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The Simple Method to Assess Land Quality of Paddy Field Using Spectral, Soil pH and Statistical Regression Technique (Case Study of Paddy Field in Majalaya Subdistrict, Bandung Region)

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Abstract

Assessing land quality has important use in understanding the capability of soil in producing food. The area of paddy fields in Majalaya Subdistrict is located around the industrial zone and this situation is urgent to understand the land quality of paddy field due to the influence effect of industrial waste to its growth. A combination of regression model and Landsat 8 image to estimate soil pH distribution is used to predict the land quality. The result of this study is shown that the regression model of red and near infrared (NIR) band combination is used to predict soil pH has been successfully given the smallest error (RMSe) as the soil pH accuracy is 1.18 and related to the land quality assessment based on predicted soil pH is shown that in the whole area of paddy field has the acid situation of soil pH.

Keywords: Spectral, Soil pH; Regression, Land Quality; Land Suitability.

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1. Introduction

The situation of paddy field located near the industrial zone is more vulnerable in decreasing land quality and giving the impact to the productivity of yield. Assessing the influence of industrial waste in affecting the soil pH is important topic and become an alternative way to evaluate the land quality. According to the study of industrial waste affecting agricultural land reported in Reference [9], there is a relation between the metal concentration and biogeochemical processes in the soil. The existence of metal in the soil is caused by industrial waste, affecting the change of soil pH has role function to control the amount of essential minerals required by paddy. Reference [6],

[7], [8] and [10] gave another perspective in relation of the existence of heavy metal from industrial waste.

In this study, the use of remote sensing technology is applied to estimate soil pH as the final result of the influence of industrial waste and heavy metal interaction in the soil. Soil pH has a negative correlation to the heavy metal concentration in the soil and for further use of the estimation result can be used to predict heavy metal concentration, soil moisture and salinity or for liming purposes. The study of pH itself which was reported in Reference [5] by knowing the relationship between pH and salt concentration. Reference [2] reported the assessment of pH and its correlation to the soil degradation. Guo *et al* [4] have tried to understand the spatio-temporal of pH in Beijing are providing the importance of studying soil pH especially in agriculture land.

Especially in many rural areas in the tropical climate zone such as Indonesia, land is used in both for economical and food purposes. Typically, there are so many types of land use in a same location of land, such as industries and paddy cultivation. Reference [9] has stated that, in the future, it would decrease the quality of land and especially in soil, harvest production and unhealthy ecosystems. Normally, optical satellite image is limited to its capability in assessing soil characteristic in the surface such as soil moisture, soil salinity and their relationship. So, this is possible to use the Landsat 8 image for predicting the soil pH. The primary goal of this study is provide a simple method for estimating soil pH by using the remote sensing data, such as Landsat 8 Satellite Image with considered to the capability and or sensitivity of its bands.

2. Materials and Method

2.1. Study area

Study estimation soil pH in the paddy field was done in the paddy field area near the industrial zone in the Majalaya Subdistrict (Figure 1). In the middle of the paddy field area, there are two river streams (Citarum and Cikeruh), and it uses for irrigating the paddy field all the season. Both of the rivers are used as the channel for throwing the liquid waste from industries. This situation cause the soil pH in the paddy field should be change due to influence by the industrial waste.

2.2. Research work flow

Research steps were conducted according to workflow given in Figure 2. Both of data used in this study are Landsat 8 satellite image and soil pH. A multispectral image of Landsat 8 on path 122 and row 65 downloaded from http://earthexplorer.usgs.gov/ and it have recorded at September, 29^{th} 2014. Soil pH also used in this study is acquired

