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Utilization of Geographic Information System(GIS) in Determining the Suitability of Fisheries Locations Cultivation of Freshwater Fish Ponds in South Aceh Regency

Meraty Ramadhini[a,1,*], Arnold Rikardo Sihombing[b,2]

[a] *Departement of Industrial Engineering, Polytechnic of Aceh Selatan, Tapaktuan, Indonesia*
[b] *Departement of Industrial Engineering, Polytechnic of Aceh Selatan, Tapaktuan, Indonesia*
[1] *meraty.ramadhini@yahoo.com*;* [2] *arnold_rikardo.s@yahoo.com*

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ABSTRACT

The potential of freshwater aquaculture area in South Aceh has not been optimally pursued; this is due to the limited technological and information capabilities, institutions and funding. The purpose of this study was to map the suitability of freshwater aquaculture land by utilizing the Geographic Information System (GIS) and multi criteria analysis in South Aceh. Determination of land suitability is done through the Multi Criteria Evaluation (MCE) and application of Geographic Information Systems (GIS). The results of the analysis show that the appropriate location (S1) is 81.55% (of the total area sample area) and the location which is not suitable is 18.45% (of the total area sample area). This indicates that the coastal areas of South Aceh have potential freshwater aquaculture areas.

I. Introduction

Almost all the districst in South Aceh are located on the side of the ocean that have a huge fisheries pot ential, one of those potentials is freswater aquaculture. Therefore, by utilizing Geographic Information Systems (GIS), it is inportant to determine the suitability of those areas to develop a freshwater aquaculture area to increase the life of the society in economy and income.

The potential described above is not well-utilized because of some reasons, such as aplicable human resources, limited technology and information capabilities, institution, and funding. There are many intensive freshwater aquacultures do not utilize the existence of Geographic Information Systems in deciding the location and manajement of Freshwater aquaculture, in fact it is important to avoid business failure. The information about the potentioal areas for aquaculture business become significant factor in fisheries development. The information and data related to the potential areas will efeectively guide business process, as stated by Hossain; the process of deciding location is used to decide rational use of the areas [2].

The purpose of this study was to map the level of land suitability for freshwater aquaculture in South Aceh Regency. This study is a comparative research that compares the analysis results with several variables used. The methodology used in this study is the Multi Criteria Evaluation (MCE) method for weighting criteria, then for land suitability for ponds analyzed spatially using GIS using the Weighted Linear Combination (WLC) technique. The results of the study are expected to be the basis for further planning in fisheries development, the national economy and improving welfare in the South Aceh District.

II. The Proposed Method/Algorithm

A. *Land Suitability*

Determination of land suitability can be done absolutely or relatively. It can also be determined based on the current state of the land or the condition of the land after a major overhaul so that the characteristics of the land conditions change significantly and can last for more than 10 years [5].

Table 1. Land Suitability Characteristic for Aquaculture

		Classification of Land			
Criteria	**Factor**	**1**	**2**	**3**	**4**
ecology	Slope (%)	0-3	>3-8	>3-8	>8
	Soil texture	loamy/sandy	Clay	Sandy clay	Sand
	rainfall (mm thn^{-1})	<1,000	>1,000-2,000	>2,000-2,500	>2,500
	Distance from river (m)	<500	>500-1,000	>1,000-1,500	>1,500
Socio-economic	Distance from road (m)	<500	>500-1,000	>1,000-1,500	>1,500
	Distance from resident (m)	<400	>400-800	>800-1,200	>1,200
	Land Utilization	Pool	Field	Garden	Shrubs

Source : Cahyaningrum, dkk [1]

B. *Spatial Multi Criteria*

Multicriteria Evaluation (MCE) is generally defined as a way of decision making and a mathematical tool that allows comparison of various alternatives or scenarios based on many criteria, often conflict, with the aim of giving guidance to policy makers to make a fair decision / objective actions [5].

