Carrying capacity of horticulture intensive farming land in Enrekang Regency (study: Anggeraja District)

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Abstract. The carrying capacity of farming land was analyzed so that the planning and development of the agriculture field can be processed according to land ability. This study aims to determine whether the carrying capacity of the status about agricultural land in the district of Anggeraja surplus or deficit, relations between land capability and carrying capacity of the land, as well as finding an effort to increase the carrying capacity of agricultural land in the district Anggeraja intensive horticulture. The research was conducted in the District of Anggeraja. This type of research is surveys using descriptive methods such as field data collection, data processing field, as well as the mapping method to see land capability at the study sites. Agricultural land carrying capacity analysis based on the Regulation of the Minister of the Environment Number 17 of 2009 and spatial analysis of land capability. The results showed that the District of Anggeraja is surplus status. Surplus for the value of the availability of land (SL) is greater than the value of the land needs (DL) which shows that the availability of land is still sufficient for biological products in the Anggeraja District. Efforts to increase the carrying capacity of agricultural land-intensive horticulture includes components the support means include a dam and road infrastructure support including fertilizers and pesticides as well as capital, support land productivity, among others, the selection of seeds, the use of organic fertilizers, and integrated pest management, support conservation of natural resources and the environment, among others, crop rotation, terracing and mounds.

1. Introduction

The increase in population is also in line with the increasing need for land for settlements for human habitation, industry, and agricultural land in accommodating the biological needs of humans. The land is exploited by humans in an effort to improve the quality of life, one of which is in agricultural business. Farming systems of managing agricultural land will consistently try increasing agricultural productivity. Farmers in Indonesia cultivate their land by implementing intensive farming systems in increasing agricultural productivity. Intensive agriculture is all activities related to growing agricultural crops which are carried out throughout the year, without identifying the climate (either dry or rainy), especially on dryland agriculture. One area in South Sulawesi Province with a properly developed agricultural sector is Enrekang Regency, especially in Anggeraja. Anggeraja is the largest vegetable producing horticulture plant in Enrekang Regency. Cultivation of land with intensive farming systems on commodities contained in Enrekang is carried out throughout the year. This shows that in the dry season, it still strives to increase productivity. The development of intensive agricultural
areas for the cultivation of horticultural crops, especially vegetables, is an effort to improve the prosperity and income of farmers.

Efforts to increase the productivity of some leading commodities should know the carrying land capacity and the land ability, so that, the lands that are managed productively are sustainable. The management of intensive agricultural land should further maximize conservation measures to maintain the stability of land capability. Determination of the carrying capacity of intensive agricultural land in the Anggeraja District is based on Environmentally Regulation No. 17/2009 and spatial analysis of land capability in the Anggeraja District.

Currently, there are several studies related to the carrying capacity of agricultural land. One of the previous studies [1]. In this study, the carrying capacity of paddy fields was calculated based on Environmentally Regulation No. 17/2009.

This research desired to determine the status of the carrying capacity of land in the Anggeraja District, the relationship of the land capability to the carrying capacity of the land, and the strategies were undertaken to increase the carrying capacity of horticultural intensive agricultural land in Anggeraja.

2. Methods

2.1. Location, time and study design

This research was conducted in Anggeraja District, Enrekang Regency in April-May 2019. This type of research is a survey using descriptive methods in field data collection, field data processing, and mapping methods to identify the ability of intensive agricultural land at the research location.

2.2. Tools and materials

This study used computer equipment, stationery, GPS (Global Positioning System), cameras and ArcGIS software.

The materials used in this study are the Anggeraja District Administration Map, the Anggeraja District Land Use Map, the Anggeraja District Slope Map, the Anggeraja District Land Type Map, and the Anggeraja District Rainfall Map as well as some supporting data obtained from relevant agencies.

2.3. Data collection

Primary data were obtained from interviews using questionnaires as well as conducting discussions through Focus Group Discussions (FGD) with farmers, agricultural instructors and stakeholders on land units that experience intensive agricultural land activities in Anggeraja District.

Secondary data collection was obtained from agencies related to the object of research, namely the Office of Agriculture, Food Crops and Horticulture, the Central Statistics Agency, the Meteorology Climatology and Geophysics Agency, and other related agencies. Secondary data were also obtained through the analysis of Geographic Information Systems (GIS). The data include land use data obtained from GeoEye Satellite Imagery acquisition in 2018, slope grade data from SRTM ASTGM V2, rainfall data obtained from BMKG Reg.IV Makassar, Enrekang Regency RTRW data and soil type data obtained from the land system (land system) Regional Physical Project for Transmigration (RePPProt) 1987.

