Application of Satellite Remote Sensing to find Soil Fertilization by using Soil Colour

Study Area Vellore District, Tamil Nadu, India.

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N. Suresh Kumar, S. Margret Anouncia, M. Prabu
VIT University, Vellore, Tamil Nadu

***Abstract*—Nowadays the usage of Remote Sensing and GIS techniques are too vast and many Earth observations had been done by Remote Sensing and GIS techniques. The innovation of this work is to use the LANDSAT image data and GIS Techniques to assess land information and soil classification in the most coming up area of Vellore district and propose the possible fertilization for this study area. Landsat image is classified by minimum distance classification algorithm and according to the reflectance characteristics of the surface material. From the classified data we can find out the best fertilization for the best soil using colour of the soil. It is proved that, within limitations the classification algorithms and threshold parameters have an important influence on the classification result.**

***Index Terms*—Remote Sensing, GIS, Soil identification, Image Classification, Fertilization by remote sensing .**

I. INTRODUCTION

Remote sensing techniques and Geographical Information System (GIS) techniques are used to estimate soil types and its spatial distribution with reasonable costs and much better accuracy in very larger earth spaces. Soil erosions were estimated by remote sensing, geographical information system and. In general, remote sensing data were used to create the cover management factor image by land cover classifications, while Geographical Information System tools were used for derive the topographic factor from DEM (Data Elevation Model) data RUSLE [1].

Remote sensing methods provided perspective for spatial and instantaneous measurement of soil content. Thermal emissions from soils in the region were used to find soil series and sensitivity of the surface. Less amount of water in a soil that emits low amount of microwave radiation. Soil series were calculated by active microwave remote sensing via synthetic aperture radata data. Microwave radiometer widely used for mapping large-area soil types [2].

The soil property is directly correlated to the reflectance based data, soil properties have been inferred from reflectance measurements under better lab conditions such as nitrogen, moisture, organic carbon and other chemical properties. Soil series were calculated by reflectance measurements of surface texture, organic matter, salinity and moisture of soil conditions [3].

Land cover is being practiced for delineating the soil boundary. Multispectral satellite data were being used for mapping soil. Soil mapping needs identification of a number of elements, these elements which are major importance for soil survey, land type, vegetation, Landuse. Visual interpretation is based on shape, size, tone, shadow, texture, pattern, site and association. Soils are surveyed and mapped by comprising interpretation of remote sensing imagery, field survey, and cartography. A soil map generated through visual interpretation of satellite images. The remote-sensing data in conjunction with ancillary data gives the best alternative with better delineation of soil mapping units [4].

Soil fertilization could be calculated by soil sampling which was taken from study area, Aerial image analysis, and Yield monitor data. Correlations of soil variables measured over the particular duration of the study were determined in order to assess temporal consistency. This is a very important consideration in precision agriculture. Every soil properties showed high temporal correlation coefficients. Cross-correlations between soil variables help to find the soil character and quality of the soil.

Aerial image data were closely related to soil organic matter Soil imagery can be useful in determining areas of high low yield potential under different weather conditions; inconsistency of this relationship limits its predictive potential [5]. Therefore some defects are there in finding soil fertilization by using analysis of organic matters, visual interpretation, and correlation of soil series, microwave remote sensing and data elevation model.

So these were the some solutions to find the soil fertilization for the better cultivation, but all of these methods has some issues and degrades. Nowadays Remote Sensing techniques and methodologies has been improved, and the satellite images show the accurate figures. These satellite images are used in several applications to find something true about the earth. At the same time Image processing techniques also improved a lot, for example finding the person using aerial view image. So here we propose novel idea for combining these two vast methodologies to find the soil fertilization for the better cultivation on the study area.

The main principle of the study is to inspect the possibilities of using remote sensing data for a common survey of the soil conditions and land use in the Vellore District area. This inspection has four processes [6]. First process is the establishment of the associations between the ground truth and the images; it is based upon the reports and maps, and the Satellite Images. Second process is creating the correlation between the soil conditions and the present day land use, vegetation and other factors of that area. Third process is the founding most appropriate augmentation techniques and best classification methods for the detection of different soil conditions of Vellore District. Final process is the mapping of different soils using satellite image classification methods.

