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Scrutinizing Crop production from Ayamaru Timur District, Maybrat-Southwest Papua Province; Land-Use and Agribusiness Cycles' Potential

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ABSTRACT

Understanding the land-use potential in Ayamaru Timur District, Maybrat-Southwest Papua Province provides insights into optimizing agricultural activities to boost local economies and ensure sustainable development in the region. The aims of study are to explore the land-use potential and agribusiness cycles in Ayamaru Timur District by analysing physiographic characteristics, soil types, and existing land utilization patterns, the research identifies opportunities and challenges for optimizing agricultural productivity. Methods employed are field observation in on land-uses of farming land and surveys by interviewing key farmers using open structural questionnaire. Samples of soils then analysed in the Soil Laboratory of Agriculture Faculty, Papua University for further syntheses. Parameters measured are physiographic of lands, soil types and suitability, crop types and actual and potential suitability, types of crops including production and productivities, revenue, cost and added to this income generation. Major challenges are recorded for future policy development. Data presented by statistical descriptives and tabulations. The finding revealed that land suitable ranges from marginal to moderately suitable. Potential land-uses are agroforestry crops, food crops, and plantation crops. Non-agricultural land (1%), followed by agroforestry crops, food and plantation crops are actually useable by farmers. Crops grown are tubers, vegetables, non-tuber crops and legumes. Revenues earned firstly from vegetables (IDR 1,890,476), followed by tuber crops (IDR 926,506), Nuts (IDR 486,170), and non-tubers (IDR 420,000). In conclusion, vegetables, tuber and non-tuber crops, including legumes have potential for agricultural development.

INTRODUCTION

In today's context of growing global population and increasing demand for food and resources (Corlett, 2020; Sheppard et al., 2020; Indrawan et al., 2019), understanding how land is used effectively and efficiently is critical. Land-use potential involves assessing the productive capacity of land for agricultural, industrial, or ecological purposes, while agribusiness cycles (IFAD, 2019) refer to the recurring patterns of growth, stagnation, and decline within the agricultural economy. Together, these two concepts are integral to addressing food security, economic development, and environmental sustainability. Land is a finite resource and a critical factor in agricultural production, serving as the foundation for food, fibre, and biomass generation. On the other hand, agribusiness cycles describe the periodic fluctuations in agricultural economic activities, influenced by factors such as market demand, input costs, climate variability, and technological advancements (Adnan et al., 2018; Khan et al., 2021; Rahman et al., 2021; Ugochukwu & Phillips, 2018). These cycles consist of phases of expansion, peak, contraction, and trough, affecting farm incomes, investment decisions, and land management practices.

Global Land-Use Trends highlights 38% of the world's land is used for agricultural purposes, yet land degradation affects over 30% of global agricultural land (Roadmap, 2022). Approximately 33% of the Earth's soils are moderately to highly degraded due to erosion, nutrient depletion, and poor management. Land-use efficiency varies widely between countries, with developed nations achieving up to 60% land productivity, while many developing countries achieve less than 40%. The land-use potential of any given area depends on a variety of factors, including soil quality, climate, water availability, and infrastructure. In the face of climate change, urbanization, and competing demands for land, unlocking land-use potential has become increasingly challenging. Land overexploitation often leads to decreased agricultural productivity and environmental degradation (Paul et al., 2018; Rivai & Anugrah, 2016). Agribusiness cycles create uncertainty for farmers and stakeholders, leading to income volatility and inconsistent land-use strategies. Climate variability and market changes further complicate the alignment of land-use potential with agribusiness cycles. Understanding these interrelationships makes for better decisions, balancing land-use optimization with the economic realities of agribusiness cycles.

