International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-3, January 2020

NDVI Classification using Supervised Learning Method

Agilandeeswari L, Swathi S Shenoy, Paromita Ray, Prabukumar M

Abstract: With the blessings of Science and Technology, as the death rate is getting decreased, population is getting increased. With that, the utilization of Land is also getting increased for urbanization for which the quality of Land is degrading day by day and also the climates as well as vegetations are getting affected. To keep the Land quality at its best possible, the study on Land cover images, which are acquired from satellites based on time series, spatial and colour, are required to understand how the Land can be used further in future. Using NDVI (Normalized Difference Vegetation Index) and Machine Learning algorithms (either supervised or unsupervised), now it is possible to classify areas and predict about Land utilization in future years. Our proposed study is to enhance the acquired images with better Vegetation Index which will segment and classify the data in more efficient way and by feeding these data to the Machine Learning algorithm model, higher accuracy will be achieved. Hence, a novel approach with proper model, Machine Learning algorithm and greater accuracy is always acceptable.

Keywords: Urbanisation, Vegetation Index, Machine Learning, Land Cover Images, Land Utilization, Classification, Prediction, NDVI.

I. INTRODUCTION

With the creation of fire, Human beings started to take first step towards civilization. As the day went by, with the gradual development of human brain, people started to understand how to utilize the elements, e.g. water, minerals, food items etc. available in nature as per the requirement. Unlike that, humans started to understand the necessity of cultivation and Urbanization, which was a greater step towards Civilization. People still uses Land as per their requirement, e.g. construction and cultivation etc. But due to the increment of population day by day, the utilization of land is getting increased in a higher rate. As a result, the Land quality is getting degraded day by day which in turn is affecting the climate.

Revised Manuscript Received on January 30, 2020.
* Correspondence Author
Agilandeeswari L, Associate Professor, School of Information Technology and Engineering, Vellore Institute of Technology, Vellore, Tamil Nadu, India, agila.l@vit.ac.in
Swathi S Shenoy S, M.Tech (CCE), School of Information Technology and Engineering, Vellore Institute of Technology, Vellore, Tamil Nadu, India, swathis.shenoy2018@vitstudent.ac.in
Paromita Ray, M.Tech (CCE), School of Information Technology and Engineering, Vellore Institute of Technology, Vellore, Tamil Nadu, India, paromita.ray2018@vitstudent.ac.in
Prabukumar M*, Associate Professor, School of Information Technology and Engineering, Vellore Institute of Technology, Vellore, Tamil Nadu, India, mprabukumar@vit.ac.in

So, to keep up the balance in weather with possible best quality of land, prediction with proper models and approach is required for further use in appropriate way.

Many methods with several techniques have been proposed for this particular purpose, over the years. Images which are used for this kind of study are satellite and aerial photos, but these images are too complicated

as these include constructions, railways, grassland, roadways, forest area etc. So, vegetation indexes are used

e.g. NDVI (Normalised Difference Vegetation Index) to segment and classify the images to identify the areas properly and on these NDVI images, Machine Learning Algorithms (both supervised and unsupervised), e.g. CA (Cellular Automata) Markov, Hybrid etc. are used to predict how the land will look like after some years. There are several software's available in the market which provides fine detailed with high resolution image after pre- processing steps and manipulates ground truth data. But these methods become failure in order to get higher accuracy when classification and prediction are taken place. So, in this paper, we focus on the comparison of the vegetation indexes e.g. NDVI, RVI (Ratio Vegetation Index), DVI (Difference Vegetation Index), PVI (Perpendicular Vegetation Index), IPVI (Infrared Percentage Vegetation Index) etc. as they give different results after segmentation and classification.

Below is general block diagram Fig 1, which gives us brief description about the process that is usually taken place in-order to predict Land Use & Land Cover Change (LULC).

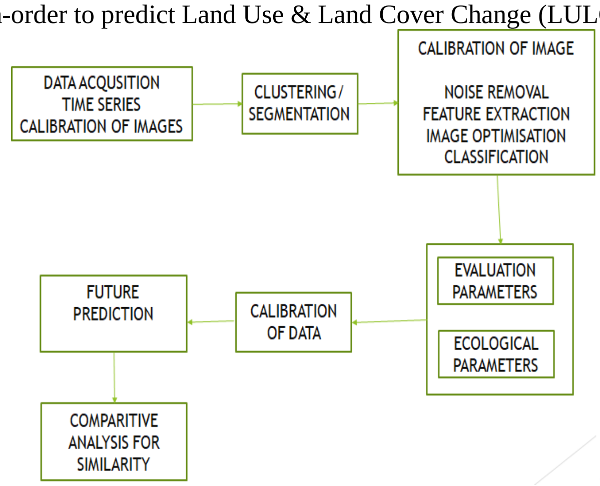


Fig 1: General Block Diagram Description

Data is acquired from various available sites. The commonly used is the USGS [10], which has collection of remote satellites images and it is collection of science directory about various natural hazard which also include impact of climate and land use change. It basically has data from US based sites.