A. *Study Region:*

Vellore district situated between 12° 20’ to 13° 20’ North latitudes and 78° 10’ to 79° 40’ East longitudes in Tamil Nadu State of India. The environmental area of Vellore district is 6080 sq. k.m. Vellore city situated 220 m above Mean Sea Level. Vellore town has a very dry and very hot climate. The minimum temperature is 17.5c in the month between November to January and the maximum temperature is 44.5 c month between April to June. The humidity ranges of Vellore district is from 40% - 63% in summer period and 67% - 86% in winter period. The average annual rainfall is 997mm. The maximum annual rainfall occurs during September to October throughout north east monsoon. The Vellore area gets a moderately good rain during south west monsoon.

The Vellore town covers an Area of 1050 hectares excluding the reserve forest are of 105 hectares. From this area, 595 hectares (56.38%) is the developed area. The gross density of the town is to 295 persons per hectare. The residential area of the town during 1981 was 306 hectares and hence the residential density is to 580 persons per hectare. Study area of Vellore district shown in figure 1.

Applications of Remote Sensing in Agriculture include a number of aspects such as plant biology, economic features, and land use management. These applications have been playing vital role and it suggests that remote sensing technology will be a more powerful tool for monitoring agricultural activities from the Earth Observation. The predictable ground methods of land use mapping are very time consuming, labor intensive and are relatively uncommon. The prepared maps became out of date, particularly in a forceful or rapidly changing environment with the initiation of remote sensing technology, mainly satellite remote sensing techniques have been developed and that proved to be of enormous value in preparing land use or land cover mapping and monitoring the changes at periodic time intervals.

II. MATERIALS AND RESEARCH METHODOLOGY

A. *Materials used:*

The LANDSAT Satellite Data is used for the Landuse identification and soil fertilization with intensive ground truth verifications.

1. Find the soil changes of different places of Vellore District were summed.
2. Create the land use map.
3. Suggesting different vegetations for different soils series in Vellore District.

This model is mainly used for assessing changes in multifaceted spatial patterns of changing land uses, because of the clear attention given to linkage between the temporal and spatial dynamics of land-use change. Soil series are identified by finding the changes of spatial patterns in and around Vellore District. Satellite image of study area is shown in figure 2.

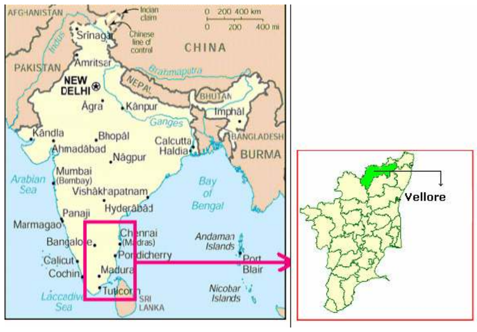

Figure 1. Location of Study Area (Vellore).

Figure 2. Satellite Image of Vellore District (Study Area)

III. METHODS AND PROCEDURES:

The land use and soil type’s classification is based on reflectance from the earth surface materials, which was performed on seven bands of LANDSAT7 data. The surface truth was provided by the means of home survey reports. In this research study the supervised classification was used. Collect a set of statistics step is main objective, and that describes the spectral response pattern for every land cover type is to be classified in a Landsat image of the Vellore district area [13].

A. *Classification:*

Classification checking steps selects the K-Nearest Neighbor classify method and proper suitable parameter. Generalized classification is using an instance-based classifying method. It shows, it can be a simple thing of locating the nearest neighbour in instance space and tag the unidentified instance with the more similar class tag as the well known located neighbour. The more amount of confined sensitivity can make nearest neighbour classifiers extremely vulnerable to noise in the training data.

The Nearest neighbour classifier referred to this system of approach. The main disadvantage of this simple approach is being short of toughness that characterizing the resultant classifiers [8]. The k-means clustering algorithm attempts to divide a given undetermined data into a fixed number (k) of clusters. Centroid is a data point (imaginary or real) at the middle of a cluster. The centroids are used to instruct the KNN classifiers. The resultant classifier is used to classify the training data and it produces a primary randomized set of clusters. Each centroid of the training data is set to the mathematics means of the clusters, similar to that it defines.

