommodation facilities, education facilities, clean water sources, communication accessibility, health facilities, and road accessibility. Overall, the data indicates an improvement in the economic and social conditions of families due to land use changes in the area. However, the study concludes that there is still a need for further improvements in essential services, including providing multiple clean water sources to each household, enhancing access to healthcare services, and improving road conditions. Improved road access will foster increased business and social activity, facilitating job opportunities and contributing to poverty alleviation within the local community.

Keywords: land use land cover change, socio-economic development, local community, Belaga, Sarawak

1. Introduction

The land serves as the fundamental basis for human survival and development, providing the necessary resources for social and agricultural production. Consequently, any changes in land use have a significant impact on people's lives and overall well-being (Wang et al., 2016). Land use involves the management and alteration of the natural environment to convert it into agricultural land, such as arable fields, grasslands, or human settlements. Additionally, the term "land use" refers to different zoning classifications for land utilization. The function of land use is determined by how it is utilized by individuals, covering various features on the Earth's surface. It encompasses human activities related to agriculture, residential areas, commercial sectors, industrial sites, and transportation systems. Land use also pertains to the specific utilization of particular land areas, playing a crucial role in territorial planning. It encompasses transforming and modifying natural environments into built environments, such as settlements, as well as semi-natural habitats like fields, pastures, and managed forests. Human activities for agriculture, forestry, settlement, and pasture utilization are all part of land use. While the terms "land use" and "land cover" are often used interchangeably, their meanings differ significantly. Land cover refers to the observable physical features on the Earth's surface, including vegetation, water bodies,

deserts, ice, soil topography, man-made structures, and other elements (Turner et al., 1995). The identification and mapping of land cover are crucial for global monitoring studies, resource management, and planning activities. By establishing a baseline of land cover, it becomes possible to monitor changes over time and create thematic maps.

Regarding land cover changes, the literature distinguishes between two types: conversion and modification (Lambin et al., 2003; Turner et al., 1995). Conversion involves a complete replacement of one land cover type with another, while modification entails alterations in structure or function without a complete change in cover type. Modifications may involve changes in productivity, biomass, or phenology. Similarly, land use change can involve either conversion from one use to another, reflecting changes in the land use pattern, or modification of a particular land use, including changes in intensity or characteristic qualities. For example, a suburban forest may transition from its natural state to a recreational area while retaining the same land area. LULC conversion occurs through various means, such as deforestation, desertification, and agricultural intensification.

Driving forces refer to the causes or factors responsible for land use and land cover changes (Braimoh, 2004). Natural environmental processes, such as weather variations, landforms, topography, geomorphologic processes, volcanic eruptions, plant succession, soil types and processes, drainage patterns, and the availability of natural resources, contribute to land use changes. Human action driver factors encompass socioeconomic aspects, including demographics, social, economic, political, and institutional factors and processes. These factors involve population dynamics, changes in industrial structure, technology, family structures, market dynamics, public sector bodies, policies, rules, values, community organization, norms, and property regimes.

In a semantic distinction, three broad forces have been identified: human forces, mitigating forces, and proximate driving forces (Moser, 1996; Turner et al., 1990; Meyer & Turner, 1994; Plieninger et al., 2016). Another categorization by Coppin et al. (2004) includes the variability in land cover types, physical environments, socioeconomic activities, and cultural contexts associated with land use change. They classify driving forces into four categories: i) Demands placed on the land, such as population and affluence. ii) Intensity of land exploitation through technology. iii) Access to or control over land resources, involving the political economy. iv) Incentives that motivate individual decision-makers include political structure, attitudes, and values (Turner et al., 1995).

Various drivers of land use and land cover change have been identified in the literature. Deforestation, for example, can result from slash-and-burn cultivation, resettlement schemes, fuel wood gathering, conversion for cattle ranching, commercial logging operations, provision of infrastructure, and large-scale forest fires (Geist & Lambin, 2004). Land use and land cover changes significantly affect the socioeconomic aspects of communities. A community refers to a group of people living together in a shared environment, while a local community refers to a group residing in a specific geographical area (Samat et al., 2014). Socioeconomic impact refers to a community's response to these changes, encompassing positive and negative components. Understanding community perceptions is crucial for effective risk management and resource management strategies (Solomon, 2007). The socioeconomic impact study provides insights into the real situation of a community, their satisfaction levels, adaptation, and responses to change (Vedman & Rhoades, 2001). It helps raise awareness among the community about the magnitude and consequences of proposed developments or environmental changes. Furthermore, it assists planners, managers, policymakers, and researchers in predicting, monitoring, evaluating, and managing various conditions. Household surveys and socioeconomic monitoring play a vital role in assessing population status and monitoring satisfaction levels within local communities (Banerjee et al., 2002; Watmough et al., 2013).

Land use and land cover changes have profound implications for socioeconomic development. These changes are driven by a combination of natural environmental processes and human actions. Understanding the drivers of change and assessing their impacts on communities' socioeconomic conditions are crucial for effective resource management, planning, and sustainable development. Therefore this study is carried out to identify the drivers of land use change and assess the socioeconomic impact on the local community in Murum, Belaga, Sarawak.

2. Description of Study Area and Research Methodology

2.1 Study Site

The study was conducted in the Belaga District, located in the Hulu Rajang area, which is the second largest area in Sarawak, covering a total area of 19,403.27 km2. Belaga town serves as the central hub of the district. Specifically, the study focused on the Murum area (Figure 1), which spans a total area of 2,750 km2 or 275,000.00 ha. Belaga town falls under the administration of the Kapit District Council (MDK) and Kapit Resident Office, both located in Kapit town. Moreover, the Belaga District has a sub-district office responsible

for overseeing Sg. Asap. The Belaga District Office is led by a District Officer (DO), while the sub-district office of Sg. Asap is managed by a Sarawak Administrative Officer (SAO). There are two primary transportation options to reach Belaga town. One option is to use the water express, which travels from Sibu to Kapit and then from Kapit to Belaga, following the Rajang River. The journey takes approximately three hours from Sibu to Kapit and an additional two hours from Kapit to Belaga. The second route is by road via the Bintulu-Bakun highway, covering a distance of around 250 km from Bintulu Town to Belaga, with an estimated four-hour car ride. The Murum area includes all residential areas situated along the main road leading to the upriver of Murum and Linau. This encompasses Penan villages located at Seping River, Metalun River, Tegulang River, and Linau River. The villages along Seping River and Linau River were established either by the local community or logging companies. On the other hand, the villages along Metalun River and Tegulang River were constructed by the government to relocate the local community (resettlement) directly affected by the construction of the Murum Hydroelectric Dam in 2013.

