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Determination of Rice Field Potential Index Based on Geographic Information System in Gowa Regency

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ABSTRACT

The Index of Land Potential (IPL) is a land evaluation method that aims to identify and utilize land according to its potential. Through IPL, it is expected to achieve optimal productivity and land sustainability. This research aims to determine the Paddy Field Potential Index with the IPL weighting method using Geographic Information Systems (GIS) in Gowa Regency. In this research, the method used is a tiered quantitative approach, where each parameter is given an appropriate weight. Overlapping techniques were applied to various maps used to assess land potential, including aspects of slope, soil type, lithology, hydrology, and disaster risk. The results of this study include a land potential index map and a map of paddy field potential in Gowa Regency. In the LMI, the dominating classes are low and very low, covering an area of 156,885.34 ha (72%), while the use of paddy fields in the very high and high potential classes covers an area of 20,604.48 ha (39%). The relationship between productivity and IPL is explained through the equation IPL = 0.1025P + 4.9539 with a value of R2 = 0.7809, which indicates that an increase in IPL can be a guide to increasing the productivity of rice plants.

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1. INTRODUCTION

A problem that often occurs in developing countries is the high rate of land conversion, especially on agricultural land. The conversion of agricultural land to non-agricultural land is commonly found in Gowa Regency, especially in the economic growth center of the community. This happens because the increase in population has an impact on the increase in the need for land as a place and food, which has an impact on the higher demand for land and food. This increase in population growth causes an increase in the need for agricultural land to meet food availability. The higher the conversion of agricultural land, the greater the decrease in food security (Samsuar et al., 2020).

Effective management of paddy fields is essential to ensuring a bountiful harvest. When planning land use for paddy fields, it is necessary to take into account the extent of the land's suitability with a land potential index. A useful method for assessing the potential of land is the Land Potential Index. In assessing the potential of a land, it is necessary to consider various factors such as soil type, slope, lithology, hydrology, and disaster risk. An evaluation is made of these factors to determine the land potential index in an area. The higher the land potential index value, the higher the land potential in the area. This approach is important for managing land sustainably in accordance with its capabilities and potential (Sitorus, 1995).

Utilizing land in accordance with its capabilities will result in suitability for agricultural crops, leading to optimal production of agricultural products. The land potential index can be used as a reference for land use planning, so that the results from land with existing potential can be useful for land evaluation (Fiqhan & Sigit, 2022).

Geographic Information Systems (GIS) are computer systems that are useful for storing, processing, and analyzing data related to topography. GIS is supported by various GIS software that can be used for various purposes, including identifying land conditions remotely using satellite imagery. These satellite images have several bands, such as NIR from Sentinel imagery, which can be used to predict rice productivity through vegetation indices (Hastina et al., 2023). Additionally, GIS can also be used in mapping the land potential index in a particular area, which can be utilized over a long period and developed to enhance superior development in the future (Effendy, 2017).

To find out the potential of an area, one can use this technology, especially in Gowa Regency, considering that Gowa Regency has varying topographic conditions, ranging from sharp slopes to land with gentle contours, which causes potential vulnerability to various types of disasters because it can affect the power of agricultural land. Therefore, there is a need for research related to determining the potential index of paddy fields in Gowa Regency.

2. MATERIALS AND METHODS

2.1. Tools and Materials

The tools that will be used in this research involve hardware such as laptops, stationery, and supporting software such as ArcGIS version 10.6 and Microsoft Excel.

The materials used in this research include rainfall data, soil type maps, slope maps, lithology maps, hydrology maps, land use maps, and erosion hazard level maps in Gowa Regency. The data was obtained from the Public Works and Spatial Planning Office (PUPR) of Gowa Regency in spatial data format (Shapefile).

2.2. Research Procedure

The research implementation of the Geographic Information System-Based Paddy Field Potential Index Determination in Gowa Regency was carried out through several stages, namely as follows:

2.2.1. Data Collection

Data collection is done by means of a literature study, collecting reports, journals, and information from decisions, reports, and maps published by relevant government agencies.

