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Regional Case Study

Spatial Planning for Agricultural Development Based on Carrying Capacity of Ecosystem Services in The Melolo Transmigration Area, East Sumba

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Abstract

Transmigration is one of the government programs that aim to create a new growth center by establishing an activity center through the development of basic business patterns. Development of the main business pattern is carried out through the management of land resources for agriculture. Improper management of land resources can lead to a decrease in environmental quality. Therefore, it is necessary to know the potential carrying capacity of ecosystem service to plan agricultural development. Parameters are used to analyze the carrying capacity of ecosystem services as provisioning based on environmental services for water and food provisioning. The environmental service assessment method for water and food provisioning is calculated using weighting and scoring. The total value of the carrying capacity of ecosystem services as provisioning is obtained from the calculation of the two parameters using the Simple Additive Weighting method. The results of the analysis show that the value of the carrying capacity of ecosystem service as provisioning is classified as very low. This indicates that the capability of the land for agricultural development is very low. Agricultural development requires conservation actions to increase the carrying capacity of ecosystem service. Recommendations for conservation actions are carried out through land use arrangements.

Keywords: Environmental; carrying capacity; ecosystem services; provisioning services

1. Introduction

East Sumba Regency is one of the regencies in East Nusa Tenggara Province which is located on Sumba Island. More than 50% of the total area of Sumba Island is included in the administrative area of East Sumba Regency. The topographical condition of East Sumba Regency is unique because it has a variety of landscapes ranging from oceans, plains, sloping and undulating plains, hills, and mountains. The agricultural sector is the driving force of the economy in East Sumba Regency. This can be seen from the Gross Regional Domestic Product of East Sumba Regency which is 27.75% dominated by the primary sector, namely agriculture, plantations, forestry, animal husbandry, fisheries, mining, and quarrying. However, development and economic growth are not evenly distributed throughout the East Sumba Regency. Economic development and growth only developed in the cities of Waingapu, Kambera, Kampung Melolo, and Lewa.

The National Development Planning Agency of the Republic of Indonesia directs to carry out equitable development by growing new economic centers. In line with these directions, the transmigration program is carried out by building and developing areas through natural resource

management as an agricultural production system to create new centers of growth. Government Regulation Number 3 of 2014 concerning the Implementation of Law Number 29 of 2009 concerning Transmigration states that the Transmigration Area is built and developed as a system of agricultural production and natural resource management that has functional linkages and spatial hierarchies with growth centers in a unified development system. Natural resource management is the main point in regional development to create new growth centers and increase economic growth.

United States Agency for International Development (USAID) predicts that the implementation of transmigration through natural resource management can threaten the environment if not done carefully. Globally the decline in environmental quality occurs due to poor management of natural resources (Sutton et al., 2016). Landis (2017) emphasized that the agricultural sector is a natural resource management activity that can result in the loss of biodiversity, ecological functions, and ecosystem services. While in a study conducted by Wadu et al. in (2019) showed that each additional 1% of agricultural land area would increase land productivity by 0.3936% and would cause a decrease in environmental quality by 0.4988%. Putri (2020) states that the current development does not take into account the environmental sector so it will slowly be followed by a decline in environmental quality. Based on the results of research that has been done, it can be seen that the management of natural resources to develop and increase the economy must be carried out by considering the carrying capacity of the environment.

Law Number 32 of 2009 concerning Environmental Protection and Management stipulates that the environment needs to be protected and managed to preserve environmental functions and prevent environmental pollution and damage. Referring to the law, the effort to preserve the environment is to maintain the continuity of the carrying capacity of the environment in every natural resource management activity. The government regulates the determination of the carrying capacity of the environment in the Regulation of the Minister of the Environment Number 17 of 2009 Regulation of the Minister of the Environment Number 17 of 2009 concerning Guidelines for Determining the Carrying Capacity of the Environment in Regional Spatial Planning. In the Ministerial Regulation of the Ministry of Environment and Forestry, it is stated that the scope of determining the carrying capacity of the environment includes: (1) determining land capability for allocation of spatial use, (2) comparison between availability and demand for land, and (3) comparison between availability and demand for water. Research on the carrying capacity of the environment by determining land capability for allocation of space utilization was carried out by Litasari et al. (2022). This study conducted a suitability assessment between land capability requirements and existing land use and land use plans. Determining the carrying capacity of the environment by comparing availability and demand can also be done using various methods. Arcana et al. (2021) analyzed the carrying capacity of the environment through space requirements related to population growth. Meanwhile, Wardana (2020) analyzed the carrying capacity of the environment based on the ability of the environment to meet human needs and then compared it to the value of biocapacity. Research related to different carrying capacities was conducted by Fahrurozi et al. (2023) using a qualitative method through the das sein - das sollen approach.

Ecosystem services are natural processes and various resources of an ecosystem that can be utilized by humans. The higher the value of ecosystem services, the higher the carrying capacity of the environment. Assessment of the carrying capacity of ecosystem services is principal in agricultural development. Agricultural development based on the carrying capacity of ecosystem services is used to ensure environmental sustainability which produces various ecosystem services for life (Riqqi et al., 2018). Within the ecosystem, there is a very complex interaction between biotic and abiotic so that it can provide an overview of the potential of the environment. The composition between biotic and abiotic affects the quality of the ecosystem. According to Endarwati et al. (2017), good ecosystem quality can create biodiversity vegetation. The interactions between soil, vegetation, and commodities influence each other to produce benefits for natural resources.