Some methods used in multi criteria analysis (MCE) include, Boolean combination, index overlay, algebraic combination, Bayesian Probability, Dempster-Shafer Theory, Weighted linear factor or better known as analytical hierarchy process / AHP, fuzzy logic and vectorial fuzzy modeling. The choices of this method depend on the complexity of the data available [5].

$$WLC = \left(\sum_{i=1}^{n} X_{ij} \times W_{ij} \right) \times C_j \quad (1)$$

Where WLC is the Weighted Linear Combination, Xij is the weight of the jth sub-factor in location i, Wij is the weight of the j-factor at the i-location, N is the number of factors, Cj is the constraint [3].

III. Method

The research was conducted in 13 (thirteen) Sub districts in South Aceh. The methodology used in this study is the Multi Criteria Evaluation (MCE) method for weighting the criteria, then for the land suitability for ponds analyzed spatially using GIS with the Weighted Linear Combination (WLC) technique.

A. *Data Collection*

The target population in this study is the government and the community as stakeholders who represent and know about the development of the fishing industry as many as five respondents. The sample in this study is stakeholders who have a significant role, if it influences the determination of the suitability of the location of fisheries in freshwater fish ponds. Primary data collection techniques were obtained through interviews with five respondents, filling out questionnaires against three community leaders per sub-district related to freshwater fish pond cultivation, collecting secondary data such as the Rupa Bumi Indonesia Map (RBI), thematic maps from BAPPEDA, reports and literature from articles in relevant scientific journals.

B. *Data Analysis*

Analysis of land suitability for ponds was carried out spatially using Geographic Information Systems (GIS) using the Multi Criteria Evaluation (MCE) method based on Table 1. Then to

establish criteria and determine the objectives of structured Analysis used Analytical Hierarchy Process (AHP). The MCE method begins with weighting the criteria, factors and sub-factors using AHP [4]. This study uses two criteria, namely ecological criteria and socio-economic criteria. The ecological criteria used consisted of four factors: slope, soil texture, rainfall and distance from the river. The socio-economic criteria used consist of three factors, namely the distance from the road, the distance from the settlement and current land use. then do spatial analysis using the Weighted Linear Combination (WLC) technique [5]. The weight of each sub-factor resulting from the AHP analysis is included in the map of each factor [3]. Land suitability analysis is carried out in stages based on the selection of criteria.

Land suitability based on each criterion is obtained by the overlay function, which is intersect on the sub-factors of each criterion. Class determination refers to the weight of sub-factors that have been obtained. Review of the S1 suitability class (very suitable), S2 (quite appropriate) and S3 (according to marginal) is done by making observations in the field. Pond cultivation in the field was asked to the farmers, their coordinates were determined and their locations matched on the map. Each class has three farmers. The selected farmers are assumed to have the same cultivation pattern.

IV. Results and Discussion

A. Criteria Weighting Results With AHP Method

Weighting criteria is done to find out the highest and lowest values of ecological criteria and socio-economic criteria from several factors in increasing the productivity and quality of freshwater fish ponds. The results of the weighting analysis of the criteria obtained can be seen in Table 2.

Ecological criteria factor analysis showed that slope, soil type and rainfall had the same weight and the highest was 0.2900. Ponds tend to require areas with flat landforms. In steeper areas, the cost of building larger ponds will be needed. Soil plays a role to hold water during the process of fish farming. The type of soil determines the success factor of freshwater cultivation. The type of soil that is good for freshwater cultivation is clay or clay. Rainfall which tends to be high is a problem for farmers, rainwater has acidity that can harm fish farmers, farmers have not taken anticipatory actions to free the pond from rainwater acidity. The smallest weight is indicated by the distance factor from the river. The distance of the water source to the location of cultivation and the discharge of the amount of water for the needs to the cultivation pond is sufficiently available.

Analysis of socio-economic factors shows that the distance factor from the road currently has the highest weight, which is 0.4100. This is related to economic principles, such as the proximity of the marketing location to the location of fish farming.

