Automatic Extraction of Built-Up area From EO-1 Hyperion Hyperspectral Satellite Image Based on NDBI Index

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Abstract - **Although urban area represents a little portion of Earth's surface area, it brings an unbalanced impact on its surrounding areas. An urban region is a complex ecosystem and made up by a heterogeneous material. In worldwide an urban expansion is done by occupying a cultivated land which causes a serious problem on our ecosystem. Now there is a need to identify an urban area and its growing pattern. A recent Hyperspectral Remote sensing technology can be used to monitor built-up areas and also it can detect the growth and spatial distribution of urban built-up. In this research, we presented an automatic and quick approach for extraction of Built-Up area from EO-1 Hyperion Hyperspectral image of 20 March 2015 of Aurangabad City (MS), INDIA. The Normalized Differential Built-Up Indexed (NDBI) is based on the new spectral index. It can extract built-up area automatically. The Range of NDBI Indexed is -1 to +1; the identified index value of pure pixels of Built-Up area was found to be 0 to 0.15. Further by using Density slicing approach, it clearly identifies built-Up area, Vegetation, Water body, Fallow Land and Barren Land. In the Study, the NDBI Index was identifies to be an effective index to map urban built-up area as compared to SAM classifier. The total overall accuracy of NDBI was 90.26% and 0.86 Kappa coefficient; whereas SAM classifier has 88.30% overall accuracy with 0.85 Kappa coefficient.**

Keywords —Normalized Differential Built-Up Indexed (NDBI), EO-1 Hyperion, Spectral Angle Mapper (SAM), Density Slicing, Urban classification.

I. INTRODUCTION

Urban land use land cover area is very heterogeneous because of various urban features. Due to increased population, urban expansion is also increasing vastly which causes the environmental hazards like less rainfall, high temperature, dryness, etc. The natural factors of environment may get disturbed by urban features like constructions, industrialization which leads global warming. Conventional techniques of urban features monitoring is time consuming and costly. Recently, satellite remote sensing imagery is providing valuable information of urban features with cost effective manner and temporal series as well as better accuracy [1] [2] [3] [4] [5]. Buildings are the main feature of urban entity from impervious surfaces may impact on the biodiversity, climate change, ecosystem, hydrologic system, etc. Hence, it is useful to monitor the urban changes using satellite remote sensing images. Spectral indices and classification techniques are the key parameters to extract the urban features e.g. built-up areas. The traditional classification methods of built-up area extraction do not provides accurate results because of spectral behavior of mixed pixels. The bare soil and road features can be reflected as built-up features lead to misclassification. Therefore, use of spectral index is vital to extract the built-up features [6] [7] [5].

In the present paper, we have used built-up index for automatic extraction of built-up areas. The purpose of this study is to provide a simple application method employing a NDBI that can be used in classifying non-urban and urban areas using images from Hyperspectral Image.

II. INDICES

Urban areas are very complex in nature, therefore, based on some generalized characteristics, specialists have tried to divide urban ecosystem into three main constituents, vegetation, built-Up (impervious surfaces) area and bare soil. This research focused only on built-Up area. The detection of impermeability on urban areas requires effective methods to quickly obtain information on built-up surfaces. However, several concepts have been designed to estimate urban surfaces using remote sensing data [6] [8] [9]. These techniques can be categorized into 4 groups.

1) Methods that use visual interpretation or multi spectral classification, considered as manual or semi-automatic classification techniques
2) Classification by integrating the results of impermeability with data from other sources
3) Classification based on the spectral mixture analysis method
4) Classification through the relationship between built up areas and other land cover types like vegetation and bare soil.

The first two methods are mainly applied to high and very high spatial resolution images, while the last two categories are applied on medium spatial resolution data. Since different types of land cover could behave differently in spectral space, certain types of objects could be enhanced or extracted with their unique spectral responses; various indices have been reported in literature for the simplified process of automatically mapping land covers [6] [9].

III. Study Area and Data sets

Aurangabad city is selected to be as Smart City by Government of India. It is one of India's most iconic travel destinations and home to an amazing array of sights, activities and events. Aurangabad district is located in central part of Maharashtra, as shown in Fig. 1. Aurangabad is located on 19° 53′ 14″ N and 75° 20′ 12″ E. The city has 113 administrative wards with an area of 143 km2. The city is a tourism hub, surrounded by many historical monuments, including the Ajanta Caves and Ellora Caves, which are UNESCO World Heritage Sites, as well as Bibi-ka-Maqbara [10] [11] [12] [13] [14] [15] [16].