Agricultural development is closely related to the utilization of natural resources. Unsuitable use of natural resources potential for agriculture can result in damage to environmental resources, water, and soil (Efendi, 2016) and a decrease in biodiversity (Landis, 2017). Sutton et al. (2016) revealed that the demand for productive land for agriculture is increasing which has an impact on reducing environmental quality by 9.2% per year. Wadu et al. (2019) confirmed that each additional 1% of agricultural land area would increase land productivity by 0.3936% and decrease environmental quality by 0.4877%. Based on the results of this research, it can be seen clearly that agricultural development harms the environment, so it is necessary to notice the carrying capacity of ecosystem services.

Carrying capacity is the ability of the environment to support all human activities and other living things as well as the balance between the two so that there is availability and need in the allocation of space utilization. Suharyani et al. (2016) revealed that the assessment of the carrying capacity of the environment using the ecosystem services approach is the most comprehensive method. The ecosystem services approach calculates all the benefits of an ecosystem that are obtained by humans starting from provisioning services, regulatory services, supporting services, and cultural services. The concept of ecosystem services is promoted by the United Nations in the Millennium Ecosystem Assessment with the assumption that the higher the ecosystem services, the higher the carrying capacity of the environment. "Formally, the natural base for ecosystem services (ES) arises from the performance of the living and non-living components of an ecosystem and the interrelations between them" (Muller, 2017). Pcap et al. (2007) explained that each ecosystem component can create biodiversity value that can be utilized. Based on the results of the assessment of ecosystem services, the natural resource potential of each area can be identified. Ecosystem services assessment can map the unity of natural resource entities, namely landscape, natural vegetation, and land use. Spatially, ecosystem services assessment provides an overview of the spatial pattern of natural resource potential by the environmental carrying capacity. Therefore, planning for agricultural development requires an assessment of ecosystem services to match the carrying capacity of the environment. This research aims to assess the carrying capacity of ecosystem services for agricultural development in the Melolo Transmigration Area.

2. Methods

2.1 Research Location

The research was conducted in the Melolo Transmigration Area, East Sumba, East Nusa Tenggara Province, Indonesia. The Transmigration Area has a spatial hierarchy that forms a unified regional service system. The smallest unit of the service system is the Settlement Unit which is intended for transmigrant residences and places of business to develop basic business patterns through agriculture and plantations. A collection of several Settlement Units that form a larger hierarchical unit is called a Development Area Unit. One of the Development Area Units will be prepared as a new growth center capable of serving activities in the Transmigration Area. Development Area Unit B is a development area unit built to create a new growth center for the Melolo Transmigration Area and development priorities in East Sumba so that it is the focus of this research location.

2.2 Data

This research requires spatial data to analyze ecosystem service as provisioning can be a basis for spatial planning of agricultural development in Development Area Unit B of the Melolo Transmigration Area. The required spatial data includes landscape maps, natural vegetation maps, and land use maps. Geomorphological characteristics can be known from the characteristics of the landscape and natural vegetation. The of natural resources is known from the distribution and type of land use. The map was published by the Ministry of Environment and Forestry of the Republic of Indonesia in 2020. Particularly for the land use map, the data was verified again through field observations from September-October 2022.

