# The Use of Web-Based Geographical Information System To Determine The Allotment of Land Settlement

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**Abstract.**The increase in residential areas leads to the process of land-use changes that is closely related to the limited land that available for settlement. The scarcity of land has become the trigger of the land-use changes that can cause landslide problems, disruption of industrial waste, etc. For example, illegal settlements are usually built without approval from the government. Regulation of the Minister of Public Works Number 41 has set characteristics, criteria, and land suitability for settlement. Therefore it can assist people and the government in the selection of appropriate land. This paper will discuss the use of web-based Geographical Information System (GIS) technology to analyze spatial data and attribute data (geoprocessing layer) in mapping the layout of the settlement, the allotment of land settlement based on soil type parameter, slope, residential areas, industrial, rivers, roads, educational and health facilities by using Multi-Attribute Utility Theory (MAUT). The sampling result for geoprocessing layer in Driyorejo, Gresik, Indonesia, shows that the slope result is 0-8% by the weight of 5, the soil type is Alluvial dark gray with clay sediment with the weight of 5, the distance from health facilities is >2,5km far from the hospital with the weight of 1, distance from educational facilities is >4km far with the weight of 1, the access road to the highway is around 0-500 meters with the weight of 5, distance from the river is around 0-1 kilometers with the weight of 5 and the range between the region to industrial areas is >500 meters with the weight of 1. The calculation using MAUT method resulted U=1,059, therefore the region is categorized as very suitable land for settlement. This application can assist the government, investors, and developers to find the location of potential land for the settlement construction.
Keywords: GIS; Web; Webmap; allotment of land settlement; MAUT

## I. INTRODUCTION

According to Law Number 4 of the year 1992, settlement is a residential area which has a number of populations equipped with infrastructure systems, environmental facilities, orderly spatial planning, and limited work places to enable optimal service and management. On the use of land for settlement, it is very important to assess the suitability of the land, whether or not the construction of settlements will affect the carrying capacity of the land. There are 10 parameters determining classes of land suitability for settlement namely the slopes, position of fault lines (no fault lines, no influence, right on the track), the strength of rocks, expands and contracts of the soil, drainage system, carrying capacity of the soil, the depth of groundwater, erosion potential, landslide potential, and flood potential [1]. It is considered difficult to obtain information about land suitability by looking at the match rate of the land for a particular usage. Land suitability can be assessed for the current state (the actual land suitability) or after improvement (potential land suitability) [2]. The basis of this paper is the difficulty in determining potential land suitability for settlement. Web-based Geographical Information System (GIS) technology can solve the problem by looking for potential land for residential and using the parameters of support for decision-making in determining ideal land for residential. Geoprocessing layer or spatial analysis in this paper is using Multi-Attribute Utility Theory (MAUT) in order to determine the layout of settlement in Gresik, Indonesia. MAUT method is also used to determine the allotment of ideal land for settlement based on the parameters of village administrative boundaries, soil type, slope, residential, industrial, river, roads, educational facilities (elementary school, junior high school, high school, university, and library) and health facilities (hospitals and health centres). MAUT method works by entering weight value and priority value then each criterion will through calculation process. This paper is useful to help government bodies, societies, and housing developers to know the process of identifying and analysing land information that has the potential for settlement. Also, this paper will help to display information and the location of settlements in Gresik.

## II. RESEARCH METHODOLOGY

Geoprocessing layer for the making of web-based GIS is using MAUT method. Buffer process will be conducted to the layer of the rivers, roads, educational facilities and health facilities to display the boundaries of its locations. This layer will be calculated based on the weight value and the priority value of each criterion.

### *A. Parameter pf Analysis*

The data requirements for geoprocessing layer process by determining the weight value in each criteria parameter and the priority value of each parameter using MAUT method in Table I to Table VII [4].

