Analysis of Carrying Capacity of Agro-Ecosystem Coconut-Cattle in South Minahasa Regency

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Abstract. Coconut plantation is very dominating in South Minahasa regency seen from its production of 49,907.33 tons in 2010. The land under coconut trees can be used for food crops or forage. The waste from food crops is the source of animal feed, while the livestock's manure is used to improve soil fertility under coconut tree. The research objective was to analyse the carrying capacity of the agro-ecosystem of coconut-cattle. Regency and district were determined purposively. A total of 86 farmers as respondents were determined based on the ownership of at least 2 cattle and cattle selling experience. Data were analyzed using effective potential of livestock development and land capability index (IDD). The result showed that the maximum potential of land resources (PMSL) was 30,872.94 animal unit (AU). The capacity increase in cattle population based on the soil resources was 18,208.94 AU. The maximum potential based on farmer house holds was 127,023.00 AU. The value of land capability index was 2.14. The conclusion was South Minahasa Regency was still potential for cattle development regarding land resources or workforce potentials. Development of cattle can be integrated with the coconut to maintain and improve agro-ecosystem sustainability of coconut plantation.

Keywords: cattle, carrying capacity, agro-ecosystem, coconut

Abstrak. Perkebunan kelapa sangat mendominasi di Kabupaten Minahasa Selatan, produksinya sebesar 49.907,33 ton pada tahun 2010. Lahan di bawah pohon kelapa dapat dimanfaatkan untuk tanaman pangan atau hijauan makanan ternak. Limbah tanaman pangan merupakan sumber pakan, dan kotoran ternak sapi dapat dimanfaatkan untuk peningkatan kesuburan lahan di bawah pohon kelapa. Tujuan penelitian adalah untuk menganalisis daya dukung agroekosistem kelapa-ternak sapi. Sampel kabupaten dan kecamatan ditentukan secara purposive. Jumlah responden sebanyak 86 petani yang ditentukan berdasarkan pemilikan ternak sapi minimal 2 ekor dan pernah menjual ternak sapi. Analisis data menggunakan analisis potensi pengembangan ternak efektif dan indeks daya dukung lahan (IDD). Potensi maksimum sumberdaya lahan (PMSL) adalah sebesar 30.872,94 unit ternak (UT). Kapasitas peningkatan populasi ternak sapi berdasarkan sumberdaya lahan sebesar 18.208,94 UT. Potensi maksimum berdasarkan kepala keluarga (KK) petani adalah sebesar 127.023,00 UT. Nilai IDD lahan sebesar 2,14. Kesimpulannya adalah Kabupaten Minahasa Selatan masih berpotensi dalam pengembangan ternak sapi, baik dilihat dari potensi sumberdaya lahan maupun potensi tenaga kerja. Pengembangan ternak sapi dapat dilakukan secara terintegrasi dengan kelapa untuk menjaga dan meningkatkan kelestarian agroekosistem lahan perkebunan kelapa.

Kata kunci : ternak sapi, kapasitas tampung, agroekosistem, kelapa

Introduction

Coconut is a tropical plant common to the Indonesians. Coconut according to Supadi and Nurmanaf (2006) as a strategic commodity has the social, cultural and economic role in society. Coconut plantation is very dominating in South Minahasa Regency as seen from its production of 49,907.33 tons in 2010 (the highest in North Sulawesi), supported by the use 26.31% of total land in South Minahasa for plantation including coconut (BPS North Sulawesi, 2010). Coconut as a plantation commodity orientates its production on exports from dry land farming. The contribution to foreign exchange, farmer's income and employment opportunities is very significant to the growth of the agricultural sector in South Minahasa.

The land under the coconut trees in South Minahasa is widely used by farmers to grow corn, rice and bananas. This pattern of an integrated agriculture shows a good growth and maintains cattle development supported by several factors such as cattle population, land and ports in several districts to facilitate cattle trading. The potential of livestock in South Minahasa is adequate. Agricultural and livestock developments are mutually supportive and beneficial; therefore, integrated farming systems provide substantial benefits for both. Furthermore, agricultural products such as maize, cassava, grass, agricultural waste can be utilized as forage to add the value. Indirectly, the needs of forage (concentrate) for livestock can be fulfilled. In addition, livestock's manure as a source of organic waste is needed for plants to enrich the soil; thereby it increases the agricultural productivity.