2.2.2. Creation of an Erosion Hazard Level Map

The erosion hazard map was made using the Universal Soil Loss Equation (USLE) formula. The equation is (Listriyana, 2006):

$$A = R \, x \, K \, x \, LS \, x \, CP \quad (1)$$

Where:

A = The maximum amount of soil loss (tons/ha/year)
R = The rain erosivity factor (cm/year)
K = The soil erodibility factor (tons/ha)
LS = The length and slope factor
CP = The crop factor and processing techniques

2.2.3. Data Processing Analysis

The initial stage of data processing is to collect several maps of the Land Potential Index (IPL) parameters. In ArcGIS 10.6 software, the Soil Type Map, Slope Map, Lithology Map, Hydrology Map, and Erosion Hazard Level Map are limited (clipped) with the administrative map of Gowa Regency with the Geoprocessing extension, so that these maps are obtained within the administrative boundaries of Gowa Regency. The parameters for the Land Potential Index analysis are soil type, slope, rock type, groundwater potential, and erosion hazard level. After all the maps were collected, scoring was done on each parameter.

2.2.4. Determination of the Land Potential Index

The determination of the Land Potential Index is based on the calculation of the total score of the values of each parameter. The calculation of the total score uses the following formula (Effendy, 2017):

$$IPL = (R + L + T + H) \times B \quad (2)$$

Where:

IPL = The Land Potential Index
R = The Slope Factor Score
L = The Lithology Factor Score
T = The Soil Type Factor Score
H = The Hydrology Factor Score
B = The Erosion Hazard Level Score

Based on the formula, the determination of the Land Potential Index is carried out using the weighting method. After weighting, it is followed by overlaying the parameters used. The score of each parameter is then summed up for the slope (R), lithology (L), soil type (T), and hydrology (H) parameters, except for the erosion hazard level (B). This erosion hazard level factor is an inhibiting factor that will be used as a multiplier factor in the sum of the scores from the RLTH map.

For the RLTH map maker, below is a scoring reference table for each.

Table 1. Slope Classification (R) (Suharsono, 1998).

No.	Slope	Percentage (%)	LS Value	Score
1.	Mountainous	>40	9,50	1
2.	Hilly	25 - 40	6,80	2
3.	Low Hilly	15 - 25	3,10	3
4.	Wavy	8 - 15	1,40	4
5.	Ramps	0-8	0,40	5

Table 2. Classification of rock types (L) (Suharsono, 1998).

No.	Rock Type	Score
1.	Fine-grained clastics (*Sedimentary*)	2
2.	Siltstone (*Plutonik*)	3
3.	Coarse-grained clastics	5
4.	Igneous (*Metamorphic*)	5
5.	Limestone	5
6.	Pyroclastic (*Vulkanik*)	8
7.	Alluvium	10

Table 3. Soil Type Classification (T) (Suharsono, 1998).

No	Soil Type	Score
1.	Organosols, Regosols and Lithosols	1
2.	Latosol and Grumosol	2
3.	Podzol and Rensina Gley humus	3
4.	Andosols and Podzolic	4
5.	Brown forest soil, Alluvial, Mediterranean	5

Table 4. Hydrological Classification (H) (Suharsono, 1998).

Groundwater Potential	Score
Scarce groundwater	1
Small potential	2
Medium potential, possible local irrigation	3
Great irrigation potential and possibilities	4

After scoring each parameter in the ArcGIS application on the attribute table menu for each parameter, Then each map is combined using the intersect extension on the Geoprocessing menu, where the output of the command is an RLTH thematic map. After making the RLTH map, it is continued by overlaying the RLTH map with the erosion hazard level map, which is a multiplier factor in the development of the land potential index map.

Table 5. Classification of the Level of Erosion Hazard (B) (Suharsono, 1998).

No.	Erosion Hazard Level	Score
1.	Very Heavy >480	0,5
2.	Weight (180-480)	0,6
3.	Medium (60-180)	0,7
4.	Lightweight (16-60)	0,8
5.	Very Light <15	1,0

After the TBE scoring is done, it is continued by overlaying the RLTH thematic map with the TBE thematic map using the intersect extension. Then multiply on the attribute table menu, where the output of this command is a Land Potential Index thematic map classified into 5 classes, namely Very Low, Low, Medium, High, and Very High, based on the predetermined reference table.

Table 6. Land Potential Index (LPI) class (Suharsono, 1998).

No.	Land Potential Class	IPL Value
1.	Very Low	<9,8
2.	Low	9,9 - 14,1
3.	Medium	14,2 - 18,4
4.	High	18,5 - 22,7
5.	Very High	>22,8

2.3. Determination of Paddy Field Potential

The determination of paddy field potential is done by combining the thematic map of the land potential index with the thematic map of the distribution of paddy fields in Gowa Regency using the intersect extension in the geoprocessing menu. The output results of the command produce a thematic map of the Paddy Field Potential index, which is classified based on the IPL value into 5 classes: very low, Low, Medium, high, and Very High

2.4. Analysis of the Relationship Between Productivity and Land Potential Index

An analysis of the relationship between productivity and the land potential index was carried out using a correlation analysis diagram. Where rice productivity data is made in relation to the land potential index shown in one graph, the axis (x) is represented by productivity (tons/ha) and the axis (y) is represented by the value of the land potential index.

