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Mapping and directing the development of rice field in supporting the sustainability of food security

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The aim of this study was to protect and sustain the availability of food land area in a sustainable manner to ensure the realisation of food independence, resilience, and sovereignty in Muna Regency, Southeast Sulawesi Province. This research used survey methods and interviews with various stakeholders while the analytical method was carried out using land suitability analysis and SWOT analysis. The results showed that the land for the development of rice plants in S2 category (quite appropriate) with an area of 3,706.22 ha consisted of 469.95 ha of existing land and 3,236.27 ha of potential land. Meanwhile, the dry land/lading area in Muna Regency was 5,941.34 ha. The long-term program of food land protection in Muna Regency: i) protection of land and water resources; ii) preservation of land and water resources; ii) management of land and water quality; and iv) control of pollution. Mid-term programs for food land protection in Muna Regency: i) provide tax relief; ii) development of agricultural infrastructure; iii) funding of research and development of superior seeds and varieties; iv) ease of accessing information and technology; v) provision of facilities and infrastructure for agricultural production; vi) guarantee for issuance of certificates for agricultural land in food crops; vii) award for high-achieving farmers. The annual program of food land protection in Muna Regency was a) Imposing sanctions, both administrative sanctions in the form of written warnings, b) Temporary suspension of activities up to closure of the location, c) Revocation of permits and d) Fines and imprisonment.

Keywords: Mapping, Rice Field, Sustainability, SWOT

INTRODUCTION

Agricultural land has a strategic role and function for Indonesians who are naturally agrarian because there are a large number of Indonesians depend on their livelihood on agriculture. In this way, land shares not only economic value, but also social, even religious one. As the result of this remarkable strategic role, land is currently under pressure from various aspects, including: (i) social aspects, such as population growth which is positively correlated with the need of it for developing settlement, facilities and social infrastructure; (ii) economic aspects, increased land demands can result to the increase of land rent, and (iii) ecological or environmental aspects, which associates with increased economic activity in which its movements through industrial sector development can lead to the increasing of land pollution which decrease land productivity especially on agricultural land (Rianda & Alwi, 2017).

The land of agriculture in Muna is faced against the increasing demand of regional development considering that the regency is still in the developing stage. This is in line with what Rustiadi *et al.*, 2011; Salim, 2010 state that an

area that is still in the stage of developing category will always be oriented towards economic growth that exploits production land (agricultural land) in order to achieve high economic growth. Thus, this phenomenon will result in a massive change in the function of food agriculture land to other function, indeed to the function of non-agricultural land utilization for the needs of residential settlements, transportation facilities, and other basic infrastructure development. This is consistent with the statement of Stiglitz, 2007 and Nugraha, 2010 who state that the era of globalization is synonymous with the need for land for infrastructure development and settlements that will continue to deplete agricultural land which leads to decreasing food security.

Observing some of these anomalies, real efforts are needed to maintain, protect and even increase the availability of food agriculture land in Muna Regency. It is mandated in Law Act No. 41/2009 concerning Protection of Sustainable Food Agriculture Land. Muna Regency as an autonomous region and within the framework of sustainable agricultural development, is necessary to establish a regional regulation for protecting the sustainable food agriculture land. This is in accordance with the opinion of Rahmawati & Saputra (2013) that in realizing sustainable agriculture, land mapping efforts based on land suitability are needed so that commodity development will be ecologically sustainable.

Furthermore, Hasrianti *et al.,* 2016; Jovanovic & Njegus, 2008; Corporal, 2005 state that the mapping of food lands is a must (necessary condition) and at the same time a major supporting factor (enabling condition). Thus, Muna Regency as an autonomous region needs to implement a policy of protecting and mapping sustainable food land so that the need for food can be relieved for generations that are not only fulfilling current one but also can relieve generations in the future.