Agricultural production globally fluctuates in 5–10year cycles, influenced by climate, demand, and price shocks. Price volatility of agricultural products has increased by 40% over the past two decades, primarily due to climate change, pandemics, and global supply chain disruptions. In India, for example, farm income experiences significant variability, with peak incomes during bumper harvests followed by stagnation during market downturns. The global agribusiness sector is valued at approximately $5 trillion annually. Over 60% of rural households in developing countries rely on agriculture for their livelihoods. Land-use optimization could increase global agricultural productivity by up to 20% without expanding farmland, reducing deforestation and conserving ecosystems. Inappropriate land use contributes to 25% of global greenhouse gas emissions, primarily through deforestation, soil degradation (Pareja-Sánchez et al., 2017; Limeneh et al., 2022), and unsustainable farming practices (Hutabarat, 2017; Hanafiah et al., 2022). Aligning land use with agribusiness cycles can help improve resource efficiency and reduce environmental impacts.

The study of "Land-Use Potential and Agribusiness Cycles" aims to explore and syntheses the dynamic relationship between land utilization and the cyclical nature of agricultural businesses. The novelty of this research highlights the opportunities and challenges in maximizing land productivity while synchronizing with the fluctuations of agribusiness cycles. This study serves as a foundation for aligning land management strategies with agribusiness growth, ensuring long-term food security and economic development.

RESEARCH METHODOLOGY

This research was conducted in Maybrat Regency, encompassing district of Ayamaru Timur. Sample villages were selected based on the diversity of biophysical existences such as soil, agricultural production, raining seasons, and socio-structural conditions in the field such as ethno-farming, and land-use ownerships. Ayamaru District (referred to here as the parent district) is located at the coordinates 01˚16'38.7" South Latitude and 132˚11'156.9" East Longitude, with an area of 254.91 km² (BPS-Maybrat, 2022; Dinas Pertanahan Kabupaten Maybrat, 2022). It encompasses one urban village and 24 rural villages.

The research employed a descriptive method using survey techniques (Rao, 2018). Surveys involved visits to sample locations and farmers targeted for this study. During these visits, several important aspects were collected and analysed, including soil types and their distribution, descriptions of land conditions, farming profiles, as well as strategic issues regarding agricultural development constraints. Communities within each district and village were considered subjects due to their status as customary landowners and their direct involvement in land-use activities. The research objects are related to aspects of soil, agriculture, plantations, livestock, fisheries, and forestry (BPS-Maybrat, 2022; Kab-Maybrat, 2023).

Table 1. Physiography, Area, and Percentage Distribution in East Ayamaru District

No	Physiography	Area (km²)	% of District	% of Regency
1	Gently Sloping Hills	282.41	66.06	0.05
2	Undulating-Wavy Terrain	35.69	8.35	0.01
3	Lake	10.78	2.52	0.00
4	Flat Terrain	12.31	2.88	0.00
5	Hills/Mountains	86.34	20.20	0.02
	Total	427.52	100	0.08

Source: The Data is derived from DEM (Digital Elevation Model) with 90-meter Resolution and Landsat Imagery, 2010.

Descriptive statistical data analysis is used to describe the characteristics of data without making broader conclusions. Quantitative data includes variables such as production, income land area. Qualitative data includes categories such as crop types and agroecological zones. Data visualization for qualitative data done by using a frequency table which is used to display the distribution of categories (Snedecor & Cochran, 1989; Sagrim et al., 2015; Rangel & Diniz-Filho, 2013).

RESULTS AND DISCUSSION

Physical Land Conditions

The physiographic condition of East Ayamaru District is categorized as a highland and hilly area, with slopes ranging between 41–60%, classified as very steep. The district has a character with elevations between 259–397 meters above sea level. A summary of the district's physiographic features, including flat, undulating, rolling, hilly, or mountainous terrain, is presented in Table 1.

Describes the type of landforms or terrain within the district. Categories include gently sloping hills, undulating to rolling terrain, lake areas, flat areas, and hilly/mountainous regions (BPS-Maybrat, 2022). The percentage of each physiographic type relative to the total area of East Ayamaru District (427.52 km²). The percentage of each physiographic type relative to the total area of the regency where the district is located. This percentage indicates how significant the physiographic type is on a broader administrative scale. Covers 282.41 km², which is the dominant physiographic feature in the district, accounting for 66.06% of the district's total area. This feature contributes to only 0.05% of the total regency area, indicating that gently sloping hills are more concentrated within this district. Covers 35.69 km², making up 8.35% of the district's area. This terrain contributes 0.01% of the total regency area, reflecting its limited extent. Lake areas occupy 10.78 km², representing 2.52% of the district's area. The lake area contributes 0.00% of the regency's total area, showing it is not a significant feature on the broader scale. Flat areas span 12.31 km², which is 2.88% of the district's area. Similar to lakes, flat terrain accounts for only 0.00% of the regency's total area, highlighting its localized distribution. This terrain covers 86.34 km², or 20.20% of the district's area. It contributes 0.02% of the total regency area, indicating moderate significance within the broader landscape. The district spans a total area of 427.52 km², with 100% of its physiography accounted for across these categories.