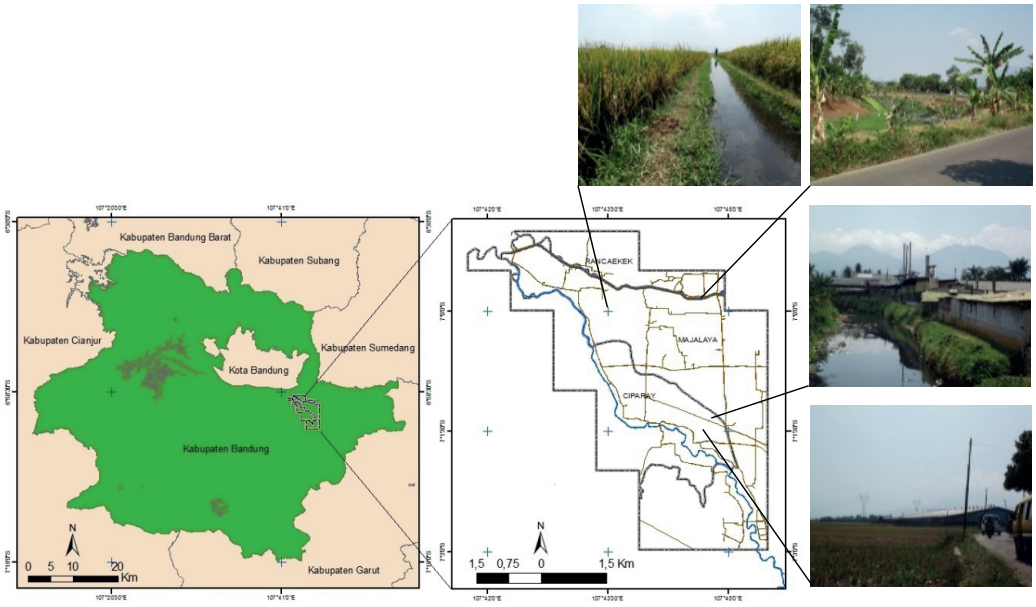

Figure 1: Study area.

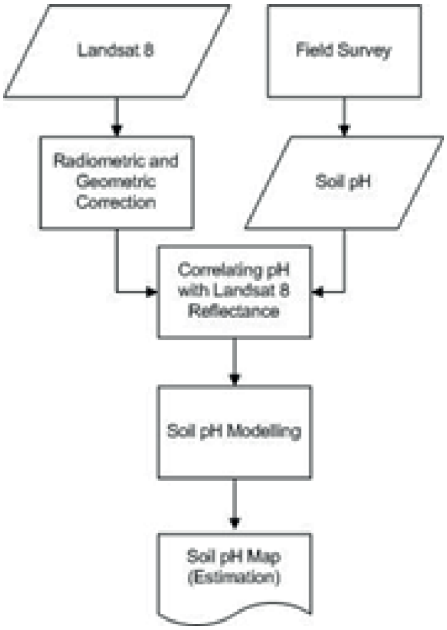

Figure 2: Research work flow.

from field using handheld digital pH meter named "4 in 1 soil tester equipment". It used directly in to the paddy soil which have extracted with 1 M KCl solution and successfully collecting 104 samples of soil pH.

The satellite imagery of Landsat 8 has eleven bands including visible and near infrared (VNIR), two bands of short wave infrared (SWIR), two bands of thermal infrared (TIR), a pan sharp image, a coastal image and a quality assurance image. The basic function of all bands is provided by USGS and cited by Reference [3] and presented in Table 1.

Table 1: Landsat 8 Band Configuration.

Band	Wave length	Useful for Mapping
Band 1- *Coastal aerosol*	0.43-0.45	Coastal and aerosol studies
Band 2- *Blue*	0.45-0.51	Bathymetric mapping, distinguishing soil from vegetation and deciduous from coniferous vegetation
Band 3- *Green*	0.53-0.59	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 4- *Red*	0.64-0.67	Discriminates vegetation slopes
Band 5- *Near Infrared* (NIR)	0.85-0.88	Emphasizes biomass content and shorelines
Band 6- *Short-wave Infrared* (SWIR)	1.57-1.65	Discriminates moisture content of soil and vegetation, penetrates thin clouds
Band *Short-wave Infrared* (SWIR)	2.11-2.29	Improved moisture content of soil and vegetation and thin cloud penetration
Band 8- *Panchromatic*	0.50-0.68	15 meters resolution, sharper image definition
Band 9- *Cirrus*	1.36-1.38	Improved detection of cirrus cloud contamination
Band 10 - *TIRS*	10.60-11.90	100 meter resolution, thermal mapping and estimation soil moisture
Band 11 - *TIRS*	11.5-12.51	100 meter resolution, improved thermal mapping and estimation soil moisture
Source: Reference [3].		

In using Landsat 8 as primary data to predict soil pH, we still need an atmospheric and radiometric correction. A dark of subtraction (DOS) method is applied to convert the radiance number in to the reflectance. All of this process was doing in ENVI environment. Actually the used of radiometric correction method is freely to choose. As like as dark of subtraction (DOS) and Fast Line-of-sight Atmospheric Analysis of Hypercubes (FLAASH) method, in this case both of the method provides the same number of reflectance. In the next step, this reflectance number will be used to make mathematical model.

Study pH is close to the soil characteristic interpretation. Especially in studying soil, Landsat 8 has blue, SWIR and TIR bands which are used in many research related to the soil. But studying soil pH is like a studying chemical property of soil. It does not like understanding the soil moisture from optical sensor image, but it should be find out the natural correlation between soil moisture and soil pH or a mathematical correlation between the bands and the soil pH.

