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Spatial Analysis of Rice Field Development in Supporting Sustainable Food Security in West Muna Regency

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ABSTRACT

This research aims to spatially analyze the development of rice fields to support sustainable food security in West Muna Regency. With a qualitative and quantitative analysis approach, this research identifies local potential as well as the obstacles faced by the agricultural sector. This research also examines agricultural area development strategies to support food security in West Muna Regency, Southeast Sulawesi, using both qualitative and quantitative approaches to obtain a comprehensive picture. The data used consists of primary data obtained from field surveys and observations, while secondary data is obtained from documentation studies in the form of literature related to the focus of the study. The data analysis techniques used are: (1) descriptive analysis; (2) Location Quotient (LQ) analysis; (3) spatial analysis using the ArcGIS application. The determination of zoning for rice productivity improvement consists of: (1) Intensive production zones for productivity enhancement, namely Sawerigadi (590 ha), South Tiworo (822 ha), Central Tiworo (169 ha), Maginti (150 ha), Tiworo Islands (258 ha); (2) Extensive development zones, namely Kusambi (10,263 ha), Wadaga (12,605 ha), and Lawa (8,492 ha); (3) Agribusiness infrastructure support zones, namely Sawerigadi (590 ha) as the agribusiness center, Barangka (3,132 ha), Lawa (8,492 ha), and Wadaga (12,605 ha) as centers for agricultural product distribution. The construction of new irrigation systems in districts such as Wadaga and Kusambi is very important for increasing productivity. Improvement of connecting roads between the districts of Barangka, Lawa, Wadaga, and Sawerigadi to facilitate the distribution of harvests. The strategy for rice field development includes; (1) Strengthening intensive production zones; (2) Extensification of new land; (3) Development of agribusiness infrastructure; (4) Empowerment of farmers and market access; (5) Climate change adaptation; and (6) Integration of agro-tourism based on rice cultivation. With these strategic steps, the agricultural sector of West Muna Regency is expected to support food security and community welfare sustainably and reduce dependence on food supply from outside the region.

Keywords: *Food Security, Land Development, Leading Commodities, Spatial Analysis, Sustainable Development.*

I. INTRODUCTION

Food security is one of the strategic issues that is a priority in national development in Indonesia. As part of efforts to support food security, the development of agricultural areas plays a very important role (Food and Agriculture Organization, 2008). Agricultural areas not only serve as sources of food production but also play a role in maintaining the economic stability of communities, especially in rural areas (Ministry of Agriculture, 2023). West Muna Regency, as one of the regions with significant agrarian potential in Southeast Sulawesi Province, faces various challenges in realizing a productive and sustainable agricultural area. West Muna Regency has geographical characteristics that support the development of the agricultural sector, such as fertile land and a climate suitable for various commodities (BPS West Muna Regency, 2023). However, this potential has not been optimally utilized. Various issues such as land conversion, limited access to agricultural technology, inadequate supporting infrastructure, and climate change have become the main obstacles in the development of agricultural areas in this region (Ministry of National Development Planning/National Development Planning Agency, 2023).

West Muna Regency has vast agricultural land with leading commodities such as corn, peanuts, and rice.

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According to data from the Central Statistics Agency (BPS) of Muna Barat, the agricultural sector significantly contributes to the Gross Domestic Product (GDP) of this region, reaching 39.42% in 2022 (BPS Kabupaten Muna Barat, 2023). However, despite this region's agricultural resource potential, agricultural productivity remains low and is not yet optimal in meeting local and regional food needs. Inaddition, demographic expansion demands sufficient and equitable food availability (FAO, 2023). In this context, an effective agricultural area development strategy has become an urgent necessity so that local food production can support food security in West Muna Regency, while also reducing dependence on supplies from other regions. The area of rice and other main local food crops in West Muna Regency in 2016 was recorded at 1,170 hectares, with a production yield of 3,223.5 tons. This indicates that the productivity of rice or other main local food crops per hectare in West Muna Regency in 2016 was 3.6 tons/ha (Department of Agriculture and Food, 2017). However, the level of productivity is not yet optimal across all regions, and only a few areas are developing this commodity. Therefore, this research is important to formulate the right strategies for the development of rice field areas. Thus, it is expected to be able to increase land productivity, strengthen the local food system, and support community welfare, while also addressing the food security challenges in West Muna Regency.

