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Analysis of Changes in Groundwater Salinity in Bangkalan District, Madura Island Using Terra Modis Satellite Image Data

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Abstract- Salinity is an important indicator in determining the quality of groundwater for agricultural or plantation land where the most suitable one is containing 10 to 25 o/oo of salinity. This study aims to obtain a complete picture of the Bangkalan Madura district regarding the conditions of the soil question which are detected by the presence of salinity concentrations scattered in the Bangkalan area so that in the future it can predict any further effect that will be caused by this salinity distribution to the conditions of plantations and ponds in the area. To answer this, the technology implemented in this research is remote sensing by utilizing Terra MODIS satellite image data from the MOD09Q1 series with a resolution of 250 meters. The results obtained from this analysis are that the surface reflectance value of the image can still be used to detect the distribution of groundwater salinity concentration where the mathematical model whose optimum correlation is the exponential model with the equation Sal (o/oo) = $0.4094e^{34,528*(Rrs\_B1)}$. It can be concluded that the quality of groundwater in the Bangkalan district is still in a good condition, has not yet been polluted and can be used for farming and for building fish ponds. Furthermore, it can be predicted that people who live in Bangkalan will still rely on agriculture and plantations in the future.

Keywords- *Soil Salinity, Remote Sensing, Terra MODIS, Bangkalan District*

I. INTRODUCTION

Salinity is closely related to the salt content in water bodies both on land and on the coast. Salinity affects indirectly the quality of the plant growth of the local community. The existence of salinity concentrations that are outside the permitted standards will damage the quality of the existing soil so that in the end it is not suitable to be called good soil and is useful for agricultural or plantation land.

Research on salinity concentration in groundwater has been conducted by many experts where the anticipated salinity value is still limited to manual research while the remote sensing technology is rarely used to detect the distribution of salinity or its correlation with other parameters (Azizpour et al., 2017; Ramoliya et al., 2004; Shi et al., 2017).

Bangkalan, Madura is an area that has a dynamic society, where the community depends on their income from farming and fishing. Research on salinity in this area has still not been conducted much, especially by using remote sensing technology (Hunter, 1998; McDougall et al., 2013). The distribution of salinity value mapping can predict the quality of Bangkalan groundwater in the future so that this information can be used to determine effective and appropriate steps to construct an area for farming and fishing on the coast.

The remote sensing technology developed for large areas is satellite imagery with wide area coverage and non-increasable resolution images, however, it still can show an image of the special water bodies parameter distribution for the groundwater salinity concentration (Lugassi et al., 2017; Omstedt et al., 2014; Solin et al., 2018).

Terra MODIS is one of the answers to mapping natural resources in a large enough area, wherewith a resolution of 250 meters this satellite records data on 2 existing channels, namely channel-1 and channel-2, where channel-1 represents the red wavelength at 650 nanometers, while channel-2 represents green at a wavelength of 530 nanometers (Yang et al., 2018; Yi et al., 2008).

The purpose of this study is to analyze and to map the distribution of groundwater salinity in the district of Bangkalan, Madura. By conducting a precise remote sensing algorithm, it will be possible to predict the future salinity values to anticipate farming techniques where there is salinity whose anomaly.

II. MATERIAL AND METHOD

A. *Case Study Location*

The research location of this study is Bangkalan district on the island of Madura which is adjacent to the coastal area of Kwanyar Bangkalan coast at coordinates -7.09° to -7,341° LS and 112.83° to 113.218° East Longitude as can be seen in Fig.1.

B. *Terra MODIS Satellite Image*

Terra MODIS satellite imagery obtained from the earth.explorer.usgs.gov web page for the Java and Madura islands with the file name MOD09Q1.A2020249.h29v09.006 data. The image data is the recording data on September 6, 2020, which is indicated by the initial A2020249, where 2020 is the recording year and the next 3 digits 249 is “Julian Day” which is the 249th day in 1 year. The form of the downloaded image data for channel-1 from Terra MODIS is shown Fig.2.