3. RESULTS AND DISCUSSION

3.1. Research Location

Gowa Regency is one of the regencies located in South Sulawesi Province. Geographically, the area of Gowa Regency is 1,883.33 km2. Geographically, Gowa Regency is located at 5°33'-5°34' South latitude and 120°38'-120°33' East longitude. Kabupaten Gowa consists of lowland areas and highland areas with altitudes between 10 and 2800 meters above sea level. However, the area of Kabupaten Gowa is mostly highland, which is around 72.26%. Gowa Regency has 18 sub-districts, which can be seen in Figure 1.

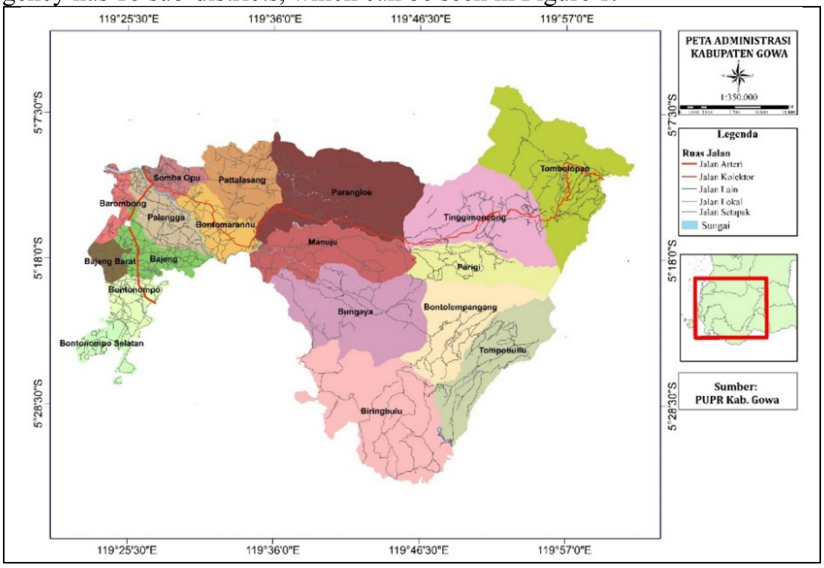

Figure 1. Research Location Map

3.2. RLTH Map

The RLTH Thematic Map becomes a parameter for the summation calculation in the Land Potential Index calculation. Based on the calculation of each parameter, the RLTH map is divided into five classes based on the IPL value, namely Very Low, Low, Medium, High, and Very High. The RLTH distribution map can be seen in Figure 2 and overlay result in figure 3.

3.3. Erosion Hazard Level

The erosion hazard level map is generated using the USLE equation. Where TBE is divided into 5 classes based on the reference table. The TBE map itself becomes a multiplying factor in the parameters for making the Land Potential Index map. The TBE distribution map can be seen in Figure 4.

3.4. Land Potential Index

The Land Potential Index map of Gowa Regency is divided into five classes, namely Very Low (Sangat rendah), Low (Rendah), Medium (Sedang), High (Tinggi), and Very High (Sangat Tinggi). The area based on the Land Potential Index (LPI) level can be seen in Table 7.

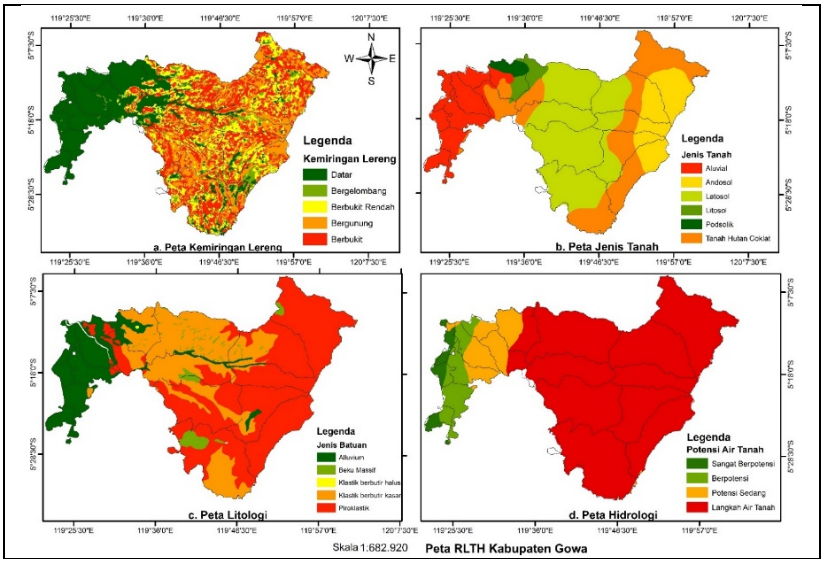

Figure 2. RLTH map of Gowa Regency.