The problems of this study are: (i) how is the land suitability for the development of rice (irrigated land, rained lowland field, tidal reclamation land and non-irrigated food agricultural land); and (ii) how the sustainable food land management and protection plan is based on the results of the identification and mapping exercise, including long-term plans, medium-term plans and annual plans..

MATERIALS AND METHODS

Object of the study

This study was a survey research diverting the area of food lands both existing land (land that was being cultivated by the community as foodstuff land and potential land which until this study was conducted, it had not been cultivated as foodstuff land).

Time and Location of the Study

Mapping research on sustainable food land took place in Muna Regency with a focus on locating activities in sub-districts that had existing and potential food fields to be developed (irrigated land, rained lowland, tidal reclamation land and non tidal land).

Population and Samples of the Study

The populations in this study were all people in Muna Regency who were able to cultivate food crops. The respondents included some food crop farmers who worked on foodstuff crop farming and other parties related to the development of food agriculture land (Department of Agriculture, Department of Public Works, Regional Development Planning Agency (BAPPEDA), Farmer Groups, and Irrigation Water User Farmers Association).

The sample was chosen purposively based on the location of the farming, the type of food crop, and the level of involvement in the development of agricultural land for food. The numbers of sample in each study location were adjusted to the amount and type of food land and the type of crop cultivated.

Types and Sources of Data

Types and sources of data used in the study consisted of primary and secondary data. The primary data was obtained from the interviews result of farmer respondents or interviews with the relevant Regional Work Unit (SKPD) or other actors involving in the study location. Primary data were collected including farmer identity, characteristics of food land, types of food crops, availability of irrigation, production, costs, income and regional policies. Meanwhile, secondary data were obtained from related agencies/departments at the provincial and district level in Muna. The secondary data types referred to land area, the area of rice field, production location, irrigation area, and demographic data.

Technique of Data collection

The data collection techniques used in this study involved: In-depth interviews using questionnaire, as well as field surveys, in the form of a visit to the location of the cultivation of food plants.

Data analysis

The data were analyzed in following analysis: The analysis method used was the physical suitability analysis of the land and SWOT analysis.

RESULTS AND DISCUSSION

Conformity of Physical Land Rice

Physical land suitability analysis was carried out to assess the level of productivity of foodstuff land in Muna Regency. Physical land suitability assessment was based on observations of the criteria of land and soil characteristics in the field then it was matched with conditions for growing rice. In addition, soil checking was also carried out to test nutrient status at the study location.

Table 1.shows the results of land suitability analysis of rice plants in wetlands that show the suitability class included in the S2 category was sufficient land suitable for the development of rice plants. The results of the land suitability analysis at the sample locations in six sub-districts in the Muna Regency region obtained were generally included in the S2oa,fh class which was sufficiently in line with the restrictive factors of poor drainage and moderate inundation. This land could be improved with moderate to high technology through the construction of drainage channels.

Determination of recommended fertilizer in the wetland area for the allocation of rice was based on the results of nutrient status testing in the field. The results of nutrient status testing were the basis of information on soil fertility in food land areas in Muna Regency. The results of the analysis of nutrient status tests showed that the nutrient status of organic matter in the wetland area in Muna Regency ranged from low to moderate; N low-moderate; P low-very low; K low-high. Nutrient status, which was generally low to moderate on the land, resulted in the addition of fertilizer by combining the use of organic material and chemical fertilizer. This is consistent with the study of Pravin *et al.* 2013; Essien, 2011; Annabi *et al.* 2006 that to increase the production of rice with low phosphorus content, low sodium is needed in combination with the use of organic and inorganic fertilizers, because the use of these two types of fertilizers consider the friendliness and sustainability of land in a sustainable manner. The results regarding wetland/rice field nutrient status in Muna Regency are as presented in Table 2.