The purpose of this research is to spatially analyze the development of rice fields to support sustainable food security in West Muna Regency.

II. RESEARCH METHOD

This research examines strategies for developing rice field areas to support food security in West Muna Regency, Southeast Sulawesi, using both qualitative and quantitative approaches to obtain a comprehensive picture. The data used consists of primary data obtained from field surveys and observations, while secondary data is obtained from documentation studies in the form of literature related to the focus of the study. The data analysis techniques used are: (1) descriptive analysis; (2) Location Quotient (LQ) analysis; (3) spatial analysis using the ArcGIS application.

III. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Administrative Region of West Muna Regency

West Muna Regency has a land area of 906.28 km² or 90,628 ha. Administratively, West Muna Regency is divided into 11 districts and 86 villages/sub-districts. The sub-districts within the West Muna Regency include the Sawerigadi Sub-district, Barangka Sub-district, Lawa Sub-district, Wadaga Sub-district, South Tiworo Sub-district, Maginti Sub-district, Central Tiworo Sub district, North Tiworo Sub-district, Tiworo Islands Sub-district, Kusambi Sub district, and Napanokusambi Sub-district. The administrative area of each sub district is indicated in table 3.1.1

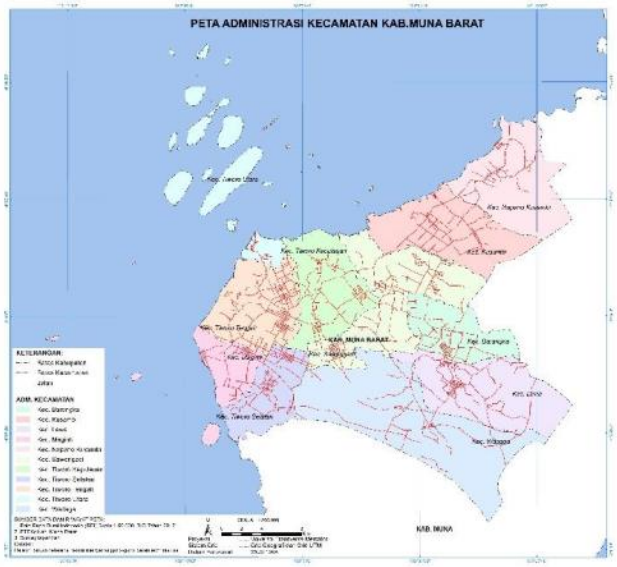

Figure 1. Administrative Map of Muna Barat District

3.1.2. Existing Condition of Agricultural Land

The area of agricultural land in West Muna Regency (table 3.1.2) consists of:1) rice paddy fields: approximately 1,989 ha, used as a medium for rice plants; 2) non-paddy agricultural land: approximately 73,798 ha used as a medium for secondary crops such as corn and peanuts, and long-term crops. Most of the rice fields used for planting rice in West Muna have an irrigation system, especially in South Tiworo (770 ha), Sawerigadi (590 ha), and West Muna as a whole (1937 ha). Meanwhile, non-irrigated rice fields that rely on rainwater are found only in South Tiworo, covering an area of 52 hectares. The regions with potential rice paddy fields are South Tiworo (822 ha), Sawerigadi (590 ha), Tiworo Islands (258 ha), Central Tiworo (169 ha), and Maginti (150 ha).

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Table 3.1.2. Distribution of agricultural land area by sub-district in Muna Barat Regency (ha) in 2022

District	Paddy Field Agriculture (ha)	Agriculture Not Rice Fields (ha)	Total (ha)	Irrigated Rice Field (ha)	Non-Irrigated Rice Fields (ha)	Total (ha)
Tiworo Kepulauan	258	5 441	5.699	258	-	258
Maginti	150	2 958	3.108	150	-	150
Tiworo Tengah	169	7 494	7.663	169	-	169
Tiworo Selatan	822	4 176	4.998	770	52	822
Tiworo Utara	-	4 065	4.065	-	-	
Lawa	-	8 492	8.492	-	-	
Sawerigadi	590	9 670	10.260	590	-	590
Barangka	-	3 132	3 132	-	-	
Wadaga	-	12 605	12 605	-	-	
Kusambi	-	10 263	10 263	-	-	
Napano Kusambi	-	5 502	5 502	-	-	
Muna Barat	**1.989**	**73.798**	**75.787**	**1 937**	**52**	**1989**

