Application of Change Detection Techniques in the fields of Environmental Management and Sustainable Development

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Abstract: In the last decade, the world has witnessed significant increase in the urbanization and modernization in all the possible aspects resulting into environmental degradation. This has led to the significance of thought over the sustainable development and management of environment. The vegetation deceased, green fields got affected and flora and fauna also suffered negative effects. This paper aims to present the spotlight to the change in vegetation fields as well as the urban landscape using the techniques of Geomatics science. The overall methodology adopted in this research work consists of dataset acquisition at the initial pre-processing step followed by its core-processing. The datasets were acquired from Landsat series satellites which emphasize over the land-based features of the earth. Environment plays impeccable part in every human's life and is essential in modern world to neutralize the increased pollution due to constant globalization. The paper portrays crisp change detection outputs showing changes over the study area and its effects. The paper lays a strong foundation in understanding the changes occurred and provides assistance for carrying out preventive steps to achieve sustainable development for our future generations to come.

Keywords: **Sustainable development, environmental degradation, change detection, remote sensing, geomatics.**

I. Introduction: The world is now moving with emerging fast-paced technologies and increased urbanization resulting into improper use of natural resources. The developed countries are utilizing resources to maintain their attributes while the developing countries are utilizing them to increase their development rate. The main foundation for environmental based research is focused on sustainable development which means using the present resources in such a way so that they are conserved for the future generations to come. In Indian context, the economy is majorly dependent on agricultural practices and products. In fact, India is a major producer of agricultural goods and exports the same to various other countries as well. But at the same time, there has been significant decrease in agricultural lands due to fast-paced urbanization in the last decade. This has affected the economy, agricultural families, environment as well as the pollution level. Due to increased urbanization, pollution has risen affecting the humans and the flora and fauna. This infers to uneven natural resources usages and affects the environment directly. It is of paramount importance that the environment is conserved instead of its degradation. This will help in countering the adverse effects of pollution as well as in providing a solidified background to resources as well as the economy. To prevent this, it is important to assess the changes in environment and there are various methodologies for achieving it.

Sustainable development means attaining a balance between environmental protection and human economic development and between the present and future need [1]. A coordinated approach is required to solve environmental problems. Sustainable development

is now considered by many organizations and their stakeholders as being the model to follow [4]. Nevertheless, some kind of description of the concepts is necessary to establish the broad domain of discussion. For instance, many proponents of sustainability and sustainable development might not wish these concepts to be applied to the economic success of a company which manufactures weapons of mass destruction, or 'sustainable futures' to the maintenance of the futures market for stocks and shares [2].

Change detection techniques serves as the best equity for assessing the changes occurred between a predefined interval of dates. To provide remedies and counter the impacts of environmental degradation, stringent actions are required which would be generated by carrying out the change detection to create schematics about the areas and their corresponding amount being affected due to loss of environmentally green areas. To perform change detection, aerial imageries are a necessity. Aerial images are acquired by either the satellites or the flights containing cameras like UAVs or drones. Google Earth provides basic photographs which can be utilized for change detection implementations. To achieve high end detection efficiency, these are not used because two factors come in to play i.e. accuracy and resolution. In order to produce effective indicators of sustainable development, one must agree on what one is trying to indicate. The climate change issue is part of the larger challenge of sustainable development [8]. The challenge in developing indicators of sustainability is to find simple ways of presenting their concept despite the complexity and uncertainty [10].

Google Earth images provides good resolution photographs with a bearable amount of accuracy but the satellite imageries are more accurate and high resolution. This research work incorporates the satellite-based imageries for carrying out the change detection process. In the space, numerous amounts of satellites are present and it is always of prime concern to select the best out of them. MODIS, Landsat, Sentinel are some of the satellites which provides free-open source satellite images of earth's surfaces for processing applications. Sentinel is the latest series of satellite but only provides data from past few years as it is a new series of satellites launched into the space. The Landsat series were then selected to carry out the change detection processing for the research work. The change detection methods are mainly categorized as classification based or spectral based [6]. The efficiency of the detection depends upon how accurate the dataset is and also on its resolution. Better resolution dataset yields better detection results but at the same time consumes larger time to process. It can be inferred that if immediate results are to be achieved, low resolution dataset can be used.