The environment-friendly farming is an approach starting with the ecosystem approach. Agriculture has a significantly negative impact on the function of ecosystem (Batie, 2009). An ecosystem is an ecological system formed by the inseparable relationship between creatures and their environment. Ecosystem can be said as an order of unity among the whole and complete environmental elements that influence each other. According to Sumarsono (2006), environment-friendly farming is approached with agroforestry principle or mixed cropping and special attention to the supply of organic matter as an indicator. Agricultural ecosystem approach is recognized as agro-ecosystem that emphasizes the basic principles as the result of the application of technology (Sumarsono, 2006).

Agro-ecosystem in South Minahasa based on the research can be distinguished into 3 (three), namely: (1) agro-ecosystem dry land; (2) agro-ecosystem rice fields; and (3) agro-ecosystem coastal region. Dry land consists of dry land based crops/horticulture. According to Amin (1997), agro-ecosystem is a group of area with similarenvironment physical condition. The agro-ecosystem approach is to cope with environmental damage caused by inappropriate agricultural system application and the specific agricultural problem solving due to the use of technology. Environmental researchers in Indonesia define agro-ecosystem dry land into several categories based on climate, altitude above sea level and soil type.

Dry land has a great potential for agricultural development, both food crops and perennial crops or plantations. According to Mulyani et al. (2006), the development of various agricultural commodities in dry land is one of the strategic options to increase production and to support national food security. However, according to Syam (2003), this type is at low productivity except for annual crops/plantation.

Problems faced by dry land farmers need optimal and sustainable management. Biophysical problems, for an instance are the destruction of the land as a growing medium such as the sensitivity of the soil against erosion, minimum nutrients and limited content of organic matter. Herrick et al. (2010) states that land degradation are a problem in many countries. In this case, dry land farming systems have not been well understood whereas the diversity of its ecosystem is quite complex. Agricultural ecosystem involves living creatures, human, livestock, crops and fields as the concept of habitat (non-biotic). The goal of ecosystem management is to increase productivity. A properly maintained agricultural ecosystem requires good management so that a continuous process can meet the needs and benefit more. In this case an effort to protect the value and service of ecosystem had been promoted by many people (Daily et al., 2009). Some researchers examined the relation of ecosystem with its funding (Tallis et al., 2009). Koch et al. (2009) and Plummer (2009) suggested in the context of refining the practice of ecosystem-based management variability and cumulative effects considered in the assessment of ecosystem services were needed.

Land under coconut trees can be utilized for food crops or forage crops fed to livestock. Waste of food crops is a source of feed, while cattle manure is used to increase fertility of the land under coconut trees. One of the factors with great impact whichis also greatly influenced by the development is natural resources and environmental carrying capacity which is actually land resources. Natural resources and environmental carrying capacity is the physical environment to be developed. The facts demonstrate that the necessary existence of harmony between developments is carried out by physical carrying capacity. To achieve harmony it is crucial to identify the carrying capacity ability of the physical environment, so that development activities can be determined in accordance with the earlier carrying capacity. The issue is the extent of the carrying capacity of agro-ecosystem coconut–cattle in South Minahasa Regency. Accordingly, a study is necessary to analyse the carrying capacity of the agro-ecosystem of coconut–cattle in South Minahasa Regency.

Materials and Methods

The research was conducted in South Minahasa Regency using survey methods. South Minahasa Regency was purposively determined in North Sulawesi as the largest coconut producer and cattlebasis. Districts in South Minahasa were determined purposively in sampling, namely: Tenga District and Sinonsayang District with the highest number of cattle production (BPS South Minahasa Regency, 2011). The respondents were 86 coconut farmers with at least 2 (two) cattle who ever sold cattle. Cross section and time series data were collected by interviews to farmers and direct observation in the field. Analysis of effectiveness of livestock development and land capability index was applied.

Results and Discussion

South Minahasa Regency is one of the districts in North Sulawesi with a capital city is Amurang. The distance from Amurang to Manado as Provincial’s capital is about 64 km. Geographically, South Minahasa Regency lies between 0°,47’-1°,24’ North Latitude and 124°,18’-124°,45’ East Longitude. It is administratively located in the southern part of Minahasa Regency, bordered with Minahasa Regency in north, Southeast Minahasa in east, Bolaang Mongondow in south and Sulawesi Sea in west.