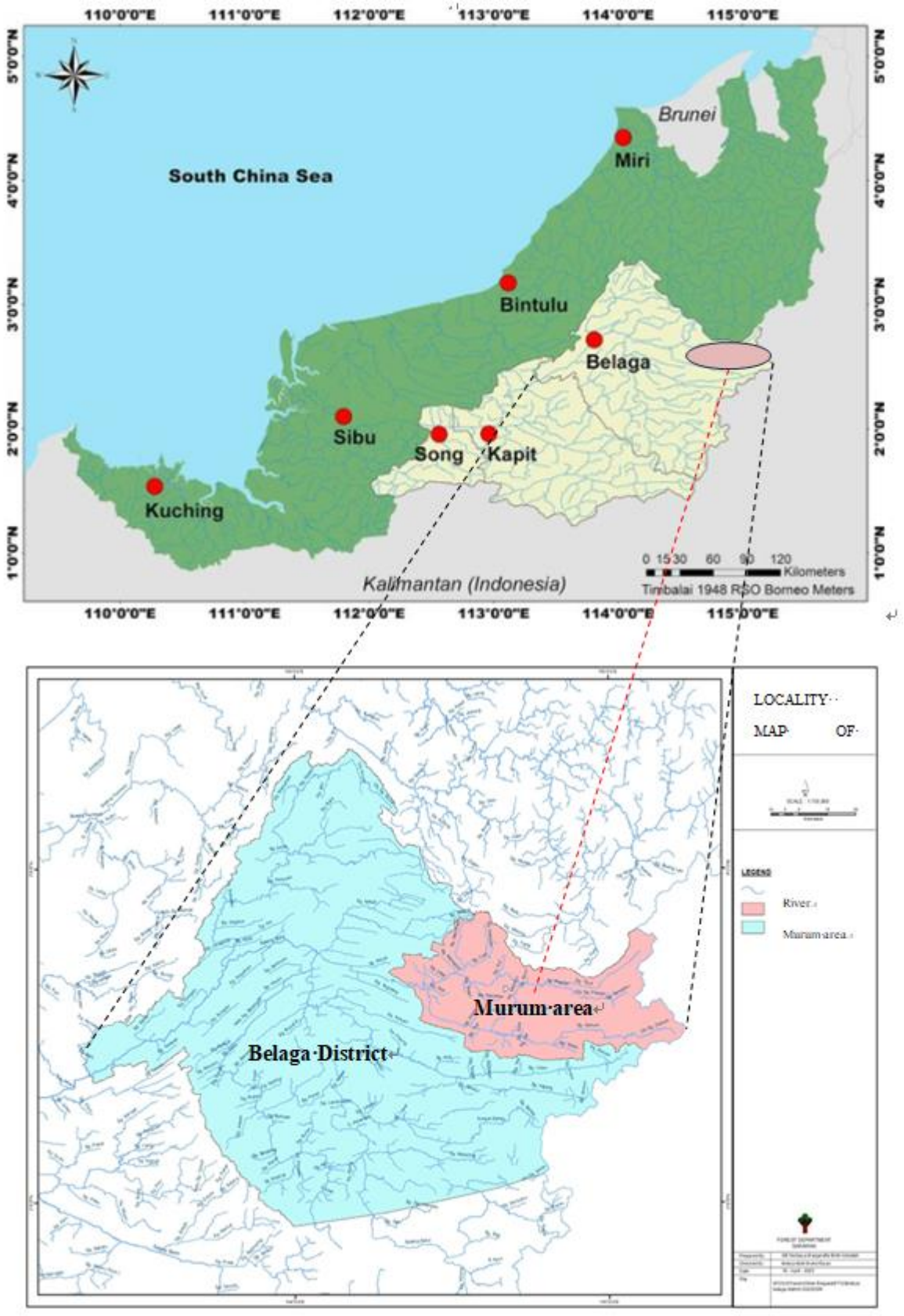

Figure 1. A map of Sarawak state showing the study area (Murum) in Belaga District.

The Metalun resettlement comprises four villages: Long Luar, Long Menapa, Long Tangau, and Long Singu. Situated further into the forest, this area is located upstream of the Murum main dam. It is estimated that the distance between the Metalun Resettlement area and the junction of the Bintulu-Bakun highway is approximately 90 km, which takes about 3-4 hours to drive via the plantation road. In the Tegulang resettlement area, there are two villages, namely Long Wat and Long Malim, situated near the main dam of Murum. The distance between Long Wat and Long Malim from the Bintulu-Bakun Highway is approximately 70 km when using paved roads, with an additional 10 km off-road. The Murum area was selected as the study area due to the rapid development occurring in this region. Consequently, various land use changes have taken place, including logging areas, forest plantations, oil palm plantations, dam construction, and more. These activities have resulted in extensive land use change, impacting not only the environment but also the communities residing in the surrounding areas.

2.2. Sample Procedures and Sample Size Determination

The population is understood as the group to which the research results are intended to apply (Frankel & Wallen, 2000). The population and number of individuals in each village are presented in Table 1. In this study, the population consisted of the Penan community residing in the Murum area. At the time of conducting the study, there were a total of 13 villages with an estimated population of approximately 3,258 individuals in the study area. The number of households per village was determined based on estimates provided by the district office, community leaders, and village heads (Maren Uma).