Data collection for determining the carrying capacity of the land is carried out based on the Regulation of the Minister of Environment No. 17 of 2009 and also spatial analysis of land capability. It was explained that how to calculate the carrying capacity of land based on the Regulation of the Minister of Environment No. 17 of 2009 was a comparison between the availability of land and the need for land for people living in an area.

Spatial use suitability analysis is to find out how far is the suitability between actual land uses compared to the spatial use direction (spatial plan) based on the Regional Spatial Planning document (RTRW). The provision of utilization can be in the form of activity and spatial allotments contained in the detailed plan or general provisions on zoning regulations contained in the District/City RTRW.
Both of these analysis processes, analysis of land use conversion and the analysis of the suitability of space use, are carried out by overlapping maps using the GIS (Geographic Information System) spatial data processing software.

2.4. Data analysis

Land Capability determination is carried out by the method of overlaying three types of maps, such as Land Type Maps, Slope Maps, and Rainfall Maps. The result of an overlay is further classified in the division of two regional functions. The division of area functions is based on the Agriculture Minister Decree Number 873/Kpts/Um/11/1980 and 683/Kpts/Um/8/1981 using the scoring method or scoring technique.

The land carrying capacity is calculated based on the Minister of Environment Regulation No. 17 of 2009 as follows:

Land Availability (SL) calculation, formula:

\[
SL = \frac{\sum P_i \times H_i}{H_b} \times \frac{1}{P_{tvb}}
\]

- \(SL\) = Land Availability (ha)
- \(P_i\) = Actual production of each type of commodity (the unit depends on the type of commodity).
- The commodities calculated include agriculture, animal husbandry, fisheries
- \(H_i\) = Unit price for commodity types (Rp/unit) at the producer level
- \(H_b\) = Unit price of rice (Rp/kg) at the producer level
- \(P_{tvb}\) = Rice productivity (kg/ha)

Land Requirement (DL) calculation, formula:

\[
DL = N \times KHLL
\]

- \(DL\) = Total land requirement equivalent to rice (ha)
- \(N\) = Number of residents (people)
- \(KHLL\) = Area of land required for the needs of decent living per person.

1. The area of land needed for the needs of decent living per population represents the need for decent living per population divided by the productivity of local rice;
2. The need for a decent living per population is assumed to be 1 ton equivalent to rice/capita/year;
3. Regions which do not have local rice productivity data, can use national average rice productivity data of 2,400 kg/ha/year.

2.4.1. Determination of the land carrying capacity. The land carrying capacity is obtained from the comparison between land availability (SL) and land requirements (DL). If \(SL > DL\), then the carrying capacity is declared surplus, whereas if \(SL < DL\), then the carrying capacity is declared deficit. This study also uses the Focus Group Discussion (FGD) method. Participants in the FGD were agricultural instructors, farmers, and related stakeholders. Furthermore, the FGD will result in determining priorities in efforts to increase the carrying capacity of agricultural land.

3. Result

3.1. Land carrying capacity status

Based on the analysis of the land carrying capacity which was carried out using the Environmental Ministerial Regulation No. 17 of 2009, the results showed that the study area has the value of land availability (SL) and land requirements (DL) for the commodities of shallots and tomatoes. Overall, Anggeraja has a surplus status where the land availability (SL) is greater than the land requirement (DL) (table 1).
Table 1. Supporting the status of horticultural intensive agricultural land in the Anggeraja District.

| Commodity       | SL     | DL     | Status   |
|-----------------|--------|--------|----------|
| Shallot/Red Onion | 23,929.17 | 10,084.01 | Surplus  |
| Tomato          | 8,867.86 | 10,084.01 | Deficit  |
| **Amount**      | **32,797.02** | **20,168.03** | **Surplus** |

3.2. Population projection

The total population in Anggeraja District in 2018 is 24,010 people and the population growth rate is 0.93% per year. To calculate the population projection for the next 10 years in Anggeraja, the following results are obtained:

\[ P_n = 24,010 \times (1 + (0.0093 \times 10)) \]
\[ P_n = 24,010 \times (1 + 0.093) \]
\[ P_n = 24,010 \times 1.093 \]
\[ P_n = 26,243 \]

The population projection in Anggeraja for the next 10 years is 26,243 people. This shows that the carrying capacity of the Anggeraja can still be predicted in a surplus. The insignificant population growth projection but, remain meets the land needs in accommodating the biological needs.