For Indian datasets, ISRO initiative web based tool, Bhuvan.

For all these data availability, National Remote Sensing Agency (NRSA) plays important role. ISRO build this Bhuvan tool, with satellites Resourcesat-1, Cartosat- 1 and Cartosat-2 to get the best possible imagery of India. The Calibration and Segmentation of image gives importance to improve the image and get the part intended for action. Calibration includes different types of image enhancement techniques like noise removal, image optimization etc.

Different parameters need to be considered when land coverage is considered. Broadly it can be said as Evaluation and Ecological parameters. Evaluation Parameter like distance from road, hill area, river, cultivation area etc whereas Ecological includes temperature, rainfall, humidity etc.

All these parameters are calibrated to form a perfect dataset for further analysis. With these calibrated data, future prediction can be achieved through supervised or unsupervised learning.

The paper is sub-divided into following sections: Section II demonstrates the research work already done on this particular topic. Section III describes area of research accomplished through this project and its results are shown in Section IV. The paper conclusion and its future scope mention in Section V.

II. LITERATURE REVIEW

In this section the general description of different vegetation index apart from NDVI are analyzed and described in detail further.

[1] Rasha Alshehhi, Prashanth Reddy Marpu, Wei Lee Woon, Mauro Dalla Mura

Methodology:

CNN classifier is used to learn and predict the roads and buildings from given image. For better enhancement of CNN out, Simple Linear Iterative Clustering Segmentation is used. CNN algorithm applied with ReLu Activation, Max Pooling, Convolution Layer, Fully connected Layers.

Advantages:

• Boundaries which are irregular can be identified
• Disjoint road regions are identified
• Enhancing multiclass prediction using special features

***Issues*:**

• Additional processing is needed to accurately identify the irregular shape
• Under segmentation due to low level feature mixing
• Error in results if shadows and occultation are on the image
• Can result in over segmentation due to superpixel combining

Metrics Used

• Mini-batch SGD
• Pixel-wise cross entropy

Extraction of roads and building measured based on:

• Correctness
• Completeness

Performance Evaluation:

• McNemar's Statistical test

Dataset - Massachusetts Dataset

Parameters Used **(Ground truth values)**

Roads, Building Boundaries, background

[2] Sopan D. Patil, Yuting Gu, Felipe S. A Dias, Marc Stieglitz & Greg Turk

Methodology

Random Forest Machine Learning Algorithm, which is ensemble based.

• It predicts the spectral band information of Landsat Images
• Input to the model are topographic and historical climatic variables

Advantages

Direct prediction of spectral information leading to highly valuable ecological related products to analyze LULC from multiple perspective

• Over-fitting of Data is reduced with combination of RF with Decision Tree (DT)

Issues

• Less number of ensemble leads to poor determination of modal performance

Metrics Used

The Landsat images are divided into Red, Green, Blue and Near Infra-red spectral bands

• Coefficient of determination (R2) determining RF model OOB score (out of box)
• True color photorealistic image with RGB
• NVDI to calculate error

Dataset - Landsat 7 reflectance Imagery

Parameters Used (Ground truth values)

Elevation, Aspect, Slope, Historical mean annual temperature & precipitation, Future mean annual temperature & perception

[3] K. Sundara Kumar, N V A Sai Sankar Valasala, J V Subrahmanyam V, Mounika Mallampati Kowsharajaha Shaik & Pullaiah Ekkirala

Methodology:

Supervised Classification with Maximum Likelihood algorithm which is obtained using ERDAS software. The output of ERDAS is LULC images which are fed to IDRISI Selva Software which is Land change modeler to model and predict the changes.

Advantages:

Accuracy of results using software more than 80% in every stages

Metrics Used

ERDAS

• Geometric correction
• UTM projection (2D co-ordinate system which gives location of area on earth)

Dataset: Landsat Satellite images

Parameters Used (Ground truth values)

Built up Area, Open Land, Light Vegetation, Dense Vegetation, Water, Sand

[4]SamerehFalahatkar,Ali Reza Soffianian, Sayed Jamal eddin Khajeddin, Hamid Reza Ziaee,Mozhgan Ahmadi Nad oushan

Methodology: Images are initially geometrically corrected using Geometric Algorithm (GM) which uses PCA to identify Barren land and NDVI for Green cover layer

GM is followed by interpretation method to obtain tone, texture, pattern, size using standard photographic keys by Aerial photo-interpretation.