The survey randomly selected household heads as the preferred respondents. However, in cases where the household head was absent, another adult member (age >18 years) from the same household was chosen for the interview. It was assumed that they could comprehend the objectives of the study and provide relevant information based on the questionnaire. The number of respondents interviewed varied between 10% and 20% of the population in each village, depending on the availability and willingness of individuals to participate in the interviews.

Table 1. List of villages and number of populations

Area	Village	Population number/(Household Number)
Metalun	Long Menapa	243
	Long Luar	282
	Long Tangau	200
	Long Singu	321
Tegulang	Long Malim	270
	Long Wat	350
	Long Jeik	248
	Long Peran	279
Seping	Long Abit	148
Linau	Long Tanyit	273
	Long Kajang	161
	Long Lidem	181
	Lusong Laku	302
	Total	3,258

(Source: Belaga District Office, 2020)

2.3. Sample Size Selection

The sample size is a subset of the total population in the study, representing a certain number of respondents. It is selected to minimize costs, time, and effort. In this study, the sample size determination followed the technique developed by Krejcie and Morgan (1970). The sample size was calculated using the formula shown below:

Where; S = required sample size

x^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level

N = the population size

P = the population proportion (.5)

e = the degree of accuracy expressed as a proportion (.05)

Where, at a 95% confidence level with the degree of freedom 1, the chi-square value is (x^2) = 3.841, population size (N) = 3258, population proportion (P) = 0.5, degree of accuracy expressed as a proportion (e) = 0.05.

$$S = \frac{3.841*3285*0.5*(1-0.5)}{((0.05)^2*(3258-1)) + 3.841*0.5(1-0.5)}$$

$$S = \frac{3154.421}{8.1425 + 0.8702}$$

$$S = 349.99 \approx 350$$

Based on Table 1 and the calculation method of Krejcie and Morgan (1970), with a total population (N) of 3,258, the minimum sample size (S) required for selection is 350 respondents. However, in this study, a total of 511 household heads were interviewed. This represents approximately 15.68% of the total population in the study area. The distribution of respondents from different areas is as follows: 30.6% from Metalun Resettlement Site (Metalun River), 21.5% from Tegulang Resettlement Site (Tegulang River), 17.8% from the Seping River area, and 30.1% from the Linau River area (Table 2). Therefore, the number of respondents exceeds the minimum sample size specified by Krejcie and Morgan (1970).

Table 2. Sample size and percentage of the respondents

Area	Village	Population number	Sample size	Sample percentage (%)
Metalun	Long Menapa	243	32	6.3
	Long Luar	282	45	8.8
	Long Tangau	200	28	5.5
	Long Singu	321	51	10.0
Tegulang	Long Malim	270	41	8.0
	Long Wat	350	72	13.5
Seping	Long Jeik	248	45	8.8
	Long Peran	279	46	9.0
Linau	Long Abit	148	18	3.5
	Long Tanyit	273	40	7.8
	Long Kajang	161	20	3.9
	Long Lidem	181	22	4.3
	Lusong Laku	302	51	10.6
	Total	**3,258**	**511**	**100**

2.4 Data Collection

Data collection is a critical aspect of this study, involving the collection of two types of data: primary data and secondary data. Primary data was gathered through field surveys, while secondary data was obtained from printed documents such as reports, official records, and other relevant sources, including local district offices and Sarawak Energy Berhad (SEB).The field surveys utilized three methods: questionnaire forms for household

interviews, key informants for taking notes, and field observations. These methods were employed to gather comprehensive information on the research variables. Figure 2 illustrates the different elements of data collection employed in this study.

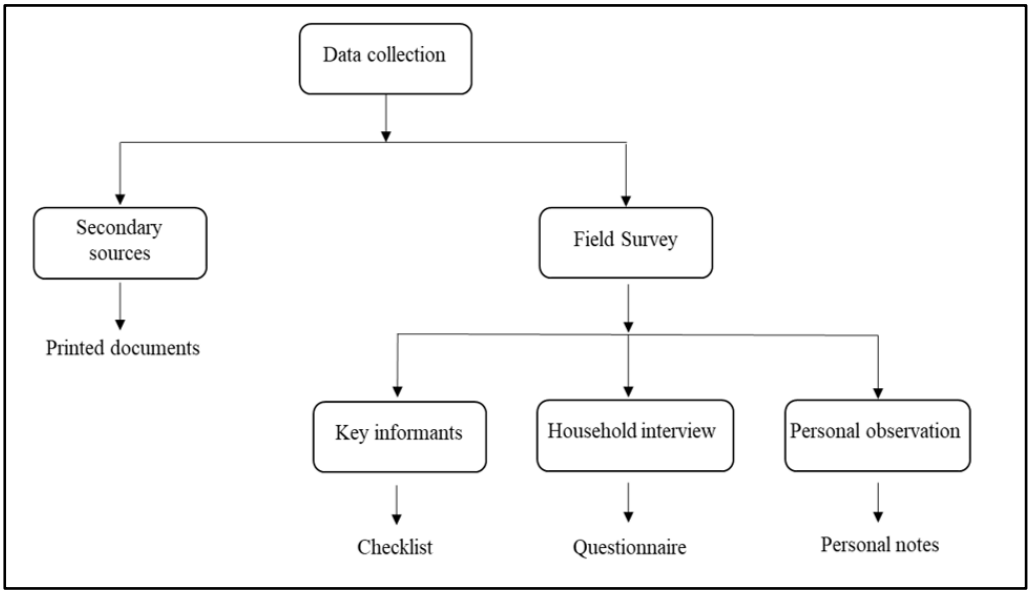

Figure 2. Elements of data collection for the socioeconomic study

2.5 Data Analysis

Data analysis involves the processing of raw data. In this study, the data collected from the questionnaires were analyzed using Statistical Package for the Social Sciences (SPSS) ver.23 and Microsoft Excel. SPSS software is specifically designed to handle the analysis of large and repetitive data quickly and efficiently, making it suitable for social and socioeconomic research (Kamarudin and Roslin, 1990). Two forms of data analysis were employed: descriptive statistical analysis and inferential analysis. Descriptive statistics were used to provide a description of the event under study. The study utilized descriptive statistics such as percentages and frequencies to describe the demographic background of the respondents, including gender, marital status, age, level of education, social participation, and economic status. The analysis included frequency, percentage, and mean scores to describe the demographic characteristics of the respondents. Additionally, frequency, percent, mean, and standard deviation (SD) were used to describe the satisfaction level of respondents towards infrastructure, their knowledge of land use change, factors contributing to land use change, economic status, and their opinions on socioeconomic upgrading challenges resulting from land use change. The table provides the five levels of mean scores as referenced in Table 3.