II. Methodology: The change detection of remote sensing images plays an important role in the land cover and water bodies' changes over a time period [7]. Landsat series contains various satellites starting from 1 to 8, 8 being the latest addition to its series. With increasing demand and growth, constant advancements in sensors as well as resolution were made so that the imageries and application processes effectively produce efficient results. The change detection process requires skill-sets of geomatics as well as environmental studies. In fact, super-resolution of such images which is an integral skill of Geomatics assists in performing the change detection process and the environmental skills assists in depicting the changes and interpreting the imageries [9]. The combination of these two is an essential flavor in any environment related management as well as conservation studies.

To detect changes in the last decade, Landsat 5, Landsat 7 and Landsat 8 imageries were used. The change detection study uses past and recent satellite data to evaluate the typical landscape change over the decades [5]. Landsat 8 images are high resolution images as compared to Landsat 5 and 7 but only provides data in the past 3-4 years. The main step is to select the images to be processed because many factors affects the processing such as:

- Clouds are the most dominant factor affecting the imagery as presence of clouds may actually prevent the satellite to penetrate it and capture the features underneath.
- Stream lines in the imageries are another factor which affects the processing as its presence provides loss of feature information in the image dataset.
- Smokes and plumes also impact the imageries and its corresponding features but however can be compensated in the optical domain.

There exist various other factors but the above discussed are the most dominant ones. It is an essentiality that the satellite image datasets are selected by keeping the above factors in mind. In most conventional means, datasets with clouds present in it are avoided. Hence, months of rainy season are avoided because maximum cloud content is present in the rainy season. Summer season is the most optimum season for selecting the datasets but even in this season, clouds are present sometimes due to inconsistent weathering conditions resultant of the global warming. Smokes are also present due to burning of agricultural lands because of hot and warm sunny conditions. If the optimum month still contains unwanted entities, the temporal resolution of the satellite acts as the key. The temporal resolution refers to the revisit period of the satellite or in simple terms, the time after which the satellite visits the same area again. Generally, it is several days for Landsat series of satellites. NDVI is a common and widely used index and is an important vegetation index, widely applied in research on global environmental and climatic change [3].

Once the dataset is selected, the next step is to pre-process it. Pre-processing contains visual interpretations of the imagery which is basically understanding the areas and features present in the imagery. After the pre-processing is carried out, the main processing part of change detection is being carried out. There exist various different ways of detecting the changes of a scene or an imagery. Classification approaches, geographic information-based approaches, machine learning based approaches and many more. This research work is based on classification-based change detection approach. The images contain many different bands in which the features and information content is captured. The optical domain is basically consisting of Red, Green and Blue bands i.e. (RGB) which is the most common phenomena for the visual interpretations. The other bands are Infrared based i.e. the Near Infrared band (NIR), Short Wave Infrared band (SWIR) and the Thermal Infrared band (TIR) and also the Panchromatic band. In general, the conventional change detection processes incorporate the use of visible band as well as the infrared bands. The following flow chart provides the insights about the methodological process for performing the change detection.