3.3. Land ability

Determination of land capability classification will result in the level of land capability in the study area based on the physical condition of the land. The physical variables used are the slope, soil type, and rainfall. Furthermore, to determine the division of area functions based on the Agriculture Minister Decree Number 873/Kpts/Um/11/1980 and Number 683/Kpts/Um/8/1981 using the scaling method or scoring technique.

The slope data analysis of Anggeraja using scoring technique shows that the slope classification in Anggeraja is divided into four classes that are ramps with slope 8-15% (score 40), quite steep with slope 15-25% (score 80), steep with slope 25-40% (score 80), and very steep with slope > 40% (score 100) (table 2).

Table 2. Classification and slope factor scores of the Anggeraja District.

| Class | Slope (%) | Classification | Total Score |
|-------|-----------|----------------|-------------|
| II    | 8-15      | Ramps          | 40          |
| III   | 15-25     | Quite Steed    | 60          |
| IV    | 25-40     | Steed          | 80          |
| V     | >40       | Very Steed     | 100         |

Soil type data analysis in Anggeraja is in accordance with the scoring technique used in determining the class of land's ability to determine soil sensitivity to erosion. The results showed that Anggeraja consisted of three types of soil namely Inceptisol (score 15) insensitive to erosion. The second type of soil is Alfisol (score 30) less sensitive to erosion. The third type of soil is Ultisol (score 45) sensitive to erosion. The higher the value of the soil factor score, the more sensitive the soil is to erosion (Table 3).

Table 3. Classification and value score of soil factors according to their sensitivity to the erosion of the Anggeraja District.

| Class | Soil Types | Classification | Total Score |
|-------|------------|----------------|-------------|
| I     | Inceptisol | Insensitive    | 15          |
| III   | Alfisol    | Less Sensitive | 30          |
| IV    | Ultisol    | Sensitive      | 45          |
Rainfall data analysis in Anggeraja is in accordance with scoring techniques like the slope and soil type data analysis. The results show Anggeraja District is divided into two types of annual rainfall intensity. The first type represents the intensity of 1500-2000 mm/year with a score of 40. The second type is the intensity of 2,000-2,500 mm/year with score 50 (table 4).

Table 4. The weighting of rainfall value in the Anggeraja District.

| Intensities (year) | Total Score |
|--------------------|-------------|
| 1,500-2,000        | 40          |
| 2,000-2,500        | 50          |

3.4. Relationship between land capability and land support capacity
Land capability classification in Anggeraja is divided into two area functions based on spatial analysis of land capability, which is the function of the cultivation area and the function of the conservation area. Land Capability Map (figure 1). The land carrying capacity is calculated based on the land capability of the area in the area of cultivation that is associated with population projections. Based on the Land Capability Map, the area of cultivation area is 8,729 ha while the population projection for the next 10 years is 26,243 inhabitants. Land requirements (DL) for the next 10 years can be seen in the following analysis.

\[ DL = N \times KHLL \]
\[ DL = 26,243 \times 0.42 \]
\[ DL = 11,022 \]

The land requirement for the cultivation area in the next 10 years is 11,022 ha, while the area of the cultivation area is 8,729 ha. Hence, if it is related to the land needs and the available land in the next 10 years, the carrying capacity of the land is a deficit-based on the ability of the land.

Figure 1. Land capability maps of Anggeraja district
3.5. Efforts to increase land support capacity
Efforts to increase the carrying capacity of horticultural intensive agricultural land for vegetable crops were carried out in discussions with several stakeholders. The discussion was carried out in a Focus Group Discussion (FGD) with several related stakeholders to get results in an effort to increase the carrying capacity of horticultural intensive agricultural land in Anggeraja. In the FGD which was carried out with farmers, agricultural instructors, agricultural entrepreneurs, and several employees in the Enrekang Regency Agriculture Office, especially in the horticultural crops subject which produced four components that were considered necessary as an effort to increase the carrying capacity of horticultural intensive agricultural land for vegetables in Anggeraja. These components are the support of facilities which include reservoirs and roads, infrastructure support which includes fertilizers and pesticides as well as capital, land productivity which includes the selection of superior seeds, use of organic fertilizer, integrated pest control, conservation of natural resources and the environment which includes crop rotation, terracing, and mounds.

4. Discussion
This study shows the carrying capacity of horticultural agricultural land in the Anggeraja is in surplus. This is because the value of land availability (SL) is higher than the value of land requirements (DL). Supply is generally limited, while demand is unlimited. A study [2], see supply as capacity, while needs as pressure. These results indicate the availability of local land can still meet the needs of biological production, especially for horticultural crops. Research [3] which states that the environmental carrying capacity is surplus to current conditions because it is supported by good land management factors, selection of high-quality seeds, and good facilities and infrastructures, and also the ability to support land. The carrying capacity of agricultural land is an absolute requirement in realizing independence, national resilience and food sovereignty [4] avoiding vulnerable to poverty in agriculture [5]. The development process is supported by land resources, environmental quality, and humans guarantee the life quality and quantity of present and future generations [6] in avoiding agrarian land conflict [7].