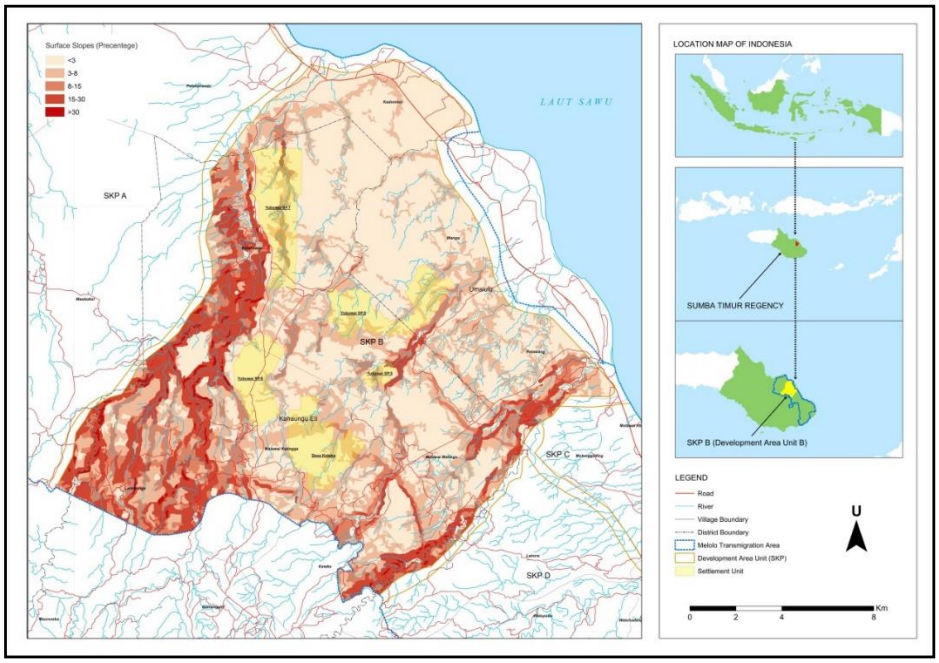

Figure 1. Research location map

2.3 Method

The carrying capacity of the ecosystem service as provisioning for spatial planning for the development of the main business pattern in Development Area Unit B follows The Guidelines for The Preparation of Environmental Carrying Capacity issued by the Ministry of Environment and Forestry of the Republic of Indonesia. The carrying capacity of ecosystem service as provisioning is calculated based on the provisioning services of water and provisioning services of food. These parameters are used because agricultural development is related to food and requires water for land management. The calculation of the index of ecosystem services as a provisioning service is carried out in stages. Broadly speaking, the index of ecosystem service as a provisioning service is divided into four stages, namely:

1. Data and map collection;
2. Calculation of environmental services;
3. Calculation of ecosystem services; and
4. The classification of ecosystem services.

The environmental service is calculated using the simple additive weighting method by weighting variables and scoring each parameter determining ecosystem services. Weighting calculations are carried out on the landscape, natural vegetation, and land use variables while scoring calculations are carried out on the parameters that make up landscapes, natural vegetation types, and land use types. The results of these calculations show the environmental services index for providing services of water and the environmental services index for providing services of food. The composite of each environmental service describes ecosystem service as a provisioning service. The steps for determining the carrying capacity of ecosystem service as provisioning are shown in Figure 2.

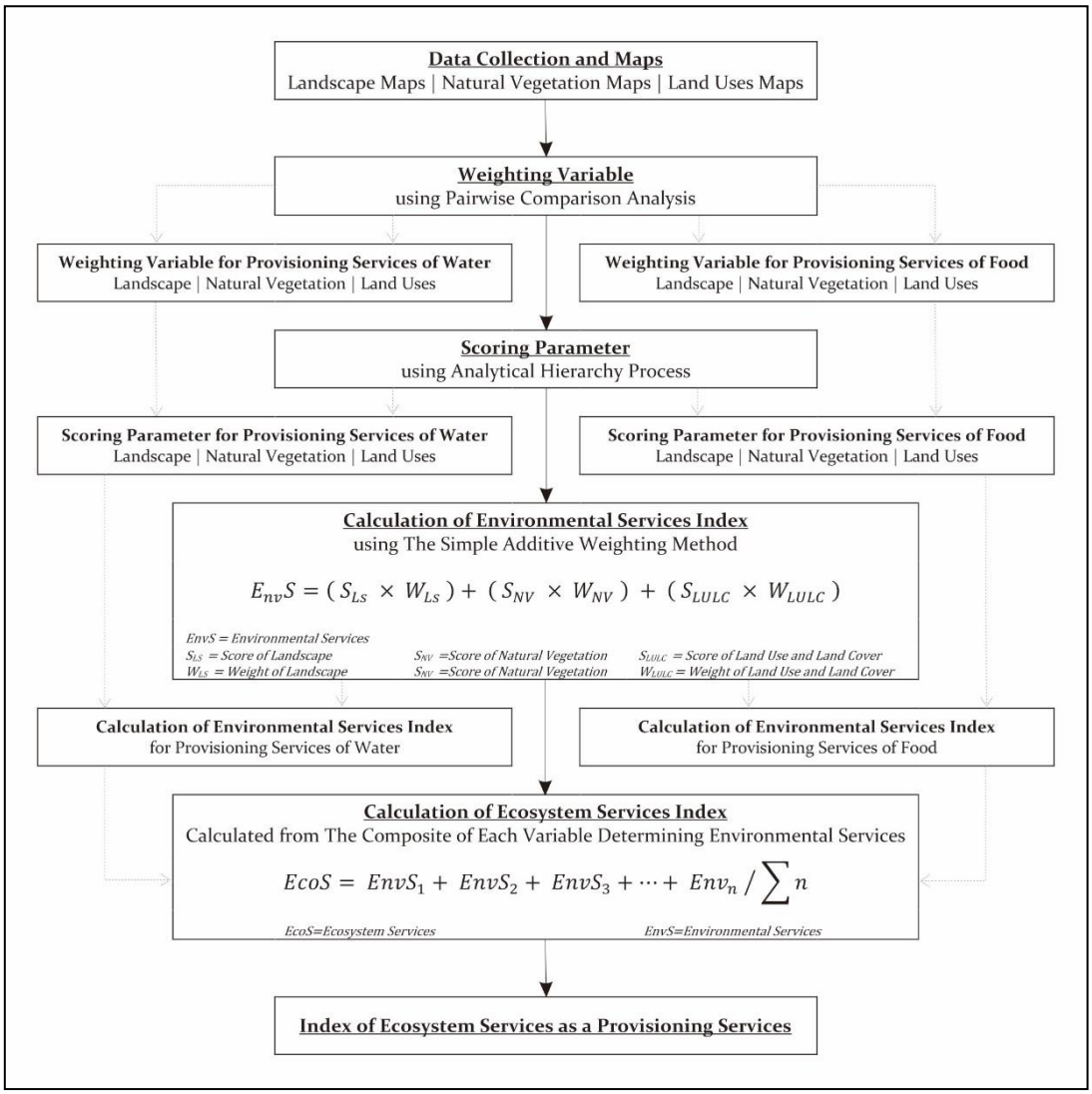

Figure 2. Research method

The results of the calculation of the environmental services index and ecosystem services index are classified into 5 classes. The classification of ecosystem services index values has an interval of 0.8 for each class. The ecosystem service index with a value of 1.00 – 1.81 is included in the very low-class category, the value of 1.81 – 2.60 is included in the low-class category, the value of 2.61 – 4.20 is included in the moderate-class category, the value of 3.41 – 4.20 is included in the high-class category, and the value of 4.21 – 5.00 included in the very high-class category. The classification of ecosystem service indices describes the performance of environmental services in supporting the utilization of natural resources based on biotic and abiotic interactions as natural capital.

