Discrimination of Suitable Agricultural Area from Landsat TM Satellite Image by Assimilation of Tasseled Cap and Weighted Overlay

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***Abstract* - Discrimination of Suitable Agricultural Area is a key element to maximize the utilization of land resource. Such measures can be done either through manual survey by field visit or digital image processing (DIP) under GIS environment. Shortfall in desired information from various algebraic index based image processing leads to propose an integrated approach. In this study biasness of individual vegetation index has been normalized by combining more than one index as per Weighted Linear Combination. The application of RS and GIS technique leads to prepare an agricultural suitability map for the year 2010 - 2011. Such experimental study was carried out in a selected remote block of West Midnapur district which have a mixed association of different green cover. Findings of the study privilege the introductory method as a best alternative in far off area with similar setup.**

***Keywords*: Index; digital image processing (DIP); image classification; Suitable agricultural area; weighted overlay.**

I. INTRODUCTION

Production is the function of land, labour, capital and organization. However, in agricultural sector the importance of land is rated top most as the production of crop directly depends on availability of suitable cultivation land.It was already established that cultivation in non suitable agricultural tract yield much lower than average resulting into a poor economic return. The availability of per capita arable land in India has decreased alarmingly from 0.34 hectares in 1951 to 0.17 hectares in 2001 (Sharma & Ram 2009). So the dream of providing food to all can never be addressed unless the agricultural suitable tract is properly identified in order to maximize the utilization of land resource.

The most precise method of determining suitable agricultural area through base level data collection from agricultural field visit is indeed very costly and requires skilled man power. Hence in the present work emphasized are given on integrated studies using remotely sensed satellite image and GIS tools. Satellite data in conjunction with sufficient ground truth is considered as a reliable source of information for any geospatial analysis. This kind of study not only save time and money but also increase the accuracy of the result as the biasness from the part of data collector is minimized.

Landsat satellite images of the selected study area was acquired and processed based on an integrated approach of indices based digital data processing and weighted overlay analysis. Tasseled cap transformation provides the base of clustering digital pixels under the theme of Greenness, Brightness and Wetness (Jensen 2009). Multi criteria assessment of parameters helps in finding the weight and sub weight while overlay analysis generates agricultural suitability map. Thus focus is set to manage both discrimination of agriculture suitable area from digital image as well as identifying the physical limit of agricultural activity set by nature.

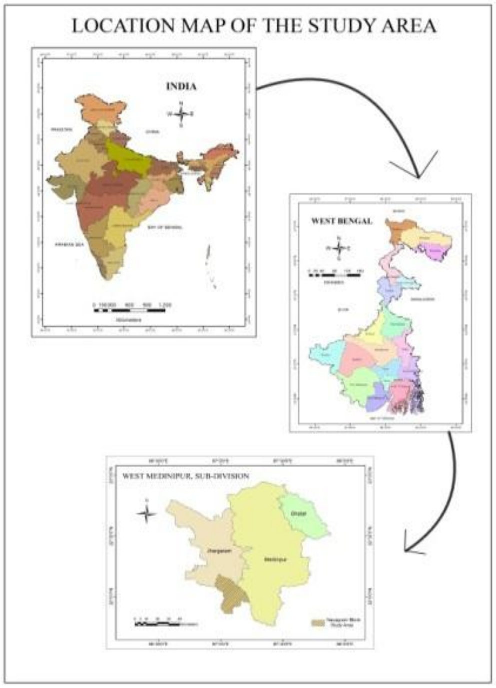
II. STUDY AREA

Nayagram, a community development block having an area of 501.44Km^2, located in south western part of West Midnapur district of West Bengal state, bounded by $22^{o} 44^{/}$ N to $22^{o} 74^{/}$ N latitude and $88^{o} 08^{/}$ E to $88^{o} 13^{/}$E longitude has been selected for on-going research rationale (Figure I). It is a community development block under Jhargram subdivision.

The selected study area has a total population of 142199 among which 40 % are tribal population (Census of India, 2011). Agriculture is the main livelihood of the people. There are large spread backwardness in terms several socio economic parameters like, Drinking Water, Education, Healthcare, Banking and Credit, Communication etc. However it is unique for its undulating topography, lateritic soil and natural forest with predominating species of Sal and Mahua tree.

FIGURE I

LOCATION OF THE NAYAGRAM BLOCK



III. DATA AND SOFTWARE USED

Landsat satellite images for the month of February covering the selected area were used. The specifications of the products are described in table I. GPS instrument was used to obtain the geographical coordinates of the selected stations for the purpose of ground truth study. ARCGIS 10.1GIS software has chosen to process the digital data bases.

TABLE I

SPECIFICATION OF SATELLITE DATA

Season	Ravi
Digital image	Landsat TM
Path / Row	139 / 45
Date of acquired	13.02.2010
Resolution	30 m.