TABLE I WEIGHT OF SOIL TYPES

| ***Soil Types*** | **Weight** |
|---|---|
| Taupe aluvial with clay sediments | 5 |
| Hidromorf alluvial with clay sediments | 4 |
| Ashen alluvial with clay sediments | 3 |
| Red brown Mediterranean san latosol with limestone parent material | 2 |
| Taupe grumusol with clay sediments | 1 |

TABLE II WEIGHT ON A SLOPE

| Slope Level | Weight |
|---|---|
| 0 – 8 % | 5 |
| 8 – 15 % | 4 |
| 15 – 25 % | 3 |
| 25 – 45 % | 2 |
| > 45 % | 1 |

TABLE III WEIGHT DISTANCE FROM HIGHWAYS

| Distance from Highways | Weight |
|---|---|
| 0 – 500 m | 5 |
| 500 m – 1 km | 3 |
| > 1 km | 1 |

TABLE IV WEIGHT OF DISTANCE FROM INDUSTRIAL RANGE

| Distance from Industries | Weight |
|---|---|
| 0 – 500 m | 3 |
| > 500 m | 1 |

TABLE V WEIGHT OF DISTANCE FROM RIVERS

| Distance from Rivers | Weight |
|---|---|
| 0 – 1 km | 5 |
| 1 – 2 km | 3 |
| > 2 km | 1 |

TABLE VI WEIGHT OF DISTANCE FROM HEALTH FACILITIES

| Distance from Health Facilities | Weight |
|---|---|
| 0 – 1,5 km | 5 |
| 1,5 – 2,5 km | 3 |
| > 2,5 km | 1 |

TABLE VII WEIGHT OF DISTANCE FROM EDUCATIONAL FACILITIES

| Distance from Educational Facilities | Weight |
|---|---|
| 0 – 2 km | 5 |
| 2 km – 4 km | 3 |
| > 4 km | 1 |

The layers to show which areas are suitable and not suitable for settlement will be divided into five suitability classes, namely:

- Class worth the 5 (dark green) is very suitable
- Class worth the 4 (light green) is suitable
- Class worth the 3 (yellow) is medium suitable
- Class worth the 2 (orange) is not suitable
- Class worth 1 (red) is very unsuitable

*B. Geoprocessing Layer*

Flowchart compilation of various layers then will be calculated the value of its weight to obtain the end result of all the layers. The following is a flowchart compilation of various layers that the value of its weight will be calculated in the next step to obtain the end result of merging all the layers.

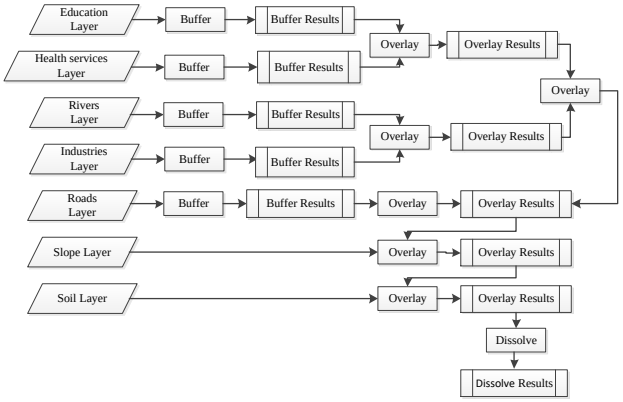


Fig.1 Geoprocessing Layer of Land Suitability

*C. Framework for Spatial with MAUT*

After the values of the weight are formed on each parameter that represents each layer, the next step is analyzing the weight value using MAUT method. To see the weight of each layer with reference to Table I to Table VII, the priority parameter should be determined in advance, therefore, it is easier to see certain criteria to be analyzed. The next step it determining the weight of each layer with the overall value of the weight is 1. The following are the selection of determinant priority parameter:

TABLE VIIIPRIORITY PARAMETER

| *Layer* | Priority Value | Total Value |
|---|---|---|
| Soil | 0,3 | 5 |
| Slope | 0,24 | 5 |
| Roads | 0,17 | 3 |
| Industrial | 0,12 | 2 |
| Rivers | 0,09 | 3 |
| Health Facilities | 0,06 | 3 |
| Educational Facilities | 0,02 | 3 |