Retrieval Number: B7083129219/2020©BEIESP
DOI: 10.35940/ijitee.B7083.019320
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

Advantages:

• Using of standard methods to acquire the data set leads to high resolution and accurate image

***Issues*:**

Complex to implement, Incurring cost high due to use of aerial photo interpretation and stero microscope, Rapid changes in Land cover would violate the proposed system i.e. the system is valid only for fixed and constant land cover changes.

Metrics Used

Input Metrics - Geometric Algorithm

Output Metrics - Kappa coefficient for error calculation and accuracy

Dataset - Aerial Photos, MSS, TM, ETM+

Parameters Used (Ground truth values)

Mountain, Barren Land, Urban areas, Green Cover River

[5] Sanaullah Khan, Said Qasim, Romana Ambreen, Zia-Ul-Haq Syed

Methodology:

Image obtained is processed using ENVI 5.1 and ArcGIS 10.2 software. These images are classified using maximum likelihood classifier. For prediction, we are using CA markov in EDRISI software. The map of reference is generated using Fuzzy segmentation combined with Weighted Linear combination

Advantages:

• Results are reliable with high consistence between actual, observed and predicted results

***Issues*:**

• Due to hilly area, pixels of images were affected leading to inaccuracy.

Metrics Used

Single Land use dynamic- difference between the land area and unchanged land area are considered over land area with inverse difference in the year. This gives the rate of land used changes.

Dataset- Landsat Satellite - LANDSAT 5, LANDSAT 7 & LANDSAT 8

Parameters Used (Ground truth values)

Water, Construction area, Bare Land, Wood Land, Farm Land

[6] Chen Liping, Sun Yujun, Sajjad Saeed

Methodology:

MODIS data is coverted to synthetic data using STARFM. This data is then classified on basis of spatial and temporaral parameters using maximum likelihood estimator.

Advantages:

• results in high quality land cover maps over 5% improvement on neural networks. Synthetic data helps in recovering the high-resolution lost images with exact degree of accuracy.

***Issues*:**

• Less accurate the actual observation

Metrics Used

• Overall Accuracy and Kappa co-efficient

Dataset - Synthetic Satellite imaging

Parameters Used (Ground truth values)

Water, Grassland, Wetland, Deciduous forest, Evergreen forest

[8] Mukunda D Behera, Santhosh N Borate, Sudhindra N Panda, Priti R Behera, Partha S Roy

Methodology:

Images are obtained via satellite which are processed by SRTM DEM using the ArcHydro Tool in ArcGIS identifying watershed areas. These Images are classified using Unsupervised Classification with spectral clustering. These classified images are fed to IDIRISI software where decision taking technique is applied along with CA Markov

Advantages:

• Suitable rating obtained by MCE. Future prediction of land using LULC parameters. 84.34 accuracy on socio -economic front line. 85.5 accurate result for LULC.

Metrics Used

Multi Criteria evaluation based on weights which are created by AHP. (Analytical Hirearchy Process), Parameter aggregation using Weighted Linear Combination

Dataset -Landsat - MSS, TM, ETM+

Parameter Used (Ground truth values)

Socio-economic:

Population, Residential development, Industrial development Road network, Railway network , Area under winter crop physiogmomic - drainage network, slope

LULC:

Agriculture, Settlement & Forest, Marshy land, Wet land & Water, Fallow & barren land.

III. PROPOSED METHODOLOGY

As discussed in Section I about the general idea of the process, we focussed our methodology to enhance the Vegetation Index as shown in Fig 2, so that further process could get benefitted. Vegetation Index is one of the major parameters on which the segmentation and classification as well as prediction depends. Vegetation indices are those which highlights the spectral bands of greens i.e. plants, trees etc by using some mathematical combination and they can be observed distinctly from image or map. It also distinct from soil to green and reduces any climatic effect, e.g. clouds, from the images as much as possible. The image acquired from satellites contains several bands which represents colours. By manipulating these bands, we get vegetation indices.

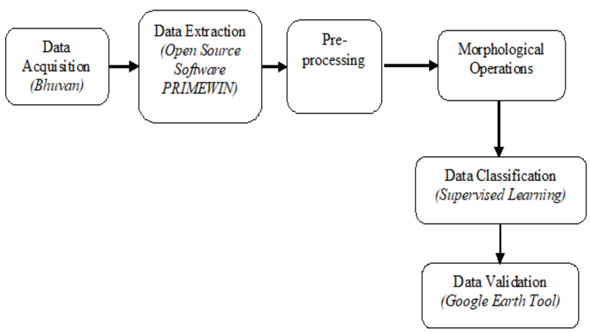


Fig.2 Proposed system methodology

As shown in Fig. 2, data for the purpose is acquired from national website available which has an open data archive for Land change namely Bhuvan (bhuvan.nrsc.gov.in). The images obtained are the time series data taken by ResourceSat I. The images are received in four different band namely Band 1: Green, Band 2: Red, Band 3: Near IR and Band 4: Short IR. We use open source software called as PRIMEWIN to extract the data. It is image processing tool which was developed using VC++ for facilitating data ingest from satellites sensor and using its utilities for data ingest, visualization, enhancement, arithmetic approach, classification etc. Fig 3 depicts the look of the Open Source Software.