The important process of classification and centroid adjustment is repeated until the value of the centroids becomes stable. The last centroids will be used to generate the final classification and clustering of the input data, successfully revolving the set of initially nameless data points into a set of data points, each with a class identity [14].

B. *KNN Classifier:*

K-nearest neighbors is very simple algorithm. It is to store all available cases and classifies new cases based on a similarity measure. KNN was used in statistical estimation and pattern recognition.

1) *Algorithm:*

A case or problem is classified by a majority vote of its neighbors, with the case being assigned to the class most common amongst its K nearest neighbors measured by a distance functions. For example if K=1, then the case is simply assigned to the class of its nearest neighbors.

KNN Algorithm:

Compute K centroid vectors {cv1, cv2,……, cvk};
For each document t in test set Do
Step 1 Search K1 neighboring centroid vectors {cvt1, cvt2, ... cvtk1} with respect to categories {Ct1, Ct2, …….. , Ctk1};
Step 2 Calculate similarities between document t And all documents in categories {Ct1, Ct2, …….. , Ctk1};
Step 3 Employ KNN decision rule to assign label to t.
End

K-nearest neighbour (KNN) classifier was used with a search radius of 5 and the number of neighbour's=3, and the correlation coefficient with the digitized soil map. Next the image clustering techniques and image correlation techniques also used to find the land types and attributes of Vellore district. From the Clustering techniques, the various types of colored maps obtained from the satellite image.

These different color satellite images showed different soils are available in the particular area and it tells about characteristics of soils and its addresses from the satellite image [9]. Next the correlation technique was used on satellite image. It showed that the individual colored map of Vellore district from the Vellore Satellite image. Basic principle concept of KNN is shown in figure 4.

In this case, distance is the squared or absolute difference between a pixel and a cluster center. The difference is typically based on pixel color, intensity, texture, and location, or a weighted combination of these factors [10]. *K* can be selected manually, randomly, or by a heuristic. This algorithm is guaranteed to converge, but it may not return the optimal solution. The quality of the solution depends on the initial set of clusters and the value of *K*. Framework of this study is derived in figure 5.

After applying the processing techniques, the satellite image is converted into different clustered images. Every clustered image denotes different soil series. That clustered satellite images shown below as figure 5.1 to figure 5.5. Figure 6 shows correlated image of study area.

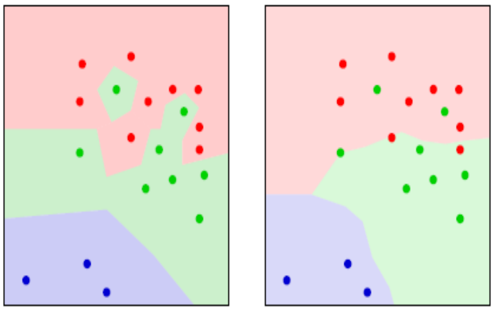

Figure 4 - Decision regions (approximately) for 1-nearest neighbor (left) and 5-nearest

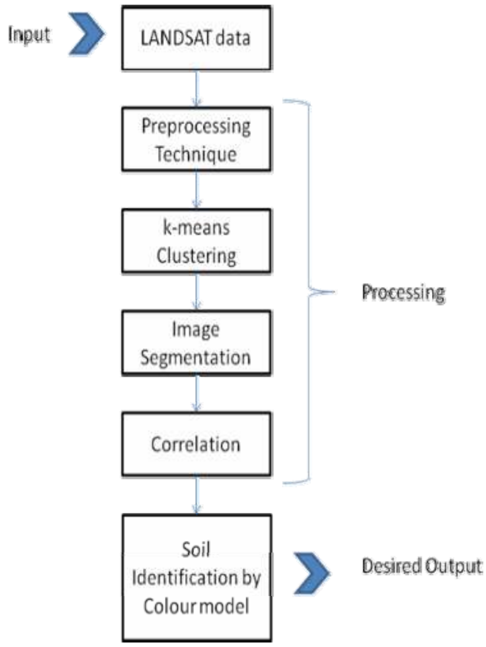

Figure 5 - Framework of Soil Identification method using Remote Sensing

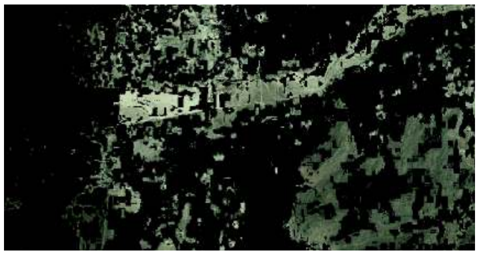

Fig 5.1 - Clustered Image 1 (Soil 1)