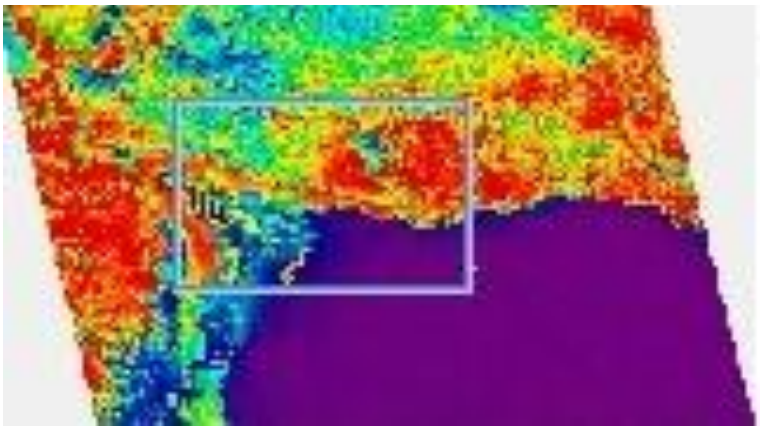

Figure 1. The research area at Bangkalan Madura Island

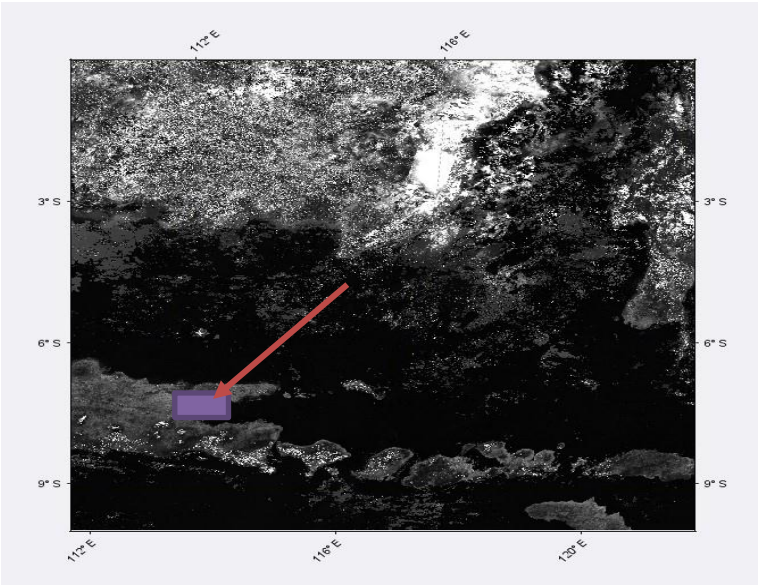

Figure 2. One view of Terra MODIS Land satellite image for Java and its surroundings

C. Terra MODIS Satellite Image

The image in Fig 2 later processed by cutting the image in the study area, Bangkalan and its surroundings. The results of the satellite image cropping process are shown in Fig. 3. for the district of Bangkalan at coordinates 6°50 '- 7° 30' south latitude and 112°30 '- 113°30' east longitude.

Figure 4 is the result of projection correction where the projection used is UTM with the WGS84 datum and the results of the correction calculations are shown in Fig. 5. This result is a refinement of the previous Fig.4. In Fig. 5, a composite coloring has been given for the existing satellite image and also a cut on the side of the unneeded image display, so that the satellite image display can be wider and more visible. This process aims to clarify the pixels in the image, making it easier to detect coordinates for field data retrieval which will later be correlated with the reflectance value of the satellite image.

Figure 3. The results of cutting the Terra MODIS satellite image for the Bangkalant and its surroundings

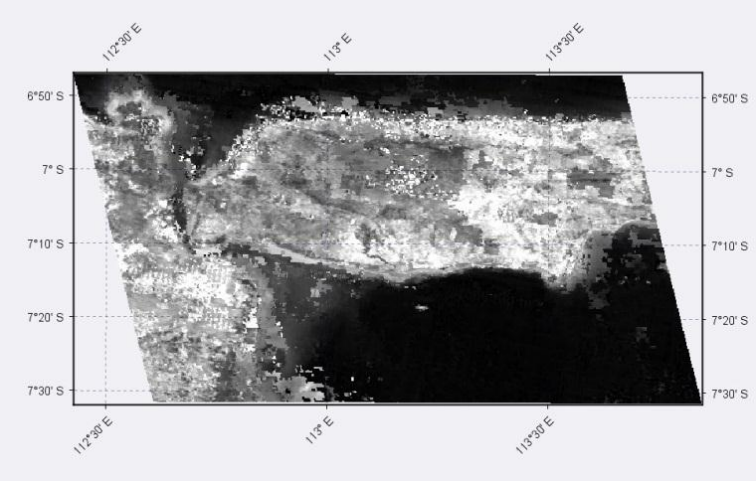

Figure 4. New compilation results for the UTM / WGS84 projection of Terra MODIS satellite imagery