Source: Central Statistics Agency of Muna Barat Regency, 2023

3.1.3. Advantages of Each Food Commodity

A high LQ value indicates that the commodity has a significant contribution to the local economy and can be a focus in the development of agricultural areas.

$$LQ = \frac{(E_i/E_t)}{N_i/N_t}$$

where:

Ei = the output value of agricultural commodities in the sub-district/region
Et = total output of all commodities in the sub-district/region
Ni = the output value of agricultural commodities at the district level
Nt = total output of all agricultural commodities in the district of the province

(Statistics Indonesia, 2023)

Interpretation of LQ Value is as follows; (a) LQ > 1: it is a leading commodity that can meet local needs and has the potential for export; (b) LQ < 1: the commodity cannot meet local needs and requires supply from outside; (c) LQ = 1: Indicates that the commodity is only sufficient to meet local needs without export potential (Tarigan, R. 2012)

Table 3.1.2a. Advantages of food commodities in West MunaDistrict

Commodity	LQ Value
Corn	**2.69**
Paddy	**0.192**
Peanut	**4.90**
Soybean	**4.15**
Cassava	**1.32**
Sweet Potato	**2.00**

Source: Analysis results, 2024

Table 3.1.2b. Commodity advantages in each sub-district

No	District	Commodity	Ei	Et	Ni	Nt	LQ	Criteria
1	Tiworo Kepulauan	Lowland Rice	0	192	240	8659	0,00	Not commodity-based
		Rainfed Rice	0	192	0	8659	0,00	Not commodity-based
2	Tiworo Tengah	Lowland Rice	40	1241	240	8659	1,16	**Base Commodity**
		Rainfed Rice	0	1241	0	8659	0,00	Not commodity-based
3	Tiworo Selatan	Lowland Rice	0	618	240	8659	0,00	Not commodity-based
		Rainfed Rice	0	618	0	8659	0,00	Not commodity-based
4	Maginti	Lowland Rice	0	159	240	8659	0,00	Not commodity-based
		Rainfed Rice	0	159	0	8659	0,00	Not commodity-based
5	Lawa	Lowland Rice	0	931	240	8659	0,00	Not commodity-based
		Rainfed Rice	0	931	0	8659	0,00	Not commodity-based
6	Sawerigadi	Lowland Rice	200	1583	240	8659	4,56	**Base Commodity**
		Rainfed Rice	0	1583	0	8659	0,00	Not commodity-based
7	Barangka	Lowland Rice	0	1153	240	8659	0,00	Not commodity-based
		Rainfed Rice	0	1153	0	8659	0,00	Not commodity-based
8	Wadaga	Lowland Rice	0	2173	240	8659	0,00	Not commodity-based
		Rainfed Rice	0	2173	0	8659	0,00	Not commodity-based
9	Kusambi	Lowland Rice	0	397	240	8659	0,00	Not commodity-based
		Rainfed Rice	0	397	0	8659	0,00	Not commodity-based
10	Napano Kusambi	Lowland Rice	0	212	240	8659	0,00	Not commodity-based
		Rainfed Rice	0	212	0	8659	0,00	Not commodity-based
11	Tiworo Utara	Lowland Rice	0	145	240	8659	0,00	Not commodity-based
		Rainfed Rice	0	145	0	8659	0,00	Not commodity-based

Source: Analysis results, 2024

The results of the LQ calculation (table 3.1.2) show that: 1) peanuts have the highest LQ value of 4.90, indicating that this commodity is a highly potential base commodity for development in West Muna Regency; 2)

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soybeans also show good potential with an LQ value of 4.15; 3) corn has an LQ value of 2.69, indicating that although it is not a main base commodity like peanuts and soybeans, corn still has a significant contribution to the regional economy; whereas, 4) rice with an LQ value of 0.192 indicates that in general, rice is not a base commodity in this area and requires more attention in its development. However, in certain areas such as Central Tiworo and Sawerigadi, rice is a base commodity. Therefore, the development of this commodity needs to be encouraged to support food security in the district, considering the vast agricultural land. The strategy for rice development should focus on increasing productivity and expanding rice fields by utilizing spatial data.