At this point, two simple statistic methods were used to determine the mathematical model which used in estimating the value of soil pH. The first stage is computing a set of scatter plot. Six scatter plots were made with Landsat 8 band as Y axis and Soil pH acquired from field as $\times$ axis. The goal of this stage is to know the correlation between each Landsat 8 bands with the soil pH. According to the plots (Figure 3), we understand that the Blue, Green, Red and Short wave Infrared (SWIR) band have a

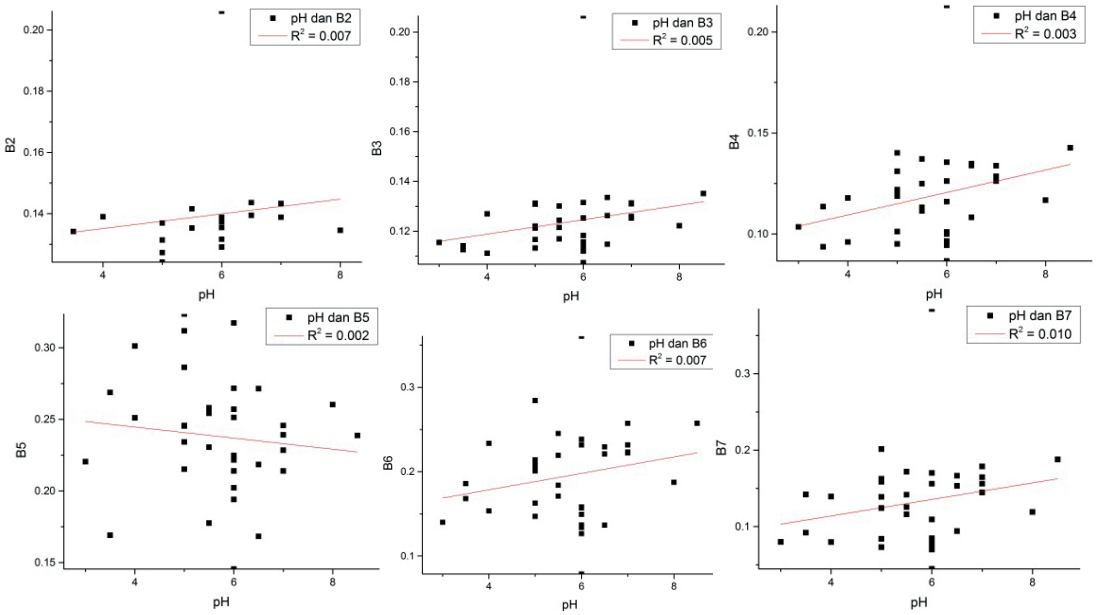

Figure 3: Correlation of Landsat 8 Band against survey soil pH.

positive correlation with the value of soil pH, although they have a little of correlation coefficient (R) and there is only one band, Near Infrared (NIR), provides a negative correlation.

All the Landsat bands provide a weak correlation to the value of soil pH. However, at this situation, it is still used to predict soil pH in the whole area of paddy field by perform the combination between simple and multiple regression from the classified band based on their R-value.

The correlation of Landsat 8 bands when it is used to predict soil pH was identified. According to their R^2 value, they could be classified as we see at the table 2. SWIR is the strongest band, the combination of SWIR, blueand green is the moderate band, and the combination of red and near infrared (NIR) is the weakest band. So, at this point the simple and multiple regressions were used to determine the mathematical model for estimating the soil pH (Equations 1, 2 and 3).

Band	**B7**	**B6**	**B2**	**B3**	**B4**	**B5**
R2	0.01	0.007	0.007	0.005	0.003	0.002
Sensitivity	Strong	Moderate			Weak	

pH = 5.149 + (1.698*B7)	R = 0.100	(1)
pH = 4.814 + (19.233*B2) - (27.361*B3) + (6.834*B6)	R = 0.248	(2)
pH = 5.562 - (0.767*B4) - (0.231*B5)	R = 0.053	(3)

Trying to know the capability of regression models made by regression, the numbers of R are considered as hypothesis. Because of the number of R from equation 1 is the biggest than another equation. This model is expected to provide the estimation of soil pH with a good distribution spatially and also with a good accuracy. So, this hypothesis also means that when the number of R decrease, the models will estimate the soil pH with less accuracy.

In the modelling process, all the models are used to predict the soil pH in the paddy field. It uses together with the Landsat 8 reflectance and calculate using band math tool in ENVI environment. The estimation result from the calculation process, provide the soil pH value and must be calculate the accuracy using root means square error. The less value of error describes the best accuracy of predicted soil pH and could be concluded that the models used for estimate pH is the best.

3. Result and Discussion

After the estimation process is done by applying the equation models in the ENVI's band math, the predicted soil pH are shown in the Figure 4. The left map is predicted soil pH calculated using Equation 1. This map provides a wide range of predicted soil pH from 5.3–7.0, the centre map is calculated by using equation 2 with 5.1 – 9.0 of soil pH range and the right map has 5.3–5.9 of predicted soil pH.

All the mathematic models indicate that the soil pH is in the acid situation (5.0), this is mean naturally soil pH of paddy field located near industrial zone are acid due to the influence of industrial waste and it uses for irrigating the land. However, further analysis is required to provide a set of evidence that the chemical materials from the industrial waste are major things causes the soil located in acid situation.