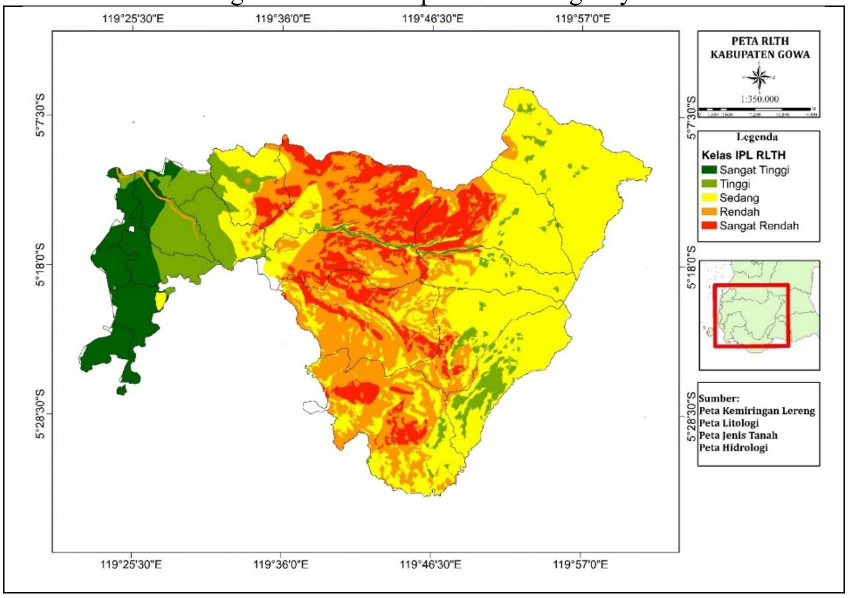

Figure 3. Map of Overlay Results of the RLTH Map in Gowa Regency

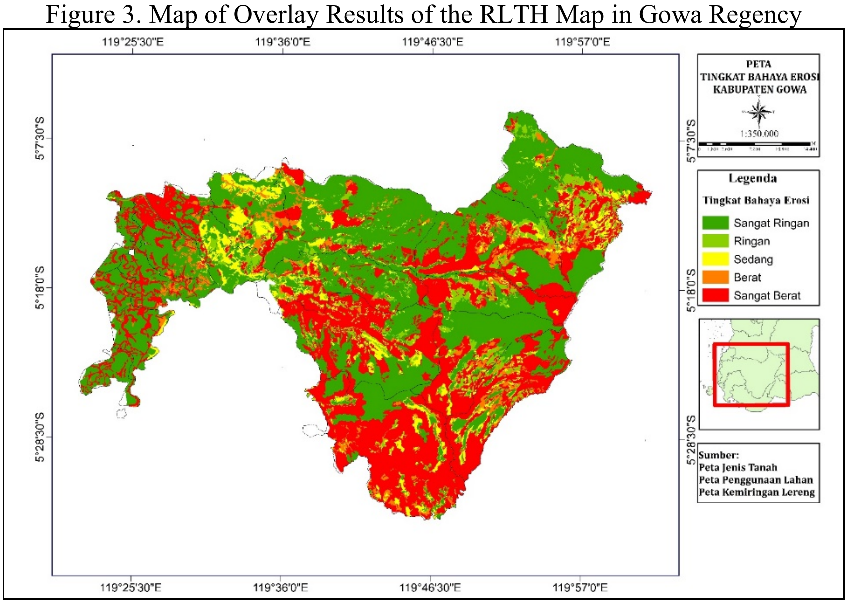

Figure 4. Map of Erosion Hazard Level of Gowa Regency

Table 7. Land Potential Index.