3.1.4. Land Potential Analysis

Based on the analysis of potential land suitability for wetland rice and upland rice commodities (tables 3.1.4a, 3.1.4b, and 3.1.4c), there is variation in land suitability levels across different sub-districts. For irrigated rice, highly suitable land (S1) is only found in the districts of Maginti, Lawa, and Kusambi with a total area of 1,215.36 hectares (2.33%). Meanwhile, the moderately suitable land (S2) dominates with an area of 28,281.74 hectares (54.29%), spread across eleven sub-districts, including Sawerigadi, Tiworo Islands, Central Tiworo, Wadaga, and others. The suitable land (S3) covers 19,232.64 hectares (36.92%) spread across districts such as Tiworo Islands, Lawa, Kusambi, and Maginti. The land that is not suitable (N) for rice paddies reaches 3,360.94 hectares (6.45%), spread across Wadaga, Lawa, North Tiworo, and several other districts.

Tabel 3.1.4a. Suitability of Potential Rice Paddy Commodity Land by Region

No	District	Land Suitability Area (Ha)			
		S1	S2	S3	N
1	Tiworo Kepulauan	-	4547,60	4.816.38	14.44
2	Maginti	766.68	1.470.35	164.66	222.02
3	Tiworo Tengah	-	4.396.51	525.48	356.42
4	Tiworo Selatan	-	3.156.29	367.84	-
5	Tiworo Utara	-	49.05		632.49
6	Lawa	247.54	2.867.74	3.296.31	855.4
7	Sawerigadi	-	5.108.69	2.904.76	-
8	Barangka	-	2.604.55	207.07	-
9	Wadaga	-	3.889.54	1.669.41	1.154.47
10	Kusambi	37.81	124.65	3.232.75	-
11	Napano Kusambi	163.33	66.77	2.047.98	125.7
	Amount	**1.215.36**	**28.281.74**	**19.232.64**	**3.360.94**

Note: N= not appropriate; S3= appropriate; S2= quite appropriate; S1= very appropriate

Source: Analysis results, 2024

Tabel 3.1.4b. Potential Land Suitability for Upland Rice Commodity by Region

No	Kecamatan	Land Suitability Area (Ha)			
		S1	S2	S3	N
1	Tiworo Kepulauan	-	4.547.60	804,61	14,44
2	Maginti	1.362,01	875,02	164,66	222,02
3	Tiworo Tengah	-	4.396.51	525,48	356,42
4	Tiworo Selatan	-	1.013.27	367,84	
5	Tiworo Utara	-	49,05	-	632,49
6	Lawa	-	3.115,28	3.296,31	855,40
7	Sawerigadi	-	5.715.97	2.297,48	-
8	Barangka	-	2.297,00	514,62	-
9	Wadaga	-	3.923,66	1.669,41	1.154,47
10	Kusambi	-	178,08	3.232,75	-
11	Napano Kusambi	-	230.10	2.047,98	125,70
	Amount	**1362.01**	**26.341,54**	**14.921,14**	**3.360,94**

Note: N= not appropriate; S3= appropriate; S2= quite appropriate; S1= very appropriate

Source: Analysis results, 2024

Meanwhile, for upland rice, the sub-district with very suitable land (S1) is only Maginti with an area of 1,362.01 hectares (2.96%). The moderately suitable land (S2) covers a wider area, namely 26,341.54 hectares (57.28%), distributed across eleven sub-districts such as Sawerigadi, Tiworo Islands, Wadaga, and Lawa. The suitable land (S3) covers an area of 14,921.14 hectares (32.45%), spread across the districts of Lawa, Kusambi, Sawerigadi, Napano Kusambi, and others. The land that is not suitable (N) for upland rice has an area of 3,360.94 hectares (7.31%), spread across Wadaga, Lawa, North Tiworo, and several other sub-districts. From these results, it can be explained that the majority of land in the region is quite suitable for the cultivation of wet rice and dry rice, with varying distributions. However, there are several sub-districts with limited land suitability that need to be considered in agricultural planning.