Table 3. Level of mean score

No.	Mean Score	Level
1	1.00 – 1.80	Very low
2	1.81 – 2.60	Low
3	2.61 – 3.40	Medium
4	3.41 – 4.20	High
5	4.21 – 5.00	Very high

(Source: Alias, 1999)

This study utilized inferential statistics, specifically Pearson (*r*) correlation and regression analysis. The Pearson correlation analysis was employed to examine the relationship between two metric variables: the dependent variable and the selected independent variable. The use of Pearson *r* because the data were normally distributed. To assess the statistical significance of the relationship between the variables, the t statistic was employed, with the population parameter symbolized as p (rho). The correlation coefficient ranges between -1 and +1, with its interpretation being influenced by the sign (+ or -) of the correlation. In this study, the significance level (α) was set at 0.05.

The study also employed Guilford's Rule of Thumb to determine the strength of correlations. According to this rule, a correlation coefficient (r) less than 0.20 indicates a very weak correlation, 0.20 to 0.40 indicates a weak correlation, 0.40 to 0.70 indicates a moderate correlation, 0.70 to 0.90 indicates a strong correlation and a correlation greater than 0.90 indicates a very strong correlation (Guilford, 1956).

Multiple regression analysis was conducted to identify the predictors of forest change in the study area. Regression models help in understanding the relationship between a dependent variable (forest change/loss) and a set of independent variables (causal factors). In other words, regression analysis provides insights into how well the independent variables explain the variation in the dependent variable.

The regression model can also identify a set of variables. The model for forest change is as follows the formula:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots\ldots B_n X_n$$

Forest change $= \alpha + \beta_1(\text{factor}_1) + \beta_2(\text{factor}_2) + \ldots\ldots\ldots\ldots \beta_n(\text{factor}_n)$

Y = DV, forest change

α = Intercept

β = Regression coefficient of factor

n = Number of variables

For impact analysis, descriptive analysis (using mean values) was conducted to describe the agreement or disagreement with the statements made by the respondents.

3. Results and Discussion

3.1 Demographic Profile

The demographic profile consisted of gender, age, marital status, and education level. Table 4 displays the demographic profile of the respondents in the study area. Out of the 511 respondents, a total of 464 (90.8%) were male, while 47 (9.8%) were female. This discrepancy can be attributed to the fact that the majority of household heads were male. However, there were a few female household heads, including single mothers. Furthermore, some female respondents participated in the study when their husbands or fathers were not present at home during data collection.

Table 4. Demographic profile of the respondents

Variables	**Attribute/Value**	**Frequency (n)**	**Percentage (%)**
Gender	Male	464	90.8
	Female	47	9.2
Age	18-24 years	23	4.5
	25-34 years	198	38.75
	35-44 years	212	41.49
	45-54 years	70	13.7
	55 years and above	8	1.57
Marital status	Single	20	3.91
	Married	485	94.91
	Divorced	6	1.15
Education level	No formal education	388	75.93
	Primary school	113	22.11
	Secondary school	10	1.96
	College/University	0	0

The age composition of the respondents played a pivotal role in this study, influencing their experiences, activities, and socioeconomic status. The data analysis revealed that the largest proportion of respondents, comprising 212 individuals (41.49%), fell within the age group of 35-44. Following closely were respondents aged 25-34, accounting for 198 individuals (38.75%). The remaining age groups, namely 45-54, 18-24, and 55

years and above, constituted 70 (13.7%), 23 (4.5%), and 8 (1.7%) respondents, respectively. The age group of 35 to 44 emerged as the backbone of both their families and the local community, with active breadwinners who shouldered the responsibility of supporting their families and assumed leadership roles within their community. Their contributions were significant in maintaining the social fabric and fostering overall development.

Regarding marital status, the survey findings indicated that the majority of respondents (485 or 94.9%) were married, while 20 (4%) were single. Only six (1.1%) of the respondents were divorced. Among the married respondents, the majority had spouses who were predominantly from the Penan community in the Murum area. It was observed that intermarriage with individuals from other tribes or Penans from different regions was relatively uncommon. This preference for spouses within their own community was influenced by cultural and lifestyle factors. Additionally, limited interaction with other communities stemmed from geographical constraints, as their settlement locations were distant from other community settlements.

More than three-fourths of the respondents (388 or 75.93%) had no formal education. Among the respondents, 113 (14.1%) had received primary education, while only 10 (12.6%) had attended secondary school. None of the respondents had pursued higher education at college or university. The majority of respondents were unable to attend school due to the considerable distance between their settlements and primary or secondary schools. Travelling to primary schools would take approximately three hours via logging roads while reaching secondary schools would require four to five hours. Moreover, transportation options were unreliable as they relied solely on logging company vehicles for travel. Consequently, a significant amount of their time was spent on the road, leaving them unable to fully concentrate on their studies once they arrived at school. Financial constraints further compounded the challenge of pursuing further education.

3.2 Ownership of Durable Items

The findings presented in Table 5 indicate that a majority of the respondents, 428 individuals (83.76%), were the owners of the houses they currently resided in. Conversely, 83 respondents (16.24%) reported that the houses belonged to their fathers or fathers-in-law. Furthermore, 345 respondents (67.51%) stated that they owned motorcycles, which served as their primary mode of transportation for commuting between different locations. The respondents highlighted the necessity of owning motorcycles for their daily mobility. In terms of communication devices, 335 respondents (65.56%) indicated that they owned handphones. Handphones were considered crucial for their communication with individuals from outside their immediate community. Moreover, handphones played a vital role in accessing information from the external world since live broadcasts, such as radio and television, were not readily available in their area. Other possessions reported by the respondents included 228 individuals (44.62%) who claimed ownership of a longboat, 179 (35.03%) who owned an outboard engine, 131 (25.64%) who possessed a television, 92 (23.87%) with a refrigerator, 62 (18.00%) with chainsaws, 62 (12.13%) with cars, 38 (7.44%) with washing machines, 21 (4.10%) with computers (laptops), and 12 (2.35%) with bicycles. These various belongings reflected the range of material possessions among the respondents, contributing to their daily lives and fulfilling their specific needs.

