EVALUATION OF SOIL pH THROUGH REMOTE SENSING

Jayagobi K, Nagarathinam V, Maruthachalam M and Palanivelu R.
Institute of Remote Sensing, Anna University
Madras 600 025. India
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ABSTRACT

The spectral signatures of salt-affected lands are extracted from Landsat Thematic Mapper imagery and are correlated with the pH values obtained by conventional tests to derive quantitative mathematical expression with the help of multiple regression analysis. Using the equations formulated, soil pH values are digitally derived for some specific sites and the results are tested for accuracy. The methodology thus developed is found to be encouraging for the determination of soil pH values through Remote Sensing.

INTRODUCTION

The irrigated lands in lowland plains of Tamilnadu are salt-affected rendering the hitherto fertile tracts into marginal lands, especially where tropical savanna regime prevails. This poses a problem to the farmers as the lands are increasingly becoming underutilised. Conventional method of soil testing is time consuming to formulate any remedial measures. In recent years, access to satellite data has resulted in data explosion, which could be beneficially utilised with computer-aided analysis. Several methods are available for identifying and delineating any category of land; however certain types are likely to be misinterpreted owing to the inherent spectral properties of the objects which very often tend to be similar. One such category is salt-affected land, which may be easily confused with sandy tract or barren ground. As these lands are marginal, they are under cultivation in some part of the year or other, in which case the discrimination becomes much more difficult. To overcome this problem, a mathematical model is developed for delineating the salt-affected lands using Landsat Thematic Mapper(TM) data and is reported in this paper.

STUDY AREA

The alluvial plains of Palar and its tributary Cheyyar in the North Arcot District of Tamil Nadu, are extensively affected by such saline conditions. The run-off during the short rainy season is stored in the numerous tanks built all over this undulating terrain and these are interlinked by channels. The entire area is intensively irrigated by these channels and canals from the rivers, and as a consequence the soil pH has increased. Exact mapping of this category of land is needed for soil reclamation which could be provided from the digital analysis of Landsat data.

METHODS:

False Colour Composite is quite adequate for visual interpretation as concluded by Sharma and Bhargava(1988), however discrimination between a dry farmland and salt affected land in a single date imagery is problematic. Computer aided analysis of Landsat TM data has been used for delineating soils with reasonable accuracy by various authors.(Kristof et al, 1977; Weismiller et al 1977) Singh, et al, (1977) have delineated salt affected soils using digital analysis of Landsat MSS data. The increased resolution in TM data ensures greater accuracy as indicated in this study.

Supervised classification using maximum likelihood algorithm was carried out for a subscene of 512x512 size in the Landsat TM imagery (SCENE ID: T541430518630500). Training sets with various soil pH range were identified and the scene was classified using the classification statistics computed with the training set areas. The classified scene was superimposed over the original scene and the pixels of salt affected areas were isolated.

Sample sites were selected on a random basis. The values of pixels of selected sites for which the pH values were collected in the field test, were extracted. About 87 pixels were identified and their digital numbers in all the bands were used to form the multiple regression equation and correlation coefficients were derived using the known pH value. With the available multiple correlation coefficients thus derived the pH values of other pixels were evaluated. About 70 such pixels were identified for this purpose and the pH value for these sites were derived using the pixel values in all selected bands and the correlation coefficients were estimated using multiple regression. The coefficient of multiple determination is one statistical measure of adequacy of the least square curve fitting process and the square root of coefficient of multiple determination is the multiple correlation coefficient. For all possible combination of Thematic Mapper bands, coefficients of multiple determination, standard error, and F value were determined. The suitable combination of bands with high coefficient of correlation was identified as suitable for the soil pH estimation. Combinations having high standard error and less correlation were identified as combination not suitable for this soil pH estimation. Soil pH can be represented by the following equation:

$$pH = a + a_1 X_1 + a_2 x_2 + . . . + a_{(n-1)} X_{(n-1)} + a_n X_n$$

where

a = Intercept

a_n = Pixel value in n^{th} band

X_n = n^{th} Regression co-efficient

SE = Standard Error

Where Standard Error is the square root of the variance and the variance is a measure of the deviation between the predicted values and the measured values.

RESULTS AND ANALYSIS:

A simple multiple regression equation is formed with 87 pixels and by using different combination of bands. Bands which are having more correlation to the pH value are selected based on the coefficient of multiple determination. Bands of less correlation were eliminated in this analysis.Table I gives the coefficient of Multiple determination for the various band combination.One particular band combination which is having maximum coefficient of multiple determination than any other combination and hence this particular combination was selected for estimating the pH values. Coefficient of multiple determination is maximum with the combination of 5 bands and they are 1,2,4,6 and 7. The multiple regression coefficients for the particular combination with maximum coefficient of multiple determination is given in the Table II. As the correlation between actual and estimated values for this particular combination is 0.6, the evaluation of soil pH by using this set of bands is more reliable. Incorporation of other bands in this calculation reduces the accuracy. The pH values of 70 selected pixels are estimated by using the multiple regression coefficients of the best band combination which is having high coefficient of multiple determination and the accuracy is tested by the conventional field test. Figure I shows the variation in spectral signature in Landsat TM bands with change in pH values.