Fig 3. PRIMEWIN – Open Source Tool

From the UTILITIES tab, we import the data extracted from the satellite, which results in image in which consists four BANDS (Fig 4). The BAND 1: Green, BAND II: Red, BAND III: Near Infra Red, BAND IV: Short Wave Infra Red.

This image obtained is pre-processed by false coloring technique and thereby enhancing the view of image using histogram equalizations. Followed by Pre- Processing are the morphological effects. We re-define the image applying various vegetation indices.

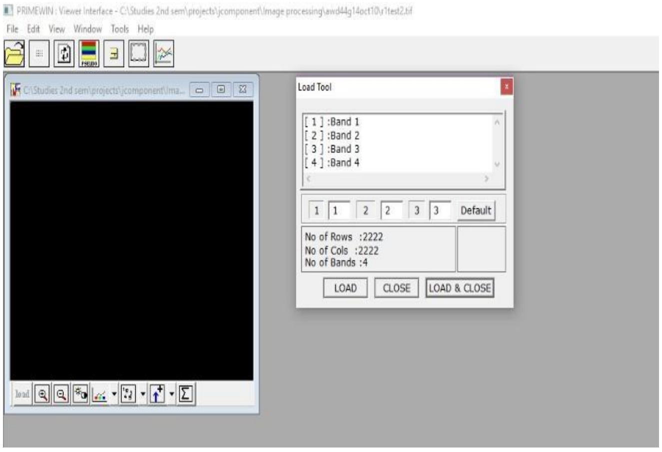


Fig 4. Loading of data into different Range

IV. RESULT AND DISCUSSION

A. *VEGETATION INDICES*

There are several vegetation indices like NDVI, RVI, DVI, PVI, IPVI etc. but every index highlights on the difference of Near Infrared (NIR) and Red band reflectance which separates the green from other elements present in the image. So, in this paper, we will observe the comparison of the vegetation indices which will help for better prediction.

DVI (Difference Vegetation Index): It is one of the simplest vegetation indices which separates green from soil. In case of reducing atmospheric effects, like any shadow or radiance, it does not make any change of those. Histogram equalization is needed.

DVI can be written as, DVI = NIR – Red (1)

RVI (Ratio Based Vegetation Index): It is a simplest ratio-based index is called the Simple Ratio (SR). This value becomes high for vegetation but low for soil, ice, water, etc. It highlights the proper amount of vegetation and climatic as well as topographical effects get reduced.

It can be written as, SR = NIR/red (2)

This simple ratio helps to reduce the climatic effect by the following:

$$L_{NIR} = \frac{E_{NIR}\, t_{NIR}\, r_{NIR}}{\pi} \tag{3}$$

Hence,

$$\frac{L_{NIR}}{L_{Red}} = \frac{E_{NIR}\, t_{NIR}\, r_{NIR}}{E_{Red}\, t_{Red}\, r_{Red}} \tag{4}$$

$$L_{Red} = \frac{E_{Red}\, t_{Red}\, r_{Red}}{\pi} \tag{5}$$

It removes irradiance and transmittance which cause the climatic and topographical effects. Also no further histogram analysis is required for this Ratio based Method.

NDVI (Normalized Difference Vegetation Index): It is mostly used index for prediction of Land Cover Images. It is a good index and its value varies from -1 to 1. It highlights amount of vegetation as well as separates them from soil. It somewhat minimizes topographic effects but cannot remove climatic effect like RVI.

NDVI can be written as, NDVI = (NIR – Red)/ (NIR + Red) (6)

Crippen (1990) found out that the red radiance subtraction from NDVI difference part was irrelevant and formulated the Infrared Percentage Vegetation Index (IPVI) thus rewriting the NDVI formula as

IPVI = (NIR)/ (NIR + Red) (7)

It's proved from the different scientist that this functionality is equivalent to NDVI and RVI, but varies in only ranges in value 0.0-1.0. Although our analysis indicates the non - removal of atmospheric effects or cloud appearance. When Histogram is applied over the image, the cloud or atmospheric effects gets highly visible as shown below.