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Table 3.1.4c. Potential land suitability according to its distribution

No	Land Suitability	Category	Distribution	Land Area	
				(Ha)	(%)
1	Padi sawah	S1	Maginti, Lawa dan Kusambi	1215,36	2,33
		S2	Sawerigadi, Tiworo Kepulauan, Tiworo Tengah, Wadaga, Tiworo Selatan, Lawa, Barangka, Maginti, Kusambi, Napano Kusambi, dan Tiworo Utara	28.281,74	54,29
		S3	Tiworo Kepulauan, Lawa, Kusambi, Sawerigadi, Napano Kusambi, Wadaga, Tiworo Tengah, Tiworo Selatan, Barangka, Maginti	19.232,64	36,92
		N	Wadaga, Lawa, Tiworo Utara, Tiworo Tengah, Maginti, Napano Kusambi, dan Tiworo Kepulauan	3.360,94	6,45
2	Padi ladang	S1	Maginti	1.362,01	2,96
		S2	Sawerigadi, Tiworo Kepulauan, Tiworo Tengah, Wadaga, Lawa, Barangka, Tiworo Selatan, Maginti, Napano Kusambi, Kusambi, dan Tiworo Utara	26.341,54	57,28
		S3	Lawa, Kusambi, Sawerigadi, Napano Kusambi, Wadaga, Tiworo Kepulauan, Tiworo Tengah, Barangka, Tiworo Selatan, dan Maginti	14.921,14	32,45
		N	Wadaga, Lawa, Tiworo Utara, Tiworo Tengah, Maginti, Napano Kusambi, dan Tiworo Kepulauan	3.360,94	7,31

Note: N= not appropriate; S3= appropriate; S2= quite appropriate; S1= very appropriate

Source: Analysis results, 2024

3.1.5. Raw Water Resources and Infrastructure

The potential of raw water resources and infrastructure in West Muna Regency includes; (1) Important water sources or springs scattered in several sub-districts such as Wakante Spring, Lameo, Matakidi, Batakalambe, and others. These springs are spread across the districts of Lawa, Barangka, Wadaga, Tiworo Islands, and Central Tiworo. In addition to the potential of spring water sources, there are also several surface waters such as river basins (DAS) that include the Bangkomalampe DAS, Balu DAS, Belan-Belan DAS, Tiworo DAS, Bakuku DAS, and other DAS. This watershed area encompasses many sub-districts in West Muna Regency such as North Tiworo, Central Tiworo, Wadaga, Kusambi, and others; (2) Water Resource Infrastructure where there are several primary irrigation networks including D.I Kambara, D.I Kampani, D.I Kasimpa Jaya, and others that supply water to sub- districts such as Tiworo, Sawerigadi, and Wadaga. In addition to primary irrigation, there are also secondary and tertiary irrigation systems that support the distribution of water for agriculture and other needs in the related districts. Some areas also rely on groundwater irrigation such as D.I.A.T. Abadi Jaya, Parura Jaya, Kasimpa Jaya, and Katangana located in several sub-districts. In addition, there are several weirs in various sub-districts to support the supply of raw water, including the D.I Kambara Weir, D.I Marobea Weir, D.I Nihi Weir, and other weirs in sub-districts such as Sawerigadi, Central Tiworo, and Wadaga (Regional Regulation of West Muna District No. 10 of 2020).

3.2. Discussion

3.2.1. The Influence of Rice Field Development on Food Security

The analysis results show that the development of rice fields in West Muna Regency plays a strategic role in enhancing local and regional food security. Food security does not only depend on the availability of production, but also includes supply stability, accessibility, and the quality of food consumption in the community (Sen, A. 1981). West Muna Regency, with an area of 1,989 hectares of rice fields and a still very vast area of non-rice fields, has a great opportunity to increase rice production to reduce dependence on external supply.