Gently sloping hills dominate the district, covering the majority of the land area, making it suitable for moderate land-use activities such as agriculture, grazing, or settlements. While lakes and flat areas are less prominent, they may hold significance for specific ecological or economic purposes, such as fisheries or water resource management. These regions, covering 20.20% of the district, likely present challenges for accessibility and development but may also serve as important conservation zones or sources of biodiversity. This land type is moderately represented and could indicate transitional zones between flat and hilly areas. The data emphasizes the need for tailored land-use planning to align with the unique physiographic characteristics of East Ayamaru District, ensuring sustainable development and optimal utilization of its diverse terrain.

Table 2. Soil Types, Area, and Percentage Distribution in East Ayamaru District

No	Soil Type	Area (km²)	% of District	% of Regency
1	Entisol	23.09	4.88	0.00
2	Inceptisol	88.24	20.64	0.02
3	Oxisol	316.20	73.96	0.06
Total	–	427.53	99.48	0.08

Source: Field Survey, RePPPRoT 1986, and Landsat Imagery, 2010

Table 3. Types of Crops and Land Suitability Classes

No	Crop Type	Actual Suitability Class	Potential Suitability Class
1	Corn	S3wa	S3wa
2	Sweet Potato	S3nr	S2wa
3	Taro	S2rc	S2rc
4	Peanut	S3wa	S3wa
5	Mustard Greens	S3wa	S3wa
6	Tomato	S3wat	S3wat
7	Rambutan	S3nr	S2t
8	Durian	S3nr	S2t
9	Cocoa	S3nr	S2t
10	Teak	S3wa	S3wa

Source: Data Processed, 2023

Notes: S3: Marginally Suitable, S2: Moderately Suitable, wa: Water Availability, rc: Rooting Media (Texture), nr: Nutrient Retention (CEC, Base Saturation, pH), t: Temperature, oa: Drainage.

Soil Types and Land Suitability

The dominant soil types in East Ayamaru District are an association of Inceptisol (Eutrudept) and Ultisol (Hapludult). The area predominantly covered by Oxisol soil type spans 316.20 km², followed by Inceptisol, which covers 88.24 km². Inceptisol soils are characterized by a medium texture (loam) to fine texture (clay). The soil reaction ranges from slightly acidic to neutral, with a pH of 5.9–6.9. These soils exhibit moderate to high base saturation (42–100%), but their Cation Exchange Capacity (CEC) is low (12–14 cmol(+)/kg). The soil fertility is classified as relatively low, primarily due to the low CEC (Table 2).

Ultisol soils have a fine texture (clay), an acidic reaction (pH 4.8–5.0), low base saturation (less than 35%), and a low Cation Exchange Capacity (CEC) (6–11 cmol(+)/kg). Consequently, the fertility of these soils is classified as low. The results of the land suitability evaluation for specific crop commodities are presented in Table 2. The land suitability in East Ayamaru District falls within the range of moderately suitable (S2) to marginally suitable (S3). Some of the limiting factors related to land suitability in East Ayamaru District include water availability, soil physical conditions, and temperature. Detailed results of the land suitability evaluation for specific crop commodities are provided in the next sections (Table 3).

The total potential land area in East Ayamaru District is approximately 426.16 km². Of this, around 281.80 km², or approximately 66.13% of the district's total area, is potential land that can be developed for agroforestry crops. Meanwhile, 35.07 km² can be developed for plantation crops. The data on the potential land area in East Ayamaru District is presented in Table 4.