3. Result and Discussion

Agriculture is a land use that utilizes natural capital. Natural capital is all natural resources available in the environment and can be used as raw materials, and energy and provide services to humans. Groot et al. (2000) revealed that land, water, atmosphere, and ecosystems are environmental assets or natural capital that can be utilized by humans now and in the future. Agriculture has the main function of producing food, feed, fiber, and fuel for populations around the world (Bergez et al., 2022), and as much as 60 % of natural resources are managed on the earth's surface for agriculture (Sutton et al., 2016). In Indonesia, especially in East Sumba, East Nusa Tenggara Province, agriculture is a driving

sector for the regional economy. One of the development programs through the transmigration system makes natural resource management in the form of assistance an effort to develop areas in creating new growth centers. Bergez et al. (2022) state that agricultural development harms the environment such as greenhouse gas emissions, reduced carbonation, and loss of habitat due to deforestation. Fahrurozi et al. (2023) revealed that the implementation of development which involves the use of natural resources must be following natural capital to reduce the risk of environmental damage. Based on research Carpenter et al. (2009) show that the trend of using ecosystem services for provisioning service has increased in the agricultural sector, namely crops, livestock, and aquaculture. According to Muller (2017), crops, livestock, and aquaculture activities in the agricultural sector are included in food supply services and require water supply services to support them. Therefore, the development of Development Area Unit B of the Melolo Transmigration Area in East Sumba requires spatial planning for agricultural development that is by natural capital based on an assessment of ecosystem services through water supply services and food supply services.

Referring to The Guidelines for The Preparation of Environmental Carrying Capacity The Guidelines for The Preparation of Environmental Carrying Capacity issued by the Ministry of Environment and Forestry of the Republic of Indonesia, the assessment of ecosystem services is based on landscapes, natural vegetation, land cover, and land use. Landscapes and vegetation are the integrity of the environmental system while land cover and land use are the result of human activities in utilizing ecosystem services (Suharyani et al., 2016). The calculation of the assessment of water supply services and food supply services is differentiated according to scores on each characteristic of the landscape, natural vegetation, land cover, and use. Characteristics of landscapes and vegetation as forming natural characteristics and characteristics of land cover and land use as a correction factor for the utilization of natural resources.

The landscape in Development Area Unit B of the Melolo Transmigration Area consists of 6 landscapes, including fluviomarine plains with alluvium material, sandy marine plains with alluvium material, river valleys with alluvium material, organic coralian plains with carbonate sedimentary rock material, organic coralian plains with undulating waves the material is carbonate sedimentary rock and the denuded hills are made of a mixture of carbonate and non-carbonate sedimentary rock. The characteristics of the organic coral plain landscape with carbonate sedimentary rock material dominate the physical structure of the rock. The rock has undergone an incomplete weathering process which originates from relatively young rocks so that it has a shallow layer of soil solum (Siregar & Yuswandi, 2018). Ecosystem service scores for such landscapes are low for both water and food supply services. Landscapes that have a high score are alluvium material river valleys. Alluvium material comes from soil deposits carried by the flow of water and rivers so the thickness of the soil solum in river basins is relatively deep.

There are 6 characteristics of natural vegetation scattered in Development Area Unit B of the Melolo Transmigration Area. The characteristics of natural vegetation include monsoon mangrove vegetation, monsoon coastal forest vegetation, monsoon forest vegetation on the banks of the evergreen river, lowland monsoon limp forest vegetation, lowland monsoon grassland vegetation, and lowland monsoon savanna vegetation. Lowland monsoon meadow vegetation is a natural vegetation that is widely spread in almost all research locations. While other types of vegetation are scattered in the landscape that becomes the ecosystem. For example, monsoon mangrove vegetation and monsoon coastal forest vegetation are often found in locations close to the coast, green monsoon forest along the banks of evergreen rivers is found in river valleys, and lowland monsoon savanna vegetation is spread over hilly landscapes. “Different combinations of climate, topography, and parent material result in the development of a range of soil and associated vegetation types” (Yang et al., 2017).

Based on field surveys, land use in Development Area Unit B of the Melolo Transmigration Area is still very low. Most of the land is in the form of land cover which is still natural vegetation there. Types of land use and land cover in Carrying Area Unit B of the Melolo Transmigration Area include forest,

shrubs, grasslands, open area, plantations, dry land agriculture, paddy fields, buildings, settlements, transmigration settlements, and transmigration settlements with a plasma system. Land used for plantations, dry land agriculture, rice fields, buildings, settlements, and transmigration settlements is less than 10% of the entire area. Meanwhile, grassland vegetation is the most dominant land cover in almost all areas with a percentage of 50.54% of the entire area.

