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# Integrative policy development for agricultural priority areas: Balancing land suitability and commodity preferences

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## ABSTRACT

**Background:** Indonesia has the potential of natural resources to support agriculture. However, there are still some areas that have not optimized natural resources. People focus on planting commodity crops without considering the physical conditions of the environment and socio-culture. This research aims to develop policy directions for agricultural priority areas that consider the physical conditions of the environment and their suitability for farmers' commodity preferences. **Methods:** This study uses a quantitative approach with a combined method to determine agricultural priority areas. It integrates ZAE analysis, land carrying capacity, and farmers' commodity preferences. **Findings:** The results showed that the commodities preferred by farmers were cocoa, corn, and upland rice. The preference for these commodities has a significant correlation, especially with the source of income and the size of cultivated land. There is a 51% mismatch of existing agricultural land with the ZAE while in general agriculture in Nangapanda is in accordance with the carrying capacity of the land because it is at a high level of carrying capacity. **Conclusion:** Based on the agricultural priority areas formed, agriculture in Nangapanda can utilize dry land mainly for plantations with the direction of the main commodities tailored to the physical conditions of the land and the preferences of farmers namely cocoa, cashew, cloves, nutmeg, pepper. **Novelty/Originality of this article:** The novelty of this research lies in the integrative approach in formulating agricultural priority area policies that combine the suitability of physical environmental conditions and farmers' commodity preferences, which has not been widely applied in similar studies.

**KEYWORDS**: agroecological zone; land carrying capacity; farmer's commodity preferences; agricultural priority area.

## 1. Introduction

Sustainable development is a complex goal of social, political, environmental, and economic aspects of harmonizing life support systems to support basic human needs (Kullenberg, 2010). Harmonization of systems securing basic human needs such as food, water, health, environmental and ecosystem protection, coastal areas, protection and adaptation to climate variability and change, other natural hazards, provision of education, ability to find work, employment, and related empowerment need to be done to support sustainable development (Kullenberg, 2010). This needs to be done because basic human needs will continue to increase along with the rising population and increasing competitive pressures for limited resources, such as food, water and land (Calota & Patru-Stupariu,

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2019). In line with the large increase in population in Indonesia, which is around 237.6 million people to

275.7 million people with a population growth rate of 1.17% in the range of 2010-2022 (Central Bureau of Statistics, 2023), there is an increasing need for land for various purposes including to produce food, fiber, and shelter (Gutierrez, 1996). Large population pressure and increasing economic and industrial growth have led to uncontrolled competition for land use in various sectors, including the agricultural sector (Brusseau, 2019; Lambin & Meyfroidt, 2011). This is related to the concept of environmental science related to ecological change, because ecology is a science that focuses on the interaction between organisms and their abiotic environment as objects and energy (Miller & Spoolman, 2015).

The availability of natural resources in quantity or quality is uneven, while development activities require increasing natural resources (Lujala & Rustad, 2011). Development activities also carry the risk of environmental pollution and damage. This condition can cause the carrying capacity, capacity, and productivity of the environment to decrease, which in turn becomes a social burden (Aziz, 2017). Therefore, Indonesia's environment must be protected and managed properly based on the principles of state responsibility, sustainability, and justice (Widowaty, 2012). In addition, environmental management must be able to provide economic, social, and cultural benefits based on the principles of prudence, environmental democracy, decentralization, and recognition and respect for local wisdom and environmental wisdom (Iswandi & Dewata, 2020). Environmental protection and management require the development of an integrated system in the form of a national policy for environmental protection and management that must be implemented in a principled and consistent manner from the center to the regions (Sutrisno, 2011). Natural resources referred to in this study refer to the definition of natural resources in the general provisions of Law no. 32 of 2009 concerning environmental protection and management (Mina, 2016). According to (Miller & Spoolman, 2015), natural resources can be categorized into 3 (three): inexhaustible resources (such as energy from the sun and wind), renewable (such as air, water, topsoil, plants, and animals), and non-renewable or depleted resources (such as copper, oil, and coal). Meanwhile, resource utilization is more emphasized on potentially renewable resources, namely air, fresh water, fertile soil and flora and fauna (Miller & Spoolman, 2015). Determining the carrying capacity of these potentially renewable resources is very important to understand and know so that their utilization is not exceeded so that they can become renewable resources or can be utilized sustainably.

Referring to the discussion above, it is necessary to carry out rational and sustainable planning and management of land resources in accordance with their carrying capacity (Hikmatullah & Ritung, 2014). Thus, accurate geospatial information on land resources is needed as basic information to support sustainable land use planning, especially in the agricultural and plantation sectors (Wahyunto & Dariah, 2014). Sustainable agricultural systems can be realized if land resources are used for appropriate agricultural systems with appropriate management methods. If land is not used appropriately, productivity will quickly decline and the land will not be utilized properly ecosystems are threatened with destruction (Damayanti, 2013). Proper land use not only ensures that land provides benefits for present users but also ensures that these land resources benefit future generations in a sustainable manner.

In an effort to support land use planning in accordance with its carrying capacity, FAO around 1978 has introduced the concept of preparing Agro-Ecological Zone (ZAE) maps to assist integrated agricultural land planning and management for developing countries in Africa, Asia and Latin America (Higgins & Kassam, 1981). The ZAE method can re-evaluate the biophysical limiting factors used and consider the production potential of various types of agricultural commodities (Hikmatullah & Ritung, 2014). The ZAE approach can be used for planning, management and monitoring of land resources, such as for inventory of potential land resources, inventory of land utilization types and production systems, land suitability and evaluation of land productivity (FAO 2002; FAO 2012). Thus, research is needed t o determine agricultural priority areas according to the commodities that will be planted by farmers based on the condition of agro-ecological zones and the assessment of their environmental carrying capacity.