Table 5. Ownership of durable items by the respondents

Item	Frequency	Percentage (%)
House	428	83.76
Handphone	335	65.56
Motorcycle	345	67.51
Longboat	228	44.62
Outboard engine	179	35.03
Refrigerator	122	23.87
Television	131	25.64
Chainsaw	92	18.00
Car	62	12.13
Washing machine	38	7.44
Computer	21	4.10
Bicycle	12	2.35

Table 6 displays the average monthly income of the respondents. A substantial proportion of the participants, 206 individuals (40.31%), reported earning below RM500 per month. This group experienced income instability due to their self-employment status, engaging in activities such as collecting non-timber forest produce or participating in small-scale farming. The lack of a steady income was primarily attributed to their dependence on traditional practices to generate earnings. Specifically, they relied on gathering non-timber forest products like rattan, wild vegetables, wild animals, and fish for their livelihood. This reliance on uncertain income sources significantly contributed to the prevalence of poverty among this population. On the other hand, 165 respondents (32.29%) reported earning between RM501 and RM1,000, while 112 individuals (21.92%) earned between RM1,001 and RM1,500. These respondents primarily worked in oil palm plantations, logging companies, and government sectors. Furthermore, 23 respondents (4.50%) had an income ranging from RM1,501 to RM2,000, while only 5 individuals (0.98%) reported earning an average income exceeding RM2,001. Individuals with higher incomes were typically involved in business or held positions as community leaders.

Table 6. Average monthly income of the respondents

Income	Frequency	Percent (%)
RM500 and below	206	40.31
RM501-RM1,000	165	32.29
RM1,001-RM1,500	112	21.92
RM1,501-RM2,000	23	4.50
RM2,001 and above	5	0.98

3.3. Source of Income

Based on the data presented in Table 7, it is evident that respondents derived their income from various sources. Approximately 237 individuals (46.38%) reported wages as their primary source of income. This category includes individuals employed in oil palm plantations, logging companies, construction sites, government sectors, and other forms of employment. It is important to note that some respondents who were also engaged in non-timber forest product collection, oil palm plantations, logging, or construction work considered wages as an additional income source. Moreover, 436 respondents (81%) mentioned that they earned income through collecting non-timber forest products. This group comprised individuals involved in activities such as non-timber forest product collection, oil palm plantations, logging, and construction work. They relied on the collection and sale of non-timber forest products as a supplementary means of generating income.

Furthermore, 330 respondents (64.58%) reported that their income was derived from creating and selling handicrafts. This indicates that a significant number of respondents engaged in crafting activities, producing various handicraft items for sale. In contrast, only 51 individuals (9.98%) mentioned agricultural activities as their source of income. These respondents were involved in agricultural practices as a means of earning money.

It is worth noting that financial assistance also served as an income source for some respondents, although specific details regarding the nature and extent of this assistance were not provided in the available information.

Table 7. Frequency and percent of respondents based on sources of income

Source of income	Frequency	Percent (%)
Wages	274	53.62
Collect forest produces	436	85.32
Handicraft	330	64.58
Agriculture	51	9.98

3.4. Satisfaction with Provided Facilities

This section focuses on discussing the level of satisfaction among respondents regarding the facilities available in their area. The study assesses eight key facilities: housing, clean water sources, electricity supply, educational facilities, healthcare facilities, communication accessibility, recreational facilities, and road accessibility.

3.4.1 Accommodation

A house or accommodation is a basic human need for protection, comfort and to carry out family activities. The design, materials, size and location of a house depended on each individual's financial abilities and tastes. Table 8 shows that 244 (47.75%) respondents were satisfied with the house or accommodation they currently own. A total of 146 (28.57%) respondents were neutral, followed by 62 people (12.13%) who were dissatisfied, while 59 people (11.55%) were very satisfied with their houses. None of the respondents were very dissatisfied during the study.

Table 8. Satisfaction level of respondents toward accommodation and infrastructure development in their residential area

Item	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean Score
	Frequency/ Percentage (%)					
House/ accommodation	0	62(12.1)	146(28.6)	244(47.8)	59(11.5)	3.59
Clean water source	0	73(14.3)	223(43.6)	185(36.2)	30(5.9)	3.34
Electricity supply	0	26(5.1)	142(27.8)	271(53.0)	72(14.1)	3.76
Education facility	0	67(13.1)	167(32.7)	214(41.9)	63(12.3)	3.53
Road accessibility	0	86(16.8)	238(46.6)	175(34.3)	12(2.3)	3.22
Health facility	0	73(14.3)	251(49.1)	172(33.7)	15(2.9)	3.25
Sport/recreational facility	0	22(4.3)	134(26.2)	273(53.4)	82(16.1)	3.81
Communication facility	0	60(11.7)	236(46.2)	204(39.9)	11(2.2)	3.32

Overall, the respondents expressed a high level of satisfaction with the housing facilities, as indicated by a mean score of 3.59. The study revealed that the majority of houses were in good condition, with the exception of the longhouse in the Long Jeik area, which appeared somewhat rundown. It should be noted that this longhouse had been converted from the staff quarters of a logging company. In contrast, most settlements were observed to be well-maintained, particularly in the Metalun and Tegulang areas. The current houses in these settlements were more spacious and provided separate rooms for family members. Respondents mentioned that the comfortable size of these houses (133 m^2) was suitable for their lifestyle.