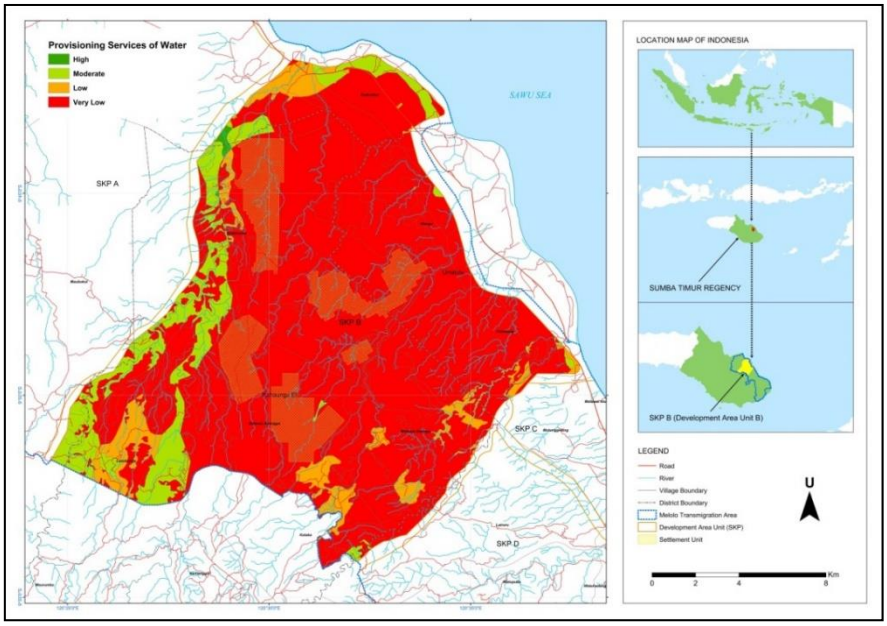

Figure 3 Environmental services of water

Assessment of water supply services is carried out to determine the carrying capacity of water availability. Ecologically, water is a natural resource that is obtained from ecosystem functions and can be used to support activities (Febriarta et al., 2020). The results of the assessment of ecosystem services providing water in Development Area Unit B of the Melolo Transmigration Area show that the carrying capacity of water supply is classified as very low. Spatial analysis shows that the potential for water availability with an area of 24,566.93 hectares or about 83.30% belongs to the very low category, 1,922.00 hectares or about 6.52% belongs to the low category, 2,949.28 hectares or about 10.00% belongs to the moderate category, and an area of 52.50 hectares or around 0.18% belong to the high category. Water supply services with a very low category are spread over the organic coral plain landscape with carbonate sedimentary rock material. Based on the results of field observations, the soil in the landscape has a gravel-to-rocky texture and a very shallow depth of soil solum. In addition, the type of land cover is grassland so there is no shade or a barrier for water to enter the soil. Baco S et al. (2020) state that land cover affects the process by which water dissolves into the soil. Meanwhile, water supply services belonging to the medium and high categories are spread across the landscape of denuded hills and river valleys. Topographically the location of the river valley is between the hills and becomes a water estuary from the denude hills so that there are lots of alluvium deposits.

The assessment of ecosystem services for food provisioning services illustrates better conditions compared to water supply services, although most are classified in the low category. Land with an area of 22,380.91 hectares or around 75.89 % of the total area in Development Area Unit B is classified as low. The carrying capacity of the land in providing food is classified according to several criteria from very low, low, moderate, high to very high. Distribution of land that has the ability as a food provisioning with very low criteria of 2,957.13 hectares of land or around 10.03 %, low criteria of 22,380.91 hectares or around 75.89 %, moderate criteria of 2,388.37 hectares or around 8.10 %, high criteria of 1,684.48 hectares or an area of 7.75 %, and very high criteria covering an area of 69.81 hectares or around 0.24 %. Land use and

land cover are the factors that most influence the value of food provisioning services. The value of food provisioning services belonging to the very low criteria is found in land that has experienced land clearing. The use of land for paddy fields has a very high value in providing food services which are supported by a landscape of river valleys made of alluvium material and the natural vegetation of the Monsoon forest along the green of the evergreen river.