EO-1 spacecraft was launched from Vandenberg Air Force Base on November 21, 2000. EO-1 is part of NASA's New Millennium Program, that was initiative to demonstrate advanced technologies for dramatically reducing the cost and improving the quality of instruments and spacecraft for future space missions [17] [18] [19].

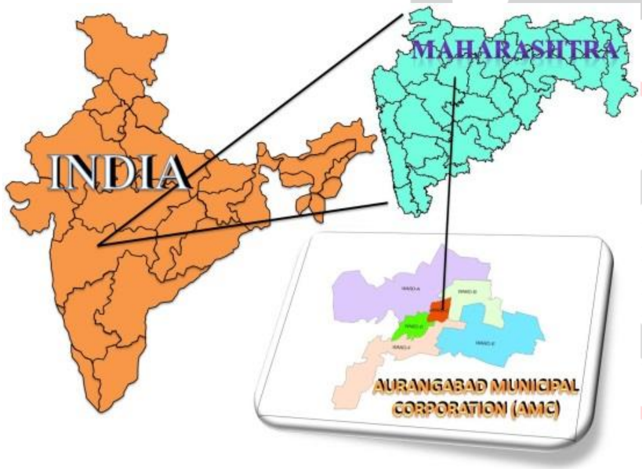

Fig. 1 Area under Study

A. *Data set*

EO-1 spacecraft contains two sensors, Hyperion and ALI. A Hyperion is a push broom Hyperspectral imaging spectrometer. This Hyperspectral Image has 242 bands that cover a large part of electromagnetic spectrum, starting from 400 nm to 2500nm and with spectral resolution of 30 m. Since Hyperion is a push broom system the entire 7.65 km wide swath is obtained in a single frame. The Hyperion data are capable of mapping the complex urban surface components [17] [19] [20]. Some preprocessing has to be done on Hyperion data, like removal of bad bands and bad columns, atmospheric correction and this can be performed by using tools. There are 242 bands in Hyperion data and among them few bands do not have meaningful values or some may contain negative values, because of low detector response [17] [21] [22] [23] [24]. In Hyperspectral Imaging a Band selection process is common technique for dimensionality reduction.

The Hyperion image of our interest was acquired on 20 March 2015; it covers the major part of Aurangabad city area, with low cloud cover. Out of 242 bands only 196 bands were used in this study. From band number 1 to 8 (in the visible and near infrared) and from band number 56 to 76 (in the range of short wave infrared) and from band number 225 to 242 were removed because these are identified as bad band [25] [26] [27] [28]. There were 46 bands identified as bad bands and spectral subset were performed also as per Region of interest Spatial sub setting was performed using ENVI tool, shown in Fig. 2.

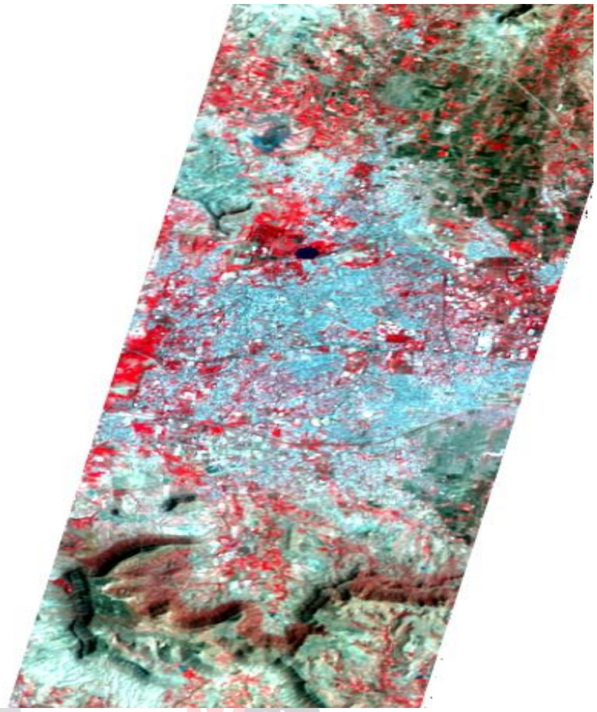

Fig. 2 Subset of Hyperion as per Study area

In remote sensing technology, different objects can be identified based on spatial characteristics or spectral indices. There are many normalized difference indices are widely used for mapping land use land cover. Very few indices are generally used in multispectral data, because of spectral limitations of Multispectral data. Hyperspectral data have become more attractive due to its large spectrum information. The Normalized Differential Built-Up Indexed (NDBI) is based on the new spectral index that can extract built-up area automatically [9]. For calculating the NDBI index on Hyperion image, the Band number 86 and 33 were used, as shown in equation (1). Fig. 3 shows the corresponding NDBI Image.