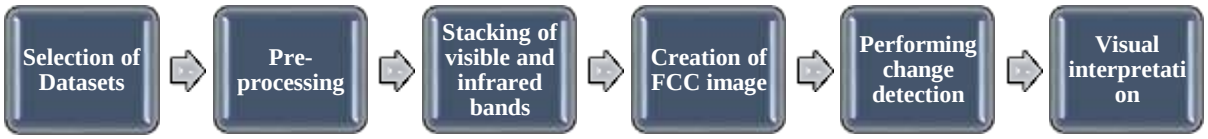


Fig 1: Process of Change Detection technique

The visible and infrared bands are to be stacked initially so that the false color composite image can be constructed. Stacking in general refers to overlap multiple images together. For example, the green band has different characteristics regarding the vegetation while the near infrared band has different characteristics. So, overlapping them (Stacking) creates a generalized image which takes into account the information content and characteristics from all of the bands. This is then followed by the creation of a false color composite image which is of utmost importance as it portrays information content about the scene from the stacked image. Another essential step is to construct a NDVI image i.e. Normalized Difference Vegetation Index. NDVI basically means to quantify the vegetation information content by calculating the difference between near infrared and red light. The near infrared is actually reflected by the vegetation and the red light is actually absorbed. So, these two bands help in yielding the NDVI content about a stacked image. NDVI information is an important characteristic regarding the remote sensing and environmental perspective as every personnel studying the vegetation related area needs to understand the concepts of NDVI for interpreting the images effectively.

For the change detection process to undergo, after the FCC image construction, the next step is to create the image difference as well as the highlighted image. These two images are the most important ones as they are the pillars of the change detection technique. The image difference technique refers to measuring of the feature-to-feature changes and differences in the two images. Images here actually refers to the images of two different years. The image difference concept works on the raster attribute of the data set and yields effective information content necessary to be visually interpreted so that change detection technique is correctly processed. The

classification process of the image difference process assists in accurately portraying the change information and is the most essential step of any change detection methodology.

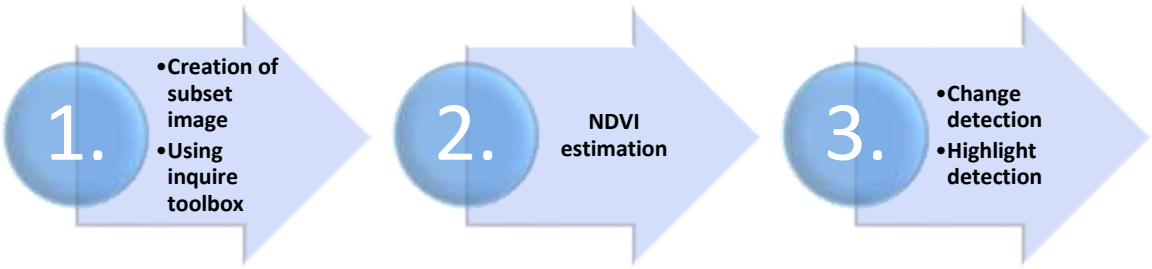


Fig 2: Sequential process for detecting changes and highlights

The next step is the construction of a highlighted image through the means of image difference and stacked image. The highlighted image displays the information in the form of multi-colored pixels. This multi-colored display provides the changes which means that one color depicts no change and the other depicts the change in the image.

III. Results and Discussion: Change detection process can be carried out by several different processes like image difference method, zonal difference method and feature extraction method. Image difference being the most conventional and the basic one. The basic functionality of image difference is carried out for the change analysis with imageries that basically depicts the same area at different points in time. The resultant images out of this process are change detected image and the highlighted image. The change detected image is in general the grayscale image portraying areas changed between the two images by displaying the information content using grayscale values. The highlighted image basically indicates the areas changed by combination of red and green (alterable) which shows areas decreased and increased between the two images.

The following sequence shows the original image-tiles taken from the Landsat satellite series.