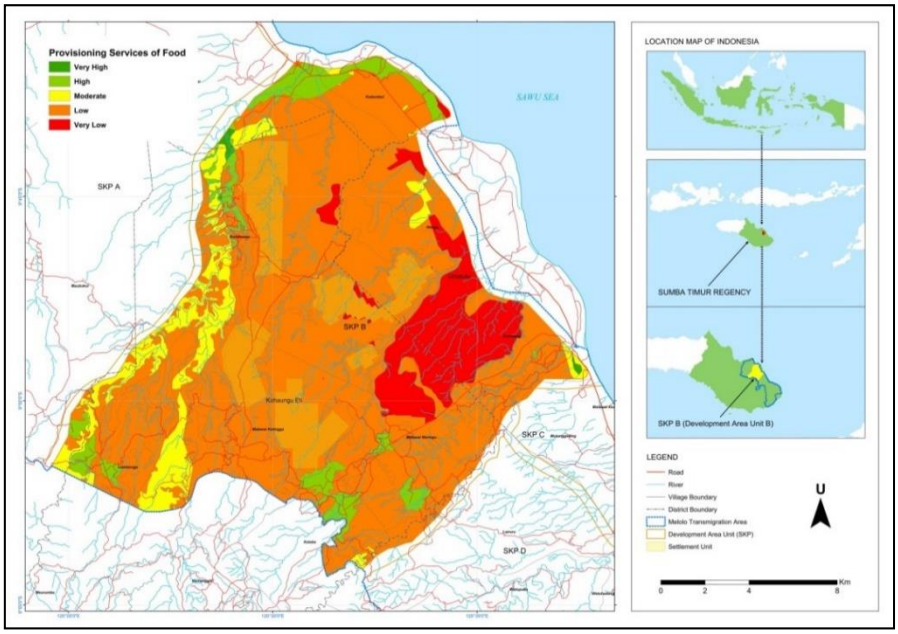

Figure 4 Environmental Services of Food

Based on the assessment of water supply services and food supply services, it can be seen that the value of ecosystem services is in Development Area Unit B of the Melolo Transmigration Area. Ecosystem services as provisioning with an area of 19,043.40 hectares or around 64.57% are classified as very low criteria, land with an area of 6,469.87 hectares or around 21.94% are classified as low criteria, land with an area of 3,721.19 hectares or around 12.62% are classified as moderate criteria and land with an area of 256.24 Hectares or about 0.87% are classified as low criteria. More than half of the value of ecosystem services as provisioning in the Development Area Unit B of the Melolo Transmigration Area is classified as very low. This indicates that the carrying capacity of the environment is very low, requiring conservation measures to carry out development.

The low carrying capacity of ecosystem service as provisioning for agricultural development has implications for land management, production yields, and time and cost efficiency in carrying out conservation actions. Land processing will be increasingly difficult because it has a heavy limiting factor so more technology and inputs are needed to produce high productivity (Erawanto & Sudaryono, 2016). According to Mubarokah et al. (2020), agricultural development is very dependent on the carrying capacity of ecosystem services as provisioning. Agricultural development is closely related to land resources, land area, and land productivity. Agricultural productivity gains tend to be lower on lands with low levels of carrying capacity of the ecosystem service as provisioning. It is necessary to carry out conservation actions to improve land quality so that land productivity results are also getting bigger. revealed that increasing the productivity of agricultural products on land with low carrying capacity of ecosystem service as provisioning requires a lot of input.

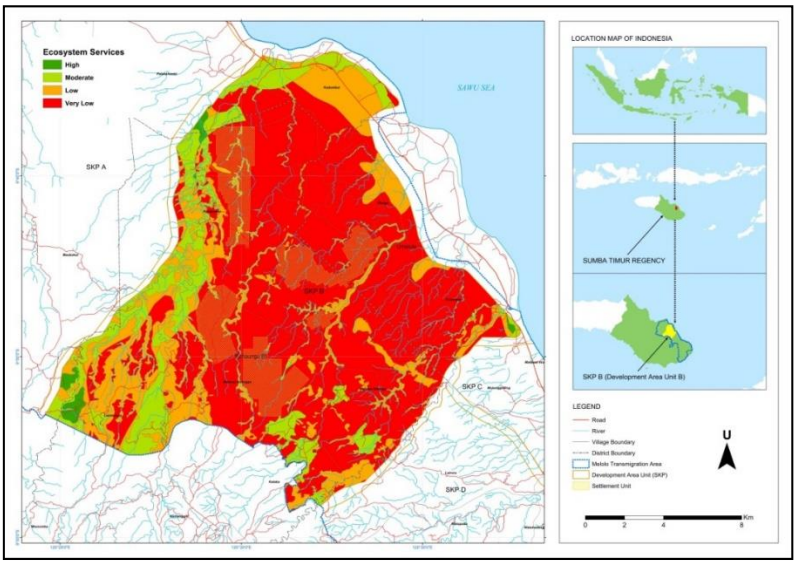

Figure 5 Ecosystem Services as Provisioning

Water supply services are a limiting factor for the carrying capacity of ecosystem services in Development Area Unit B of the Melolo Transmigration Area. Meanwhile, land use and land cover are factors that influence the assessment of ecosystem services as provisioning. The cause of the low value of ecosystem services is the land cover which is mostly dominated by grasslands. There needs to be a selection of vegetation in land use to improve land quality and increase the value of ecosystem services as provisioning. Vegetation density can produce humus and water with low Ph levels so that it can dissolve carbonate ($CaCO_3$) and accelerate the process of rock formation (Baco S et al., 2020). Conservation actions to enhance ecosystem services can be carried out by planting titled vegetation. The data used as the basis for assessing ecosystem services shows that land uses other than grasslands such as shrubs, plantations, dry land agriculture, and paddy fields have ecosystem service values above grasslands, which are between low and moderate.