3.4.2 Clean Water Source

Access to clean water is essential for various daily activities such as drinking, cooking, and hygiene. It can be obtained from rivers, rain, and underground sources. Clean water ensures good health and enhances the quality of life. According to the findings presented in Table 8 a significant number of respondents (223 or 43.64%) expressed a neutral stance regarding their satisfaction with the availability of a clean water source. Meanwhile, 185 respondents (36.20%) reported being satisfied, while 73 respondents (14.29%) indicated dissatisfaction. Interestingly, 30 respondents (5.87%) reported being very satisfied, while none expressed being very dissatisfied.

In most Penan settlements in Murum, the primary source of water supply was gravity-fed from nearby hills. Mini water dams were constructed to channel water through pipes to the longhouses. However, the respondents still expressed a desire for improvements in the water supply system. They frequently experienced water disruptions and issues with water quality, particularly during heavy rainfall when the water would become muddy. Addressing these issues would often take several weeks due to limited funds and resources. In the meantime, they had to rely on rainwater, which was scarce during the dry season. Overall, while the respondents recognized the existing water supply infrastructure, they highlighted the need for ongoing improvements to ensure consistent access to clean water throughout the year.

3.4.3 Electricity Supply

Access to electricity is crucial for powering various appliances and devices in households, including light bulbs, machines, refrigerators, and entertainment devices. It can be obtained from different sources such as solar panels, hydroelectric dams, dynamos, and generators. The availability of electricity is an important criterion used to

evaluate the socioeconomic development of an area. According to Table 8, more than half of the respondents (53.03%) expressed satisfaction with the electricity supply in their area. A significant portion of respondents (27.79%) reported a neutral stance, while 14.09% stated being very satisfied, and 5.09% expressed dissatisfaction. None of the respondents reported being very unhappy during the study. In Seping, Metalun, and Tegulang areas, the villages enjoyed a 24-hour electricity supply. Seping and Tegulang obtained electricity from the SEB GRID provided by Sarawak Energy Berhad, while Metalun relied on generator sets directly provided by Sarawak Energy Berhad (SEB). The availability of 24-hour electricity positively impacted the residents, enabling them to store perishable items in refrigerators and save money since the SEB GRID was provided free of charge. Previously, they had to purchase fuel for their own generator sets. In the Linau settlement area, villages in Lusong Laku, Long Tanyit, and Long Lidem were supplied with electricity through solar panels, which provided continuous power based on their consumption capacity. However, the settlements in Long Abit and Long Kajang still relied solely on their own generators for electricity and did not have access to a 24-hour supply. Additionally, the cost of fuel for generators was expensive in these areas. while the majority of respondents expressed satisfaction with the electricity supply, there were variations in the source and continuity of electricity across different settlements. Improving access to reliable and affordable electricity remains a priority in ensuring better living conditions and further socioeconomic development in these areas.

3.4.5 Education Facility

Regarding education facilities, the majority of respondents expressed varying levels of satisfaction. Approximately 41.88% reported being satisfied, 32.68% remained neutral, 13.11% expressed dissatisfaction, and 12.33% were very satisfied. None of the respondents reported being very dissatisfied during the study. Primary schools were observed in the study areas, namely SK Metalun, SK Tegulang, and SK Lusong Laku. The presence of these schools was seen as an improvement, making it easier for parents to send their children to school compared to when there was only a school in Lusong Laku. The proximity of the schools also allowed parents to actively participate in school activities. However, it was noted that most children did not continue their education beyond primary school. This was primarily due to the lack of access to secondary schools, which were located far away, and financial constraints that hindered transportation arrangements.

3.4.6 Road Accessibility

In Table 8, it is evident that the majority of respondents, 238 (46.58%), remained neutral regarding their views on road accessibility. Additionally, 175 (34.25%) respondents expressed satisfaction, 86 (16.83%) were dissatisfied, and 12 (2.35%) were very satisfied. None of the respondents reported being very dissatisfied. These responses indicate that there has been limited improvement in road accessibility in the area. Roads serve as vital routes for residents to commute to work and send their children to school, as well as connect them with the outside world. Therefore, the development and maintenance of roads are crucial to uplift the socioeconomic status of the local community and ensure they are not left behind in the nation's progress.

3.4.7 Health Facility

Table 8 illustrates that nearly half, 251 (49.12%) respondents, provided a neutral response regarding the available health facilities in their area. Of the respondents, 172 (33.66%) expressed satisfaction, while 73 (14.29%) were dissatisfied. Only 15 (2.94%) respondents reported being very satisfied, and none were very dissatisfied. The study revealed the presence of only one clinic in the study area, located in the village of Lusong Laku. The distance between Lusong Laku and other villages in the Linau area spans approximately 50 to 100 kilometers, with a travel time of 2 to 5 hours via the logging road. The nearest clinics are located in Belaga town and Sg. Asap. For the Metalun community, the distance to reach these clinics is approximately 100 kilometers via the logging road and 50 kilometers via the paved road. Although the clinics were perceived as comfortable, the primary concern was the distance and time required to access medical consultation, especially during emergencies. Financial constraints also posed a challenge as transportation costs were exorbitant. Consequently, individuals with limited resources faced difficulties in obtaining timely medical attention, resulting in the loss of lives. It is crucial for the government to ensure that all Malaysians have access to quality healthcare services throughout the country.

3.4.8 Communication Facility

Regarding information dissemination, smartphones, television, and radios were the primary mediums available. The study area had internet access known as "ConnectMe," which provided smartphones approximately five months before the study. However, access was limited to watching Indonesian satellite channels on television and listening to Iban radio broadcasts, as these were the only available options in the area. Table 8 indicates that almost half of the respondents, 236 (46.18%), expressed neutrality regarding their communication accessibility.

Meanwhile, 204 (39.92%) respondents reported satisfaction, 60 (11.74%) were dissatisfied, and 11 (2.15%) were very satisfied. None of the respondents expressed high dissatisfaction with the level of communication during the interviews.