Mathematical equations of MAUT method are as follow:

$$U(A_i) = \sum_{k=1}^{K} w_k u_k(x_{ik}), \qquad (1)$$

Where $U(A_i)$ is a number of alternative to *i*, $w_k$ is weight attribute/criteria with the value of *k*, and $u_k(x_{ik})$is the utility of criterion *k* from many alternatives *i* to put a value on criteria *j* of alternative *i* is $x_{ik}$.

$$U = \left(\left(\frac{Tanah}{5}\right) * 0.3\right) + \left(\left(\frac{kemiringan\ Lereng}{5}\right) * 0.3\right) + \left(\left(\frac{Jalan}{3}\right) * 0.17\right) + \left(\left(\frac{Industri}{2}\right) * 0.12\right) + \left(\left(\frac{sungai}{3}\right) * 0.09\right) + \left(\left(\frac{Sarana\ Kesehatan}{3}\right) * 0.06\right) + \left(\left(\frac{Sarana\ Pendidikan}{3}\right) * 0.02\right)$$

After analyzed based on (1) the final value will be shown on each small section on a map layer. The next step is to determine the smallest and largest value of all the calculations, where the minimum value = 0 and maximum value = 14. Then the process of classification is based on the minimum and maximum values, divided into the following classes:

- Values from 0 to 2.8 = Grade 1 categorized as very unsuitable (red)
- Values from 2.8 to 5.6 = Grade 2 categorized as not suitable (orange)
- Values from 5.6 to 8.4 = Grade 3 categorized as medium / fair (yellow)
- Values from 8.4 to 11.2 = Grade 4 categorized as suitable (light green)
- Values from 11.2 to 14 = Grade 5 categorized as very suitable (dark green)

## III. Result and Discussion

To find a potential location for settlement and no potential location for settlement, the user can simply select the layer of land allotment for settlement as the result of Fig.2 below.

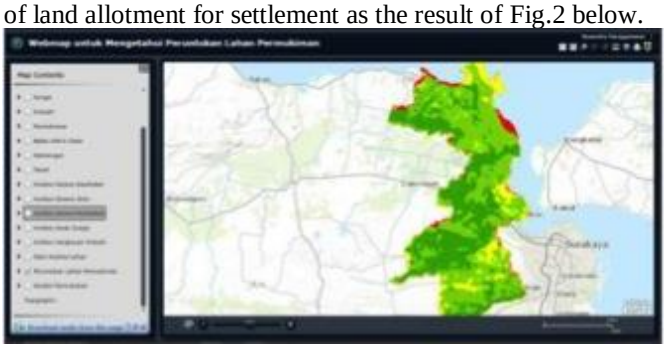

Fig.2 Geoprocessing Result of Allotment of Land for Settlement

In Fig.2, the value of each color on the layer explained as follows:

- Dark green color with the value of 5 is the most potential area
- Light green color with the value of 4 is potential area
- Yellow color with the value of 3 is categorized potential enough
- Orange color with the value of 2 is no potential area
- Red color with value of 1 is very bad category for residential area

To find out residential areas that are already suitable and which are not suitable can be seen on layer “Condition of Land Settlement” as shown in Fig.3 below.

Fig.3 Geoprocessing Layer Result for Condition of Land Settlement

In Fig.3, the value of each color on the layer explained as follows:

- Dark green color with the value of 5 is the most potential area
- Light green color with the value of 4 is potential area
- Yellow color with the value of 3 is categorized potential enough
- Orange color with the value of 2 is no potential area
- Red color with value of 1 is very bad category for settlement

Sampling for the research is conducted in Driyorejo, Gresik, Indonesia, by inputting parameters as shown in Table 1 to Table 7 to be calculated using MAUT method, the results shown in Fig.4 to Fig.10 below.