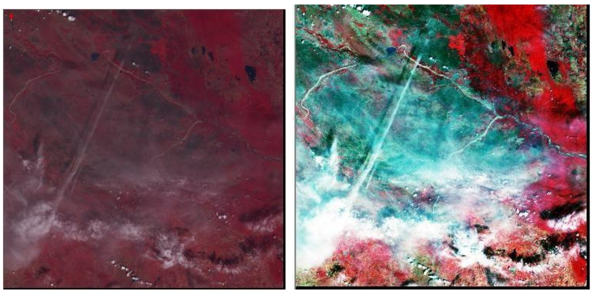


Fig. 5 Original Input and Histogram Stretched Images

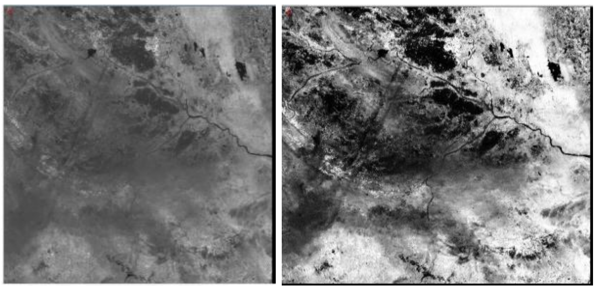


Fig. 6 DVI on Original Input and Histogram Stretched Images

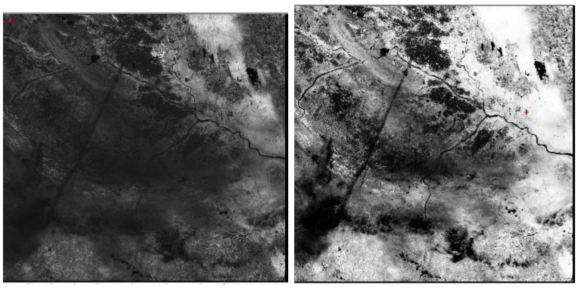


Fig. 7 RVI on Original Input and Histogram Stretched Images

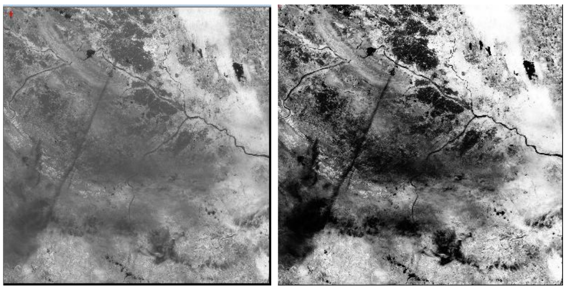


Fig. 8 NDVI on Original Input and Histogram Stretched Images

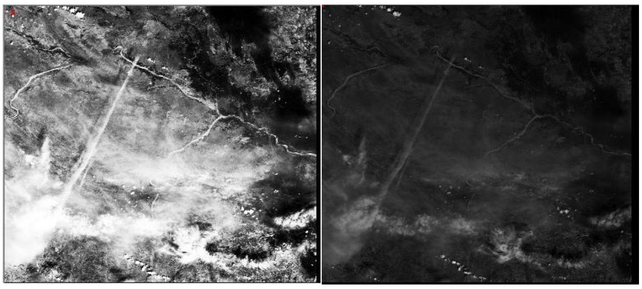


Fig. 9 IPVI on Original Input and Histogram Stretched Images

For better analysis and comparison of different vegetation index, we intended to take high resolution of all the vegetation Index and thus comparing it with the rest.

Fig 10: Raw Original Image

The highlighted area resembles the portion on which we are analyzing the high resolution effects. The Original Image of Fig.10 and its highlighted portion in High Resolution is shown in Fig.11

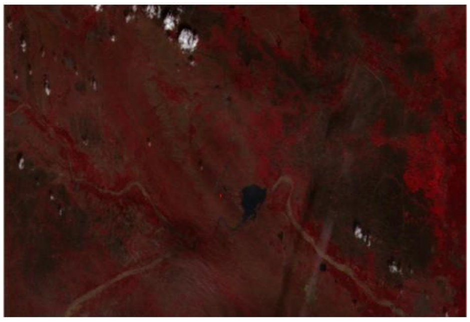


Fig 11: High Resolution – Raw Image

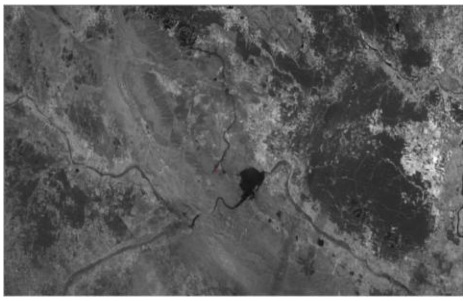


Fig 12. High Resolution DVI

Fig. 12 shows the cloud coverage has visibility and not completely removed. The shadowing effects of clouds also exists. Visibility of other details is not as clearer as RVI.