Table 1. Analysis of land suitability for rice in Muna District

No. Sample	Sub-districts	Land Suitability Class	Restrictive Factor	Technology Improvement
1	Tongkuno	S2oa,fh	Poor Drainage and Moderate Inundation	Making Drainage Channels
2	Parigi	S2oa,fh	Poor Drainage and Moderate Inundation	Making Drainage Channels
3	Kabawo	S2oa,fh	Poor Drainage and Moderate Inundation	Making Drainage Channels
4	Kabangka	S2oa,fh	Poor Drainage and Moderate Inundation	Making Drainage Channels
5	Maligano	S2oa,fh	Poor Drainage and Moderate Inundation	Making Drainage Channels
6	Batukara	S2oa,fh	Poor Drainage and Moderate Inundation	Making Drainage Channels

Source: Analysis Results, 2017

Table 2. Nutrient Status in Wet / Paddy Fields in Muna Regency

No	Sub-districts	Nutritional Status and Recommended Fertilizer Requirements			
		BO	N	P	K
1	Tongkuno	Low	Low	Low	High
2	Parigi	Moderate	Moderate	Very low	Low
3	Kabawo	Low	Low	Moderate	High
4	Kabangka	Low	Low	Low	High
5	Maligano	Low	Low	Low	High
6	Batukara	Low	Low	Low	High

Source: Analysis Results, 2016

* Unit (Tons / Ha)

Table 3.Weighting, Scale and Values Matrix for Internal Factors (Strengths) of Rice Crops Development in Muna Regency

No	Internal Variable	Strengths (+)		
		Weight	Rating	Score
A.	HR aspects			
1.	There is motivation in efforts	0.4778	3.00	1.43
B.	NR aspects			
1.	The availability of land is wide enough for food crops and can be protected	0.4778	2.33	0.64
2.	Land ownership status is owned land	0.3353	2.67	0.89
3.	Availability of superior types / varieties	0.1694	2.33	0.40
4.	Access to resources / raw materials	0.1694	2.67	0.45
C.	Institutional Aspects			
1.	Institutional structure	0.1733	2.00	0.35
2.	Institutional work mechanism	0.2312	2.00	0.46
D.	Business / Activity Aspects			
1.	Diversity of food agriculture business	0.1733	1.33	0.23
2.	Management	0.2312	2.33	0.54
3.	Availability of raw materials	0.1694	2.33	0.40
Total				5.79

Source: Results of Primary Data Analysis, 2017

Table 4. Weighting, Scale and Values Matrix for Internal Factors (Weaknesses) of Food Crop Development in Muna Regency

No	Internal Variable	Weakness (-)		
		Weight	Rating	Score
A.	**HR Aspects**			
1.	Leadership in companies is low	0.0747	1.33	0.10
2.	Level of education and farmers are quite low	0.0805	1.67	0.13
3.	The skill level is still low	0.0736	2.33	0.17
4.	Weak technology adoption rate	0.0682	2.00	0.14
B.	**Institutional Aspects**			
1.	Inter-agency / stakeholder coordination lack of integration	0.0605	1.33	0.08
C.	**Business / Activity Aspects**			
1.	Business costs are still low	0.0747	1.33	0.10
2.	Business profit is not optimal	0.0690	1.67	0.11
3.	Poor integrated distribution network	0.0948	1.33	0.13
	Total			**0.96**

Source: Results of Primary Data Analysis, 2016

Strategy for Developing Sustainable Rice

The strategy for developing sustainable rice in Muna District was identified based on issues related to the development of food crops in the study area. Marsuki & Alwi, 2015; Jumakir & Enrizal, 2013 state that the strategy for developing rice is determined based on crops development criteria and the factors influencing (internal and external) plant development in the study area. Furthermore Jumakir *et al.* 2014; Umar, 2007 state that the determination of the criteria for developing food crops begins with identifying issues related to aspects of human resources, aspects of natural resources, institutional aspects and aspects of businesses/activities. The strategy of developing rice is influenced by several factors (internal and external) that can be strengths or weaknesses and opportunities as well as threats.

Internal Factor Analysis

SWOT analysis results of internal factors (strengths) based on weight, scale and full values are presented in Table 3.