Currently in Indonesia there are still people who do not know the agricultural potential in their area (Harahap et al., 2020; Sulaiman et al., 2019). Information on which areas can be designated for agricultural activities to optimize production and what commodities are optimal for planting in certain areas is still very minimal among agricultural extension workers and farmers in Nangapanda District, Ende Regency. So then many agricultural areas are not in accordance with the agro-ecological zone or its carrying capacity and capacity. Referring to this, it is necessary to conduct research on agricultural priority areas in Nangapanda Subdistrict, Ende Regency to better suit the preferences of farmers and the assessment of their physical environmental conditions. Based on the explanation above, this research aims to (1) analyze the relationship between farmer characteristics and commodities that are farmers' preferences; (2) analyze the current condition of agricultural commodity suitability based on agroecological zones; (3) analyze the current condition of suitability of agricultural commodities with land carrying capacity; (4) develop agricultural priority areas based on farmers' preferences, agroecological zones, and land carrying capacity.

## 2. Methods

### *2.1 Research approach*

The approach in this research is based on the measurements used in processing data, which is in a measurable numerical form and there is a relationship between variables. This approach is also used to process data in the form of geospatial information that has a relationship between variables. The research method used is a combined method between qualitative and quantitative research methods, which is an approach that combines or connects qualitative and quantitative forms in a study (Creswell, 2009). Qualitative methods were used to find out more about the characteristics of farmers and the agricultural commodities that farmers prefer. Qualitative methods were also used to explore commodity development directions with help from experts. Meanwhile, the quantitative method was used to find out four things.

First, it was used to analyze the relationship between farmer characteristics and farmer preference commodities. Second, to analyze the current condition of agricultural commodity suitability based on agro-ecological zones. Third, to analyze the current condition of suitability of agricultural commodities with land carrying capacity. Quantitative geospatial data is suitable for investigating environmental phenomena by incorporating additional quantitative data such as deforestation studies, forest type mapping, vegetation analysis, surface water runoff estimation, and others. Fourth, quantitative methods are used to organize agricultural priority areas.

Defines the word analysis as a way of examining something by putting forward all the basic elements and the relationship between the elements concerned. According to the KBBI, analysis can also be interpreted as an investigation of an event, essay, action and so on to find out the real situation, cause, sitting case and so on. Based on some of the above definitions, it can be seen that what is meant by the analysis method is a way to get the right understanding and understanding of an object. The following is the correspondence between the research question and the data analysis method used (Table 1).

Table 1. Compatibility between research objectives and methods used

| No. | Research Question | Data Analysis Method |
|---|---|---|
| 1. | How relationship characteristics farmers with commodities that farmers prefer? | Correlation analysis, descriptive analysis |

| | | |
|---|---|---|
| 2. | How condition the current suitability of agricultural commodities based onagroecological zone? | Overlay analysis, correlation analysis, descriptive analysis |
| 3. | How condition the suitability of current agricultural commodities with carrying capacity of the land? | Overlay analysis, correlation analysis, descriptive analysis |
| 4. | How agricultural priority areas are formed based on farmer preferences, agroecological zones, and carrying capacity land? | Synthesize data on agroecological zones, land carrying capacity, commodity preferences and literature studies with descriptive quantitative and qualitative methods. |

*2.2 Chi square analysis*

Chi square analysis is a non-parametric statistic. Non-parametric statistics are used when the data used is not normally distributed and the type of data used is nominal data and ordinal data. Non-parametric statistics are also used when interval or ratio data types are not normally distributed. Chi square analysis is used to test the relationship or influence of two nominal and or ordinal type variables and measure the strength of the relationship using the coefficient of contingency (Usman & Akbar, 2020). This chi square analysis has a formula:

$$\chi 2 = \left[\frac{\sum(f_0 - f_e)}{f_e}\right] \quad \text{(Eq. 1)}$$

The chi-square ($\chi^2$) test is a statistical method used to assess whether there is a significant relationship between an independent variable and a dependent variable. This test utilizes specific notations, including $\chi^2$ for the chi-square value, $f_e$ for the expected frequency, and $f_0$ for the observed frequency. In conducting a chi-square analysis, the hypotheses tested are as follows. $H_0$, the independent variable has no significant effect on the dependent variable. $H_1$, the independent variable has a significant effect on the dependent variable.

The criteria for hypothesis acceptance are established as follows. $H_0$ is accepted if the calculated $\chi^2$ value is less than or equal to the critical $\chi^2$ value from the chi-square table, or if the obtained significance value exceeds the predetermined significance level of 0.05. $H_1$ is accepted if the calculated $\chi^2$ value is greater than the critical $\chi^2$ value from the chi-square table, or if the obtained significance value is below the predetermined significance level of 0.05. By applying this statistical approach, researchers can determine whether an independent variable has a meaningful influence on a dependent variable. The chi-square test serves as a crucial tool in data analysis, facilitating informed decision-making based on statistical evidence.

The magnitude of the coefficient of contingency ranges from 0-1. However, this coefficient of contingency value cannot indicate whether the relationship between the two variables is unidirectional or inverse, it can only indicate the strength of the relationship (Usman & Akbar, 2020). The stronger the level of relationship, the greater the coefficient of contingency value, the following is an interpretation of the strength of the relationship based on the coefficient of contingency value:

Table 2. Interpretation of the strength of the relationship between two variables

| CC value | Relationship strength |
|---|---|
| 0.00-0.19 | Very low |
| 0.20-0.39 | Low |
| 0.40-0.59 | Simply |
| 0.60-0.79 | Strong |
| 0.80-1.00 | Very Strong |

(Usman & Akbar, 2020)

### 2.3 Overlay analysis

Overlay spatial analysis is a basic method to concisely analyze spatial correlation (Zhang et. al., 2021). It mainly combines multiple (two or more) layer features to create a new feature layer, and contains the feature analysis of the previous layer (Sun & Guo, 2012; Zhang et. al., 2021). With breakthroughs in earth observation technology, particularly the advent of high-resolution satellite remote sensing technology and geographic data, overlay analysis has been increasingly used.