Fig.4 Layer Slope with the Weight of 5

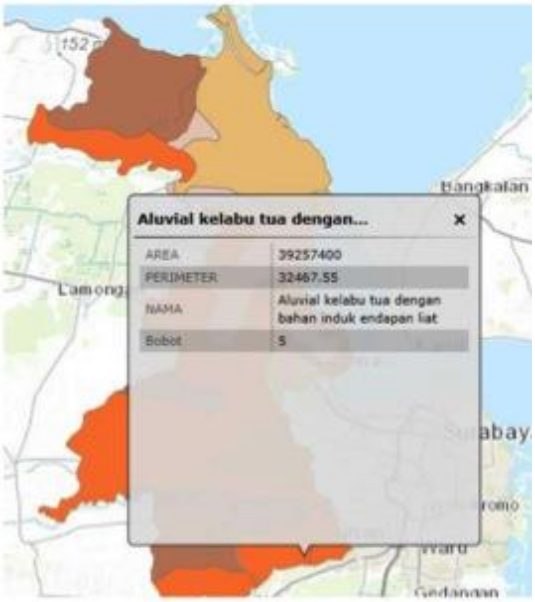


Fig.5 Layer Soil with the weight of 5

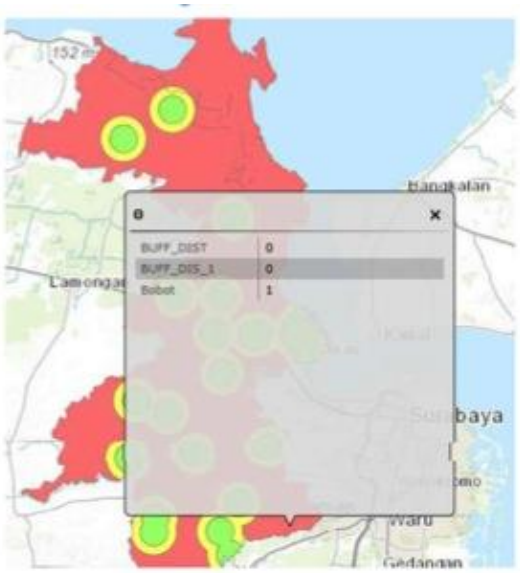


Fig.6 Layer of Health Facilities with the weight of 1

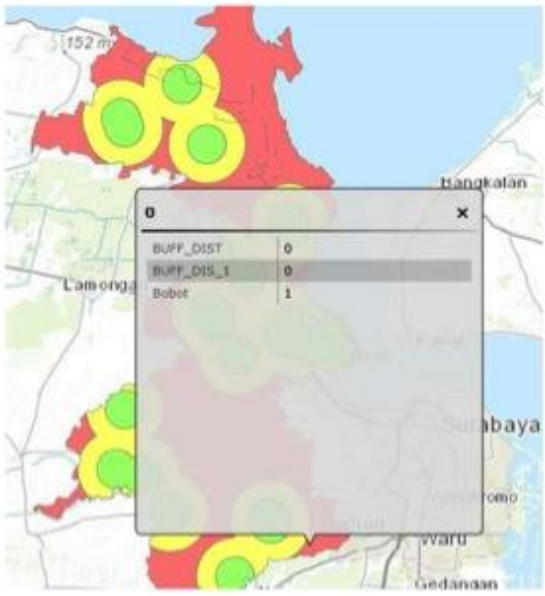


Fig.7 Layer of Educational Facilities with the weight of 1

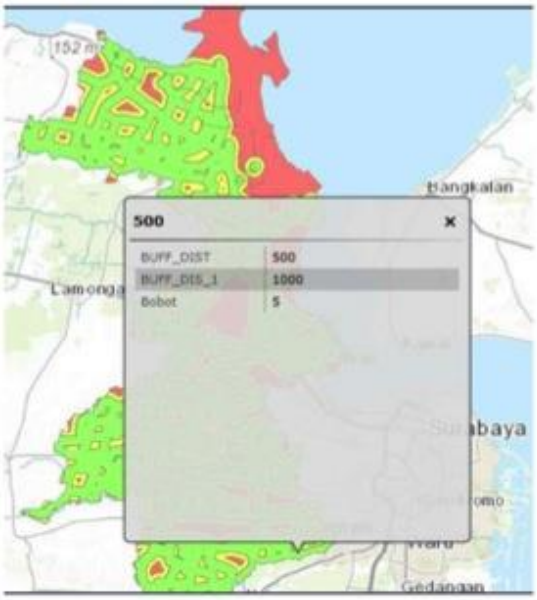


Fig.8 Layer of Road Access with the weight of 5

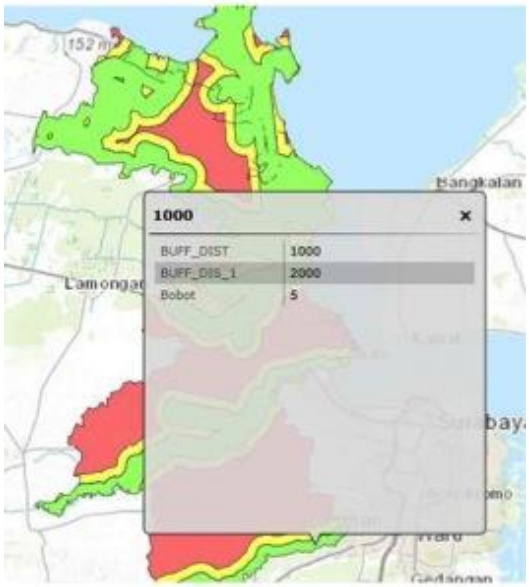


Fig.9 Layer of Distance from Rivers with the weight of 5

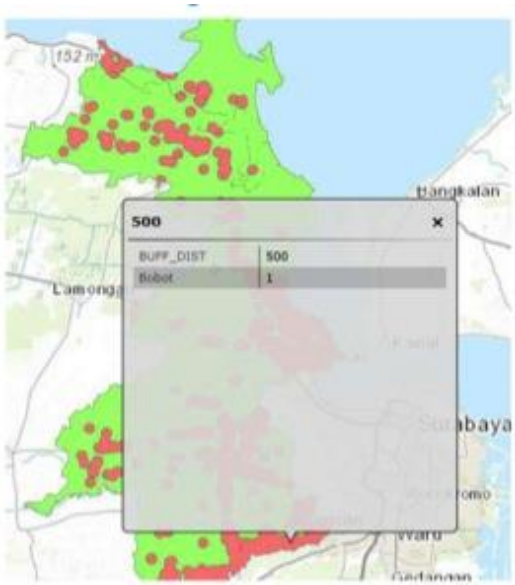


Fig.10 Layer of Distance from Industries with the weight of 1

From the overall value, the calculation results with (1) obtained with calculated *U*= 1.059 that included the weight