Table 4. Potential Land, Area, and Percentage Distribution in East Ayamaru District

No	Potential Land Use	Area (km²)	% of District	% of Regency Area
1	Conservation	87.26	20.48	0.016
2	Agroforestry Crops	281.80	66.13	0.050
3	Food Crops	12.25	2.87	0.002
4	Plantation Crops	44.85	10.52	0.008
	Total	426.16	100	0.076

Source: Data Processed, 2023

Table 5. Actual Land Use, Area, and Percentage Distribution in East Ayamaru District

No	Actual Land Use	Area (km²)	% of District	% of Regency Area
1	Lake	9.78	2.29	0.04
2	Conservation	87.26	20.48	0.37
3	Non-Agricultural Land	237.60	55.76	1.00
4	Agroforestry Crops	65.00	15.25	0.27
5	Food Crops	12.25	2.87	0.05
6	Plantation Crops	14.27	3.35	0.06
	Total	426.16	100	1.79

Source: Data Processed, 2023

Table 6. Types of Agricultural Fields, Planting Area, Production, and Productivity

No	Type of Agriculture	Planting Area (m²)	Production (kg)	Productivity (kg/ha)
1	Tuber Crops	610.93	922.86	15,105.82
2	Vegetables	226.50	356.25	15,728.48
3	Legumes	1,329.69	56.75	427.76
4	Non-Tuber Carbohydrate Crops	620	600	9,677.42

Source: Data Processed, 2023

The actual land area in East Ayamaru District is approximately 426.16 km². In general, there is no significant difference between the potential and actual land areas in the district. The actual land area that can be developed for agriculture is 91.42 km². The types of crop groups that can be developed include plantation crops, food crops, and crops that can be integrated with forest plants (agroforestry) (Table 5).

Farming Conditions

The types of agricultural commodities, along with their production and productivity, are categorized based on the agricultural sectors cultivated by the community in East Ayamaru District (Table 6). Among all agricultural sectors, legumes (especially peanuts and mung beans) are the crops with the largest cultivated area but the lowest productivity. In contrast, vegetables are horticultural crops with the smallest cultivated area but the highest productivity. In terms of farming types, tubers widely cultivated by the community include taro (bete), sweet potato, cassava, and taro johar. Commonly grown vegetables include bok choy, cabbage, long beans, spinach, *gedi* leaves, sugarcane shoots, and corn. Legumes analysed in this study consist of peanuts and mung beans, while the non-tuber carbohydrate crop cultivated in significant quantities is banana. Previous study reported by Rumere (2024) that Maybrat and several regencies in Papua Barat province are suitable for agricultural crops development.

For outsiders observing the agricultural land along the roads in East Ayamaru District, from the easternmost village of Viane to the area around Kambuaya Airport, the impression is of barren land with very low productivity. This perception is inaccurate. When managed using local technology, specifically the No-Tillage Technology (NOT) combined with burning and direct planting, crops such as legumes, tubers, and vegetables (notably long beans, spinach, mustard greens, cabbage, beans, and collards) yield high production and significantly contribute to farmers' income in the district (Munasinghe et al., 2019; Fatmasari et al., 2018).

Revenue, Production Costs, and Income

The average values of non-cash or cash revenue, total revenue; variable costs, fixed costs, and total costs; as well as non-cash or cash income, and total income from agriculture among the community in East Ayamaru District (Table 7).

The table provides an overview of the types of agricultural activities, their outputs, and associated revenues in East Ayamaru District. It details the quantities consumed and sold, along with the revenues generated from non-cash and cash sources for each type of crop farming. This categorizes the farming activities into tubers, vegetables, legumes, and non-tuber carbohydrates. These represent the main agricultural sectors in the district.

The selling price per kilogram for each category. Prices vary based on the type of crop tubers IDR 3,330/kg, Vegetables IDR 2,500/kg, Legumes IDR 10,000/kg (highest price due to higher market demand or limited supply), non-tuber carbohydrates IDR 2,500/kg. The amount of production consumed by households for their needs. For example, vegetables have the highest consumption (126.67 kg), reflecting their importance in daily diets. Legumes have the lowest consumption (16.46 kg), likely due to their higher market value and price. The quantity of each crop sold to generate cash income. Vegetables have the highest sales (242.38 kg), while legumes have the lowest (46.04 kg). The value of the crops consumed by the household, calculated based on the unit price. This reflects the total value generated from each type of crop: vegetables: IDR 1,890,476 (highest total revenue). Legumes is IDR 486,170 (lowest total revenue).