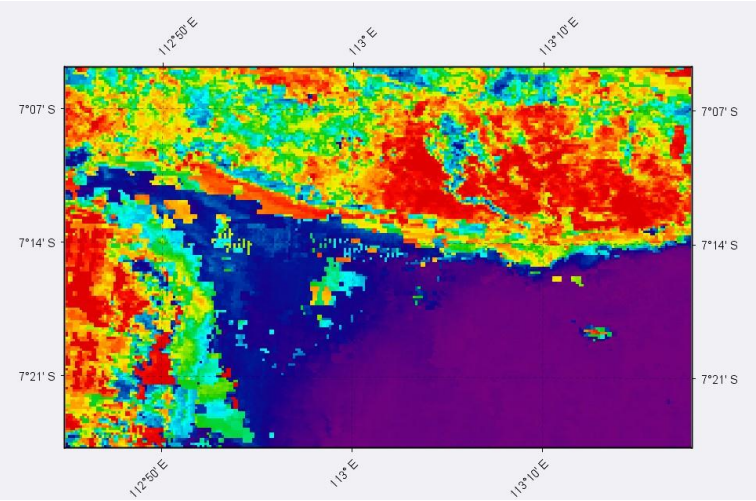

Figure 5. The shape of the FCC (false-color composite) color from the Terra MODIS satellite image on Band 1

III. RESULT AND DISCUSSION

The results of measurements in the field obtained deep salinity data (o/oo) where this data is obtained from taking soil at a depth of 20-30 centimeters and tested in the laboratory for existing salinity values, these results are shown in Table 1.

From Table 2, the salinity data obtained was carried out using the remote sensing algorithm by performing linear regression analysis on various existing mathematical models in accordance with the previous research conducted by Zainab for salinity levels in seawater in the Bangkalan area.

TABLE I. SALINITY DATA WITH FIELD COORDINAT

Lon	Lat	Soil Salinity (o/oo)
112,89622	-7,18844	3,8
112,89832	-7,18843	8,2
112,90041	-7,18842	8,6
112,90252	-7,18841	5,4
112,90461	-7,18841	16,3
112,90672	-7,18840	14,1
112,90881	-7,18839	15,8
112,91091	-7,18838	22,6
112,91301	-7,18837	25,1
112,91511	-7,18836	23,8
112,91722	-7,19044	16,5
112,91512	-7,19045	14,9
112,91302	-7,19046	16,2
112,91092	-7,19047	11,7
112,90881	-7,19048	19,2
112,90672	-7,19048	18,3
112,90463	-7,19049	24,2
112,90253	-7,19050	15,7
112,90043	-7,19051	11,8
112,89832	-7,19052	4,7

TABLE II. CALCULATION OF MATHEMATICAL MODEL OF REMOTE SENSING ALGHORITM

No	Algorithm	Mathematical Model	R^2
1	Linear	$y = 402,65x - 25,679$	0,8087
2	Exponential	$y = 0,4094e^{34,528x}$	0,8263
3	Logarithmic	$y = 37,445\ln(x) + 101,21$	0,7911
4	Power	$y = 22921x^{3,2334}$	0,8196

TABLE III. MEASUREMENTS FOR FIELD DATA VALIDATION USING 5 REMAINING DATA

	Salinity (o/oo)				
Point	Linear	Exponential	Logarithmic	Power	In-situ
16	17,485	16,582	17,593	16,767	18,3
17	18,049	17,404	18,079	17,486	24,2
18	5,848	6,113	5,830	6,072	15,7
19	5,446	5,906	5,349	5,825	11,8
20	5,043	5,705	4,861	5,585	4,7