of 5 and categorized as very suitable location for settlement. The result of the parameters is shown in Fig.11 below.

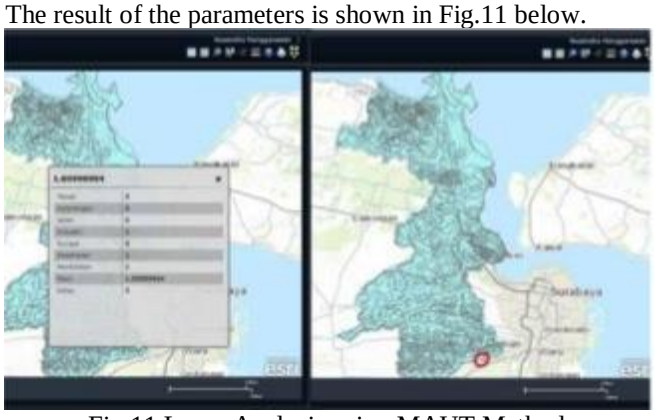

Fig.11 Layer Analysis using MAUT Method

## IV. Conclusions

Web-GIS application can perform geoprocessing layer using MAUT method. The government of Gresik as the decision-makers, societies and housing developers can use this system as an alternative choice to find conducive areas for the development of residential.


## Acknowledgment

This paper is the result of research in 2014 with independent charge. The data obtained from Bappeda Gresik which refers to the spatial plans in Gresik district years 2010– 2030.


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