Water salinity evaluation suitability for settlement after ten year tsunami in Banda Aceh, Indonesia

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Abstract

Banda Aceh is a residential area that is most severely impacted by the earthquake and tsunami on December 26, 2004. Recently, ten years after the incident, many settlements were rebuilt. As a disaster-prone areas, Banda Aceh would need to be evaluated against the settlement area base on water salinity. The focus of the study centered on the application of geographic information systems in handling spatial data bearing capacity of the land into the concept of the FAO land suitability. To ensure the application works, it requires geospatial analysis compiled based on the salinity of the water variables that can be observed and measured for the residential requirements. The results showed that 86 percent (ordo S) suitable for residential areas and 14 percent (ordo N) is not suitable.

Keywords: GIS; Water salinity; Land suitability, Residential

1. Introduction

On December 26, 2004, an earthquake of 9.0 on the Richter scale occurred on the west coast of northern Sumatra, Indonesia. Global Seismic Network stated that the point of the quake was at a depth of 10 km in the ocean Hindi. Based on a review of geography, it is located at position 95.85 N 3:32 E, which is approximately 149 km south-west of Meulaboh, Aceh western (Shofiyati, Dimyati & Kristijono, 2005). The Settlements in Banda Aceh was destroyed in the earthquake and tsunami. Settlement is part of the cultivated area and is outside the protected area. Settlement area serves as the residence of the environment and activities that support community life (UU-RI, 2011). Rebuilding the settlements in the region has been hit by disaster and a sense of community anxious to disasters that could happen again. In addition, the housing itself fostered by residents often do not pay attention to the physical condition of the land and the environment. According to, (Chiara & Koppelman, 1997) housing design has several requirements: a) attractive building foundation, appropriate and economical, b) provides safety, comfort and functional, c) balancing the nature with foundation of the structure. Therefore it is necessary to evaluate the suitability of land settlement with the current environmental conditions. Therefore it is necessary to evaluate the suitability of land settlement with the current environmental conditions. Land suitability evaluation is an approach or a way to determine the potential of land resources (Hardjowigeno & Widiatmaka, 2007). Niekerk (2010) said that land evaluation is also integral part of land use planning for continuous land management. Land use for
settlement should go inline with environment supporting ability (Masri, 2012). Therefore, it is essential to measure whether building structure on the soil will affect soil bearing capacity or not. Further Woro (2014) stated that salinity is one of the factors in the carrying capacity of the land for settlement. Results of the study McLeod et al. (2010) which states that the effect of salinity on land affected by the tsunami.

The use of GIS (Geographic Information System) in the land evaluation suitability for settlement will ease and speed up the process of data analysis (Setyowati, 2007). GIS technology has advantages for input, editing and analysis of data, both geographic data and attribute data in an appropriate manner at the time of rapid.

2. Material and method

Direct field testing to determine the water salinity with Salt Meter (Cahyadi et al., 2013) and positioning using GPS receiver (Abidin, 2007). The work mostly concentrated on spatial analysis of salinity values and land suitability evaluation model of FAO (FAO, 1976, 1985, 1990, 2007) adjusted for settlements. GIS is used in managing spatial data and presenting visual classification results.

3. Result and discussion

3.1. Water salinity

Salinity is the saltiness or salinity levels dissolved in water (Effendi, 2003). Water is one resource that has an important role in human life. One example of its use is to provide a source of clean water for residential area. It is necessary to plan for sustainable settlements. The results of measurements of salinity in Banda Aceh is presented in Table 1. By using GIS (Dai, Lee & Zhang, 2001; Kalogirou, 2002) distribution of salinity measurement results can be seen in Figure 1.