Fig 5.2 - Clustered Image 2 (Soil 2)

Fig 5.3 - Clustered Image 3 (Soil 3)

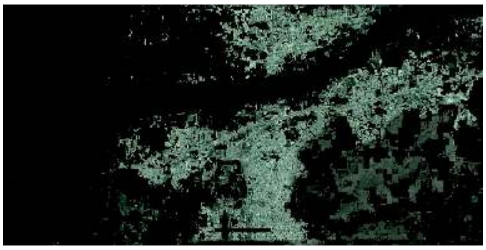

Fig 5.4 - Clustered Image 4 (Soil 4)

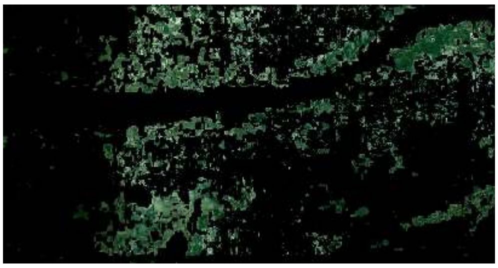

Figure 5.5 - Clustered image 5 (Soil 5)

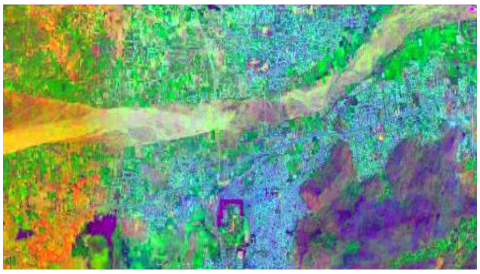

Figure 6 - Soil map of a part of the Vellore District, produced by the image classification from Landsat image (MATLAB output).

C. *Preprocessing Techniques:*

Before applying the algorithm, the LANDSAT image should be processed with some preprocessing techniques. These techniques are used to enhance the quality of the Landsat data. Those are read an image, check how the image appears in the workspace, Improve image contrast, Write the image to a disk file, Estimate the background, View the background approximation, subtract the background image from the original image and Compute area of an object.

K-means clustering:

The K-means clustering algorithm has been widely used in segmentation of color images. It takes large amount of computation time for large size image. Many algorithms use an iterative refinement technique due to its ubiquity, which is called the k-means algorithm.

Given an initial set of k means m1(1), ..., mk(1), the algorithm proceeds by alternating between two steps.

Assignment step: Assign each observation to the cluster with the closest mean.

$$S_i^{(t)} = \{x_p : \left\|x_p - m_i^{(t)}\right\| \le \left\|x_p - m_j^{(t)}\right\| \forall 1 \le j \le k\}$$

Where each *xp* goes into exactly one $S_i^{(t)}$,

Update step: Calculate the new means to be the centroid of the observations in the cluster.

$$m_i^{(t+1)} = \frac{1}{|S_i^{(t)}|} \sum_{x_j \in S_i^{(t)}} x_j$$

This k-means algorithm commonly used initialization methods are Forgy and Random Partition. The Forgy method randomly chooses k observations from the data set and uses these as the initial means. The Random Partition method first randomly assigns a cluster to each observation and then proceeds to the Update step, The Random Partition method is generally preferable for algorithms such as the k-harmonic means and fuzzy k-means. Demonstration of the standard algorithm is shown below. Basic working concept of k-means algorithm explained in figure 7.

Mapping :

The 12 spectral classes that were classified and were added together according to the spectral character and the units in the ground truth. Same units were labeled to same colour by regrouping different classes as one colour set [11].

D. *Soil Type*

Maximum area in Vellore district is under red soil (47.6 percent of the total geographical area) which is followed by sandy loam (7.3 per cent), black soil (5.0 percent) and sandy clay loam (3.6 percent) in that order. In problem soils like saline and alkaline soils and eroded or degraded soil, the crop productivity is lesser. Also, only selective crops which could withstand such adverse conditions are cultivated in such soils [7]. In all the seven divisions of the district, such problem soils were present. Seven per cent of the total geographical area was under problem soils like saline and alkaline soil. Arakonam division had a maximum area (29.4 per cent of the total area under saline and alkaline soils in the district) under such soils and it was followed by Arcot (28.3 percent) division.