Table 3. shows that the greatest strength in the development of food crops is the motivation in doing efforts. The value of motivation in effort was high enough force in the effort to develop food

crops to protect the sustainable rice fields while the biggest weakness in developing rice crops was the level of farmers' skills which was far low in the management and development of rice crops. The value of farmers' skill level was still low becoming a weakness in the business of developing food crops. This is in accordance with the opinions of Rianda & Alwi, 2017 and research by Alwi *et al.* 2016 which suggest that the weakness in the development of smallholder agriculture is the low level of farmers' resources including skills and knowledge in farming which has implications for the low productivity obtained in each hectare.

External Factor Analysis

Based on Table 5, it shows that the greatest opportunity in developing rice is the needs of consumers so that it requires an increase in production which is beneficial in fulfilling the needs of the community in the Muna Regency.

Threats in the development of rice were: (1) the import policies, (2) Understanding of foreign trade markets and practices, (3) Competition in the global market, (4) Transportation and infrastructure problems, (5) Procurement and distribution of production inputs lack according to field needs, and (6) Urbanization of youth farmers to the city. The results of the SWOT analysis of external factors (threats) based on weight, scale and full value are presented in Table 6.

Based on Table 6, it shows that the biggest threat in the development of food crops is the problem of procurement and distribution of input less suitable with field needs so that it often does not match the needs of farmers and even distribution patterns tend to be less optimally utilized by farmers in the Muna Regency. The value of input and distribution problems in production input does not match the needs of the field to be an important threat in the business of developing food crops.

The variables included in the SWOT diagram calculated for equation were used to determine the central point of the food crop development strategy in the study area. Based on the results obtained by the strategy of developing food crops in the study area, it was in the quadrant I (Aggressive Strategy). The strategy in quadrant I shows the use of all power to take advantage of opportunities that have the potential of the region for the development of food crops.

Guide to Rice Field Crops Agribusiness Development

Pre-Production Subsystem Development

The agribusiness development plan in the pre-production sub-system in Muna Regency included planning for hatcheries, fertilizing, and planning for agricultural machinery or production equipment. To facilitate farmers' accessibility in order to obtain plant seeds, research centers and plant hatcheries are needed so that they are easily accessible by farmers. The existence of these facilities plays an important role in the provision of seeds and plant research so that it is expected the farmers will have no difficulty in obtaining seeds and are able to produce new better quality seeds. In village areas located far from the sub-district, seed procurement can be obtained from the Village Unit Cooperative (KUD) in the village area. Syairudin & Mahirul, 2014 state that farming planning can be done by optimizing the function of agricultural stalls in the district capital, especially in the aspect of distribution of goods to farmers.

Food crops have a high selling value and are in demand by many consumers. Therefore, to support food commodities to be able to produce well, it is necessary to support the use of fertilizers by farmers. Utilization of organic fertilizer is one alternative to increase crop production and it is more profitable than the use of inorganic fertilizers, though at present there are more farmers using inorganic fertilizers than organic fertilizers.

On the other hand, Syairudin & Mahirul, 2014 state that to maintain the availability of fertilizer, fertilizer warehouses need to be made. So that fertilizer needs can always be available and can be accessed by farmers.

Modern agricultural machinery and equipment are needed to support the efficiency and effectiveness of land management, crop maintenance, harvesting and post-harvesting. Planning of agricultural machinery and equipment needs to be done in collaboration with universities or other related agencies.

Guide to the Development of Production Subsystems

The development of a production sub-system is an activity that uses capital goods and natural resources to produce rice. The development of this sub-system includes aspects of land management technology, maintenance, harvesting and post-harvesting, irrigation systems, and marketing of rice production.