TABLE IV. MEASUREMENT OF THE CORRELATION OF IN-SITU SALINITY TO EXISTING MATHEMATICAL MODELS

	Linear	Exponential	Logarithmic	Power	In-situ
Linear	1,000				
Exponent	1,000	1,000			
Logaritmic	1,000	0,999	1,000		
Power	1,000	1,000	1,000	1,000	
Insitu	0,820	0,816	0,823	0,816	1,000

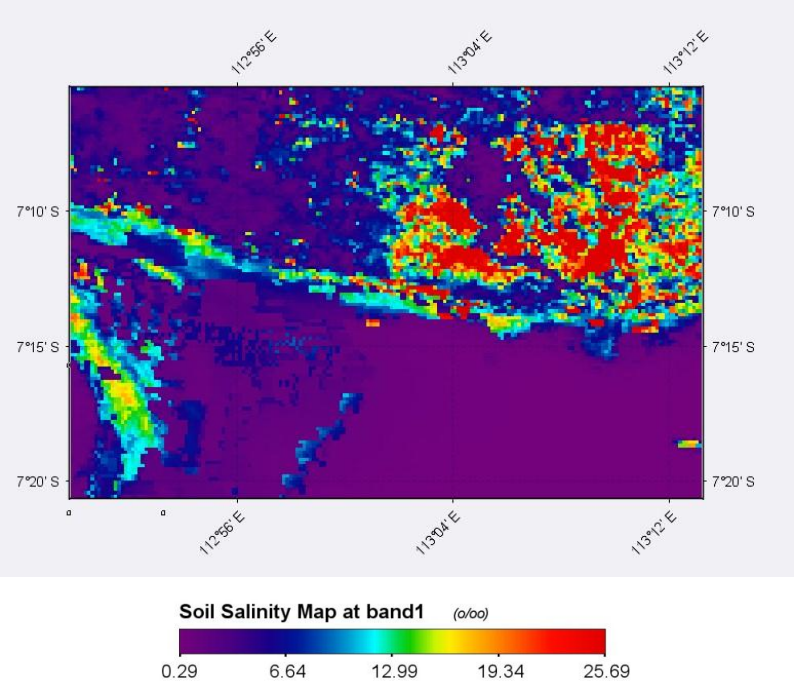

Figure 6. Thematic map of groundwater salinity from the Terra MODIS Channel B1 imagery for the exponential model.

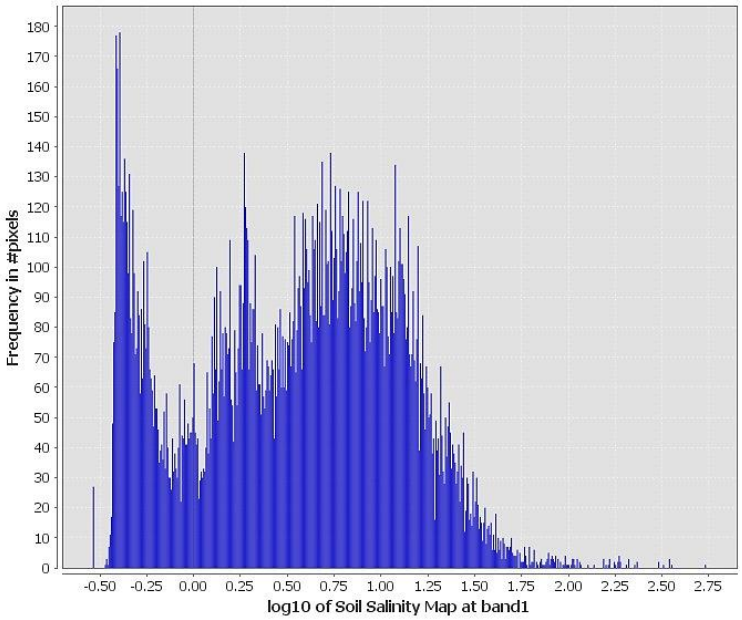

Figure 7. Display of groundwater salinity histogram in Bangkalan, Madura

IV. CONCLUTION

The salinity of groundwater in the Bangkalan, Madura area is still within safe limits for good soil quality for agriculture or plantation, where the distribution value is shown by the Exponential algorithm $y = 0.4094e^{34.528x}$ and the degree of determination $R^2 = 0.8263$. Remote sensing Terra MODIS imagery provides significant results for an error rate of 5% of the statistical measurements performed.

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