$$NDBI = \frac{(Band\ 86 - Band\ 33)}{(Band\ 86 + Band\ 33)} \quad (1)$$

IV. Results and Accuracy

In Remote Sensing Technology classification is used to produce thematic maps, it extracts the parameters from remote sensing data or from the original Digital Numbers (DN) values. The urban remote sensing indices are based on spectral values and have some limitation to distinguish between built-up area and barren land; because of this the accuracy is always affected. It is possible to extract urban area from remote sensing imagery by using NDBI index. It uses the spectral information alone.

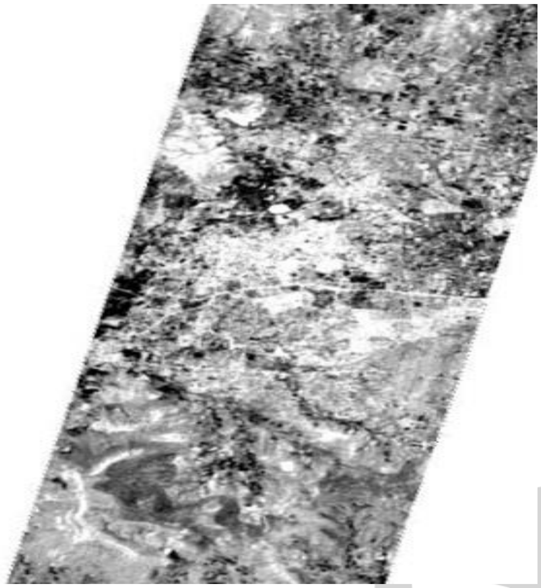

Fig. 3 NDBI Index

The Range of NDBI Indexed is -1 to +1; the identified index value of pure pixels for Built-Up area was 0 to 0.15. Further by using Density slicing approach, it clearly identifies built-Up area, Vegetation, Water body, Fallow Land and Barren Land as shown in Fig. 4. In order to perform the accuracy assessment of this proposed NDBI method, the original Hyperion subset image was classified by using conventional Supervised Spectral Angle Mapper (SAM) classifier. The NDBI has produced higher accuracy as compared to SAM classifier. The accuracy was found to be 90.26 with Kappa value of 0.86 from NDBI and 88.30 with 0.85 Kappa from SAM classifier.

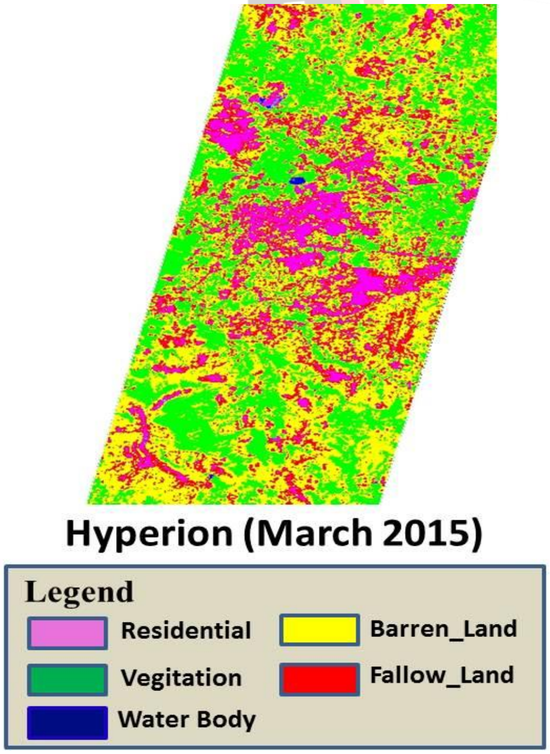

Fig. 4 Color Density Slicing on NDBI

V. Conclusion

We have computed the values of NDBI index from Hyperspectral Remote sensing data for Aurangabad City. The range of this index was found to be 0 to 0.15 for the Built-up area. The total overall accuracy from the technique was found to be better than the technique based on SAM classifier, which is more complex.

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