Table 7. Types of Agricultural Enterprises, Unit Price, Consumption, Sales, Total Revenue

No	Type of Agricultural Enterprise*	Unit Price (IDR/kg)	Amount Consumed (kg)	Amount Sold (kg)	Non-Cash Revenue (IDR)	Cash Revenue (IDR)	Total Revenue (IDR)
1	Tuber Crops	3,330	90.80	187.43	302,364	624,142	926,506
2	Vegetables	2,500	126.67	242.38	205,714	1,684,762	1,890,476
3	Nuts	10,000	16.46	46.04	25,853	460,317	486,170
4	Non-Tuber Carbohydrates	2,500	51.00	33.00	255,000	165,000	420,000

Source: Data Processed, 2023 * Number is per yield

Table 8. Variable Costs, Fixed Costs, Total Costs, Non-Cash and Cash Income, Total Income

No	Type of Agricultural Enterprise	Variable Costs (IDR)	Fixed Costs (IDR)	Total Costs (IDR)	Non-Cash Income (IDR)	Cash Income (IDR)	Total Income (IDR)
1	Tuber Crops	309,074	25,741	334,815	-32,451	289,291	256,840
2	Vegetables	113,238	50,000	163,238	42,476	1,521,524	1,564,000
3	Legumes	214,365	19,484	233,849	-207,996	226,468	18,472
4	Non-Tuber Carbohydrate Crops	88,712	14,244	102,956	152,044	62,044	214,088

Source: Data Processed, 2023

Vegetables generate the highest total revenue (IDR 1,890,476), driven by a combination of high consumption and sales volume. Legumes have the highest unit price (IDR 10,000/kg) but generate the lowest total revenue (IDR 486,170), as their production and consumption are much lower compared to other crops. Tubers have moderate consumption (90.80 kg) and sales (187.43 kg), resulting in total revenue of IDR 926,506, making them a significant crop for both subsistence and income. These crops (e.g., bananas) contribute a balanced amount of non-cash and cash revenue, with total revenue of IDR 420,000. This table highlights the economic and nutritional contributions of various crops in East Ayamaru District like reported by Sheliena et al. (2024) in Probolinggo. Vegetables are the most lucrative crop, while legumes, despite their high value, contribute less due to lower production. Tubers and non-tuber carbohydrates play dual roles in both subsistence and income generation, emphasizing their importance in the district's agricultural system. These insights can help prioritize agricultural policies and practices to maximize revenue and food security in the region (Wijka et al., 2018; Ferdous et al., 2016; Hervas 2021; Ferdous et al., 2016; Hervas & Isakson, 2020).

Cassava, as found as tuber crops, contributes the largest share to farmers' non-cash income. This indicates that the production of cassava is primarily allocated for family consumption compared to other tubers such as taro, sweet potato, and johar taro. Conversely, vegetables provide the highest contribution to cash income, followed by tubers and legumes (Hervas, 2020; Syed, 2018; Kirkpatrick & Davison, 2018; Niftiyev & Ibadoghlu, 2023; Ferdous et al., 2016; Petrovic et al., 2019). The relatively low cash income from legumes, which places them third, is due to the high variable production costs of legumes (especially peanuts) compared to mung beans or other agricultural crops. In terms of net income (after deducting production costs), vegetables remain the top-ranking crop, followed by tubers and non-tuber carbohydrates such as bananas.