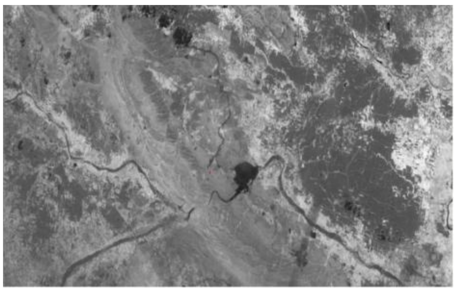


Fig 13. High Resolution NDVI

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

Fig. 13 shows the shadowing effect mentioned in DVI has been completely removed. It also eliminates the atmospheric effect. The lack of feature visibility is only disadvantage of the NDVI.

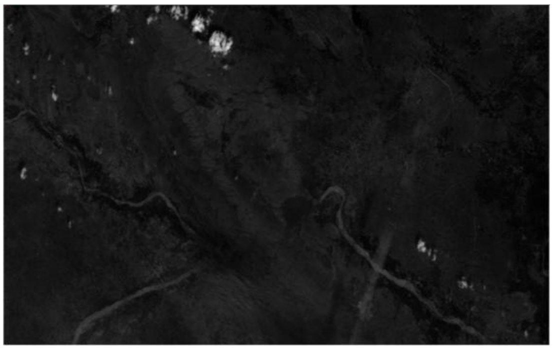


Fig 14. High Resolution IPVI

Fig. 14 shows that an IPVI has good visibility of features, but it is worse enough when it comes to atmospheric and shadowing effects. The Clouds and shadows are highly visible along with other features.

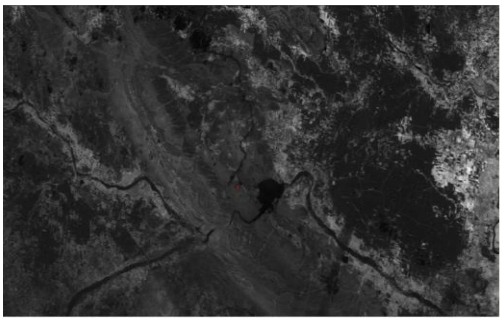
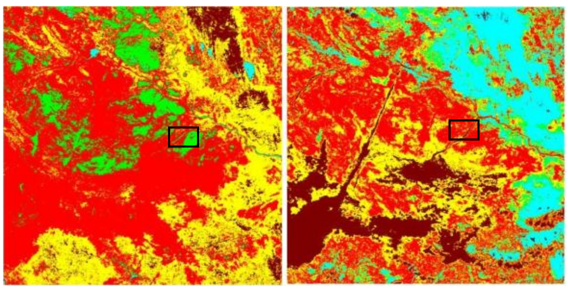


Fig 15: High Resolution RVI

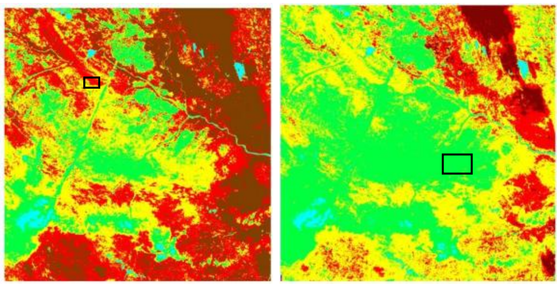
Fig. 15 shows that the RVI has the best representation in high resolution. It gives good visibility to land features and also eliminates the atmospheric and shadowing effects efficiently. Using these histogram equalized images, we are going to apply the supervised classification method of Maximum Likelihood. The various color indication are mentioned below Table 1, following the classification results.

Table. 1 Classification Color Table

RED	Populated Area
GREEN	Vegetation Land
BROWN	Forest Area
YELLOW	Barren Land
BLUE	Water



(a) (b)



(c) (d)

Fig 16. Classified Image (a) IPVI (b) DVI (c) NDVI (d) RVI

Verification of the Classification is obtained by comparing the result with Google map of this location. The Process of identifying and locating the land is described below.

Initially, we define the area to be validated. Using the mouse we mark a point on the image, to gets its location Fig 19. By using those location highlighted in Fig 17, we copy paste the location in Google Earth Pro Tool and the search the area Fig 18.