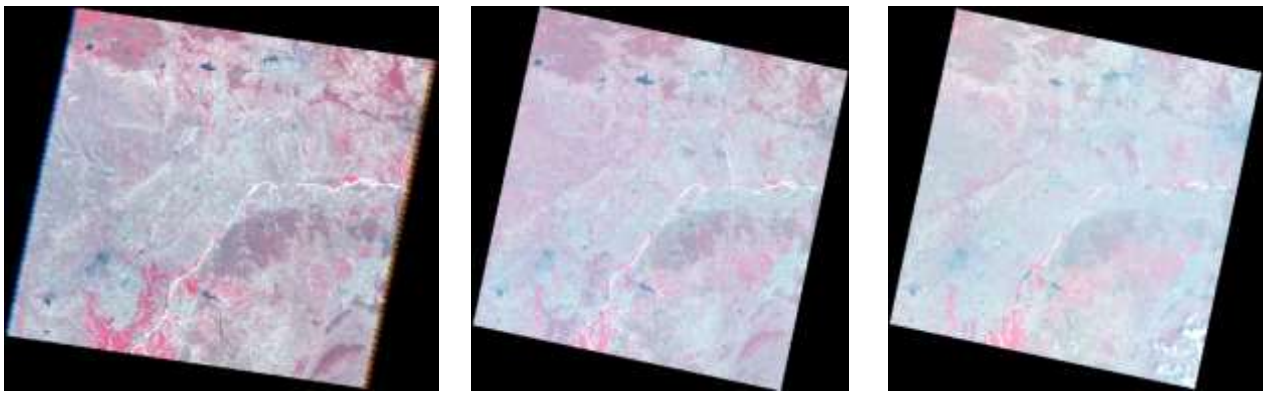


Fig 3: Three image-tiles taken of the years 2008, 2014 and 2019 of Chhattisgarh State area

The tiles are taken of the month of April as this month contains minimum interference and presence of clouds. The study area was chosen to be Chhattisgarh state. Since, the state of Chhattisgarh is not small and to study change detection in a big area like this could be hectic and computational power requirement would be intense, it is desirable to reduce the image-tile or as we say create a subset image out of the original raster dataset image.

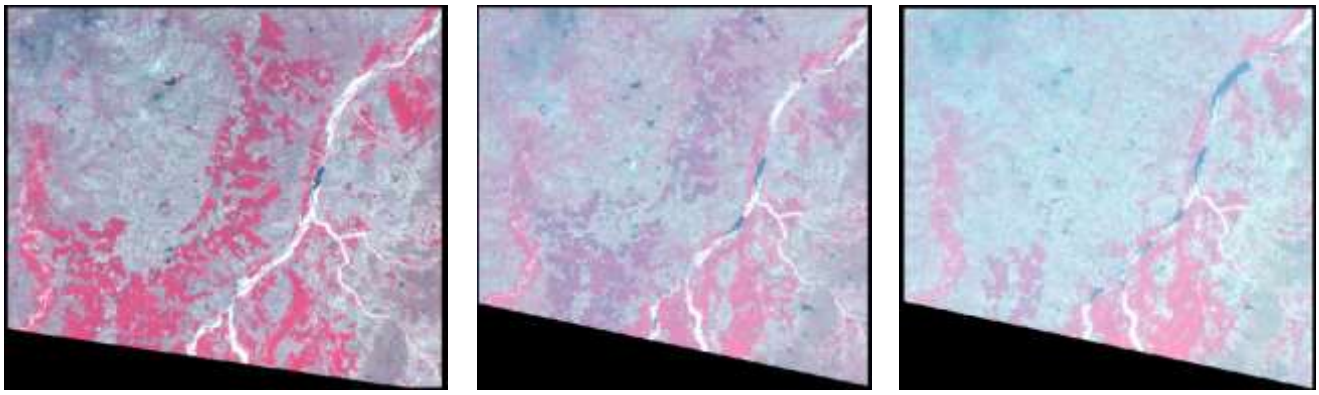


Fig 4: The subset images taken to reduce the area to Abhanpur and Kurud districts of Chhattisgarh state area

The subset image was created by keeping in mind the areas restricted to Abhanpur-Naya Raipur region to Kurud-Dhamtari districts as visually vegetation can be seen altering in these regions. The bands are kept as to be Green, Blue and NIR (Near Infra-Red) as NIR is an essential band while characterizing the vegetation-based features.

The next step is to create a NDVI image out of the subset images. The expression theoretically for NDVI is as follows:

$$NDVI = (NIR – Red) / (NIR + Red)$$

The following image sequence shows NDVI images created from the subset images. The image is grayscale consisting of combination of black and white illumination values. It is clearly visible that the three images consist of some significant changes as seen by variation in illumination.