The characteristic of land use in South Minahasa Regency was potential for wetland and agricultural fields, plantations and large plantations. Itcould absorb a lot of manpower both for coconut plantation and manufacture that might stimulate the regional economic growth. The increase of human population and needalso raised pressure for agricultural land.

Agricultural land in South Minahasa Regency consisted of all dry land farming (upland) and coconut plantations. Overall, both Tenga and Sinonsayang were dominated by dry land agriculture as an excellent sector. While the excellent commodity as a source of livelihood and income was coconut. The problem was the productivity of coconut lands cultivated by people was very low or under 1 ton equivalent to copra (range 0.5–0.9 tons of copra/ha). The productivity classified as very low was located on the hill slopes without adequate top soil, only remaining sub soil with poor organic matter and nutrients (Public Works Agency, South Minahasa, 2007).

The result showed that land acquisition by coconut farmers as respondents of cattle maintenance were grouped into three criteria (Table 1), namely one respondent (1.16%) of narrow criteria with less than 0.5 ha area, 50 respondents (58.14%) of medium criteria with 0.5-< 1.0 ha area,and 35 respondents (40.70%) of large criteria with of > 1 ha area. This condition indicated that the carrying capacity of land was based on land tenure for different respondents. The amount of carrying capacity and productivity of natural resources preservation, land and water was determined by the way people managed the natural resources itself and biophysical environmental factors. Carrying capacity of land wasthe combination of land capability and suitability, namely: (1) it was estimated based on the boundary of an ecosystem resilience in facingthe impact to grow and enhance its benefits which were still able to bring satisfaction to the user, (2) it depended on the balance of land capability used as benchmarks with the background of selected purposes and interests, and (3) the feasibility of land according to capability and suitability considerations.

The cattle in South Minahasa were one of the resources maintained and developed as a source of livestock farmers' income. According to Nelson et al (2009), some researchers made natural resource decisions effectively, efficiently and sustainably. Development of cattle could be done by considering the existing agro-ecosystem. Agro-ecosystem land under coconut trees was potential for cattle development. The maximum potential of land resources (PMSL) for South Minahasa reached 30,872.94 AU (Table 2) owing to land resources' capability to accommodate cattle population of PMSL value. Moreover, the increasing capacity of cattle population based on the land resources in South Minahasa was 18,208.94 AU (Table 3). It assumed that the maximum potential of land resources for cattle population in South Minahasa still could be increased by 18,208.94 AU. This effort might be done in order to optimize the land under coconut trees. As mentioned by Mulyani et al (2011), optimizing the utilization of land resources in supporting the agricultural development in the future needed to be improved. To be a proper balance between the increase in population and the food need, strategies and efforts of land resources utilization could be done by optimizing the utilization of land resources that exist today to be more productive and sustainable (Mulyani et al., 2011).

The study showed that the maximum potential based on farmer's households in South Minahasa Regency reached 127,023.00 AU (Table 4). That was based on labour availability so that the population of cattle could be increased up to 127,023.00 AU. Meanwhile, the increase in cattle population based on the farmer's households in South Minahasa Regency could still be increased by 114,359.00 AU (Table 5). One of the important aspects according to Barus (2004) was carrying capacity of resources in provision of labour.

This finding showed that based on the IDD land (Index of Carrying Capacity of Land) the carrying capacity of the land under coconut trees in South Minahasa Regencywas relatively high, namely 2.14 (Table 6). It implied that increasing 1 AU of cattle could be fulfilled by 2.14 Ha of land under the coconut trees. The index of carrying capacity of Tenga district was still greater than that of Sinonsayang. This condition was different from the one stated by Tola et al. (2007) that the decreasing of lands fertility caused the livestock development face a tough challenge, especially to the availability of land resources. Land under the coconut trees in South Minahasa could still be optimized as a source of forage. The growth of the grass would be better to use organic fertilizer/compost derived from the mixture of Chromalaena and livestock manure. Fertilizers of this type could replace about 50% of chemical fertilizers (Urea and SP-36) (Abdullah and Puspitasari, 2007). Provision of organic matter from manure and crop residues could improve soil physical properties (Prasetyo and Suriadikarta, 2006).