Table 1 Ecosystem Services by Land Use and Land Cover

No	Characteristic	Area (Ha)	%	Status
A	**Sandy Marine Plains with Alluvium Material Monsoon Coastal Forest Vegetation**			
1.	Paddy Fields	329.08	1.12	Moderate
2.	Shrubs	0.88	0.00	Low
3.	Grasslands	839.11	2.85	Low
4.	Dry Land Agriculture	34.37	0.12	Low
5.	Open Area	53.43	0.18	Very Low
6.	Settlements	0.96	0.00	Very Low
B	**Fluviomarine Plains with Alluvium Material Monsoon Mangrove Vegetation**			
7.	Paddy Fields	17.31	0.06	High
8.	Shrubs	4.09	0.01	Moderate
9.	Dry Land Agriculture	38.29	0.13	Moderate
10.	Grasslands	139.64	0.47	Low
11.	Open Area	326.99	1.11	Low
12.	Plantations	0.01	0.00	Low
13.	Transmigration Settlements with a Plasma System	12.18	0.04	Low

C	**River Valleys with Alluvium Material**			
	Monsoon Forest Vegetation on The Banks of The Evergreen River			
14.	Paddy Fields	52.50	0.18	High
15.	Shrubs	76.21	0.26	Moderate
16.	Grasslands	285.48	0.97	Moderate
17.	Dry Land Agriculture	2.01	0.01	Moderate
18.	Transmigration Settlements	5.53	0.02	Moderate
19.	Open Area	13.42	0.05	Low
D	**Organic Coralian Plains with Carbonate Sedimentary Rock Material**			
	Lowland Monsoon Limp Forest Vegetation			
20.	Paddy Fields	67.88	0.23	Moderate
21.	Shrubs	683.87	2.32	Low
22.	Plantations	64.84	0.22	Low
23.	Dry Land Agriculture	61.61	0.21	Low
24.	Grasslands	954.18	3.24	Very Low
	Lowland Monsoon Grassland Vegetation			
25.	Paddy Fields	347.92	1.18	Moderate
26.	Shrubs	80.88	0.27	Low
27.	Dry Land Agriculture	85.18	0.29	Low
28.	Grasslands	1,722.58	5.84	Very Low
29.	Open Area	279.52	0.95	Very Low
E	**Organic Coralian Plains with Undulating Waves and The Material is Carbonate Sedimentary Rock**			
	Lowland Monsoon Grassland Vegetation			
30.	Forest	13.01	0.04	Moderate
31.	Paddy Fields	684.95	2.32	Moderate
32.	Shrubs	2,973.04	10.08	Low
33.	Dry Land Agriculture	194.14	0.66	Low
34.	Grasslands	10,092.62	34.22	Very Low
35.	Open Area	2,621.88	8.89	Very Low
36.	Plantations	13.89	0.05	Very Low
37.	Buildings	0.03	0.00	Very Low
38.	Settlements	1.31	0.00	Very Low
39.	Transmigration Settlements	2,351.93	7.98	Very Low
40.	Transmigration Settlements with a Plasma System	951.06	3.22	Very Low
F	**Denude Hills are Made of a Mixture of Carbonate and Non-Carbonate Sedimentary Rock**			
	Lowland Monsoon Grassland Vegetation			
41.	Paddy Fields	7.77	0.03	High
42.	Shrubs	1.17	0.00	Low
43.	Grasslands	17.36	0.06	Low
	Lowland Monsoon Savanna Vegetation			
44.	Paddy Fields	178.66	0.61	High
45.	Shrubs	1,837.50	6.23	Moderate
46.	Dry Land Agriculture	29.23	0.10	Moderate
47.	Grasslands	855.01	2.90	Low
48.	Plantations	86.17	0.29	Low
	Total	**29,490.70**	**100.00**	

Based on the results of the analysis it is known that land use for paddy fields has the highest ecosystem service value in each landscape. Land use for paddy fields is most suitable for areas with fluviomarine plains and river valleys made of alluvium material and denudational hills made of a mixture of carbonate and non-carbonate sedimentary rocks. The carrying capacity of ecosystem services in these landscapes is included in the high criteria. However, for the development of agriculture in these locations, it is necessary to pay close attention to the area of land and the condition of the landforms there. The land area in the landscapes of fluviomarine plains, valleys, and denudational hills is too small to be used for agricultural development. According to the landscape conditions, fluviomarine plains are formed due to faster coastal waves resulting in alluvium deposits that form deltas (Hidayat & Lumbanatu, 2010). The threat of agricultural development in river valleys with alluvium material is flooding. The river valley is located between hills with slightly sloping slopes (15–30%) so that when the water discharge increases the rate of water flow will be fast and the volume of water will also increase. Whereas in denudational hill landscapes, the level of slope needs to be the main consideration. Most of the land conditions have a slightly sloping slope (15–30%) and steep (30–45%). Therefore, it is necessary to know the characteristics of plants that can hold the soil.

Agricultural development requires large areas of land and is supported by abundant water availability. Landscapes with a high environmental carrying capacity for ecosystem services as provisioning are only found in certain locations and relatively small land areas. On large areas of land, the carrying capacity of the environment has a very low value of ecosystem services as provisioning. Agricultural development in Development Area Unit B of the Melolo Transmigration Area requires a lot of conservation measures. The carrying capacity of the environment for water supply is very low coupled with the characteristics of the landscape that cannot absorb and hold back the flow of water. Water and soil conservation measures need to be taken first to develop agriculture.