Tabel 2. Analysis Result of Weighting Criteria

Criteria	**Factor**	**Weighting**	**Criteria**	**Factor**	**Weighting**
Ecology (0,39996)	Slope of Land	0,2900	Socio-economic (0,29900)	Land Utilization	0,3300
	Type of Soil	0,2900		Distance from road	0,4100
	Rainfall	0,2900		Distance from resident	0,2600
	Distance from river	0,1400			
	Total	**1,0000**		**Total**	**1,0000**

The results of the WLC analysis based on factor weights are as follows:

(1) Land suitability based on ecological criteria (WLC_1)
*WLC_1 = (0,2900*slope of land) + (0,2900*types of land) + (0,2900*rainfall) + (0,1400*distance from river)*

(2) Land suitability based on ecological criteria (WLC_2)
*WLC_2 = (0,3300*land use) + (0,4100*distance from the road) + (0,2600*distance from residence)*

(3) Overall land suitability (WLC_3)
*WLC_3 = (0,39996*WLC_1) + (0,29900*WLC_2)*

B. Suitability of Land based on ecological and socio-economic criteria

Determination of land suitability is carried out to produce land suitability based on ecological and socio-economic criteria along with its suitability gradations. The results of the weighting analysis of the criteria obtained can be seen in Table 3.

The Weighted Linear Combination (WLC) analysis using the weight values according to the results of the Analytical Hierarchy Process (AHP) analysis produces a wide area of land suitability along with its suitability gradations based on ecological and socio-economic criteria. Based on Table 3. Gradation of suitability for ecological criteria ranged from 0.2900 to 3.1900, while for socio-economic criteria ranged from 0.0000 to 2.6800. The closer the value of 3.1900 and 2.6800 means the more suitable the location for freshwater aquaculture.

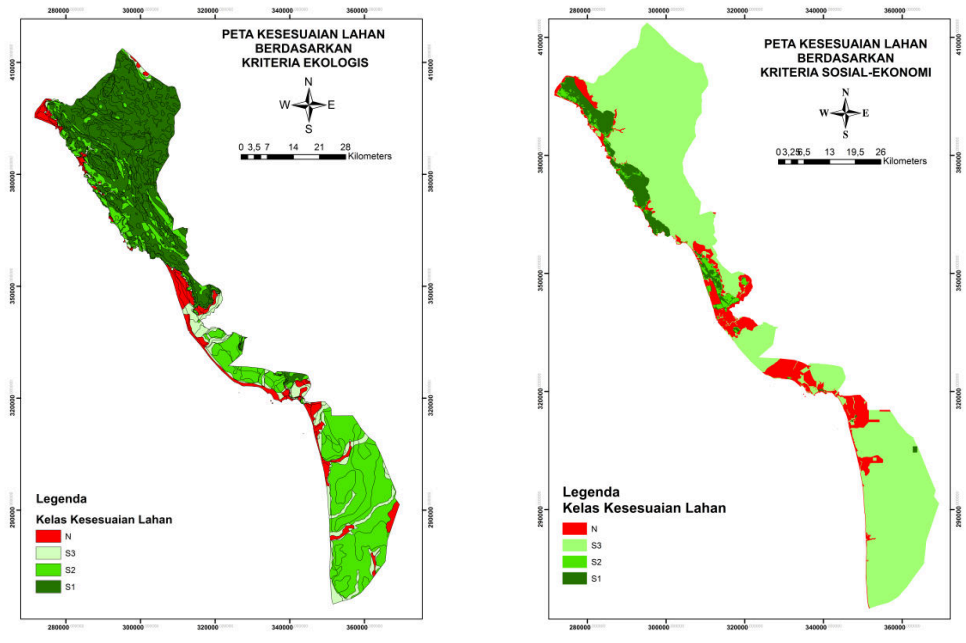
Table 3. Gradation suitability Based on Ecological and Socio-Economic Criteria

Suitability Level for Aquaculture Area	Gradation Suitability for Aquaculture Land	
	Ecology	Socio-economic
S1	2,3200 – 3,1900	2,0100 – 2,6800
S2	1,7400 – 2,3200	1,4800 – 2,0100
S3	1,4500 – 1,7400	0,7800 – 1,4800
N	0,2900 – 1,4500	0,0000 – 0,7800

Spatial analysis of seven factors divided into two criteria aims to obtain the overall location suitability analysis as shown in Fig.1. The results of the analysis based on the two criteria indicate that the potential location for freshwater aquaculture in socio-economic criteria is lower than in ecology criteria (Table 4)