IV. METHODOLOGY

Present assessment was primarily based on an integrated approach of indices based digital data processing and weighted overlay analysis. A series of activity has been performed in order to prepare the agricultural suitability map of the study area. As the present study area is enriched with deep cover of Sal forest, an utmost effort has been taken for the selection of proper geospatial technique by which forest can be discriminated from agricultural land.

Researcher commonly used general image classification for the discrimination of area of interest from the satellite image (Rees 2001). It is the most popularly used information extraction technique in digital remote sensing (Bhatta 2013). Although a no. of study also used indices approach to distinguish cropped area from satellite images (Bannari 1995, Choudhury 1987). NDVI, SAVI, TSAVI are some renowned vegetation index which are frequently used in this regard for their high sensitiveness to vegetation. While deriving agricultural suitable area with these approaches are bound to suffer from lack of accuracy as spectral reflectance of dense vegetation and cropping land are very close in nature like in the case of present study.

To mitigate such challenges, a multi criteria decision making (MCDM) approach based overlay analysis of tasseled cap derivation has been developed in this regard. The tasseled cap transformation provides excellent information for agricultural applications because it allows the separation of barren soil from vegetated and wet soils (Thompson 1980). In the present study a multi parametric dataset, resulted from tassel cap transformation i.e. Greenness, Brightness and Wetness have been processed by overlay or multi criteria analysis (MCA) under GIS environment with same weight i.e. 33.33% (Wi) in order to delineate the agriculture suitable tract as shown in table II and figure II. All three dataset were classified into five categories on the basis of natural jerks in their value and assigned with sub weight (Xi) within the range 1to 5as their internal capacity to support agricultural practice. Such large amount of interdisciplinary data waseasily combined with weighted linear combination (WLC). In WLC the total score (S) for each alternative was obtained by multiplying the importance weight assigned to each parameter (Wi) by the feature score (Xi) and then summing the products overall attributes [S = Wi*Xi] (Moyra, Hazra& Roy 2014).In table no. 3, weights of datasets and theirfactors sub weights are revealed.

By the help of Saaty's Eigenvector method, consistency of the each sub weight set is determined. Cconsistency ratio (Cr),indicator for errors in judgment was calculated(Satty 1980) by the help of formula 1:

$$Cr = (Ci/Ri)$$

(Where Ci represents Consistency index, whichis calculated with web based calculator and Ri stands for Random index, a composite of two different experiments performed by Satty at the University of Pennsylvania has the value of 0.5 for 3 observations.)

TABLE II

SELECTION OF WEIGHT AND SUBWEIGHT

Dataset	Wi	Value	Identified Feature	Xi
Greenness Index	33.33	-30.30 - -8.91	Water	1
		-8.91 - -0.86	Agricultural Fallow Land	4
		-0.86 - 3.66	Agricultural Crop Land	5
		3.66 - 9.20	Degraded Forest	2
		9.20 - 33.86	Dense Forest	1
Brightness Index	33.33	0 - 125.74	Dense Forest	1
		125.7 - 148.0	Degraded Forest	1
		148.0 - 174.7	Agricultural Land	5
		174.7 - 220.3	Agricultural Fallow Land	4
		220.3 – 283.7	Sand Deposit	4
Wetness Index	33.33	-251.4 - -77.1	Sand Deposit	3
		-77.11- -53.3	Agricultural Land	5
		-53.39 - -35.6	Degraded Forest	1
		-35.6 - -10.70	Dense Forest	1
		-10.70 - 50.9	Water	1

V. RESULT AND DISCUSSION

Above mentioned methodological approach has been introduced not only to minimize the mixing of agricultural class with vegetation class but also to achieve a universal acceptance as a powerful agricultural area discriminating approach.

In first phase result of Greenness, Brightness and Wetness and prepared by tasseled cap transformation has been studied.

A Greenness map

In general the range of Greenness was between -30.30- 33.86. Highest greenness class was associated with forest vegetation, whereas lowest vegetation denotes bareness condition of surface.

B. Brightness map

The range of Brightness was between 0.0 - 283.7 respectively. Highest brightness class was found in sand deposit. With increasing brightness cultivable land gets sandy texture.