Overlay analysis is used to analyze three things, namely 1) analysis of the suitability of agricultural land use and its commodities with agro-ecological zones, 2) analysis of the suitability of agricultural land use and its commodities with land carrying capacity, 3) agricultural priority areas formed based on agro-ecological zones and land carrying capacity. This overlay analysis was conducted using mapping software. The data from the overlay process which is very varied will then be simplified by using the Pivot Table feature in Microsoft Excel software. Pivot Table is a feature that is able to analyze all the data in a worksheet, thus helping to make conclusions from a lot of data. Pivot Table makes it easier to summarize, analyze, explore, and present data so that it is more interactive, information-dense, and can be equipped with charts.

## 3. Results and Discussion

### 3.1 Farmer characteristics and farmer preference commodities

There are nine things observed as farmer characteristics, namely age, formal education, number of family members, source of income, amount of income, allocation of working time, area of land ownership, length of farming experience, and cropping patterns used. Farmers' age is a factor that is most closely related to the strength and ability of farmers in carrying out agricultural activities. The productive age of farmers is in the range of 20-60 years (Hapsari et al., 2019; Roseline & Amusain, 2017; Zakaria et al., 2020). In this study, productive age is then divided into two, namely young productive age with ages 20-40 years and old productive age with ages 41-60 years. Meanwhile, ages above 60 years are included in the non-productive age. Based on the sample of farmers in Nangapanda Sub-district, it was found that the age of farmers ranged from 26-69 years with an average age of 50 years. Respondents with productive age amounted to 80 people or 80%. This shows that farmers in the study area have the potential to carry out agricultural activities (Zakaria et al., 2020).

Formal education is categorized based on education level, namely primary school, junior high school, senior high school, and university. Farmers with a high level of education are assumed to be able to carry out better sustainable agricultural practices (Ghosh & Hasan, 2013). The respondents' education level was dominated by upper secondary education as many as 57 respondents. There were still respondents with primary education levels although only 4 respondents were found. This condition can be said to be better than the condition of the education level of farmers in Indonesia where 73.97% of Indonesian farmers only have elementary level education (Arvianti et al., 2019).

The number of family dependents is all family members who live in the same house or not with the farmer or anyone whose living expenses and other needs are borne by the respondent farmer as the head of the family (Syahran, 2022). The number of dependents of respondents is relatively high with 90% of respondents having more than 3 family members. Furthermore, the questionnaire results showed that 80% of the farmers completely relied on agricultural activities as their main source of income. Meanwhile, 20% of respondents have side income sources such as from fishing, renting rice mills, animal husbandry, and working as employees. The average income of respondents was IDR 900,000 per month.

This income is far below the Ende Regency/City Minimum Wage in 2023, which reaches IDR 2,123,994 per month. As many as 83% of the total respondents have monthly income in the range of IDR 500,000 - IDR 1,000,000. Only 2% of respondents have an income above IDR 2,000,000 per month because the respondents have other jobs as employees. Generally, farmers who use farming as their sole source of income will allocate almost the entire day to farming activities. This allocation of working time is flexible and can be longer or shorter depending on conditions. Furthermore, the status of land ownership also varies, but in general farmers work on customary land, where the customary chief will lend the land to be cultivated by the community. Only a few people own their own land. The area of cultivated land cultivated by each farmer is also limited, usually no more than 2 hectares with an average cultivated area of 1.3 hectares. With this condition, the average farming experience of respondents is at least 5 years and the highest is 41 years. The average farming experience of respondents is 22 years.

It was also found that the cropping patterns used by respondents were intercropping for plantations and fields, rotation for fields, and monoculture for paddy fields only. Only 11% of respondents use monoculture because they have a paddy rice farm. Generally, in plantations, intercropping can be done with up to 3 types of plants, for example candlenut as the highest canopy, coconut as the medium canopy, and cocoa as the low canopy. Meanwhile, intercropping in fields can be done with many types of crops. The fields with the most varied crop types found in the field have field rice, corn, barley, sesame, black beans, and chili planted on the same land.

A chi square statistical test was then conducted to find out the influence of farmer characteristics on commodity preferences. Based on the results of the calculation, six farmer characteristics had an influence on commodity preferences while only three characteristics had no influence. Farmer characteristics that have a relatively strong relationship with commodity preferences are the number of dependents, income, source of income, land size, and time allocation for agricultural work. These characteristics are interrelated with each other in influencing commodity preferences. 80% of respondents are totally dependent on farming for income while the number of family members borne by farmers is quite large and the average cultivated land area owned by farmers is only 1.2 hectares so that farmers will tend to choose commodities with high selling prices. Meanwhile, gender, age, and farming experience had no relationship with commodity preferences.

Table 3. Relationship between farmer characteristics and farmer preference commodities

| No. | Characteristics | Relationship with Commodity Preferences | Parameters |
|---|---|---|---|
| 1 | Gender | No relationship | p value >0.05 at 5% significance |
| 2 | Age | No relationship | p value >0.05 at 5% significance |
| 3 | Education | There is a low relationship | p value <0.05 at 5% significance CC value 0.339 |
| 4 | Number of Dependents | There is a fairly strong relationship | p value <0.05 at 5% significance CC value 0.553 |
| 5 | Revenue | There is a strong relationship | p value <0.05 at 5% significance CC value 0.700 |
| 6 | Source of Income | There is a fairly strong relationship | p value <0.05 at 5% significance CC value 0.563 |
| 7 | Land Area | There is a fairly strong relationship | p value <0.05 at 5% significance CC value 0.512 |
| 8 | Farming experience | No relationship | p value >0.05 at 5% significance |
| 9 | Allocation Time Agricultural Work | There is a strong relationship | p value <0.05 at 5% significance CC value 0.613 |

### *3.2 Suitability of agricultural commodities with agroecological zones*

Data from the Center for Research and Development of Agricultural Land Resources (BBSDLP) identified three agroecological zones in Nangapanda sub-district: Zone I, IIay, and IVay. Zone I, which covers 98.2% of the area (18,694.50 ha), is recommended for forest crops due to steep slopes (>40%). Zone IIay, with an area of 148.68 ha (0.8%), is suitable for perennial crops such as cocoa, cashew, and cloves. Zone IVay (188.26 ha, 1.0%) is in the lowlands and uplands with relatively flat terrain, favored for food crops such as corn, soybeans, and field rice. BBSDLP agroecological data was then compared with agricultural land use to see the suitability of existing commodities in the field. However, due to intercropping cropping patterns, mapping per commodity is difficult. On plantation land, there are usually three types of crops, such as cocoa and coconut, while fields have a variety of more than five types, such as corn and chili.