3.4.9 Sport/Recreational Facility

Sports and recreational facilities, such as football fields, *takraw* courts, and futsal courts, were available in all villages within the study area. These facilities were established to meet the recreational needs of the local community. Additionally, sports tournaments were organized at these venues, providing an arena for young people to showcase their skills and foster friendships among individuals from different villages. The study findings revealed that more than half of the respondents, 273 (53.42%), expressed satisfaction with the sports and recreational facilities in their area. Conversely, 134 (26.22%) remained neutral, 82 (16.05%) were very satisfied, and 22 (4.31%) were dissatisfied. None of the respondents reported being very dissatisfied with the provided sports facilities. Table 9 presents the mean scores for each facility based on rank and satisfaction level. Four types of infrastructure received high rankings: sport/recreational facility (3.81), electricity supply (3.76), house/accommodation facility (3.59), and education facility (3.53). Clean water source (3.34) and communication facility (3.32) were ranked as a medium, while health facility (3.25) and road accessibility (3.22) received the lowest ranks. None of the facilities had very high or very low mean scores.

Table 9. Infrastructure satisfaction level, mean score and ranking

No. item	Infrastructure	Mean score	Level	Rank
D7	Recreational facility	3.81	High	1
D3	Electricity supply	3.76	High	2
D1	House/accommodation facility	3.59	High	3
D4	Education facility	3.53	High	4
D2	Clean water source	3.34	Medium	5
D6	Communication accessibility	3.32	Medium	6
D5	Health facility	3.25	Low	7
D8	Road accessibility	3.22	Low	8

3.5 Causes of LULC Change

The primary focus of all countries worldwide is to promote development in order to enhance the quality of life for their people. Governments are intensifying efforts in industrial development, commercial agriculture, and other sectors to create stronger economic opportunities and achieve these objectives. As a result, certain suitable areas have been cleared to make way for high-impact economic projects. Table 10 presents the mean scores for factors contributing to forest changes based on ranks and satisfaction levels. Among the six factors listed, the development of hydroelectric dams obtained the highest mean score of 4.28, followed by oil palm plantations (4.23), logging (4.18), government policy (4.17), and the development of planted forests (3.99). Agricultural activities received the lowest rank, with a mean score of 3.85.

The launch of SCORE as a development zone in the central region of Sarawak represents a government initiative aimed at bolstering the state's economy. Numerous large-scale projects have been implemented in this area to create employment opportunities and generate income for the community and the entire state. Notably, the construction of the Bakun and Murum Dams stands out among these mega projects. The impact of these two hydroelectric dams on the forest landscape, environment, and socioeconomics of the local population has been substantial, as highlighted by Supriya and Aggarwal (2019). The creation of reservoirs for these dams has resulted in the submergence of forest areas and agricultural lands to generate electricity. The analysis of remote sensing images during the study period revealed a significant increase in water coverage, amounting to 200% or approximately 200,000 hectares. This data clearly indicates that hydroelectric construction is the primary driver of land use change in the Belaga area, a finding consistent with the respondents' views (Table 10), as they identified hydroelectric construction as the leading cause of land use change in the region.

Table 10. Frequency, percent, mean score and ranking that cause LULC changes

Cause of land use change	Frequency and percent (%) of respondents based on their responses					Mean Score	Rank
	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree		
Logging	0.00	0.00	44(8.6)	329(64.4)	138(27.0)	4.18	3
Development of planted forest	0.00	0.00	85(16.6)	345(67.5)	81(15.9)	3.99	5
Development of oil palm plantation	0.00	0.00	49(9.6)	294(57.5)	168(32.9)	4.23	2
Development of hydroelectric dam	0.00	0.00	46(9.0)	277(54.2)	188(36.8)	4.28	1
Agricultural activities	0.00	0.78	134(26.2)	322(63.0)	55(10.8)	3.85	6
Government policy	0.00	0.00	31(6.1)	362(70.9)	118(23.1)	4.17	4

The study identifies the establishment of oil palm plantations as the second leading cause of land use change in the research area. This finding is consistent with previous studies conducted by Azhar et al. (2021), Afawubo et al. (2019), Gaveau et al. (2016), Wilms-Posen et al. (2014), and Gunarso et al. (2013). Satellite images revealed an increase in the infrastructure and area dedicated to oil palm plantations, expanding from 26,488.60 hectares to 36,248.9 hectares. Therefore, most respondents consider oil palm plantations to be the primary driver of land use conversion in the study area.

Logging activities are perceived by respondents as the third factor contributing to land use change. Logging has been a significant sector in Sarawak since the 1970s, with annual returns to the state reaching around 6 to 7 billion ringgit. In the study area, ten active logging licenses contribute an estimated 260,000 cubic meters of logs annually. The Murum area alone accounts for approximately 10% of the state's total timber output. The extensive clearance of forests for logging, coupled with the development of infrastructure such as veneer factories, log ponds, logging camps, and logging roads, has significantly altered the forest landscape.

Government policies are considered the next major factor influencing land use change. Wang et al. (2012) identified government policy and management as key driving forces behind land use and land cover changes. Policies determine the direction of development and often involve clearing areas for various projects such as buildings, roads, and commercial agriculture. As a result, government policy plays a crucial role in shaping land use changes.

Forest plantations rank fifth among the factors affecting land use change in the study area. These plantations have been established to support timber production as natural forests dwindle. Fast-growing species, including exotic ones such as Acacia, Eucalyptus, Falcataria, and native species like Neolamarckia, are planted in these forest plantations. The State government has granted 54 licenses for forest plantations, resulting in the conversion of 554,000 hectares of natural forest into plantations. The aim is to reach a target of 1 million hectares of forest plantations, which would inevitably lead to further conversion of natural forests. Agriculture is identified as the last factor contributing to land use conversion in the study area, albeit with a lesser impact compared to other commercial activities. Shifting cultivation, specifically hill paddy planting has been practiced for many years. Agricultural activities that convert forests into staple food crops like rice, vegetables, and fruits are among the earliest causes of land use change. However, respondents consider these activities to have a relatively insignificant impact compared to land conversion for oil palm plantations, dams, forest plantations, and logging areas. Additionally, development pressures for infrastructure construction, settlement expansion, and population increase are also recognized as factors driving land use change. Forests and surrounding areas are cleared to make way for infrastructure projects and socioeconomic development of the local population. These findings align with studies conducted by Geist & Lambin (2002), Etter et al. (2006), Miyamoto et al. (2013), Sarmin et al. (2017), and Miyamoto (2020).

