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The Potential For Agricultural Area Development In Bedadung Watershed

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Abstract. Food security can be achieved through the development of agricultural area and water supply. This study aims to figure out the potential of land development for food crop cultivation, both of the technical irrigation land and rainfed land in Bedadung watershed. The suitability principle of natural resources for food crops is utilized to determine the potential for agricultural area development. In this case, the parameters are land suitability based on the water availability which can be seen from the Oldeman classification, land elevation, and land topography. The results showed that Bedadung Watershed more suitable for corn (S2). The rice cultivation can be done by considering the S3 classification and it must be supported by good water availability for providing an adequate irrigation system.
Keywords: Watershed, Water Availability, Natural Resources, Agricultural Development

1. Introduction

Law Number 18 year 2012 concerning Food mandates that the state is obliged to realize the availability, affordability, and fulfillment of adequate, safe, quality and nutritionally balanced food consumption, both at the national and regional levels to individuals evenly throughout the territory of the Republic of Indonesia all the time by utilizing local resources, institutions and culture.

In the context of strengthening food security, in 2015-2019 the Ministry of Agriculture will focus on increasing the production of strategic staple foods for rice and corn and other agricultural commodities, to meet domestic food needs.

Increasing rate of Jember population in 2016-2017 was around 0.46%. The the total population in 2016 was 2,419,000 and it became 2,430,185 in 2017. The food needs obviously will be increased along with the increasing population [4].

Based on these data, it can be confirm that with increasing population, the need for food will increase. One way to meet food needs is to increase land productivity based on land suitability.

Land suitability is an assessment of a land to determine its suitability in particular matter. In this case, the land suitability is obtained by comparing the land state with land use requirements. It is expected to increase the land productivity in order to meet the food needs of Jember resident . Based on the explanation above, the researchers focused their research on land suitability for rice and corn.

Paddy is a food crop commodity that produces rice, which plays an essential role in the economic life of Indonesia. Hence it is hard to substitute rice with the other staple foods [5].

Rice plants (Oryza sativa L.) are the staple food of more than half of the world's population because they contain nutrients for the body [11]. Ground rice contains 78.9% of carbohydrate, 6.8% of

protein, 0.7% of fat and 0.6% of others. As a country with a large population, it is definitely a challenge for Indonesia to meet such huge needs of food [11].

Hamum (2008) stated that rice can be cultivated in diverse climates. It grows in tropical and subtropical regions at 45 north latitude and 45 south latitude with a hot weather and high humidity along with its 4-month rainy season. The average rainfall is 200 mm / month or 1500-2000 mm / year. Rice can be cultivated during the the dry or rainy season. In the dry season, the rice production can be increased as long as the irrigation system is sufficient. In the rainy season, the rice production can be decreased due to its less intensive pollination. Rice requires an altitude of 0 - 650 m above sea level with a temperature of 22-27oC in the lowlands, while in the highlands with the high altitude around 650-1500 masl it requires a temperature of 19 – 23ºC.

Rainfall is not a limiting factor for rice plants in wetlands (irrigated fields), but in dry land, rice plants require an optimum rainfall more than 1,600 mm / year [2].

Corn is classified into the second staple food after rice, which is used as a source of carbohydrates and used as industrial raw materials and animal feed [9].

Corn is one of the most important commodities, besides of being a staple food for some residents in the territory of Indonesia, corn is also the main feed ingredient for poultry farms and is a raw material for processed industries. Before 1970, local corn was utilized as a staple food for people. However, in line with the development of the feed industry and the widespread preference of rice to be the staple food for basic needs, the demand for corn had significantly decreased [3]

Corn plants require open spaces and it needs a sufficient amount of sunlight. The suitable land elevation for growing corn is around 0 to 1300 m above sea level. The temperature needed to support the growth of corn is 23-27C. The ideal rainfall for maize plants is generally between 200 to 300 mm per month or it must has an annual rainfall between 800 and 1200 mm. The optimal soil acidity (pH) for growth and development of maize plants ranges from 5.6 to 6.2. Growing corn does not depend on the season, but it depends on the availability of sufficient water. When the irrigation system is good, planting corn in the dry season will produce a better quality corn [12].

2. Methods

2.1. Criteria

Land evaluation is a process of evaluating land resources for a particular purpose using a proven approach or method. The results of the land evaluation will provide information and directions for land use as needed. Land suitability is the level of suitability for a particular land use. Land suitability can be assessed for current states (actual land suitability) or after some improvements that have been made (potential land suitability) [17][18].

The structure of land suitability classification can be divided into Class S1 (very suitable), Class S2 (quite suitable), Class S3 (marginal appropriate), and Class N [6]. Explanations regarding to this are presented in Table 1. below.