The comparison results show that only 0.03% of agricultural land use is in accordance with the agroecological zone direction, as the 1:250,000 data scale is not detailed enough for the sub-district level. With a more detailed scale (1:50,000), the agroecological zones were reprocessed and divided into five classes, namely Zone I, IIay, IIby, IIIay and IVay. Zone I continues to dominate Nangapanda with an area of 8,432.29 ha (44.31%), followed by Zone IIay with an area of 9,120.87 ha (47.93%). Table 4. shows the percentage of land use suitability by agroecological zone: fields are only suitable 3.4% (89.7 ha), plantations 67.7% (2,503.4 ha), and rice fields 20.2% (5.3 ha). This mismatch occurs because many steep-sloped lands are utilized as fields, which are considered by the community to remain suitable for crops such as field rice and erosion-resistant corn.

Table 4. Area of agro ecological zones in Nangapanda sub-district

| No. | Zone | Extensive | Percentage |
|---|---|---|---|
| 1 | I | 8,432.29 | 44.31 |
| 2 | IIay | 9,120.87 | 47.93 |
| 3 | Iiby | 517.69 | 2.72 |
| 4 | IIIay | 690.58 | 3.63 |
| 5 | IVay | 270.00 | 1.42 |
| Total | | 19,031.44 | 100.00 |

### *3.3 Suitability of agricultural commodities with land support capacity*

Based on the 1:250,000 scale ecosystem service- based environmental carrying capacity data from the Bali and Nusa Tenggara Ecoregion Development Control Center (P3E), there are seven types of ecosystem services used in this study, namely as follows. (1) Ecosystem services that provide food; (2) water supply ecosystem service; (3) ecosystem services that provide genetic resources; (4) climate regulation ecosystem services; (5) ecosystem services supporting habitat and biodiversity; (6) ecosystem services supporting soil formation and regeneration; (7) ecosystem services supporting nutrient cycling. These seven types of ecosystem services were selected from other ecosystem services to adjust the needs of physical environmental conditions for agricultural activities such as water needs, climate effects, soil types, and biodiversity

These seven types of ecosystem services were then combined to obtain data on the carrying capacity of land for supporting agricultural activities. The land carrying capacity is dominated by high carrying capacity with an area of 16,858.90 hectares or 88.58%, followed by very high carrying capacity with an area of 1,487.68 hectares or 7.82% and medium carrying capacity with an area of 684.86 hectares or 3.60%. Land carrying capacity with a very high level is scattered next to north of Nangapanda Sub-district. Meanwhile, land carrying capacity with a high level is almost evenly distributed in Nangapanda Sub-district and a few areas with a moderate level of land carrying capacity are scattered in the northern tip and some coastal areas of Nangapanda Sub- district.

The combined land carrying capacity data was then matched with agricultural land use data, namely plantations/gardens, rice fields, and tegalan/fields to see the suitability of agricultural land use with the condition of land carrying capacity in Nangapanda Sub-district. Rice fields with an area of 26.3 hectares are at a high level of land carrying capacity. Plantations with an area of 31.5 hectares are at a medium level of land carrying capacity and dominated by high level of land carrying capacity at 3,668.8 hectares. Fields are located at all three levels of land carrying capacity with 24.3 hectares of fields located at a medium level of carrying capacity, 2.547.9 hectares at a high level of carrying capacity, and 64.8 hectares located at a very high level of carrying capacity.

If this land carrying capacity data is matched with the overall land use data, it can be seen that very high land carrying capacity is generally spread in forest areas which are actually not suitable for agricultural activities, especially in terms of slope. This is also in line with the agroecological zones where forest land use falls into Zone I and is not suitable for agriculture, especially in terms of slope. This happens because the carrying capacity data used is ecosystem service data where ecosystem services are benefits obtained by humans from ecosystems (MEA, 2005). Based on this, it is then reflected that forests actually have a high level of carrying capacity because forests provide high land provision, regulation and support services that are beneficial for life.

In addition, the ecosystem service-based carrying capacity data from P3E does not include agricultural limitation factors such as slope, soil type, and climate regime in its preparation but only uses landforms, natural vegetation, and land use. This causes the condition of carrying capacity based on ecosystem services as opposed to agroecological zones for agricultural activities. Agroecological zones emphasize which areas are suitable for certain types of commodities or describe general land suitability. Meanwhile, ecosystem service-based carrying capacity emphasizes land conditions and natural processes that are beneficial for life, especially for humans.