Production Patterns and Technology

In East Ayamaru District, farmers typically practice polyculture farming, cultivating more than one type of crop on the same plot of land. In a garden primarily designated for tubers (e.g., taro), vegetable crops are often planted as opening crops. For example, after burning the land, farmers simultaneously plant tuber seedlings along with spinach, bok choy, cabbage, corn, bananas, and gedi vegetables along the edges of the field. Within 3–4 weeks, spinach, bok choy, and cabbage are ready to harvest, making them the opening crops. In peanut gardens, long beans, cabbage, and spinach are often intercropped either within or along the edges of the same plot. Tubers and non-carbohydrate crops harvested twice a year on average. Vegetables and legumes harvested three times a year. Farmers apply No-Tillage Technology (NOT) and do not fertilize crops except for vegetables, where foliar fertilizers are used to stimulate vegetative growth (leaf fertility). Physical pest control methods are predominantly used. For vegetables, pesticides are applied only when pest infestation is severe (Reganold & Wachter, 2016).

Major Challenges

A common issue in the region is a disease that causes tuber rot after the tubers have formed, resulting in dried leaves and non-edible fruit. Wild boars are a significant challenge in farming. Farmers stated during interviews that if wild boars were not an issue, the cultivated gardens would be more extensive and diverse. Post-harvest processing is rarely conducted. Most agricultural products are sold directly at markets. However, some products, such as peanuts, are processed into coated peanuts or fried peanuts, which increases their value. The price of dried peanuts is IDR 20,000 per kg, but when processed into fried or coated peanuts, the value increases to IDR 50,000 per jar (0.25 kg), equivalent to IDR 200,000 per kg. The challenges faced by farmers include technical agronomic issues, capital constraints, and the solutions or alternatives proposed either by the farmers themselves or through discussions with researchers. A summary of these technical agronomic issues, capital needs, and suggested solutions from farmers is presented in Table 9.

Table 9. Technical agronomic and capital problems and suggested solutions.

No	Type of Farming Branch	Technical Agronomic Problems	Capital Problems	Suggested Solutions According to Farmers
1	Tuber Crops	Wild Boar Pests, Leaf Blight Disease	Labor Costs	Need for Input Assistance (Saprodi) and Capital Funds
2	Vegetables	Wild Boar, Deer, and Diseases	Costs of Seeds and Medicine	Need for Input Assistance (Saprodi) and Capital Funds
3	Legumes	Wild Boar and Deer	Labor Costs and Seed Costs	Need for Input Assistance (Saprodi) and Capital Funds
4	Non-Tuber Carbohydrate Crops	Wild Boar and Deer	Labor Costs	Need for Input Assistance (Saprodi) and Capital Funds

Source: Data Processed, 2023

In agricultural development, the entire community stated that all agricultural activities face pest problems, specifically wild boars and deer (Yudha et al., 2022; Andrian et al., 2023). However, they acknowledge that these pests, especially wild boars, are a long-standing issue passed down through generations. To address this, every garden they cultivate is always fenced to protect against attacks by these pests. The capital challenges faced by farmers include the high cost of labor for activities such as land clearing, burning, and fencing for tuber and legume crops, as well as planting, harvesting, and peeling legumes. To overcome the capital issues mentioned above, during the field research, the community collectively suggested that the local government, particularly the Department of Food Crops and Horticulture, should provide financial assistance as capital support to aid the development of their farming activities. Furthermore, they expressed a strong preference for such financial assistance (Bianco, 2016; Mwaura et al., 2021; Nabikyu & Kugonza, 2016) to be provided in the form of grants, rather than loans, as a commitment to support and empower farming communities.

CONCLUSION

The land suitability in East Ayamaru District falls within the range of moderately suitable (S2) to marginally suitable (S3). Some of the limiting factors related to land suitability include water availability, soil physical conditions, and temperature. Lakes and flat areas are less prominent and may hold significance for specific ecological or economic purposes, such as fisheries or water resource management. It challenges for accessibility and development but may also serve as important conservation zones or sources of biodiversity. Crops such as legumes, tubers, and vegetables (notably long beans, spinach, mustard greens, cabbage, beans, and collards) yield high production and significantly contribute to farmers' income in the district. In terms of net income (after deducting production costs), vegetables remain the top-ranking crop, followed by tubers and non-tuber carbohydrates such as bananas. Physical pest control methods are predominantly used. For vegetables, pesticides are applied only when pest infestation is severe. In recommendation, local government particularly the Department of Food Crops and Horticulture should provide financial assistance as capital support to aid the development of their farming activities.

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