No.	Land Potential Class	IPL Value	Extensive (Ha)	Extensive (%)
1	Very Low	<9,8	81.667,57	37
2	Low	9,9 - 14,1	75.217,82	35
3	Medium	14,2 - 18,4	38.833,81	18
4	High	18,5 - 22,7	12.280,91	6
5	Very High	>22,8	9.787,30	4
	Total Area		181.553,45	100

The dominating land potential index classes are the very low and low classes, with an area of 81,667.57 ha (37%), and 75,217.82 ha (35%), respectively, of the total land potential index area, which is spread across all sub-districts in Gowa Regency; only Bajeng, West Bajeng, and South Bontonompo sub-districts are not included. Followed by the medium land potential index class with an area of 38,833.81 ha (18%) of the total land potential index area, which is spread across all sub-districts in Gowa Regency. The high and very high land potential index classes only amount to 9% of the total land potential index area with an area of 12,280.91 ha and 9,787.30 ha, respectively. The high land potential index class is spread across all sub-districts in Gowa Regency; only West Bajeng, South Bontonompo, and Bungaya sub-districts are not included in it, while the very high land potential class is only found in Bajeng, West Bajeng, Barombong, Bontonompo, South Bontonmpo, Pallangga, and Somba Opu sub-districts. The distribution of the land potential index can be seen in Figure 5

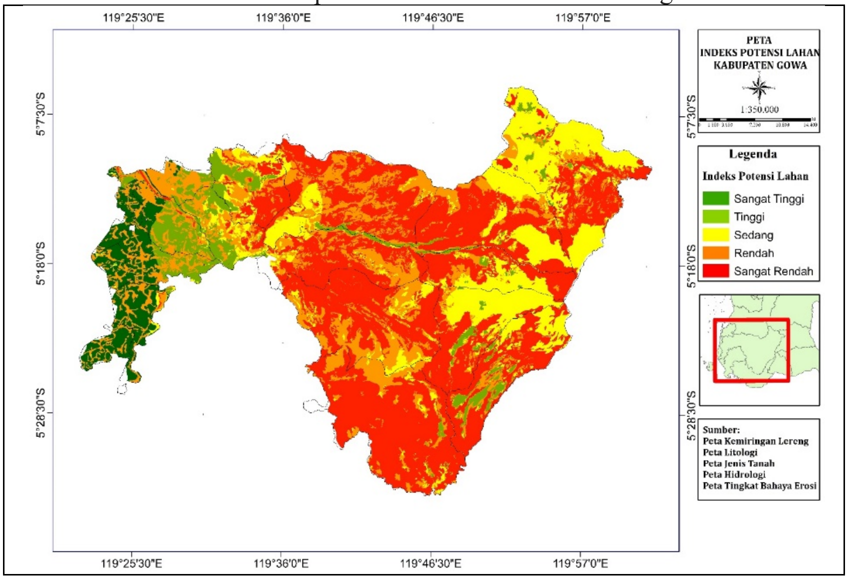

Figure 5. Land Potential Index Map of Gowa Regency.

3.5. Paddy Field Potential Index

The distribution of the Land Potential Index map is divided into 5 classes based on the IPL value, namely Very Low, Low, Medium, High, and Very High. The area based on the Land Potential Index (LPI) level can be seen in Table 8.

Table 8. Paddy Field Potential Index.

Potential Land Use	Extensive (ha)	Extensive (%)
Rice field potential is very high	9.573,38	18
High paddy field potential	11.030,70	21
Medium paddy field potential	9.024,29	17
Low paddy field potential	14.078,87	27
Rice field potential is very low	9.021,62	17
Total Area	52.729,27	100

Based on the paddy field potential index (figure 6), the results of the dominating land potential class are low-potential rice fields with an area of 14,078.87 ha, or 27% of the total potential area of rice fields, which are spread across all sub-districts in Gowa Regency; only Bajeng, West Bajeng, Bontonompo, South Bontonompo, and Somba Opu sub-districts are not included in it. Followed by high-potential rice fields with an area of 11,030.70 ha, or 21% of the total potential area of rice fields, which are scattered in all sub-districts in Gowa Regency; only

West Bajeng, South Bontonompo, and Bungaya sub-districts are not included in it. Paddy fields that have medium potential are scattered in all sub-districts in Gowa Regency. Then followed by very high-potential paddy fields with an area of 9,573.38 ha, or 18% of the total potential area of paddy fields, which are scattered in Bajeng, West Bajeng, Barombong, Bontonompo, South Bontonompo, Pallangga, and Somba Opu sub-districts. Medium paddy field potential and very low paddy field potential have the same percentage of land area, which is 17% of the total potential area of paddy fields, with an area of 9,024.29 ha and 9,021.62 ha, which are spread across all sub-districts in Gowa Regency, except Barombong, South Bontonompo, and Somba Opu sub-districts.