CONCLUSION:

As the coefficient of multiple determination for the combination of 1,2,4,6,7 is very high and the coefficient of correlation is 0.6 the estimation of soil pH using this combination is very reliable. However the correlation coefficients have to be more generalised by using the increased number of test sites. Though conventional test is more effective the estimation of soil pH using remotely sensed data is more useful to select the areas for detailed investigation. Also the pH estimation through Remotely Sensed data is more speedy. However this study needs identification of salt affected areas through visual interpretation from FCC formed with TM bands 2,3 and 4 for supplying the ground truth information and classification as a subsequent step to classify the salt affected pixels and finally the pixel values in related bands of salt affected pixels should be used to estimate the soil pH of the site.

Table I

No of Bands used	Bands used	Coefficient of Multiple Determination
1	1	0.0001
1	2	0.0001
1	3	0.0015
1	4	0.0142
1	5	0.0819
1	6	0.1205
1	7	0.0543
2	1 2	0.0000
2	1 3	0.0131
2	1 4	0.0529
2	1 5	0.1198
2	1 6	0.1286
2	1 7	0.1045
2	2 3	0.0316
2	2 4	0.0672
2	2 5	0.1152
2	2 6	0.1289
2	2 7	0.1100
2	3 4	0.0376
2	3 5	0.1161
2	3 6	0.1215
2	3 7	0.1148
2	4 5	0.1043
2	4 6	0.1170
2	4 7	0.0895

No of Bands used	Bands used				Coefficient of Multiple Determination
2	5	6			0.1494
2	5	7			0.0242
2	6	7			0.0633
3	1	2	3		0.0317
3	1	2	4		0.0674
3	1	2	5		0.1198
3	1	2	6		0.1290
3	1	2	7		0.1105
3	1	3	4		0.0489
3	1	3	5		0.1163
3	1	3	6		0.1391
3	1	3	7		0.1111
3	1	4	5		0.1037
3	1	4	6		0.1408
3	1	4	7		0.0908
3	1	5	6		0.2232
3	1	5	7		0.0370
3	1	6	7		0.1701
3	2	3	4		0.0667
3	2	3	5		0.1050
3	2	3	6		0.1663
3	2	3	7		0.1029
3	2	4	5		0.0931
3	2	4	6		0.1483
3	2	4	7		0.0882
3	2	5	6		0.2179
3	2	5	7		0.0530
3	2	6	7		0.1842
3	3	4	5		0.1091
3	3	4	6		0.1215
3	3	4	7		0.1097
3	3	5	6		0.1977
3	3	5	7		0.0515
3	3	6	7		0.1826
3	4	5	6		0.1888
3	4	5	7		0.0084
3	4	6	7		0.1560
3	5	6	7		0.0713
4	1	2	3	4	0.0669
4	1	2	3	5	0.1099
4	1	2	3	6	0.1666
4	1	2	3	7	0.1034
4	1	2	4	5	0.0980
4	1	2	4	6	0.1487
4	1	2	4	7	0.0887
4	1	2	5	6	0.2242
4	1	2	5	7	0.0459
4	1	2	6	7	0.1857
4	1	3	4	5	0.1033
4	1	3	4	6	0.1449
4	1	3	4	7	0.0977

No of Bands used	Bands used					Coefficient of Multiple Determination
4	1	3	5	6		0.2244
4	1	3	5	7		0.0349
4	1	3	6	7		0.1800
4	1	4	5	6		0.2215
4	1	4	5	7		0.0136
4	1	4	6	7		0.1710
4	1	5	6	7		0.0429
4	2	3	4	5		0.0739
4	2	3	4	6		0.1881
4	2	3	4	7		0.0655
4	2	3	5	6		0.2284
4	2	3	5	7		0.0434
4	2	3	6	7		0.1650
4	2	4	5	6		0.2161
4	2	4	5	7		0.0329
4	2	4	6	7		0.1694
4	2	5	6	7		0.0784
4	3	4	5	6		0.1997
4	3	4	5	7		0.0453
4	3	4	6	7		0.1956
4	3	5	6	7		0.0685
4	4	5	6	7		0.0240
5	1	2	3	4	5	0.2849
5	1	2	3	4	6	0.0000
5	1	2	3	4	7	0.2651
5	1	2	3	5	6	0.0000
5	1	2	3	5	7	0.1103
5	1	2	3	6	7	0.2258
5	1	2	4	5	6	0.0000
5	1	2	4	5	7	0.0362
5	1	2	4	6	7	0.3502
5	1	2	5	6	7	0.0174
5	1	3	4	5	6	0.0000
5	1	3	4	5	7	0.0594
5	1	3	4	6	7	0.3039
5	1	3	5	6	7	0.1140
5	1	4	5	6	7	0.0981
5	2	3	4	5	6	0.0000
5	2	3	4	5	7	0.0626
5	2	3	4	6	7	0.2746
5	2	3	5	6	7	0.1051
5	2	4	5	6	7	0.0459
5	3	4	5	6	7	0.0364