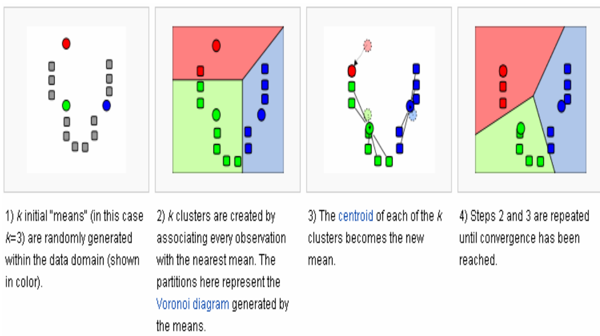

Figure 7 - Basic working concept of k-means algorithm

TABLE I.
SOIL TYPES IN VELLORE DISTRICT

Soil Series	Area(Ha)	Depth(cm)	Texture
Mangalathu Petty	127522	94	Loamy sand
Kolathur	77292	75+	Sandy clay
Ethapur	41630	75+	Sandy clay loam
Chickarasampalayam	11243	112+	Sandy clay loam
Vadayalam	9862	150+	Clay loams
Idayapatti	4020	105	Silty Clay
Vadapudupattu	10093	183+	Loamy sand
Total Red Soil	**281662**		
Gurumangalam	29860	143	Clay loams
Total Black Soil	**29860**		
Vannpatti	24293	27	Sandy loam
Arasantham	7341	120	Sandy loam
Kadambadi	6612	196	Sandy loam

As far as the eroded soils are concerned, the area under such soil was more than that of the saline and alkaline soils. The district had 12 per cent of its total geographical area under eroded soil. Walajah division had the largest area (21 per cent of the total area under eroded soil in the district) followed by Vaniyambadi (17.8 per cent), Thirupathur (17.2 percent) [12]. Available soil types of study area listed in table 1.

Soil series graph is generated from the table I is shown in figure 8.

IV. RESULTS AND DISCUSSION

Here the LANDSAT data is used as input for this study. Methodology of this study is differ from other referenced studies. In this study, KNN classification and mapping are used to find soil fertilization for the study area. This classification algorithm seperates the soil colours from the satellite data. Correlated image shows clear classifications of the different soils on the study area. KNN algorithm is powerful algorithm when comparing with other classification algorithm techniques [10]. It helps us to classify the image accurately with better reponse. K-means clustering technique is used to segment the classified objects from the input data. Mapping process is continue with K-means clustering segmentation process. This technique is much better than previously used techniques to find the suitable soil for the fertilization Mapped image of study area Vellore is shown in figure 9.

Comparing to other studies regarding with finding soil fertilization, this methodology won and prove it as this is simple and easy way to analyze the large coverage area

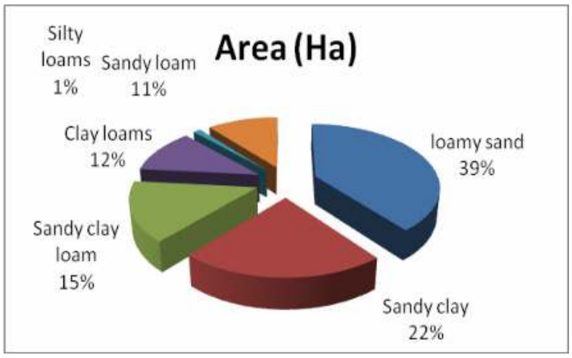

Figure 8. Graph representation of soil series in Vellore district.