The development of cattle under the coconut trees could be done with ani ntegrated ecosystem management. The integrated livestock farming was a part of development so the utilization of livestock resources might decrease the business risk in sustainable principle (Soedjana, 2007). The pattern of development was done by livestock farmers forming a group. Armitage et al. (2009) defined that ecosystem management related to institutional development with an adaptive co-management approach.

Global warming happened due to the increase of CO_2 emissions. Some of the recommended programs were to maintain forest sustainability. According to Hurteau and North (2009), the forest was seen as a potential carbon sink that contributed to climate change. CO_2 emissions from land use change could be reduced by forest conversion (Herman et al., 2006). Livestock was considered as one of the causes of CO_2 emissions. CO_2 emission reduction strategy had been widely studied by researchers including Fissore et al. (2010). Efforts to do in South Minahasa Regency according to the results of research were the land under coconut trees could be used as forage crops fed to livestock. Planting forage fodder could also be beneficial in reducing CO_2 emissions, although in this study it was not technically studied more deeply. The management of grass planting under the coconut trees should be in accordance with the recommendation. Grazing should be managed in such a way to avoid over-grazing. This was due to erosion problems that arose due to over grazing of cover grass (Rahim, 2006). Control of erosion on grazing land was largely determined by the number of livestock grazing in a pasture area (stocking rate). The number of livestock grazing should depend on the carrying capacity of the land under the coconut trees.

Table 1. Distribution of respondents in tenure area of coconut for cattle rearing

Criteria of land areas	Amount	%
Narrow (< 0.5 ha)	1	1.16
Medium (0.5-1.0 ha)	50	58.14
Large (> 1.0 ha)	35	40.70
T o t a l	86	100.00

Table 2. Results of the analysis maximum potential of land resources

Variable	South Minahasa Regency
A	0.80
LG	37,121.05
B	0.50
PR	2,309.00
C	1.20
R	18.00
PMSL	30,872.94

A = coefficients are calculated based on the ratio of ruminant in livestock units (AU) with an area of arable land (ha), (0.8 AU/ha); LG = coconut land area of research areas (ha); B = coefficient is calculated as the capacities of natural grassland (0.5 AU/ha); PR = grassland area (ha); C = coefficient is calculated as the capacities of wetlands (1,2 AU/ha); R = marsh area (ha); PMSL = maximum potential of land resources.

Table 3. Results of the analysis increasing capacity of cattle population based on land resources

Variable	South Minahasa Regency
PMSL	30,872.94
POPRIL	12,664.00
KPPTR (SL)	18,208.94

PMSL = the maximum potential in units of cattle (AU) based on land resources, the adult cattle = 1.00 AU/ha, heifers = 0.60 AU/ha and calf = 0.25 AU/ha; POPRIL = the real population of cattle (AU) in the study area; KPPTR (SL) = capacity increased cattle population (AU) based on land resources.

Table 4. Results of the analysis maximum potential based on the farmer's households

Variable	South Minahasa Regency
D	3
KK	42,341.00
PMKK	127,023.00

D = coefficients are calculated based on the number of livestock units of cattle raised by family farmers without having to use a hired labor (3 AU/house holder); KK = head of family farmers; PMKK= maximum potential (AU) based on head of family farmers.

Table 5. Results of the analysis cattle population capacity increased based on the farmer's house holds

Variable	South Minahasa Regency
PMKK	127,023.00
POPRIL	12,664.00
KPPTR(KK)	114,359.00

PMKK= maximum potential (AU) based on head of family farmers; POPRIL = the real population of cattle (AU) in the study area; KPPTR(KK) = capacity increased cattle population (AU) by the head of family farmers.

Table 6. Results of the analysis capability index

Variable	South Minahasa Regency
PMSL	30,872.94
k	1.14
POPRIL	12,664.00
TK (kxPOPRIL)	14,436.96
IDD	2.14

PMSL = the maximum potential in units of cattle (AU) based on land resources, the adult cattle = 1.00 AU/ha, heifers = 0.60 AU/ha and calf = 0.25 AU/ha; k = the constant need for dry matter digested by one unit of livestock, namely: 1.14; POPRIL = the real population of cattle (AU) in the study area; TK = total feed requirements.

Conclusion

Based on the result, it showed that South Minahasa regency was still potential in the development of cattle regarding land resources and the potential of labour. Development of cattle could be integrated with coconut in order to maintain and enhance the sustainability of agro-ecosystem of coconut plantations.

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