3.6 Correlation Analysis of Land Use and Land Cover Change and Causes

The extent of the relationships between the scale of forest change and various causes was assessed using Pearson product-moment correlation coefficients. The correlation results are presented in Table 11. It was observed that

all variables exhibited a positive correlation with forest change in the study area. Four variables, namely the development of planted forests (r=0.609), the development of hydroelectric dams (r=0.591), the development of oil palm plantations (r=0.584), and government policies (r=0.484), demonstrated a moderate correlation with forest change (Guilford, 1956). On the other hand, logging (r=0.298) and agricultural activities (r=0.296) exhibited weak relationships with forest change (Guilford, 1956). This correlation analysis also provided the p-values for five variables: logging (0.000), development of planted forests (0.005), development of oil palm plantations (0.004), development of hydroelectric dams (0.003), and government policies (0.002). These p-values were found to be less than 0.01, indicating a significant relationship between these variables and forest change at the 0.01 level of significance. However, the p-value for agricultural activities was 0.276, which is greater than 0.01, suggesting that this variable does not have a significant relationship with forest change at the 0.01 level.

Table 11. Correlation of forest change scale and cause of variables

Variables	**Coefficient of correlation**	**P value**
Logging	.298**	0.000
Development of planted forest	.609**	0.005
Development of oil palm plantation	.584**	0.004
Development of hydroelectric dam	.591**	0.003
Agricultural activities	.296**	0.276
Government policies	.484**	0.002

**. Correlation is significant at the 0.01 level (2-tailed).

This correlation test also showed the P value for five variables, namely logging (0.000), development of planted forest (0.005), development of oil palm plantation (0.004), development of hydroelectric (0.003) and government policies (0.002) less than 0.01. This means that these five variables have a significant relationship with forest change at 0.01 level, while the p-value for agricultural activity was 0.276 > 0.01, indicating that these variables do not have a significant relationship with forest change at 0.01 level.

3.7 Regression Analysis of LULC Change and Cause Variables

The results of the ANOVA test for the dependent variable and the independent variables are presented in Table 12. This analysis aims to examine the relationship between the dependent variable and several independent variables using regression modelling, as described earlier. From the coefficient table, it is observed that only four variables significantly contribute to the equation model. These variables are logging activities ($p = 0.000$), development of oil palm plantations ($p = 0.000$), development of hydroelectric dams ($p = 0.000$), and agricultural activities ($p = 0.012$). On the other hand, the development of planted forests and government policies are found to be insignificant, with p-values of 0.231 and 0.071, respectively. Based on the model, a one-unit change in logging development, development of oil palm plantations, and development of hydroelectric dams is associated with an increase of 0.135, 0.337, and 0.485 units of forest loss, respectively. Conversely, a one-unit increase in agricultural activities is linked to a decrease of 0.059 units of forest loss. The analysis indicates that hydroelectric dam development has the highest contribution to deforestation in the study area, as evidenced by its standardized Beta coefficient.

Table 12. Multiple Regression output for the analysis of LULC change and causes.

Multiple Regression output	
Multiple R	0.88
R^2	0.774
Adjusted R^2	0.771
Standard Error	0.262

ANOVA

	df	Sum of Squares	Mean Square
Regression	6	118.167	19.695
Residual	504	34.475	0.068
F = 287.923		Significance of F = 0.000	

COEFFICIENT TABLE (VARIABLES IN THE EQUATION)

Variable	b	SE[b]	Beta (β)	T	Significance of T
Constant	0.528	0.117		4.499	0
Logging	.130	.030	.135	4.377	.000
Development of planted forest	.032	.027	0.033	1.198	.231
Development of oil palm plantation	.303	.030	.337	10.244	.000
Development of hydroelectric dam	.430	.029	.485	14.770	.000
Agricultural activities	-.055	.022	-.059	2.524	.012
Government policies	.050	.028	.011	1.810	.071

With the value of variable constant = 0.528, coefficient regression variable logging (x1) = 0.135, development of oil palm plantation (X2) = 0.337, development of hydroelectric dam (X3) = 0.485 and agricultural activities (X4) = -0.05. From the regression result, the equation for forest change is as follows;

Forest Change (Y) = 0.528 + 0.135 (logging) + (0.337) (oil palm) + (0.485) (hydro dam) + (-0.059) (agricultural).

Y = 0.528 + 0.135 (logging) + 0.337(oil palm) + 0.484(hydro dam) - 0.059 (agricultural)

4. Conclusion

Based on the findings, the hydroelectric dam project emerged as the most significant driver of deforestation in the study area, followed by oil palm plantations, logging activities, planted forests, government policies, and agricultural activities. These results highlight the prominent role played by large-scale infrastructure projects and commercial ventures in driving land use change and forest loss. Furthermore, when considering the satisfaction level of the infrastructure provided in the area, the respondents ranked sport/recreational facilities as the most important, indicating the growing importance of leisure and recreational activities for the community. This was followed by electricity supply, housing/accommodation, education facilities, clean water sources, communication facilities, health facilities, and road accessibility. These rankings reflect the progress made in terms of development in the study area. However, it is evident that several aspects of infrastructure, such as road accessibility, health facilities, communication facilities, and clean water sources, still require improvement. These findings suggest that while development efforts have brought positive changes to the rural communities' socio-economic status, there is still room for further development and investment in certain areas to meet the needs and expectations of the local population. In conclusion, the study highlights the significant impact of specific causes, particularly the hydroelectric dam project, on deforestation in the study area. It also emphasizes the importance of addressing infrastructure deficiencies to ensure the overall well-being and quality of life for rural communities. By striving for sustainable development and addressing the shortcomings identified, it is possible to strike a balance between economic progress and environmental conservation in the study area.

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