The number of residents and the rate of population growth in the Anggeraja per year is almost the same. The projection of the Anggeraja population for the next 10 years is 26,243 people according to the results obtained using the arithmetic formula. As same as with the analysis of land carrying capacity based on the comparison between land availability and land requirements, it can be predicted that the carrying capacity of agricultural land in the Anggeraja for the next 10-20 years is still in surplus status. The projected population for the next 30 years will be higher so that the carrying capacity of the land is predicted will decrease. Population pressure is the impetus for the population, especially the peasant population to expand their arable land or move out of agricultural employment [8]. The higher the population pressure, the lower the carrying capacity [9]. Development policy should not only be directed to address current population problems, but also be carried out to anticipate the state of population problems in the future [10].

In this study, land capability in Anggeraja was divided into two regional functions, that are cultivation area and conservation area. In special cultivation areas designated for agricultural production activities, while conservation areas are designated as cantilever zones. In practice, most farmers manage agricultural land in the restricted area because it is a conservation area. To maintain the carrying capacity of the land is cultivated areas, strategies are needed to increase land productivity.

Land capability is seen as the capacity of the land itself for kind or level of general use [11]. Land capability in Anggeraja is classified into two regional functions, that are cultivation area and conservation area. In this study, the land capability is associated with land carrying capacity based on land requirements for population projections for the next 10 years. The results show the land carrying capacity in the cultivation area is in a deficit. This is due to an increase in population, while the capacity of the land for cultivation areas is stable.

Referred to research [12] which explains that high agricultural production is influenced by many factors including soil fertility factors, the presence or absence of pest attacks, good cultivation
techniques, and maintenance. This is in line with efforts to increase the carrying capacity of agricultural land in Anggeraja including several components, that is the reservoir as the aqueduct for water supply in horticultural agriculture to supply water to plants during the dry season, roads as the most essential and fundamental infrastructure for horticulture agricultural areas that functions to distribute agricultural products in every village.

Superior seeds used for an effort made to obtain a high level of production. Organic fertilizers have enormous benefits in increasing agricultural production, reducing environmental pollution, and can increase the land carrying capacity in a sustainable manner. Farmers in Anggeraja eradicate pests still using chemical pesticides. A small number of farmers eradicate pests maintaining a traditional system without chemical pesticides. One of the measures of soil conservation is to implement a crop rotation system.

Anggeraja is one of the horticultural production areas in the Enrekang Regency. The dominant horticultural commodity managed intensively is onion plants. The productivity of onion plants has a significant impact on land degradation, water pollution, and air. The terrace is one of the conservation measures to prevent and reduce impacts like erosion. The terracing technique has been implemented by farmers in the Anggeraja, which is an area with a high slope level topography. Mounds are also applied to flat plots that are cultivated on horticultural farms in Anggeraja. Evoking the agricultural sector by preserving the environment through an agricultural revitalization program [13].

5. Conclusions and Suggestions

5.1. Conclusion

The carrying capacity of the horticultural intensive agricultural land in the Anggeraja is in surplus at all. Land capability in Anggeraja is classified into two regional functions, that is the cultivation area and conservation area. In this study, the land capability is associated with land carrying capacity based on land requirements for population projections for the next 10 years. The results show the land carrying capacity in the cultivation area is in deficit. This is due to the population increase, while the capacity of the cultivation land areas is stable. Based on the results of the Focus Group Discussion (FGD) summary, it can be stated that efforts to increase the land carrying capacity of horticultural intensive in Anggeraja include the creation of aqueducts, road improvements, optimization of the organic fertilizers and pesticides, savings and loans, crop rotation, selection of crops superior seeds, integrated pest control and conservation of agricultural areas with terracing and mound techniques.

5.2. Suggestion

The farming system implemented can be multicultural by planting rotations. The effort is implemented to halt many losses for farmers in many ways including pest’s overpopulation and diseases which are hard to control and can stabilize production. There is an encouragement to use fertilizers and pesticides from organic materials both from local governments and from agricultural instructors to farmers. This is implemented to increase the competitiveness of horticultural production in the market. Development with a sustainable agricultural system needs to receive more attention from all stakeholders so, that the impact of environmental damage can be reduced, especially in areas that demonstrate the potential for horticultural crop productivity in Anggeraja.

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