Table 1. Land Suitability Classification

Class	Explanation
S1	Land does not have a significant limiting factor to sustainable use or a non-dominant limiting factor and will not reduce land productivity
S2	Land has a limiting factor and this limiting factor will affect its productivity which requires an additional input. These restrictions can usually be overcome by the farmers themselves.
S3	Land has a dominant limiting factor and this limiting factor will affect its productivity which requires more additional inputs than the land which is classified to S2. To overcome the limiting factors in S3, it requires high asset, so it is necessary to help farmers to overcome them.

N   An inappropriate land (N) which has a dominant limiting or is difficult to overcome.

Every type of plant has a different land suitability criteria. [19] The land suitability criteria for paddy are presented in table 2. and criteria for corn are presented in table 3.

Table 2. Criteria for Rice Plants

Land use requirements or characteristics	Land Suitability Class			
	S1	S2	S3	N
Temperature (tc) Average annual temperature (° C)	25 – 28	> 28 - 30 23 - < 25	> 30 - 33 21 - < 23	> 33 < 21
Water availability (wa) Number of wet months (> 200 mm / month)	6 – 8	4 - < 6	2 - < 4 > 8 - 10	< 2 > 10
Rooting Media (rc) Drainage	Obstructed, slightly obstructed	Moderate	Very obstructed, good, slightly faster	fast
Texture	Smooth, slightly smooth	moderate	slightly coarse	coarse
Soil Type	alluvial, andosol		grumosol, litosol, mediterian	regosol
Erosion hazard (eh) Land Slope (%) Erosion hazard	< 3 -	3 – 5 ethereal	5 – 8 light	> 8 moderate – heavy
Altitude (masl)	0 – 600	600 – 1500	1500 - 2500	> 2500
Land use	Rice field	fields, gardens, vacant land	forest	settlement, lake, river

Table 3. Corn Crop Criteria

Land use requirements or characteristics	Land Suitability Class			
	S1	S2	S3	N
Temperature (tc) Average annual temperature (° C)	21 – 26	> 26 - 29 20 - < 21	> 29 - 33 18 - < 20	> 33 < 18
Water availability (wa) Number of wet months (>200 mm/bl)	3 – 5	< 3 and > 5 - 7	> 7 - 8	> 8
Drainage	good, slightly good	Slightly fast, slightly obstructed	obstructed	Very obstructed, fast

Texture	smooth, slighltly smooth, moderate	moderate	Slightly coarse	Coarse
Soil Type	alluvial, andosol, litosol, mediterian	latosol, grumosol,	-	-
Erosion Hazard (eh) Land Slope (%)	< 8	8 – 15	15 - 25	> 25
Erosion Hazard	-	Ethereal	light	moderate – heavy
Altitude (mdpl)	0 – 600	600 – 1500	1500 - 2500	> 2500
Land use	Rice fields	fields, gardens, vacant land	forest	settlement, lake, river

2.2. Land Suitability Parameters

2.2.1. Rainfall

The influence of rainfall is quite significant on crop production. The total rainfall is very important in determining crop yields [17][18].

[8] Oldeman made a climate classification system that is associated with the agriculture that utilizes elements of the rain climate, in which the limits concern on the rainfall, effective rain and crop water requirements. From these three factors, they are described in detail as follows:

Wet Month (WM)   : a month with an average rainfall of more than 200 mm.
Humid Month (HM)   : a month with an average rainfall of 100-200 mm.
Dry Month (DM)   : a month with an average rainfall less than 100 mm.

2.2.2. Slope

The steeper the slope, the greater the volume and velocity of surface runoff which has the potential to cause erosion. Besides steepness, the length of the slope also determines the magnitude of landslides and erosion. The longer the slope, the greater the erosion. Generally, more than 40% landslides often occur on slopes, this happens mainly due to the gravity [10].

The slope is divided into 5 criteria that will be explained in the following table.

Table 4. Slope Criteria

Slope	Description
0 – 8 %	Flat
8 – 15 %	Sloping
15 – 25 %	Slighlty steep
25 – 45 %	Steep
> 45 %	Very steep

Source: [16]

2.2.3. Elevation

Elevation is another term for measuring the height of a certain location above sea level. Mountainous land based on elevation is divided into medium plains (350-700 masl) and highlands (> 700 m asl). Elevation is closely related to the types of commodities which is suitable for maintaining an environmental sustainability [10].

2.2.4. Soil

Erosion and landslides often occur in hilly and mountainous areas, especially in sandy soils (Regosol or Psamment), Andosols (Andisols), rocky shallow soils (Litosol or Entisols), and calcareous shallow

soil (Renzina) or Mollisols). In a bumpy area, the intensity of erosion and landslides is slightly reduced, except in Podsolic (Ultisols), Mediteran (Alfisols), and Grumusol (Vertisols) soils [10].