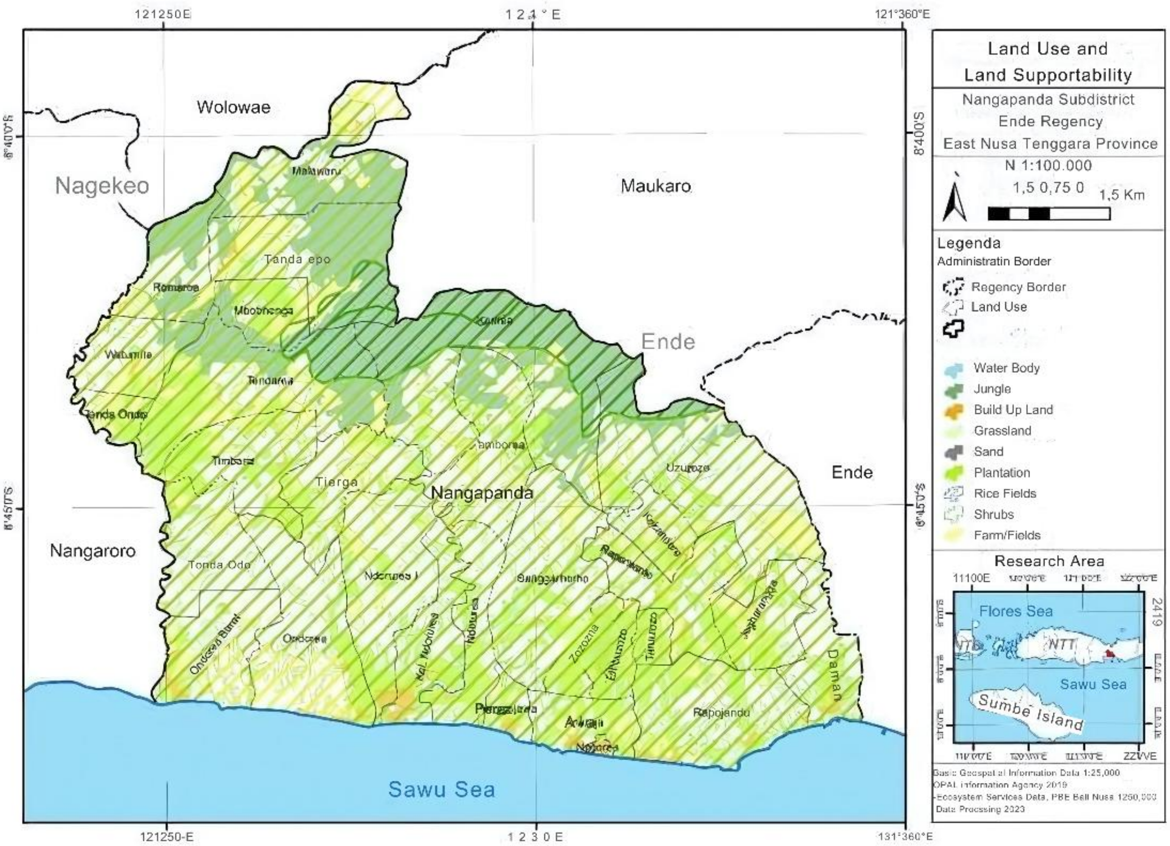


Fig. 1. Land use and land supportability

*3.4 Agriculture priority areas*

The discussion on the direction of land use in the development of agricultural commodities was prepared using the results of questionnaires and interviews with expert resource persons. Based on previous research (Arham et al., 2018; Satria et al., 2018), four aspects are used for consideration of assessing the direction of land use in the development of agricultural commodities, namely physical environmental, social, economic, and institutional aspects. Based on these four aspects, three commodity development directions were derived, namely conservation of agricultural land, land conversion for the development of superior commodities, and compatibility with the social culture of the community. The limitation in determining the direction of land use in commodity development is the lack of expert sources who participate, there are only three people (from P3E Bali Nusa Tenggara, Head of BPP Nangapanda, and PPL) and the results obtained are different regarding the final results of the direction.

Based on the results of the scoring calculation, the first expert is more inclined towards land conservation where agriculture should consider the physical aspects of the environment so that agriculture can be in accordance with the capabilities and land use. This is mainly influenced by the topographic conditions of Nangapanda Sub-district, which tend to be hilly and mountainous. For this reason, if following the direction of the agro-ecological zone, it should be utilized for natural vegetation areas so that very steep slope conditions while for relatively steep slope conditions but not more than 40% can be utilized for strong annual crops.

Based on the scoring results of the second expert's answers, it was found that the second expert was more inclined to carry out agricultural activities that were economically beneficial to the community. Based on the interview, the second expert also stated that currently there are several commodities that since 2021 have begun to be developed in Nangapanda, including nutmeg and pepper because the price is quite competitive with cocoa commodities and both with relatively easy maintenance. The selling price of nutmeg reaches IDR 50,000/kg and the price of pepper reaches IDR 120.000/kg. According to the second expert, agriculture needs to be economically beneficial because the Nangapanda community's main livelihood is as farmers. Currently, Nangapanda's farmers outsmart their relatively narrow cultivated land area by intercropping so that one field can produce two to four types of commodities so that there is always something to sell or utilize throughout the year.

Meanwhile, the scoring results of the third expert's answers are more inclined to direct land use based on suitability to the social and cultural conditions of the community. Based on the interview with the third expert, the people of Nangapanda Sub-district are part of the Lio-Ende custom where the planting of field rice and corn is included in their cultural rituals. Field rice and corn are part of the cultural rituals because they are the staple food consumed by the community and are believed to have been passed down by the ancestors of the Lio-Ende tribe. As a result of their need for food sourced from field rice and corn, the Lio-Ende people who live in Nangapanda have strong animist beliefs that still maintain customs such as providing offerings for ancestors and carrying out agricultural customs and maintaining their behavior such as doing good, not acting outside the norm, and others to prevent crop failure or not raining.