Table 5. Weighting, Scale and Values Matrix for External Factors (Opportunities) for Food Crop Development in Muna Regency

No.	External Variable	Opportunity (+)		
		Weight	Rating	Score
A.	Government Policy Aspects			
1	Government Policies (Laws / Regional Regulations) that Encourage the Protection of Sustainable Food Agriculture Land	0.1012	1.67	0.17
2	Tax Determination	0.1710	1.67	0.29
3	Market Policy	0.1012	1.33	0.13
4	Licensing	0.1710	1.33	0.23
5	Instructor performance	0.2025	1.67	0.34
B.	Geographical Aspects			
1	Climate	0.0877	1.00	0.09
2	Geography	0.0550	1.33	0.07
3	Location	0.1710	2.33	0.40
C.	Technological Aspects			
1	Cultivation / Farming	0.2654	2.67	0.71
2	Farming Tools and Mechanical Equipments	0.1348	1.33	0.18
3	Post-harvest	0.1348	1.33	0.18
4	Processing of Results	0.1348	1.33	0.18
D.	Socio-Economic and Cultural Aspects			
1	Marketing Results	0.0949	1.67	0.16
2	Access of Credit	0.0670	1.33	0.09
3	Partnership Pattern	0.0670	1.33	0.09
4	Consumer Needs	0.2654	2.67	0.71
5	Market Absorption	0.2654	2.33	0.62
	Total			4.62

Source: Results of Primary Data Analysis, 2016

Table 6. Weighting, Scale and Values Matrix for External Factors (Threats) for Food Crop Development in Muna Regency

No.	Internal Variable	Threat (-)		
		Weight	Rating	Score
A.	Government Policy Aspects			
1.	Import Policies	0.0550	1.00	0.05
B.	Geographical Aspects			
1.	Market understanding and practice of foreign trade is lacking	0.0477	1.00	0.05
C.	Socio-Economic and Cultural Aspects			
1.	Competition in the global market	0.0545	1.00	0.05
2.	Transportation problems	0.1327	1.33	0.18
3.	Procurement and distribution of product is less match with field needs	0.1327	2.00	0.27
4.	Urbanization of youth farmers to the city	0.0873	2.00	0.17
	Total			0.77

Source: Results of Primary Data Analysis, 2016

Table 7. SWOT Matrix for Sustainable Rice Field Development Strategies

INTERNAL FACTOR **EXTERNAL FACTOR**	**STRENGTH (S)** a. The availability of land was wide enough for food crops and its existence could be protected b. Land ownership status (farmer owner) c. Availability of superior types / varieties d. Access to adequate resources or raw materials e. Institutional Structure f. Institutional work mechanism g. Diversity of food agriculture business h. Management	**WEAKNESS (W)** a. Lack of Leadership in the company b. The level of education of farmers was quite low c. Low skill level. d. Poor technology adoption rate. e. Coordination between institutions / stakeholders was less integrated. f. Low business costs g. Business profit was not optimal. h. Poor integrated distribution network
OPPORTUNITY (O) a. Government policies (Laws / Regulations) that encourage the protection of sustainable agricultural land b. Tax determination and market policy c. Licensing d. Instructor performance e. Climate, Geography, Location f. Cultivation / Farming g. Farming tool and mechanical equipment h. Post-harvest i. Processing and Marketing product j. Access to credit and partnership patterns k. Consumer and market needs	**STRATEGY (S-O)** a. Increasing of farmers' independence through coaching and counseling. b. Strong motivation, availability of land, and diversity of business could be done. Access to credit and the availability of processing technology should be the basis for expanding market access beyond the region and meeting the needs of consumers. c. Development of partnerships in agro-industry activities in an effort to increase production value. d. Community empowerment in efforts to improve the economy by utilizing soft loans. e. Development of regional potential to support leading plantation agro-industry	**STRATEGY (W-O)** a. Increase farmer productivity b. conduct more intensive demonstration plots of appropriate technology. c. Collaboration with other parties, especially in capital, marketing and technology. d. Improvement of HR skills in cultivation / farming, post-harvest, processing and marketing of superior plantation commodity products
TREATS (T) a. The import policy b. Lack of understanding of markets and foreign trade practices c. Small extent of market access d. Competition in the global market e. Inadequate transportation problems f. Procurement of production distribution was not compatible with the needs g. Urbanization of young farmers to the city	**STRATEGY (S-T)** a. Farmer group business development. b. Open and strengthen new market networks. c. Provide assurance of business guarantees carried out by farmers.	**STRATEGY (W-T)** a. Increasing the use of technology through coaching and counseling. b. Community empowerment in efforts to create new jobs field