Concerning to the detail of soil pH distribution, the area with black color on the map represents the industrial zone has paddy field with lower soil pH than its surrounding. It provided a different situation from the paddy field near the stream river, the soil pH are interchangeable between acid to the almost neutral situation according to the most left and centre image of predicted soil pH map on Figure 4.

All of the predicted soil pH map provided a bit confused distribution of soil pH. The question of which one of soil pH map is the best soil pH distribution always become a basic problem after the estimation process is done. For that need, validation process is done in two different steps. The first step is put the all the predicted soil pH against survey soil pH in a scatter diagram to see their distribution, and the second step is calculate the root mean square error (RMSe).

According to a diagram on Figure 5, the red dot, green and blue triangle describe the estimated soil pH from model 1, 2 and 3 respectively and the black square describes soil pH acquired from field survey. The predicted soil pH from model 1 and 2 are distributed

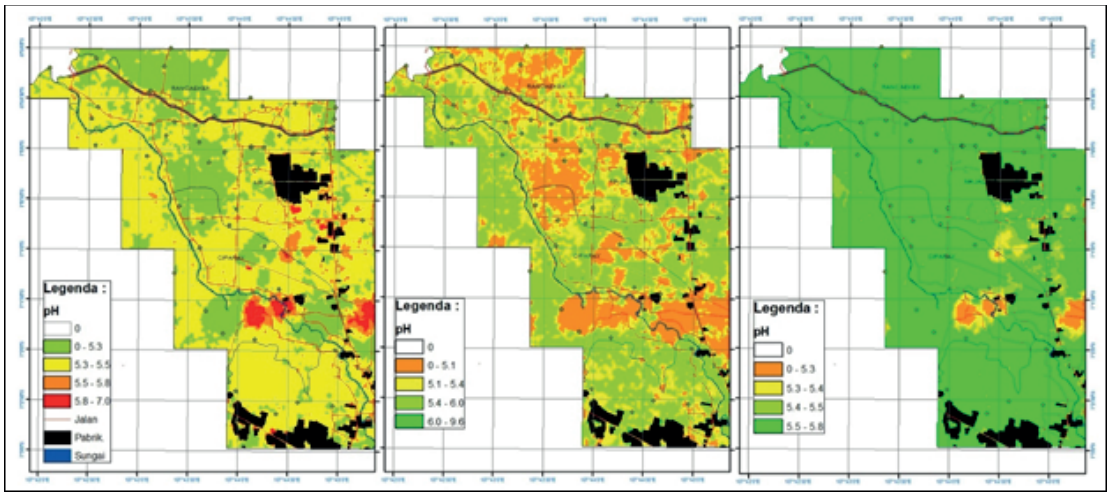

Figure 4: Predicted Soil pH.

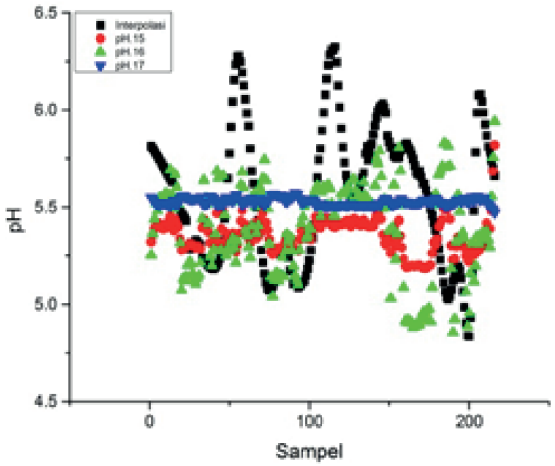

Figure 5: Scatter plot comparison between predicting and field soil pH.

well to the soil pH from survey than from model 3. But its distribution does not provide the best accuracy. The soil pH from model 3 provided the best accuracy than another. The numbers of accuracy for model 1, 2 and 3 are 1.19, 1.20, and 1.18, respectively.

The number of predicted soil pH distribution and its accuracy gave a negative correlation with the number of coefficient correlation (R) from the model, which is a little number of R, provided the best value of accuracy.

4. Conclusion

According to the results of this study, it can be concluded that:

1. Estimating soil pH using the remotely sensed data, especially from the optical sensor image, are successfully done and giving the best result due to the variability of R, result error and also with the spatially distribution of soil pH.

2. The use of Landsat 8 band with the useful capability in assessing the soil characteristic is not enough to provide a good result. It could be happen due to the low correlation of reflectance and soil pH from survey.

3. The use of the predicted result of soil pH, as a basic of standard to assess the paddy field quality, indicated that more than a half area of paddy field are located in acid situation and all the models used in this study described the same result.

Acknowledgements

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