3. Results and Discussion

3.1. Rainfall
The rainfall data are used to determine climate in the Jember Regency. The results rainfall data interpretation from 77 rain gauges for 38 years denote that Jember Regency has the following values and show that Wet Month (WM) equal 7 and Dry Month (DM) equal 4.

Based on these data, the Bedadung watershed is classified into the Oldeman type B, which means it can be planted with rice twice a year with short-lived varieties and a short-dry season is suitable for growing polowijo (herbs and spices).

3.2. Slope
Based on the results of data interpretation, it shows that the land suitability for rice and maize is presented in table 5. below.

Table 5. Land Suitability Results Based on The Land Slope

Land Suitability	Types of Plants			
	Paddy		Corn	
	Areas	Presentase	Areas	Presentase
S1	3.009,06	3,53 %	29.848,68	35,04 %
S2	11.983,77	14,07 %	23.265,90	27,31 %
S3	14.855,85	17,44 %	11.960,46	14,04 %
N	55.340,82	64, 96 %	20.114,46	23,61 %

Based on the table, it can be concluded that the Bedadung watershed's elevation is not suitable for planting rice with land suitability for category N (64.96%) and it is suitable for growing maize with land suitability for category S1 (35.04%).

This shows that Bedadung watershed is not suitable for growing rice. Rice plants would be planted perfectly on land with a slope of 15% - 40% [15].

Corn plants would be planted perfectly on land with a slope of no more than 8%, which depends on the type of soil [15].

3.3. Elevation
Based on the results of data interpretation, it denotes that land suitability for rice and maize based on the land slope is presented in table 6 below.

Table 6. The Results of Land Suitability Based on The Elevation

Land Suitability	Areas	Presentase
S1	42.354,00	49,63 %
S2	27.115,02	31,77 %
S3	9.712,08	11,38 %
N	6.174,81	7,23 %

Based on the table, it can be concluded that Bedadung watershed has a perfect elevation for growing rice and maize which belongs to the land suitability in category S1 (49.63%).

It would be suitable for growing rice and maize in the lowlands and in the land with an altitude of 1,700 masl [15]. However, we need to manage the availability of water for rice plants. Plains with inappropriate categories that are not suitable for cultivating rice still can be used as long as the availability of water is adequate. This also depends on the type of soil on the land.

Rice cultivation in the highlands could increase grain yield for hybrid rice and in the middle plateau for rice inhybrids [1].

3.4. Soil Type
Based on the results of data interpretation, the soil types of Bedadung watershed are presented in table 7. below.

Table 7. The Soil Types of Bedadung Watershed

Soil Types	Land Suiability	Area	Presentase
Aluvial, Regosol, Andosol, Latosol	S1	72.775,62	86,06 %
Mediteran, Gley	N	11.787,83	13,94 %

Based on the table, it can be concluded that the type of soil in the Bedadung watershed is suitable for growing rice and corn with S1 criteria of 86.06%. This shows that the potential of Jember in the agricultural sector comes from rice and corn. Suitability of soil as a medium for growing rice and corn plants can increase the yield of both crops.

The most suitable land for cultivating rice would be the land with the Alluvial soil types and it not suitable for Mediterranean soil types [15]. And the most suitable land for growing maize would be the land with Latosol soil types [15].

However, the land suitability based on its soil type also needs to focus on some nutrient retention factors and its erosion hazard level [13]

3.5. Land Use
Based on the results of data interpretation, the land use for Bedadung watershed is presented in table 8. below.

Table 8. Land Use in Bedadadung Watershed

Name	Area	Presentase
Urban	12.492	14,90 %
Plantation	14.572	17,38 %
Moor	9.508	11,34 %
Rain-fed Fields	4.396	5,24 %
Irrigation Field	25.216	30,07 %
Shrubs	3.484	4,15 %
Forest	14.192	15,92 %

Based on the table above, it can be concluded that the land use for Bedadung watershed is dominated by rice fields (30.07%). This land suitability indicates that the rice fields should be utilized as a media to cultivate rice and corn. Whereas, plantations, fields, rain-fed rice fields, shrubs, and forests can be converted into agricultural land to support the productivity of rice and corn. However, this land use change needs to be reconsidered by focusing on the type of soil and potential rainfall in that area.