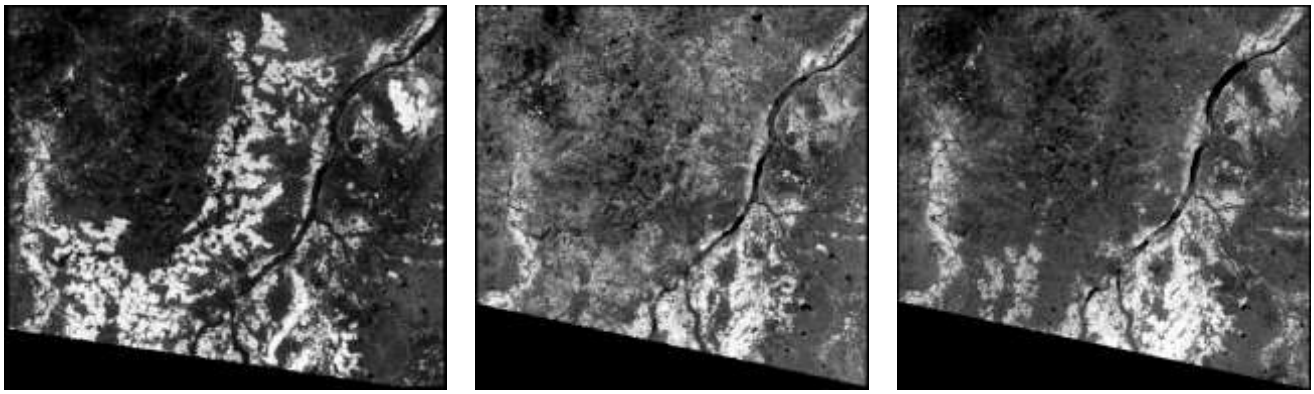
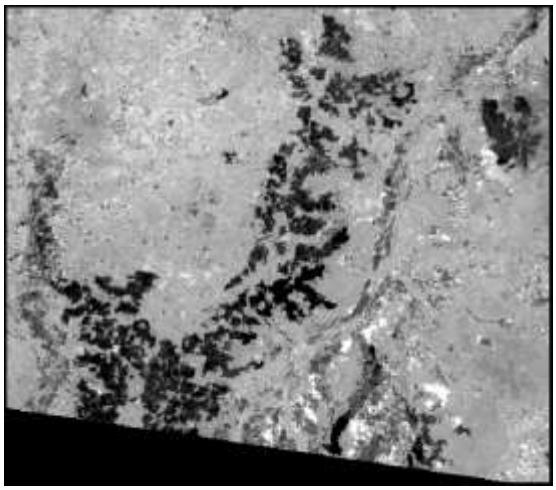


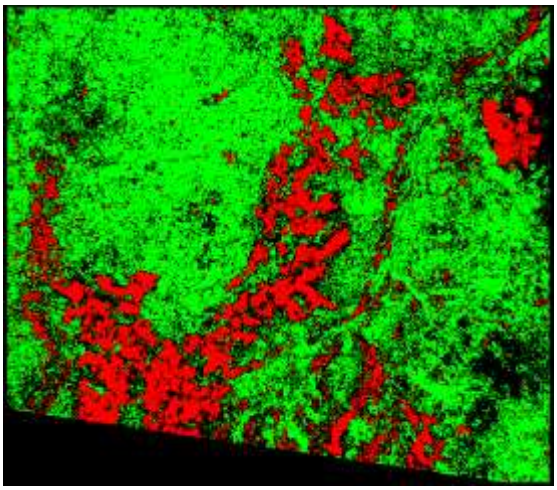
Fig 5: Normalized Difference Vegetation Index (NDVI) images of the corresponding subset images

Once the NDVI images are computed, the next step is to compute the change detection and highlight detection images. The resultant image sequences are portrayed as below.