C. Wetness map

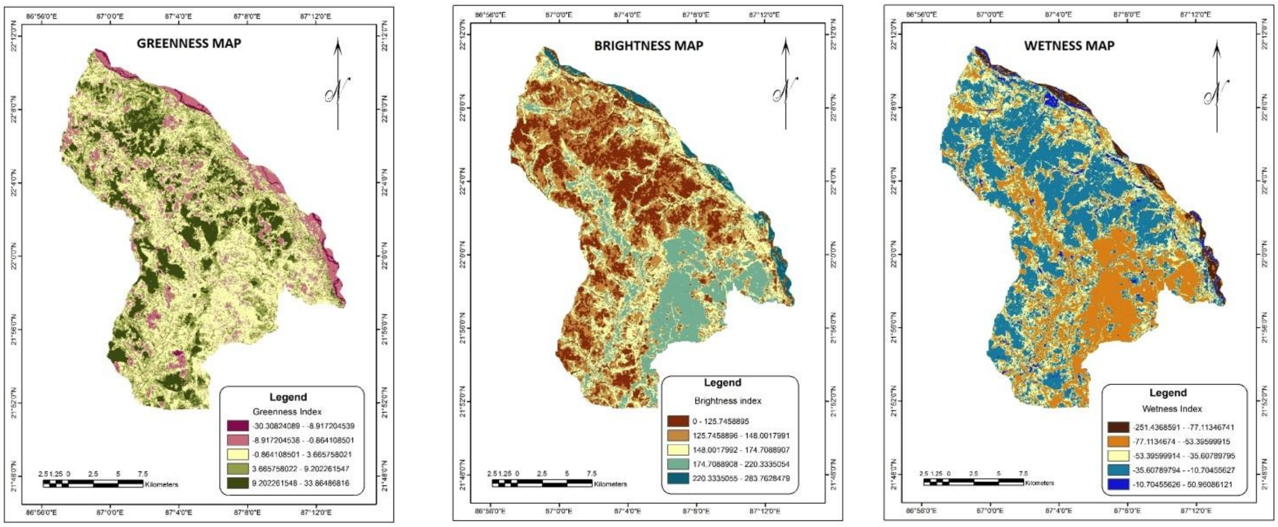
Wetness was ranging between -251.4 - 50.9. In shallow marshy land highest wetness class was found. Wetness of agricultural field was regarded as less than forest wetness and greater than sand deposits.

It was found that moderate greenness was associated with agricultural tracts (-8.91-3.66). In case of wetness second lowest class was identified as agricultural area having value -77.11- -53.3. Again third and fourth highest class (148.0-220.3) of brightness index has been selected as agricultural suitable area.

Condition of Greenness, Brightness and Wetness information is dynamic in nature. In the study it was normalized by gathering information from image of same season. As the study was conducted on the basis of Ravi season image, hence the agricultural field were found semi green, poorly wet and highly bright.

FIGURE II

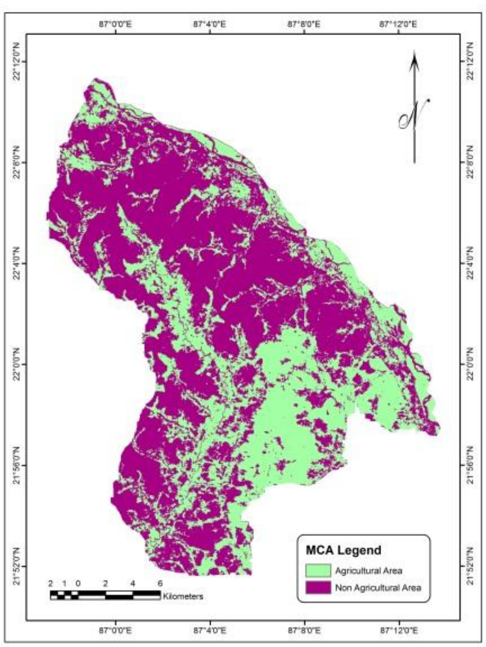
TASSELED CAP OUTPUTS



Unlike the digital image processing (DIP) based first phase, the second phase is more of GIS based data processing. From the result of weighted overlay analysis agricultural suitability map has been prepared. In the present study, determination of agricultural suitable area is done by the process of reclassifying the result of overlay analysis.

FIGURE III

AGRICULTURALSUITABILITY MAP



The map has been broadly categorized into segments, i.e. suitable agricultural area and non suitable agricultural area (Figure II). The total suitable agricultural area was assumed as 297.365 Km.^{2}.

Accuracy of the combination was determined in order to increase the reliability of result. If the value of Cr is found less than or equal to 0.1, then it is accepted. Value greater than 0.1, requires reconsideration of judgments. The Cr of each dataset were tabulated below.

TABLE III

ACCURACY OF SUBWEGHT

Dataset	C.R.
Greenness Index	0.0317
Brightness Index	0.0724
Wetness Index	0.0665

VI. CONCLUSION

Overall analysis of our study explore that such analysis enables to find out the potential propotion of land utilisation for agricultural purose as well its suitability.Using overlay analysis based result in discrimination of agriculturalsuitability area is something which have been never done before. The method provides effective options to truly grouped suitable area under GIS environment with the help of very little ground truthing.Thus the present approach sets a new methodology of monitoring agricultural suitable area.

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