| No. | Salinity | Unit | No. | Salinity | Unit | No. | Salinity | Unit |
|-----|----------|------|-----|----------|------|-----|----------|------|
| 1   | 1.33     | %    | 19  | 0.5      | %    | 37  | 0.04     | %    |
| 2   | 2.53     | %    | 20  | 0.5      | %    | 38  | 0.02     | %    |
| 3   | 0.11     | %    | 21  | 0.7      | %    | 39  | 0.07     | %    |
| 4   | 0.06     | %    | 22  | 0.3      | %    | 40  | 0.71     | %    |
| 5   | 0.04     | %    | 23  | 0.3      | %    | 41  | 0.06     | %    |
| 6   | 0.02     | %    | 24  | 1.8      | %    | 42  | 0.08     | %    |
| 7   | 2.32     | %    | 25  | 0.1      | %    | 43  | 0.47     | %    |
| 8   | 2.92     | %    | 26  | 0.1      | %    | 44  | 0.11     | %    |
| 9   | 0.15     | %    | 27  | 0.2      | %    | 45  | 0.13     | %    |
| 10  | 0.06     | %    | 28  | 0.1      | %    | 46  | 0.01     | %    |
| 11  | 0.01     | %    | 29  | 0.1      | %    | 47  | 0.11     | %    |
| 12  | 0.05     | %    | 30  | 0.1      | %    | 48  | 0.13     | %    |
| 13  | 0.04     | %    | 31  | 0.4      | %    | 49  | 0.12     | %    |
| 14  | 2.27     | %    | 32  | 0.1      | %    | 50  | 0.31     | %    |
| 15  | 0.04     | %    | 33  | 0.9      | %    | 51  | 2.97     | %    |
| 16  | 0.14     | %    | 34  | 0.12     | %    | 52  | 0.05     | %    |
| 17  | 0.4      | %    | 35  | 0.14     | %    | 53  | 0.4      | %    |
| 18  | 0.4      | %    | 36  | 0.03     | %    | 54  | 0.4      | %    |

Figure 1. Spatial distribution from water salinity measurement results.

3.2. Analysis spatial of water salinity

Results analysis of water salinity like Fig 1 still comes in point. To predict the overall land surface, GIS is used with interpolation concept. Spatial classification based on field salinity value is used in applying this function (Prahasta, 2009; ESRI, 2013). In summary interpolation is the process of changing the data points into the area. Inverse distance weighted, natural neighbor, spline, and kriging trend are rules used interpolation. Further more Booth and Mitchell (2001), Gorr and Kurland (2008) and Pramono (2008) confirms that Kriging rules has the
advantages of unbiased properties, minimum variance, and it is a linear combination rather than observation. Kriging interpolation results from data analysis of water salinity in Banda Aceh, is presented in Figure 2 as follows.

3.3. **Land evaluation suitability based on water salinity for settlement**

Based on the modification of Fandeli (1988), PP RI (2001) and Effendi (2003) distribution of salinity level class table can be incorporated into the FAO land suitability classes, as shown in Table 2. The relationship between salinity to land suitability is comparable where the higher the salinity, the greater obstacle for suitability classes (settlement/residential).

| Class | Salinity (%) |
|-------|--------------|
| S1    | 0            |
| S2    | 0.1 - 0.5    |
| S3    | 0.6 - 1.0    |
| N1    | 1.1 - 1.5    |
| N2    | >1.6         |

Table 2

Land suitability evaluation system adopted the FAO. Suitability categories used are S1 (highly suitable), S2 (moderately suitable), and S3 (marginally suitable). Order N to not comply with Class, N1 (currently not suitable) and N2 (permanently not suitable). Salinity class into thematic criteria land suitability requirements settlements based analysis literature review (FAO, 1976; Sugiyanta, 2003; Setyowati, 2007). Adoption of the concept of this matching, then the interpolated maps based on criteria reclassify suitability classes.

Suitability classes salinity distribution maps provide preliminary information regarding the carrying capacity of land in general. Based on the broad suitability of salinity in Banda Aceh, are presented in Table 2, while the percentage can be seen in Figure 3. Results reclassify into residential land suitability map based on salinity, as shown in Figure 4.

| Class | Hectare |
|-------|---------|
| S1    | 686     |
| S2    | 2,975   |
| S3    | 1,614   |
| N1    | 888     |
| Total | 6,136   |

Table 3

Figure 2. Map of kriging interpolation results from water salinity.

Figure 3. Graph the percentage of salinity suitability for settlement.
4. Conclusion

The results of this study showed that the salinity suitability for settlements in Banda Aceh, 86 percent are in the ordo of S (suitable) and 14 percent of the ordo N (not suitable). The detailed extent of the percentage of suitability classes; S1 (highly suitable) covering 686 ha or 11%, S2 (moderately suitable) covering 2,975 ha or 48% and S3 (marginally suitable) covering 1,614 ha or 26%. While the details for ordo N; N1 (currently not suitable) covering 888 ha or 15 %.

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