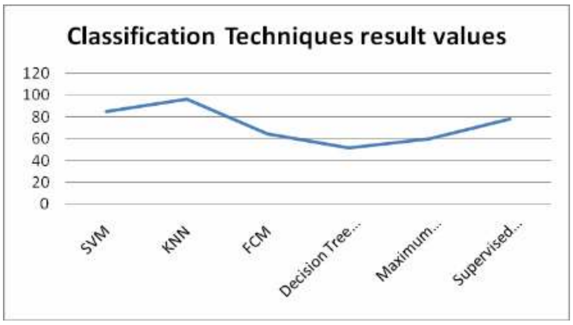

Figure 9. Comparison with other classification techniques and trueness

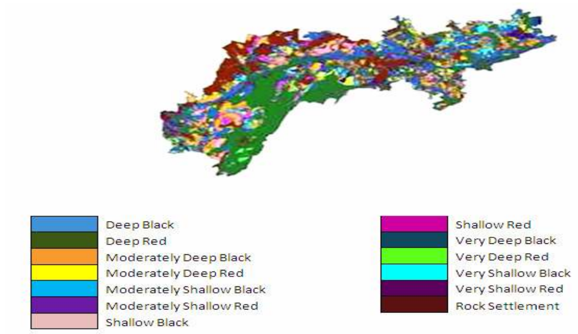

Figure10. Classified Vellore district map according to different Soil types

for the process of finding soil fertilization. As we discussed before, those methodologies cannot prove and they could not analyze very large area with high radius, here this study analyzed and proved it is possible to find soil type and soil fertilization with the help of Remote sensing and Image processing techniques by using the soil colour. Even we can find soil moisture with help of this techniques. The classification. Segmentation techniques which we are used here is very fast classification techniques in the current trend. This knn algorithm given true results about the soil series when comparing with other classification techniques. Those results of the classification techniques and its trueness is derived by the graph below in figure 9. These results has been checked by real field data.

Vellore district has been classified with respect to different soil series availability. These classified data was applied on Vellore Terrain map. Different colors on Vellore map shows different soil series available in Vellore District. Classified image is shown in figure 10.

From the conclusion, the different soils and their vegetations are described in table II.

TABLE II.
SOIL TYPES AND ITS SUGGESTED CULTIVATIONS

Soil Type	Soil Image	Properties of Sand	Suggested Cultivations
Loamy Sand		This sand containing a mixture of Sand, Clay and Silt. It provides good drainage, these are easier to till and provide more nutrients. Trees: Various pine species, soft maple, honey locust, cottonwood, willow and Douglas firs, Rose, sumac, honeysuckle, hazel and juniper, Tomatoes . Flowers: Gladiolus, various lilies, amaryllis, hostas and iris. Lemon balm, sage, basil, horehound, lavender and thyme.	
Sandy Clay		Potatoes are a traditional crop for breaking up clay soils. These plants grow in a wide range of soils, although they prefer gardens high in organic matter with a relatively acid pH. Adding compost or other organic material improves potato yields and ashes or peat decreases pH, since alkaline soils lead to potato scab disease. Potatoes reduce compaction in your clay-soil garden, making the environment friendlier for other vegetables.	
Sandy Clay Loam		Loam is a soil that combines all three soil types -- clay, silt and sand -- in relatively equal proportions. Loam is the richest, most nurturing soil, and just about anything will grow in it. Suggest vegetations are Tomatoes, grains like rice, Rose flowers, pear, peach, apricot, plum and almond trees	
Silty Clay		Microscopic silt particles feel like a fine powder and have a similar structure and mineral makeup as sand. Silt is one of three types soil particles, the others being clay and sand. Vegetables for Silty Soil: Rich, mucky soils are a favorite of farmers for growing various fruit and vegetable crops.	

V. CONCLUSION

This research work describes about the use of Satellite images (LANDSAT data) for the study of soil conditions and the Classifications and preprocessing have an important influence on the classification results. GIS Technique which is a powerful tool to improve the accuracy of soil and land use mapping based upon the remote sensing data and the LANDSAT data are very suitable for soil mapping and the relation between the spectral characteristics and soil subunits checked based on ground truth. By using image processing and GIS, we can easily find out the close relationship between the distribution of soils and land use types. And hope this research study has given the details of the sand classifications and suggested vegetation cultivations for the different soil types.

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AUTHORS

N. Suresh Kumar is Senior Assistant Professor, School of Computing Science and Engineering, VIT University, Vellore, Tamil Nadu

S. Margret Anouncia is Director, Professor, School of Computing Science and Engineering, VIT University, Vellore, Tamil Nad

M. Prabu is Research Associate, School of Computing Science and Engineering, VIT University, Vellore, Tamil Nad

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