Table 5. Scoring level of desire to plant commodities by farmers

| No | Village | Plantation | | | | | | | | | | Food | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | KL | KM | KK | KP | CK | VN | MT | PG | PS | SR | JG | UJ | UK | K | C |
| 1 | Anaraja | 3.7 | 2.0 | 4.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.3 | 1.0 | 1.0 | 1.0 | 1.0 |
| 2 | Bheramari | 3.0 | 1.0 | 3.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 3.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 3 | Jegharangga | 3.0 | 2.3 | 2.3 | 1.0 | 1.0 | 3.0 | 1.0 | 3.0 | 1.0 | 1.0 | 3.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 4 | Kerirea | 1.6 | 3.4 | 3.0 | 2.2 | 2.8 | 1.8 | 1.0 | 3.4 | 1.0 | 1.0 | 2.8 | 1.0 | 2.4 | 1.0 | 2.2 |
| 5 | Malawaru | 1.4 | 3.6 | 2.4 | 2.0 | 2.0 | 1.0 | 1.6 | 3.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 6 | Mbhobhenga | 1.4 | 3.2 | 3.0 | 2.0 | 2.6 | 2.6 | 1.0 | 3.4 | 1.0 | 1.0 | 1.0 | 1.0 | 2.0 | 1.0 | 2.6 |
| 7 | Ndeturea | 4.0 | 2.0 | 3.5 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 3.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 8 | Ondorea Barat | 3.6 | 3.4 | 2.9 | 1.7 | 1.5 | 2.1 | 1.0 | 3.4 | 1.0 | 1.0 | 3,1 | 1.0 | 2.4 | 1.0 | 2.3 |
| 9 | Romarea | 1.4 | 3.3 | 3.5 | 1.8 | 1.6 | 1.7 | 1.0 | 3.2 | 3.1 | 1.0 | 3.5 | 1.0 | 3.0 | 1.0 | 2.3 |
| 10 | Tenda ondo | 2.6 | 3.0 | 2.8 | 2.4 | 1.8 | 2.4 | 1.2 | 2.6 | 3.2 | 2.0 | 3.6 | 2.0 | 2.6 | 1.2 | 1.6 |
| 11 | Tendarea | 1.2 | 3.2 | 3.2 | 1.6 | 2.6 | 1.6 | 1.0 | 3.2 | 1.6 | 1.0 | 3.0 | 1.0 | 2.0 | 1.0 | 2.2 |
| 12 | Timbaria | 3.0 | 4.0 | 3.0 | 1.0 | 2.0 | 2.0 | 1.0 | 3.0 | 1.0 | 1.0 | 3.0 | 1.0 | 2.5 | 1.0 | 2.0 |
| 13 | Titwerea | 3.0 | 3.8 | 3.0 | 1.6 | 1.8 | 2.4 | 1.0 | 3.0 | 1.0 | 1.0 | 3.0 | 1.0 | 2.1 | 1.0 | 2.5 |
| 14 | Watumite | 1.4 | 3.0 | 2.9 | 2.2 | 2.9 | 1.5 | 1.1 | 3.0 | 1.2 | 1.0 | 2,9 | 1.0 | 2,4 | 1.0 | 2.2 |
| 15 | Zozozea | 1.0 | 2.0 | 3.0 | 1.0 | 1.0 | 1.0 | 1.0 | 3.0 | 1.0 | 1.0 | 3.0 | 1.0 | 2.0 | 1.0 | 1.0 |

Table 5 lists the plant codes and their types to facilitate identification in research. The code KL represents Coconut, VN for Vanilla, JG for Corn, KM for Candlenut, MT for Cashew, UJ for Sweet Potato, KK for Cocoa, PG for Upland Rice, UK for Cassava, KP for Coffee, PS for Wetland Rice, K for Potato, CK for Clove, SR for Sorghum, and C for Chili. These codes are used to simplify data presentation in the analysis and interpretation of research results.

Agricultural priority areas were then developed based on recommendations from agroecological zones and carrying capacity based on ecosystem services. Commodity directions based on agroecological zones are then adjusted to the commodities that become farmers' preferences. Agricultural areas in moderate ecosystem service-based carrying capacity conditions are not included in the agricultural priority areas compiled because they are considered less suitable, so that the agricultural priority areas compiled are at high and very high levels of ecosystem service-based carrying capacity conditions. Based on the assessment of the three variables, a matrix was compiled to develop agricultural priority areas (Table 6).

Table 6. Agricultural priority area compilation matrix

| Zone | Subsystem | ZAE Commodity Direction | Commodity Preference | Commodities under Development | Agricultural Land Use |
|---|---|---|---|---|---|
| I | Non-Agricultural Crops | Natural Vegetation | - | | Jungle |
| IIay | Lowland dryland perennial crops dry climate | Cocoa Cashew Distance Clove Kapok Pala | Clove Cocoa | Cashew Nutmeg Pepper | Plantation |
| IIby | Medium dryland perennial crops dry climate | Cocoa Kapok Nutmeg Candle nut | Cocoa Candle nut | Nutmeg Pepper | Plantation |
| Zone | Subsystem | Commodi ty Direction ZAE | Commodity Preference | Commodities under Development | Agricultural Land Use |
| Ivay | Lowland dryland food crops in arid climates | Upland rice Corn Soybean Green bean Groundnu t Cowpea Sweet potato Wood onion Sugarcane Cayenne pepper | Paddy Rice upland rice Maize Sweet potato Cassava Cassava | Sorghum Cayenne pepper | Plantation, Field, Rice Field |

Priority agricultural areas in Nangapanda were defined based on agroecological zones, land carrying capacity and farmers' commodity preferences, divided into existing and potential farms. Of the total area of 6,360.06 hectares of existing farms, only 4,312.89 hectares meet the priority criteria, with fields in Zone I retained for the socio-cultural values of the Lio-Ende community. Table 7. details the eligible existing agricultural area by agroecological zone (ZAE) and commodity type. Spatially, this area refers to the agroecological zone map, with the main recommendation on plantations or production forests, due to steep topographic conditions. In the midlands, it is recommended that fields be converted into plantations, while food crops are placed in coastal areas such as Kel. Ndorurea, Ondorea Barat, Penggajawa, Anaraja and Bheramari villages. For potential areas, priority areas include previously unutilized land, such as grasslands and shrubs that are compatible with the carrying capacity of the ecosystem, focusing on dryland plantations.