Table II

No of Bands selected		: 5
Selected Bands for pH estimation		: TM 1,2,4,6,7
Intercept 'a'		: -11.52139
Regression Coefficients	a1	: -.03208
	a2	: .00114
	a3	: -.28612
	a4	: .14675
	a5	: .28272
Standard Error		: 1.09987

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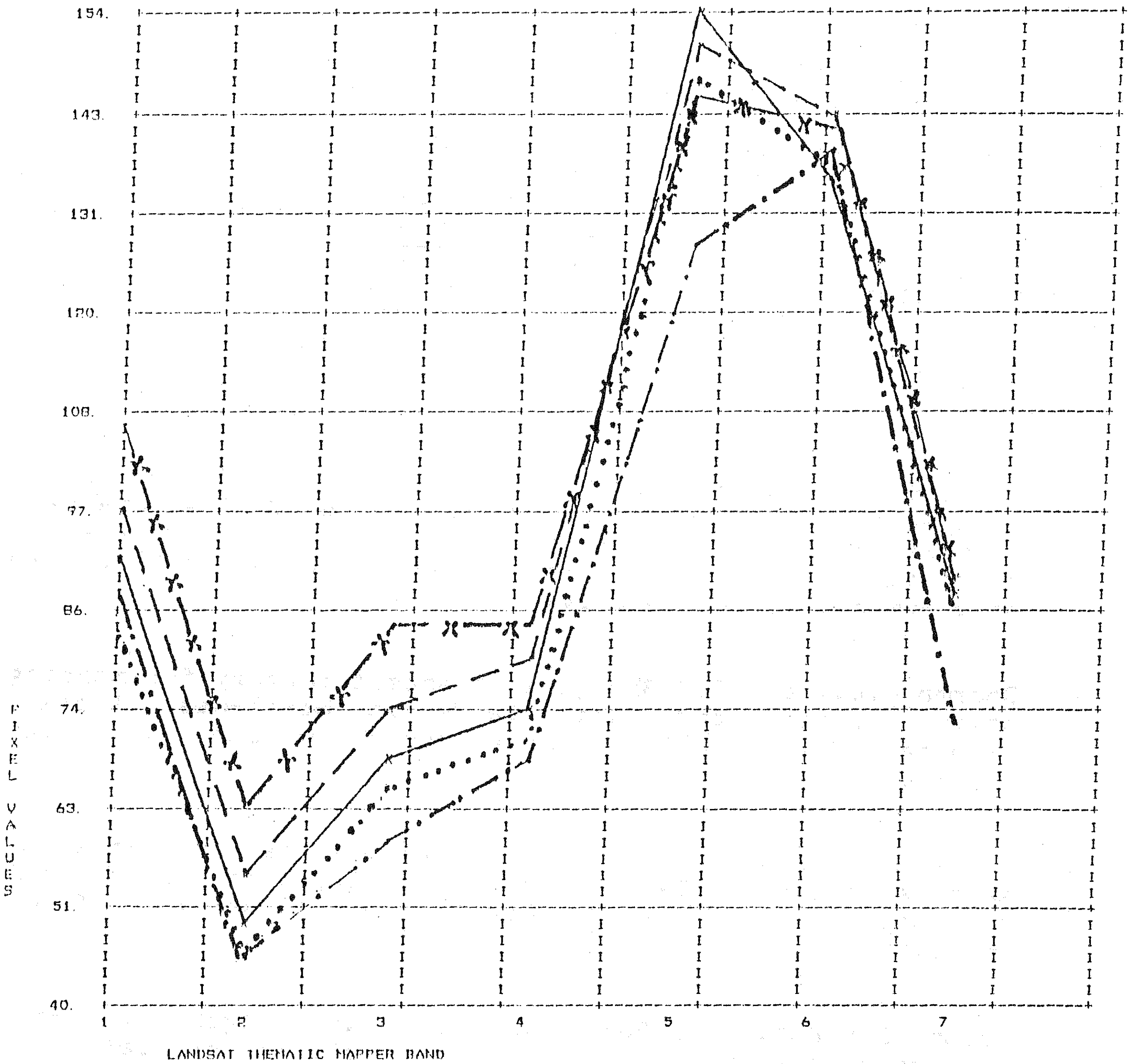

Figure I

symbol	pH
-----	7.5
.....	8.0
———	8.5
-•-•-	9.0
-x-x-	9.5