According to the data in tables 3.1.4a, 3.1.4b, and 3.1.4c, it can be explained that the majority of land in West Muna Regency has the potential to be developed as rice farming land. Currently, rice production is not optimal, as evidenced by the Location Quotient (LQ) value of 0.192, which indicates that rice is not a base commodity in this region. This means that rice production is still lower than the local community's consumption needs, so rice imports from other regions are still necessary. In the long term, this condition can weaken food security because the regional food supply becomes vulnerable to external supply disruptions, such as price fluctuations, climate change, and distribution chain uncertainties. However, in certain areas such as Central Tiworo and Sawerigadi, rice is the primary commodity. Therefore, it is necessary to implement a spatial-based land development strategy so that West Muna Regency can be self-sufficient in meeting its food needs.

The main influence of rice field development on food security lies in increasing food availability through the intensification and extensification of agriculture (Suwarno, 2010). Sawerigadi and South Tiworo sub-districts, which have the largest rice field areas, need to be optimized through agricultural intensification, such as the use of superior varieties, modern irrigation systems, and digital-based agricultural technology to maximize productivity per hectare. With a better irrigation system, which is currently mostly available in the Sawerigadi (590 ha) and South Tiworo (822 ha) regions, rice production can significantly increase. Additionally, the implementation of precision agriculture, which involves the use of soil sensors, data-based fertilization, and agricultural mechanization, can increase production efficiency and reduce crop yield losses due to suboptimal cultivation techniques. On the other hand, the extensification of rice fields in the districts of Wadaga, Kusambi, and Lawa, which have the largest non-rice land (Wadaga 12,605 ha, Kusambi 10,263 ha, Lawa 8,492 ha), has the potential to increase the area of agricultural land and enhance regional food security. The conversion of non-paddy fields into new paddy fields must be accompanied by the construction of adequate irrigation infrastructure, considering that most of this area does not yet have an optimal irrigation system. If agricultural expansion is carried out sustainably and based on appropriate land zoning, rice production in West Muna Regency can experience significant increases in the coming years. With the increase in local production, dependence on supplies from outside the region can be reduced, thereby ensuring greater food stability.

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In addition to increasing production, the development of rice fields also affects price stability and food accessibility for the community. West Muna Regency still faces food distribution imbalances due to limited infrastructure access, especially in remote areas that are difficult to reach. Improving road connectivity between sub-districts, such as Barangka, Lawa, and Wadaga, is very important so that the distribution of harvested rice is more efficient and prices remain stable throughout the region. Without good distribution, surplus production areas will still face challenges in distributing food to the areas in need, thereby increasing the risk of shortages and price spikes in the rice market. Therefore, land development strategies must be accompanied by the construction of transportation and logistics facilities to support a more resilient food security system.

Another factor to consider is the impact of climate change on food security, where extreme weather conditions, such as droughts and heavy rainfall, can disrupt agricultural production. The improvement of technology-based irrigation systems in potential rice fields, as well as the implementation of climate-resilient planting systems, such as rice varieties that are more resistant to drought and flooding, can help reduce the adverse impacts on crop yields. In addition, the development of early warning systems for weather changes and the implementation of soil and water conservation practices, such as terracing and agroforestry, can support the long-term sustainability of agriculture. Thus, West Muna Regency can be more adaptive to environmental challenges that affect food security.

In addition to production and distribution aspects, the availability of food storage infrastructure also affects regional food security. Without adequate storage facilities, rice harvests can be damaged before reaching consumers. Therefore, the construction of strategic harvest storage warehouses in Sawerigadi and South Tiworo is an important step in supporting food security. This warehouse can serve as a temporary storage place before distribution, reducing the risk of crop waste due to damage or pests. If food storage capacity is increased, food availability will be more stable, especially in facing lean seasons or production disruptions due to weather factors.

The development of rice fields can also increase farmers' income and welfare, which ultimately strengthens food security from the perspective of people's purchasing power. Farmers who have access to modern agricultural technology, better cultivation training, and broader market access will have higher productivity and more stable incomes. Therefore, farmer empowerment programs through training, agricultural input subsidies, and access to capital must be integrated into rice agricultural development strategies. Thus, the community not only benefits from increased food availability but also from better economic conditions, which enable them to purchase and consume quality food sustainably. Overall, the development of rice agricultural land in West Muna Regency has a wide-ranging impact on food security, both in terms of increased production, supply stability, accessibility, and the purchasing power of the community. With strategies based on spatial data and good spatial planning, this region can become more self-sufficient in food production, reduce dependence on imports, and improve the welfare of farming communities. To achieve this, synergy between local governments, farmers, and the private sector is essential to create a productive, sustainable agricultural system that is resilient to environmental challenges and climate change.