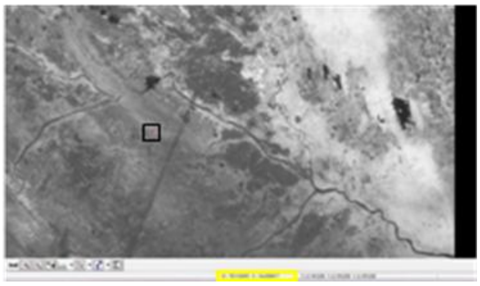


Fig 17. Image in PRIMEWIN- Location detection of selected area

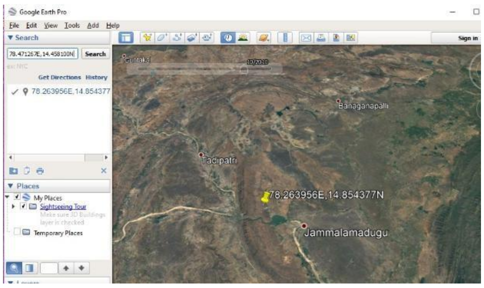


Fig 18. Google Earth Pro Tool- Location identified

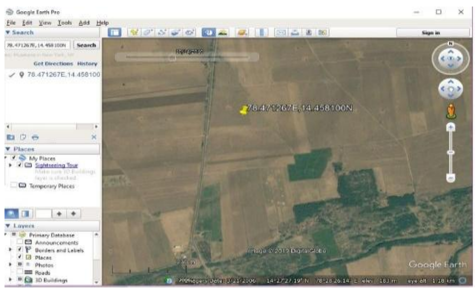


Fig 19. Google Earth Pro Tool-Zooming the area we can verify its cultivation area there by coming under vegetation cover

Retrieval Number: B7083129219/2020©BEIESP
DOI: 10.35940/ijitee.B7083.019320
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

As we have already marked the area of interest for different vegetation indexed classified images as shown above Fig 16 and comparing it with result of Google earth Pro tool, it is vegetation cover area, so should be colored in green as per Table 1. From Fig 16 (a) shows IPVI & (b) defines DVI were not able to recognize the vegetation cover, however Fig 16 (c) NDVI manages to determine few of the vegetation cover but Fig 16 (d) RVI gives the exact cover. Hence RVI proves to better Vegetation Index than the rest.

Google earth pro is an open source, geospatial software which displays a virtual globe with ability to analyze and capture geographical data as shown in Fig. 17-19. It is having a feature of displaying older data of a region i.e. if someone wants to know about a place from 20-30 years ago from now on, one can get the experience to see how the place used to look like. Here, in this work, using this feature, we have obtained the LULC image of the place, mentioned in the images above, for the year of 2010 and predicted the condition of the land using our proposed method for next 2-3 years.

V. CONCLUSION AND FUTURE WORK

We analyzed different Vegetation index like DVI, RVI, NDVI and IPVI in histogram stretching of original as well as high resolution histogram view. The difference method DVI lags to remove the atmospheric and shadowing effects and also lack in feature visibility. NDVI leads in minimizing of topographic effects, but complete removal is not achieved. The feature visibility lags in expressing, but histogram equalization of the same, results in better representation. IPVI is the best method for feature visibility but has a major disadvantage of atmospheric and shadowing impact even worst and clearer than DVI. RVI removes topographic effects and atmospheric effects with better feature feasibility view. Supervised Classification on the above Vegetation Indices also resulted in correct mapping of different features like water, vegetation land, barren land, rocky land etc with respect to RVI. The validation of correctness is done by comparing the results with Google Earth Pro tool. Hence, RVI method is most accurate compared with other different Vegetation Index which includes NDVI, DVI, and IPVI.

This work can be further extended for predicting the future land coverage of particular region, by intense training of data collected and classified using the neural nets.