Table 7. Tutorial Development Sub Agribis Pre-Production System

No.	Aspect	Plan
1	Seed/Seedling	- Research and - Hatchery Center Recent Seed Information with Quality and Affordable Prices from PPL to Farmers - Provision of Plant Seeds at Village Unit Cooperatives (KUD) - Optimizing the Function of Agricultural Store in Provision of Plant seeds
2	Fertilizer	- Utilization of organic fertilizer to increase the value of agricultural production - Manufacture of fertilizer warehouse
3	Agricultural Machinery and Equipment	- Utilization of Modern Agricultural Equipment that Facilitates the Process of Land Management, Maintenance, Harvesting and Post Harvesting

The form of the plan in the aspect of soil management is the introduction of effective and efficient land management technologies, and paying attention to the carrying capacity of the surrounding environment, so that it will facilitate the process of farming (*on farm*) per se. Introduction of technology to farmers through the provision of information from field extension is conducted to officers in the area.

Cepriadi *et al.* 2011 state that in order to realize a sustainable agronomic system, it is important to plan in the aspect of marketing the products of production in the form of marketing facilities and appropriate marketing strategies. Development of marketing facilities for agricultural commodities is needed in order to localize farmers, sellers, and consumers. The marketing platform is an agribusiness market not only orienting to profit (*profit oriented*) but also encouraging the development of agriculture.

Furthermore, Handriyanta *et al.* 2012; Cepriadi *et al.* 2011state that marketing facilities planning must also be supported by appropriate marketing strategies, such as determining crop rotation to avoid falling agricultural commodity prices.

Guide to Supporting Subsystem Development

Supporting business sub-system development is the final part which is a service sub-system for the upstream agribusiness sub-system, farming sub-system and downstream agribusiness sub-system including: research and development, credit and insurance, transportation and government policy support (micro-economics, spatial planning, macroeconomic). This is consistent with Erfit's research (2011) stating that research and development as well as agricultural credit and insurance are important variables in agricultural development. Through research and development as well as the support of credit agencies and agricultural insurance, they can increase the motivation of agricultural businesses farmers in increasing productivity. Guide to planning for developing a support sub-system is presented as follows:

CONCLUSION

Based on the results of the analysis of land suitability for the development of rice in Muna Regency, it is concluded as follows:

1-Land for the development of rice plants with the category S2 was quite appropriate with an area of 3,706.22 hectares consisting of 469.95 hectares of existing land and 3,236.27 hectares of potential land. Meanwhile, the area of dry land/lading in Muna Regency was 5,941.34 Ha.

2-Long-term program for food land protection in Muna Regency: i) protection of land and water resources; iii) preservation of land and water resources; ii) management of land and water quality; and iv) control of pollution.

3-Mid-term program for food land protection in Muna Regency: i) provides relief for property tax; ii) development of agricultural infrastructure; iii) funding for research and development of superior seeds and varieties; iv) ease of accessing information and technology; v) provision of facilities and infrastructure for agricultural production; vi) guarantee for certificates issuance for agricultural land in food crops; vii) award for high-achieving farmers.

4-The annual program of food land protection in Muna Regency is a) Imposition of sanctions, both administrative sanctions in the form of written warnings, b) Temporary suspension of activities up to the closure of the location, c) Revocation of license and d) Fines and imprisonment.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

LG designed and performleed the experiments and also wrote the manuscript. LOA and MTH designed experiments and performed data analysis. NPP reviewed the manuscript. All authors read and approved the final version.

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