Table 7. Agricultural priority area based on existing agriculture

| ZAE | Commodities | Existing PL | Area (ha) | % |
|---|---|---|---|---|
| IIay | Cocoa, Cashew, Cloves, Nutmeg, Pepper | Plantation | 3,626.36 | 84.08 |
| IIby | Cocoa, Cashew, Cloves, Nutmeg, Pepper, Candlenut | Plantation | 79.36 | 1.84 |

Comparison of priority areas with Ende District's RTRW spatial planning shows land use conformity, although there are differences in the details of RTRW planning related to wetlands. The more accurate MoEF forest area map is considered to be more in line with the ZAE directive. The 2016 CSP from the Ministry of Agriculture also supports strategic commodities such as rice and maize in Nangapanda, in line with existing major food crops. Food security is an important issue, as the people of Nangapanda have become more dependent on plantation commodities since the 1970s, reducing the cultivated rice land that used to be the main source of food. To maintain food security, it is recommended to conserve customary food lands and educate the community to utilize existing land for food crops.

## 4. Conclusions

Based on the research methods previously mentioned, the results show that farmers in Nangapanda District have age characteristics that are dominated by the age range of 41-60 years (61%), education level is dominated by senior high school level (57%), the number of dependents of farmers is 4-5 people (43%), make agriculture the main and only source of income (80%), monthly income in the range of IDR 500,000-IDR 1,000,000 (83%), allocate working time for agriculture 7-8 hours (58%), have an average arable land area of 1 hectare, average farming experience of 22 years, use monoculture cropping patterns only for paddy fields, the rest use intercropping and rotational cropping patterns. The plantation commodity that is the preference of the Nangapanda District as a commodity that can be traded is cocoa while the food and horticultural commodities that are mostly grown are field rice and corn to fulfill farmers' personal consumption.

The use of agricultural land that is in accordance with the directives of the agro-ecological zone is 2,598.5 hectares while the use of agricultural land that is not in accordance with the directives of the agro-ecological zone is 3,761.6 hectares. The use of agricultural land in general is in accordance with the conditions of agricultural carrying capacity because the conditions of agricultural carrying capacity in Nangapanda District are quite good with medium, high and very high levels. The use of land that is located at a moderate level of carrying capacity is 55.9 hectares, at a high level of carrying capacity is 6,234.0 hectares, and at a very high level of carrying capacity is 64.8 hectares. Based on the agricultural priority areas formed, agriculture in Nangapanda can take advantage of the lowland dry land conditions and dry climate that dominates the Nangapanda region, especially for plantations with main commodity directions that are adapted to the physical conditions of the land and farmers' preferences, namely cocoa, cashew, cloves, nutmeg, and peppercorn.

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## Author Contribution

This research was conducted collaboratively by N. P. P., E. F., and A. W., was responsible for conceptualization, methodology, investigation, as well as writing—preparation of the original draft. Meanwhile, J.D.I. contributed to the writing—reviewing and editing, as well as supervising.

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## References
Arham, I., Sjaf, S., Darusman, D. (2019). Sustainable Agricultural Development Strategy in Rural Areas Based on Drone Imaging (Case Study: Sukadamai Village, Bogor Regency). *Environmental Science Journal, 17*(2), 245-255. https://doi.org/10.14710/jil.17.2.245-255

Arvianti, E. Y., Masyhuri, M., Waluyati, L. R., & Darwanto, D. H. (2019). Overview of the Indonesian young farmer crisis. *Agriekonomika, 8*(2), 168-180. https://journal.trunojoyo.ac.id/agriekonomika/article/view/5429/0

Aziz, N. A. (2017). Local Wisdom in Environmental Protection and Management (Study in Janggolan Village, Sumpiuh District, Banyumas). *Environmental Law Journal, 2*(1), 99–107. https://doi.org/10.24970/jbhl.v2n1.9

Brusseau, M. L. (2019). Sustainable Development and Other Solutions to Pollution and Global Change. In *Environmental and Pollution Science* (3rd ed.). Elsevier Inc. https://doi.org/10.1016/b978-0-12-814719-1.00032-x

Calota, A. M., & Patru-Stupariu, I. (2019). Pasture resilience towards landscape changes: Assessing pastures quality in the context of land-use and land-cover changes in Romania. *European Journal of Geography, 10*(2), 12–26. https://www.eurogeojournal.eu/index.php/egj/article/view/180

Central Bureau of Statistics. (2023). *Indonesia Statistics 2023*. Central Bureau of Statistics

Creswell, J. W. (2009). *Research design: qualitative, quantitative, and mixed methods approaches* (Q. S. Knight. V, Connely. S, Habib. L & . K (eds.); 3rd ed.). SAGE Publications Ltd.

Damayanti, A. (2013). Agroecological Zone Analysis for Sustainable Watershed Management Strategy. *Geography Journal, 5*(1), 1–16. https://doi.org/10.24114/jg.v5i1.8080

FAO. (2002). *Global Agroecological Assessment for Agriculture in the 21st century.* Laxenburg: IIASA Research Report.

FAO. (2012). *Global Agroecological Zonas*. Laxenburg: IIAS.