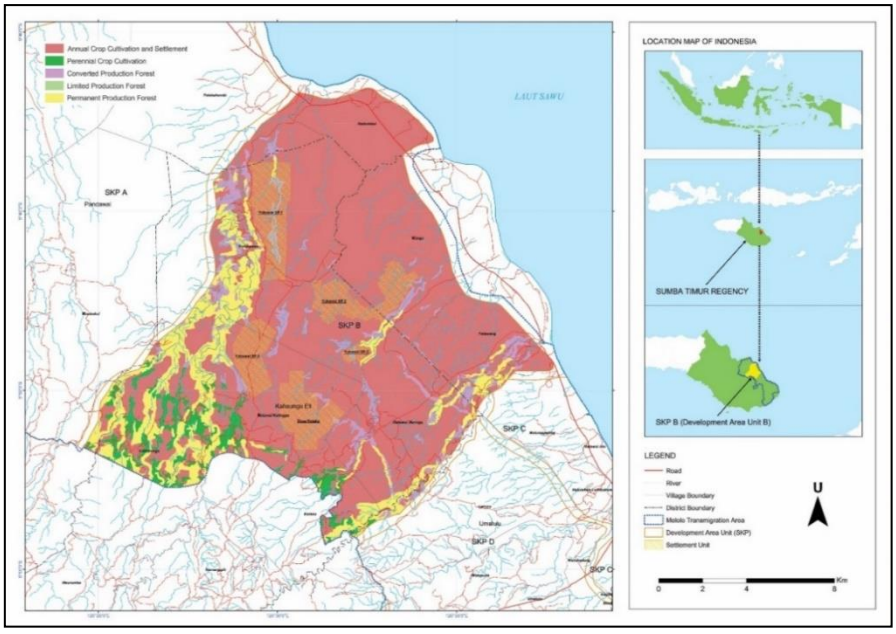

Figure 6. Spatial planning for development agriculture

Data and analysis show that the factors that influence the carrying capacity of ecosystem service as provisioning are land cover and land use. The results of the data and analysis indicate that the carrying capacity of ecosystem service as provisioning can be increased by regulating land use. Based on the scoring of land cover and land use, it is known that forest land cover and paddy field use have high scores for water supply services, while forest land cover and shrubs as well as paddy field use and dry land agriculture have high scores for food supply services. Sallata (2017) added that in regulating land use it is

also necessary to apply an agrotechnology system. The application of agrotechnology systems must use the principles of soil and water conservation. In Law Number 37 of 2014 concerning soil and water conservation it is explained that soil and water conservation techniques include agronomic, vegetative, mechanical, and management techniques. Landis (2017) stated that an interesting point regarding agricultural development is that more specific goals are needed in developing agriculture. Productivity and the environment, both are interrelated in agriculture development. The aim of agriculture development for high productivity results will reduce environmental quality. Vice versa, agriculture development to improve land quality will reduce total productivity. Land use arrangements are carried out according to conservation techniques with the main types of land cover types and land use for agricultural development must be adjusted to the carrying capacity of ecosystem services (Erawanto & Sudaryono, 2016).

Based on the results of the analysis of the carrying capacity of ecosystem service as provisioning, land use for agricultural development is recommended for the cultivation of seasonal crops and settlements, cultivation of annual crops, conversion production forests, limited production forests, and permanent production forests. The land use area for cultivating seasonal crops is 22,678.50 Ha. Agricultural development for annual crops needs to pay attention to water availability. The assessment of ecosystem service as provisioning at these locations is included in the very low category, requiring mechanical conservation measures. The allocation of 1,235.58 Ha of land is used for cultivating annual crops. Perennial crops are considered to be able to maintain and maximize land use for annual crops. In addition, annual crops can provide added value over a long period. The land use for conversion production forest is 1,634.82 Ha. Forest and land products can be converted to other land uses that can generate economic value. Land use change is a threat to conversion production forests. Proper land management and control of land conversion are important to protect the environment (Ustaoglu & Williams, 2023). Land use for the conservation function is limited production forest with an area of 224.33 Ha and permanent production forest with an area of 3,733.56 Ha. Both land uses are maintained to maintain ecological functions.

The carrying capacity of ecosystem services as provisioning can be used as a basis for agricultural development (Miswar et al., 2023). The results of the analysis describe the potential for environmental ecosystem services so that they can be used to formulate appropriate land use, land management, and conservation measures. The goal of economic development is achieved and the preservation of natural resources can be maintained.

4. Conclusions

Spatial planning for agricultural development in Development Area Unit B of the Melolo Transmigration Area is carried out based on an assessment of ecosystem services to water and food provisioning. The results of the assessment of ecosystem services illustrate the ability of the natural carrying capacity of the environment to support activities on it. Based on the results of the analysis, shows that 64.57% of the area has the value of ecosystem services as provisioning, which is classified as very low. This indicates that the ecosystem has a very low environmental carrying capacity for agricultural development. Agricultural development in Development Area Unit B of the Melolo Transmigration Area requires conservation measures for water and soil to increase the carrying capacity of the environmental ecosystem service provisioning. Conservation actions are carried out through land use regulation. Recommendations for land arrangements for agricultural development are for the cultivation of annual crops, cultivation of perennial crops, conversion production forests, limited production forests, and permanent production forests.

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