3.2.2. Identification of Marginal Land That Can Be Utilized

West Muna Regency has a fairly large agricultural land potential, but its utilization has not been optimal. Based on the research findings, there is a significant difference between the area of rice fields that have been utilized and the non-rice fields that have not yet been maximally utilized. Currently, the area of rice fields in West Muna Regency is only about 1,989 hectares, while non-rice fields reach 73,798 hectares. Several sub-districts have very large non-paddy fields, such as Wadaga (12,605 ha), Kusambi (10,263 ha), and Lawa (8,492 ha), which have the potential to be developed into new rice fields or other productive agricultural lands. These lands are classified as marginal lands due to several factors, such as limited irrigation systems, low soil fertility, and inadequate agricultural infrastructure. However, with the implementation of appropriate agricultural extensification programs, these marginal lands can be optimized to increase local food production, especially rice as the main commodity in supporting food security. In this context, the main strategy that can be implemented is the conversion of non-paddy fields into irrigated paddy fields through the construction of adequate irrigation systems and the application of modern cultivation techniques. In addition, most of the land in several districts has a fairly good land suitability level for wet rice and dry rice farming. Based on land suitability analysis, highly suitable land (S1) for wet rice is spread across Maginti, Lawa, and Kusambi with a total area of 1,215.36 ha, while moderately suitable land (S2) reaches 28,281.74 ha, distributed across various sub-districts such as Sawerigadi, Wadaga, and Tiworo Islands. With proper planning, these areas can be developed into new agricultural production centers that support the increase in rice production in West Muna Regency. This is supported by the FAO's (1976) statement in its report "Sustainable Agricultural Production: Implications for International Agricultural Research," which emphasizes the importance of research in supporting global food security through the development of sustainable agricultural technologies, as well as paying attention to efficient spatial management to maximize the sustainable use of land and natural resources.

3.2.3. Spatial Planning for Rice Field Development

Spatial planning is necessary to increase rice production sustainably by considering optimal land use zoning. This zoning includes intensive production areas, the development of rice land extensification, as well as agribusiness supporting infrastructure to support distribution and post-harvest. This approach aims to improve food security, farmer welfare, and efficiency in the sustainable utilization of natural resources.

a) Intensive production zone

The intensive production zone includes areas with productive rice fields that have good irrigation system support. This region has high potential for increasing crop yields through the application of modern agricultural technology and optimal agronomic practices.

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- Sawerigadi (590 ha), South Tiworo (822 ha), Central Tiworo (169 ha), Maginti (150 ha), Tiworo Islands (258 ha) are areas with developed irrigated rice fields. To increase productivity, agricultural intensification is carried out through the use of superior varieties that are adaptive to climatic conditions and resistant to pests and diseases. In addition, balanced fertilization based on specific soil needs will be implemented to improve soil fertility and crop yields.
- The application of precision agriculture technology based on soil sensors and spatial mapping allows farmers to optimize the use of water, fertilizers, and pesticides. Thus, production efficiency increases and environmental impact can be minimized.
- Technical and institutional support for farmers through training and access to agricultural innovations will continue to be enhanced to improve farmers' capacity to manage their land optimally.

b) Extensification Development Zone

This zone includes areas with the potential for rice field expansion through the construction and development of irrigation infrastructure. With the expansion of land, it is expected that rice production can significantly increase to meet the continuously growing food needs.

- Regions with extensification potential include Wadaga (12,605 ha), Kusambi (10,263 ha), and Lawa (8,492 ha). This area has land that can be converted into productive rice fields with the support of adequate irrigation system development.
- The development of irrigation systems is a key factor in the land conversion process. The construction of new irrigation channels and the optimization of water resources such as ponds and small reservoirs will support the sustainability of the agricultural system.
- The approach to soil and water conservation is essential to maintain land quality in the long term, such as terracing, the use of cover crops, and the utilization of rainwater harvesting technology, which can be applied to reduce soil degradation and increase land productivity.

c) Agribusiness Infrastructure Support Zone

This zone plays a role in supporting post-harvest activities, distribution of agricultural products, and processing of agricultural products to increase added value for farmers and agricultural entrepreneurs.