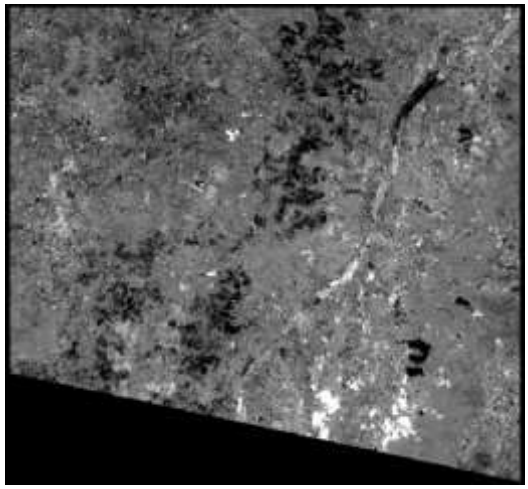
It is clearly visible that when talking about the changes between 2008 and 2014, there has been significant amount of changes. The red pixels in the highlight image indicated that there has been decrease in the pixel values and the green pixels indicate that there has been increase in the pixel values between the subsequent image tiles.



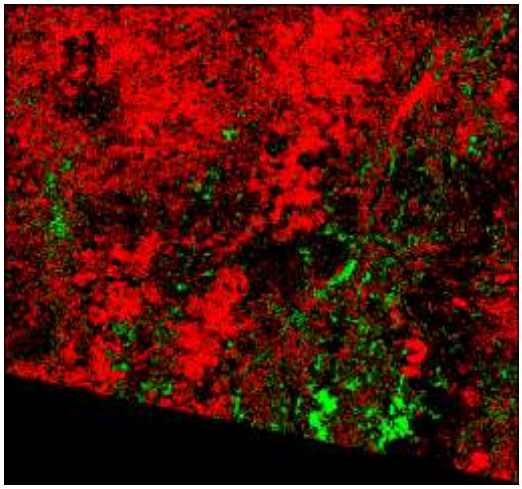
Change detected between the images of 2008 and 2014



Highlight image between images of 2008 and 2014



Change detected between the images of 2014 and 2019



Highlight image between images of 2014 and 2019

Fig 6: Change and Highlight detected images between 2008-14 and 2014-19

It is clearly understandable that in the last decade, vegetation has been decreased due to urbanization and several other factors. This creates an open doorway for researchers to look into the environmental conservation factor as this is now an alarming condition so as to conserve the resources at present so that it can be placed into the sustainable zone of development. Vegetation is one of the main sources of oxygen production as well as neutralizes the pollution contamination level. To achieve development, it is important that environment is conserved which would create hassle-free future for the generations to come.

IV. Conclusion and Future Scope: This research study consisted of detecting the changes between the last decade occurred in the regions of Chhattisgarh state. The results depicted significant decline in the vegetation which could be due to factors like urbanization and industrialization. The highlighted images were also constructed indicating decrease and increase in the pixels of image-tiles over the subsequent years. NDVI estimation played an important and impeccable role as when the study is focused upon the vegetation areas or change detection process, NDVI provides essential information necessary.

Environment and its resources are necessary for the humans to survive and prevail in this era of fast-paced globalization. Degradation of the environment has been increasing exponentially in regular intervals and is of prime concern in this modern evolving world. Due to improper use of natural resources, the nature has become imbalanced and this can be understood and felt by inconsistent weather and meteorological conditions. For our future generations to come and survive effectively, sustainable use of environmental resources is very paramount. Conserving flora and fauna, properly utilizing the resources are only alternatives to avoid calamities which can be significant in the nearby future to come.

With context to future scope of the work carried out, this research opens doorway for carrying ahead this methodology and applying this to cases like weathering and meteorological changes, urban landscape changes, hotspot changes and many more. Selection and processing of the dataset is the most significant step and the rest gets sequentially batched alongside with the methodological concepts. Change detection technique prevails as the most essential process to apply for gathering information about time-series analysis of a geographic location.

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