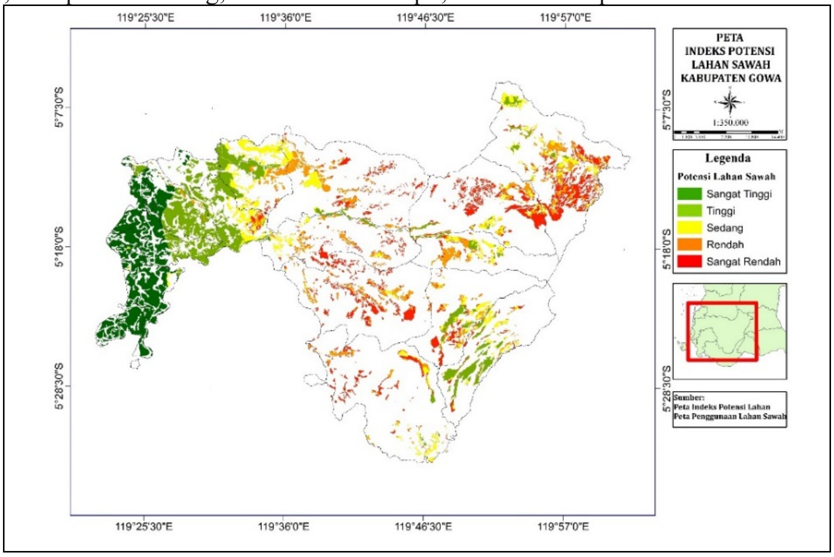

Figure 6. Map of the Paddy Field Potential of Gowa Regency.

3.6. Relationship between Productivity and Land Potential Index

Rice production data was obtained from the Central Bureau of Statistics for rice productivity in 2022. The rice production data was then linked to the land potential index value. This relationship was analyzed using regression analysis.

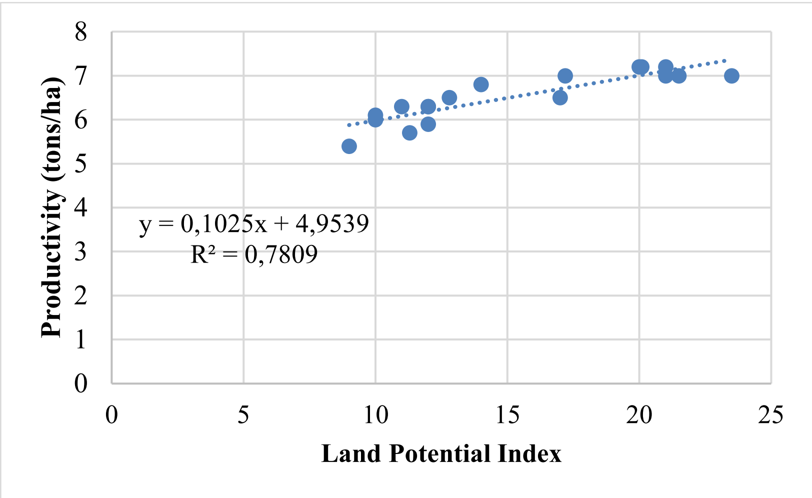

Figure 7. Relationship between Land Potential Index and Rice Productivity in Gowa Regency.

The results of the correlation curve of the relationship between the land potential index and productivity are expressed by the equation IPL = 0.1025P + 4.9539 with a correlation coefficient value of R2 = 0.7809, which means that there is a strong correlation relationship between IPL and productivity, which means that an increase in the value of IPL can be used as a reference to increase rice productivity in Gowa Regency.

4. CONCLUSION

Based on the results of the research that has been done, it can be concluded :

1. The Land Potential Index (LPI) classification in Kabupaten Gowa consists of five levels, namely very high, high, medium, low, and very low. The dominant IPL classes are low and very low, with an area of 156,885.34 ha (72%), which covers almost all sub-districts in Gowa Regency except Bungaya, Bontolempangan, South Bontonompo, and Somba Opu.

2. The utilization of paddy fields in the very high and high paddy field classes covers an area of 20,604.48 ha (39%), which is spread in almost all sub-districts in Kabupaten Gowa except Kecamatan Bungaya.
3. The relationship between productivity and IPL is expressed by the equation IPL = 0.1025P + 4.9539 with a value of R^2 = 0.7809, which means that an increase in the value of IPL can be used as a reference to increase rice productivity in Gowa Regency.

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