- Sawerigadi is developed as an agribusiness center with modern storage facilities, agricultural product processing, and marketing based on digital technology. With these facilities, agricultural products can be stored longer and processed into value-added products that are more competitive in the market.
- Barangka, Lawa, and Wadaga are focused as centers for agricultural product distribution, with improvements in road infrastructure connectivity to expedite access to regional and national markets.

3.2.4. Rice Field Development Strategy

Land development strategies for rice commodities can be implemented based on previous spatial planning analysis with the following program directives:

a) Strengthening intensive productive zones

Priority Areas: Sawerigadi (590 ha) and South Tiworo (822 ha) as productive irrigated rice fields Strategy:

- Agricultural intensification with the use of superior varieties
- Utilization of precision agriculture technology based on soil sensors and spatial mapping
- Training farmers in modern cultivation techniques, post-harvest management, and access to agricultural innovations
- The government's policy in the form of subsidies for superior seeds and fertilizers

b) Expansion of new rice paddy fields

Potential Areas: Wadaga (12,605 ha), Kusambi (10,263 ha), and Lawa (8,492 ha). Strategy:

- Converting non-paddy fields into productive paddy fields with adequate irrigation.
- The implementation of soil and water conservation systems to maintain land fertility.
- Development of irrigation infrastructure such as reservoirs and water distribution channels.
- Land conversion considers environmental balance and sustainability aspects.

c) Development of agribusiness infrastructure

Supporting Zone: Sawerigadi as the agribusiness center, Barangka, Lawa, and Wadaga as distribution centers. Strategy:

- The construction of storage warehouses for harvested crops to reduce post-harvest losses.
- Improving transportation access between districts to accelerate distribution.
- Utilization of e-commerce and digitalization of the agricultural supply chain.

d) Empowerment of farmers and market access

Strategy:

- Increasing farmers' access to technology and agricultural information.
- Providing subsidies for seeds, fertilizers, and agricultural tools to increase productivity.
- Strengthening farmer institutions through cooperatives and partnerships with the private sector.

e) Adaptation to climate change

Strategy:

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- The implementation of water-saving irrigation systems to face the risk of drought.
- The use of drought-resistant and flood-resistant rice varieties.
- Development of an early warning system for mitigating extreme weather risks.

f) Integration of Agrotourism Based on Rice Cultivation

The integration of agro-tourism aims to increase the added value of agriculture, strengthen the local economy, and preserve agricultural culture.

Strategy:

- Development of educational agrotourism
- Development of culinary agrotourism
- The use of agricultural land as an ecotourism destination
- Rice harvesting tourism and cultural attractions

By systematically implementing this strategy, it is hoped that West Muna Regency can achieve stronger food security, improve farmers' welfare, and reduce dependence on food supplies from outside the region.

IV. CONCLUSION

West Muna Regency has great potential in the development of rice agricultural land to support sustainable food security. Spatial analysis reveals that there are several areas with high potential for the intensification and extensification of rice farming, such as Sawerigadi, South Tiworo, Wadaga, Kusambi, and Lawa. However, the Location Quotient (LQ) value indicates that rice has not yet become a basic commodity in this area, so its development still needs to be enhanced. The development of rice agriculture has a significant impact on increasing production, supply stability, food accessibility, and farmer welfare. Factors such as the development of irrigation infrastructure, road connectivity, agricultural processing, and the application of modern technology are key in enhancing productivity and the sustainability of the agricultural system. In addition, challenges such as limited water resources, land degradation, and climate change must also be addressed to ensure long-term food security in the region. The recommendations in this study are

1. The local government needs to expedite the construction of irrigation infrastructure and connecting roads.
2. Increasing investment in agricultural research and technology innovation to enhance production efficiency and market competitiveness.
3. Further action is needed in the form of developing an Agricultural Geographic Information System (GIS), integrating GIS with production and climate data, mapping supporting infrastructure, creating a GIS-based monitoring system, developing agricultural productivity prediction models, and providing GIS data access for policymakers.

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