Ghosh, M. K., & Hasan, S. S. (2013). Farmers' attitude towards sustainable agricultural practices. *Bangladesh Research Publications Journal, 8*(4), 227-235. http://www.bdresearchpublications.com/admin/journal/upload/1308408/1308408.pdf

Gutierrez, A. P. (1996). *Applied Population Ecology: A Supply-Demand Approach*. Wiley. https://books.google.co.id/books?id=bUR6oSpMLx4C

Hapsari, H., Rasmikayati, E., Karuniawan, A., Saefudin, B.R. (2019). *Characteristics of Farmers and Sweet Potato Farming Profiles in Arjasari District, Bandung Regency. Journal of Social Sciences and Humanities, 21*(3), 247-255. https://doi.org/10.24198/sosiohumaniora.v21i3.21288

Harahap, M., Siregar, G., & Riza, F. V. (2020). Village Potential Mapping for Socio-Economic Improvement in Agriculture in Lubuk Kertang Village, Berandan Barat District, Langkat Regency. *Journal of Agribusiness Science, 4*(1), 8–14. https://jurnal.umsu.ac.id/index.php/JASc/article/download/6267/5211

Higgins, G. M., & Kassam, A. H. (1981). Regional assessments of land potential: a follow-up to the FAO/Unesco soil map of the world. *Nature & Resources, 17*(4), 11–23. https://unesdoc.unesco.org/ark:/48223/pf0000061300

Hikmatullah, Ritung, S. (2014). Development of Agro-Ecological Zone (AEZ) Mapping in Indonesia. *Land Resource Journal, 8*(1), 17–30. https://doi.org/10.2018/jsdl.v8i1.64411

Iswandi, U., & Dewata, I. (2020). *Natural Resource Management.* CV Budi Utama.

Kullenberg, G. (2010). Human empowerment: Opportunities from ocean governance. *Ocean and Coastal Management, 53*(8), 405–420. https://doi.org/10.1016/j.ocecoaman.2010.06.006

Lambin, E. F., & Meyfroidt, P. (2011). Global land use change, economic globalization, and the looming land scarcity. *Proceedings of the National Academy of Sciences of the United States of America, 108*(9), 3465–3472. https://doi.org/10.1073/pnas.1100480108

Lujala, P., & Rustad, S. A. (2011). *High-Value Natural Resources and Post-Conflict Peacebuilding* (1st ed.) (1st ed.). Routledge. https://doi.org/10.4324/9781849775786

Lukina, N. V., Geraskina, A. P., Gornov, A. V., Shevchenko, N. E., Kuprin, A. V., Chernov, T. I., Chumachenko SI, Shanin VN, Kuznetsova AI, Tebenkova DN & Gornova, M. V. (2021). Biodiversity and climate-regulating functions of forests: current issues and research prospects. *Вопросы лесной науки, 4*(1), 1. https://doi.org/10.31509/2658-607x-202141k-60

Lwin, K. K., Murayama, Y., & Mizutani, C. (2012). Quantitative versus Qualitative Geospatial Data in Spatial Modelling and Decision Making. *Journal of Geographic Information System, 04*(03), 237–241. https://doi.org/10.4236/jgis.2012.43028

MEA (Millennium Ecosystem Assessment). (2005). *Ecosystems and Human Well- Being: wetlands and water synthesis*. World Resource Institute.

Miller, G. T., & Spoolman, S. (2015). *Environmental Science*. Cengage Learning.

Mina, R. (2016). Decentralization of Environmental Protection and Management as an Alternative Solution to Environmental Issues. *Arena of Law, 9*(2), 149–165. https://doi.org/10.21776/ub.arenahukum.2016.00902.1.

Roseline, O., & Amusain, O. (2017). Effect of Fulani herders' intrusion on the economic livelihood of crop farmers in Yagba East Local Government Area of Kogi State, Nigeria. *International Journal of Agricultural Policy and Research, 21*(40), 80-85. https://doi.org/10.15739/IJAPR.17.009

Satria, J., Falatehan, A. F., & Beik, I. S. (2018). Strategy for Sustainable Agricultural Land Protection in Bogor Regency. *Journal of Regional Development Management, 10*(2). https://doi.org/10.29244/jurnal_mpd.v10i2.27786

Sulaiman, A. A., Sulaeman, Y., & Minasny, B. (2019). A framework for the development of wetland for agricultural use in Indonesia. *Resources, 8*(1), 1–16. https://doi.org/10.3390/resources8010034

Sun, G., Guo, C. (2012). Research and implementation of WebGIS spatial analysis system based on SVG. *Journal Chin Comp System. 33*(08), 1770–1773. https://doi.org/10.4028/www.scientific.net/AMR.230-232.694

Sutrisno, S. (2011). Politik Hukum Perlindungan Dan Pengelolaan Lingkungan Hidup. *Jurnal Hukum Ius Quia Iustum, 18*(3), 444–464. https://doi.org/10.20885/iustum.vol18.iss3.art8

Syahran, H. (2022). Analysis of Influencing Factors Income of Corn Farmers (Zea mays L.) (Case Study in North Tolo Village, Kelara District, Jeneponto Regency). *Contributions of Central Research Institute for Agriculture, 16*(2), 32-36. https://doi.org/10.59651/cceria.v16i2.19

Usman, H., & Akbar, P. S. (2020). *Introduction to Statistics (Third Edition): An Easy Way to Understand Statistics.* Bumi Aksara.

Wahyunto, Dariah, A. (2014). Land Degradation in Indonesia: Existing Conditions, Characteristics, and Harmonization of Definitions to Support the One Map Movement. *Land Resource Journal, 8*(2), 81-93. https://doi.org/10.2018/jsdl.v8i2.6470

Widowaty, Y. (2012). The Concept of Sustainable Development as a Form of Protection. *Media Law Journal, 19*(2). https://doi.org/10.18196/jmh.v19i2.105

Zakaria, W. A., Endaryanto, T., Indah, L. S. M., Sari, I., & Mutolib, A. (2020). Income and Welfare of Cassava Farming Households in Lampung Province*. Journal of Indonesian Agribusiness, 8(*1), 83-93. https://doi.org/10.29244/jai.2020.8.1.83-93

Zhang, A., Yang, Y., Chen, T., Liu, J., & Hu, Y. (2021). Exploration of spatial differentiation patterns and related influencing factors for National Key Villages for rural tourism in China in the context of a rural revitalization strategy, using GIS- based overlay analysis. *Arabian Journal of Geosciences*, 14(2). https://doi.org/10.1007/s12517-020-06381-9

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