Table 4. Suitable and not suitable land area for freswater aquaculture based on ecological and socio-economic criteria

Suitability Level of Freshwater Aquaculture Area	Ecological Criteria		Socio-economic Criteria	
	acreage (ha)	percentage (%)	acreage (ha)	percentage (%)
S1	94803,057	41,76	15843,946	6,98
S2	93000,626	40,97	4490,513	1,98
S3	21160,382	9,32	181566,756	79,98
N	18046,778	7,95	25108,856	11,06
Jumlah	**227010,843**	**100,00**	**227010,071**	**100,00**



(a) (b)

Fig. 1. the Map of Land Suitability based on ecological criteria (a) and socio-economic criteria (b)

The area of land resulting from suitability analysis based on ecological and socio-economic criteria is influenced by the factors that shape it. Based on ecological criteria, the most extensive land is in the S1 class (Very Appropriate) which means it is land that can be said to have no inhibiting factors that affect the continuity of the aquaculture business so it is very suitable to be used as pond land.

Based on socio-economic criteria, the most extensive land is in the S3 class (according to Marginal) which means that land is still possible to be used as pond cultivation but needs further processing because there are quite a lot of obstacles when compared with land with very suitable classes and suitable land.

C. Suitability based on ecological and socio-economic criteria

The results of the land suitability analysis indicate that the location suitable for the pond is greater than the location that is not suitable (Fig.2). Locations with suitable land amounted to 185,133,578 ha (81.55% of the total area of the study area) while the locations with land that were not suitable were 41876,493 ha (18.45%) (Table 5). From the total of the study area. This proves that the coastal areas of South Aceh Regency have potential areas for freshwater aquaculture.

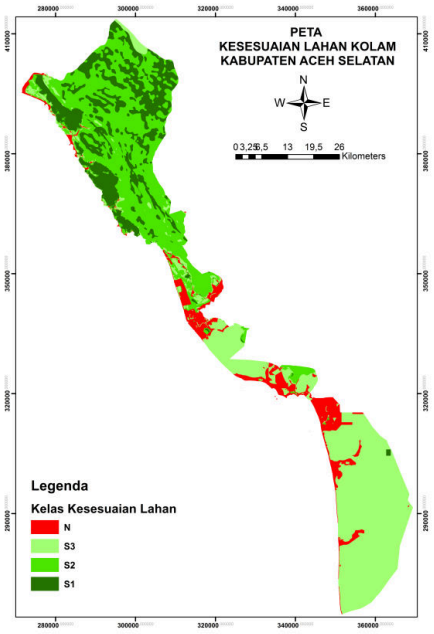


Fig. 2. the Map of Aquaculture land suitability in South Aceh

Tabel 5. Extent of Land Suitability for Pools

Suitability Level of Freshwater Aquaculture Area	Land Suitability for Aquaculture	
	acreage (ha)	percentage (%)
S1	19441,085	8,56
S2	90780,253	39,99
S3	74912,240	33,00
Jumlah Sesuai	185133,578	81,55
N	41876,493	18,45
total	**227010,071**	**100,00**

Land at a very suitable level (S1) supported by socio-economic conditions and ecological conditions suitable for aquaculture. Land in the pond is quite suitable (S2) and according to marginal (S3) has constraints that affect productivity and profits, so input is needed to overcome this.

V. Conclusion

The coastal area of South Aceh have land suitability that varies from very suitable (S1) 8.56%, quite suitable (S2) 39.99%, and maginally suitable (S3) 33.00%, then most coastal area of South Aceh have the corresponding category 81.55% and the inappropriate category is 18.45%. This shows that coastal area in South Aceh have a potential for freshwater aquaculture.

The inhibiting factors in the Coastal area of South Aceh to be used as pond land are soil texture factors which are sometimes not suitable for aquaculture; the community has difficulty in getting fish seeds and feed, lack of understanding of ponds and irregular water circulation factors. So for national economic development and improving welfare, wise management is needed by placing economic interests in proportion to the interests of the environment, both in the short and long term preparation.

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