REFERENCES

1. Rasha Alshehhi , Prashanth Reddy Marpu , Wei Lee Woon , Mauro Dalla Mura , "*Simultaneous extraction of roads and buildings in remote sensing imagery with convolutional neural networks*", ISPRS Journal of Photogrammetry and Remote Sensing 130 (2017) 139–149, 0924-2716/ 2017 International Society for Photogrammetry and Remote Sensing, Inc. (ISPRS). Published by Elsevier B.V.
2. Sopan D. Patil , Yuting Gu, Felipe S. A Dias, Marc Stieglitz & Greg Turk, "*Predicting the spectral information of future landcover using machine learning*", International Journal of Remote Sensing, 38:20, 5592- 5607, DOI: 10.1080/01431161.2017.1343512
3. K. Sundara Kumar, N V A Sai Sankar Valasala, J V Subrahmanyam V, Mounika Mallampati Kowsharajaha Shaik & Pullaiah Ekkirala, '*Prediction Of Future Land Use Land Cover Changes Of Vijayawada City Using Remote Sensing And GIS*', International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163 , Issue 3, Volume 2 (March 2014).
4. Samereh Falahatkar , Ali Reza Soffianian , Sayed Jamaleddin Khajeddin , HamidReza Ziaee , Mozhgan Ahmadi Nadoushan , '*Integration of Remote Sensing data and GIS for prediction of landcover map*'. International Journal of Geomatics And Geosciences,Volume 1, No 4, 2011, ISSN 0976 – 4380
5. Sanaullah Khan, Said Qasim, Romana Ambreen, Zia-Ul-Haq Syed, '*Spatio-Temporal Analysis of Landuse/Landcover Change of District Pishin Using Satellite Imagery and GIS*', Journal of Geographic Information System, 2016, 8, 361-368, Published Online June 2016 in SciRes. http://www.scirp.org/journal/jgis, http://dx.doi.org/10.4236/jgis.2016.83031
6. Chen Liping, Sun Yujun, Sajjad Saeed, '*Monitoring and predicting land use and landcover changes using remote sensing and GIS techniques ĐA case study of a hilly area, Jiangle, China* https://doi.org/10.1371/journal.pone.0200493
7. Yong XU & Bo HUANG (2014), '*Spatial and temporal classification of synthetic Satellite imagery: land cover mapping and accuracy validation'*, Geo-spatial Information Science, 17:1, 1-7, DOI: 10.1080/10095020.2014.881959
8. Mukunda D Behera, Santhosh N Borate, Sudhindra N Panda, Priti R Behera, Partha S Roy '*Modelling and Analyzing the watershed dynamics using Cellular Automata(CA)-Markov model-A geo-information based approach*' J.Earth Syst. Sci. 121, No. 4,August 2012,pp. 1011-1024
9. https://bhuvan.nrsc.gov.in/
10. https://www.usgs.gov/

AUTHORS PROFILE

Agilandeeswari.L completed her PhD and working as HOD & Associate Professor in the Department of Digital Communications, School of Information Technology & Engineering (SITE), VIT Vellore. She received her Bachelor's degree in Information Technology and Master's in Computer Science and Engineering from Anna University during 2005 and 2009 respectively. She got best researcher award for the past four years from 2015 to till date. She is having around 13+ years of teaching experience and published 50+ papers in the peer reviewed reputed journals. Her reputed publications includes research articles in peer reviewed journals namely Expert Systems with Applications, Journal of Ambient Intelligence and Humanized Computing, Multimedia Tools and Applications, Journal of Applied Remote Sensing indexing at Thomson Reuters with average impact factor of 5. She is the peer reviewer in journals include IEEE Access, Array, Artificial Intelligence Review, Informatics in Medicine Unlocked, Neuro computing, Computers and Electrical Engineering, Journal of King Saud University – Computer and Information Sciences, IET ReView, Journal of Engineering Science and Technology (JESTEC), etc. She also published about 13 engineering books as per Anna University Syllabus. She is a life time member in Computer Society of India. Her areas of interests include Image and video watermarking, Image and Video processing, Neural networks, Fuzzy Logic, Machine Learning, Cryptography, IoT, Information Centric Networks and Remote Sensing.

Swathi S Shenoy received her Bachelor's in Electronics and Communication Engineering from College of Engineering Chengannur, Chengannur, Alapuzzha, Kerala, India in 2014 and currently pursuing her Master's in Computer and Communication Engineering from Vellore Institute of Technology, Tamilnadu, India. Her area of interests include Remote sensing, Image Processing.

Paromita Ray received her Bachelor's in Electronics and Communication Engineering from IMPS College of Engineering and Technology, Nityanandapur, Chandipur, West Bengal, India in 2015 and currently pursuing her Master's in Computer and Communication Engineering from Vellore Institute of Technology, Tamilnadu, India.

Her area of interests include Remote sensing, Image Processing

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

Prabukumar M working as Associate Professor department of computer applications & creative media(CACM) in the School of Information Technology and Engineering at VIT, Vellore, Tamil Nadu, India. He has 15+ years of experience in teaching & research that includes HOD of CACM from 2015 to 2017.He completed Ph.D in computer graphics on 2014 at VIT University. He obtained his M.Tech in Computer Vision and Image Processing in 2007 from Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Coimbatore, India and BE in Electronics and Communication Engineering in 2002 from Mahindra Engineering College, Namakkal affiliated to Periyar University. His research area of interest are machine learning, computer graphics, image processing, video processing, remote sensing, Image and video watermarking and pattern recognition. He has published 50+ research papers in peer reviewed international journals and conferences. He is reviewer of various international Journals such as IEEE Access, IET Image Processing, Journal of Applied Remote Sensing, JESTEC and Inderscience Publishers Journals. He is guiding 5 research scholars. He is a life time member in Computer Society of India.

Retrieval Number: B7083129219/2020©BEIESP
DOI: 10.35940/ijitee.B7083.019320
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)