In addition, a low quality land can be improved to a better quality by using a certain technology. However, a technology cannot upgrade the entire qualities or characteristics needed [7]
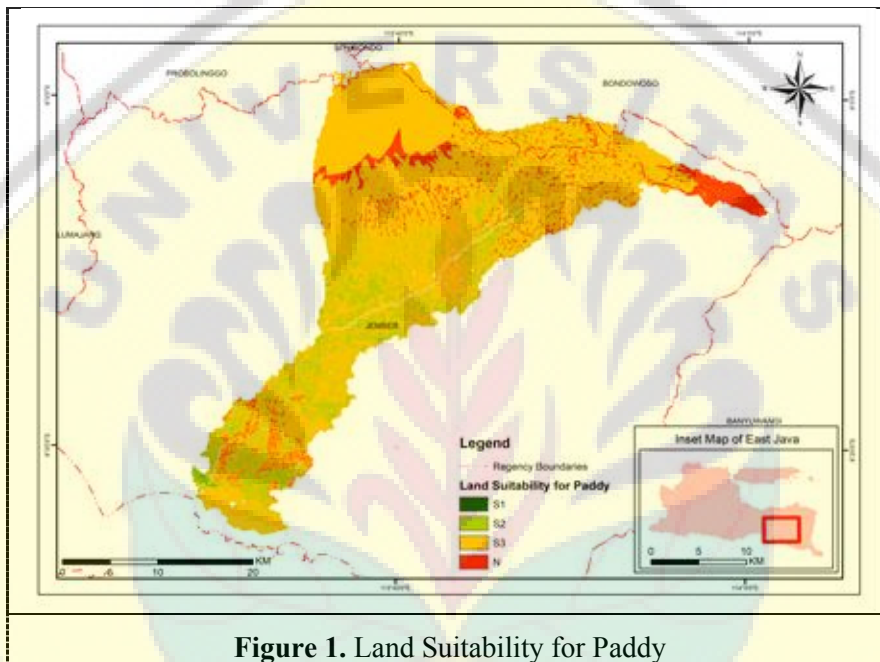
3.6. Land Suitabilty
Based on the interpretation of each parameter, the land suitability in the Bedadung watershed for rice and corn are show in Table 9 is then presented in Figure 1 for rice plants and Figure 2 maize plants.
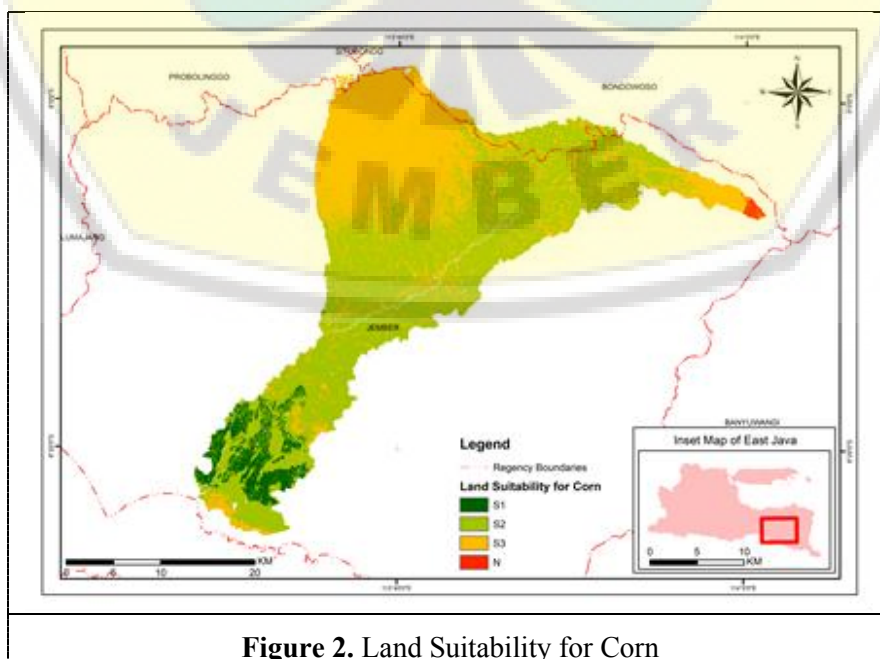
Table 9. Land Suitability for Paddy and Corn

Land	Type of Plants

Suitability	Paddy		Corn	
	Area (ha)	Presentase (%)	Area (ha)	Presentase (%)
S1	50,65	0,06 %	4.379,19	5,22 %
S2	11.745,60	14,00 %	47.666,44	56,83 %
S3	64.561,67	76,97 %	31.532,94	37,59 %
N	7.523,23	8,97 %	302,58	0,36 %
Total	83.881,15	100,00 %	83.881,15	100,00 %

Figure 1. Land Suitability for Paddy

Figure 2. Land Suitability for Corn

4. Conclusions
The results denote that Bedadung watershed is is classified into the Oldeman type B, meaning that it is able to plant rice twice a year with short-lived varieties, while short dry seasons is suitable for growing polowijo (herbs and spices). Based on parameter slope, soil type, elevation and land use, show that Bedadung watershed are suitable for growing paddy (S3) and corn (S2). So, it can be concluded that corn is the most suitable plant to this kind of land's state (S2). Cultivating rice actually can be done by following the S3 classification as long as the water availability for irrigation system are sufficient enough.

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