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CHANG E DETECTION ANALYSIS IN URBAN WATERSHED USING GEOSPATIAL TECHNOLOGIES

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Abstract Access to water and its proximity have been critical factors for human settlements. These water bodies in urban spaces provide recourses like recreation, health benefits, tourism, drinking water, and food. Due to rapid urbanization and anthropogenic activities, these water bodies are under tremendous stress. In this context, the Spatio-temporal study was carried out for two different water bodies IDL lake and Buffalo lake in Hyderabad, India, by Geographic Information System (GIS). Change detection study of water bodies was performed using Digital Elevation Model (DEM) data and Landsat satellite images. The extraction of watersheds has been delineated using DEM data for the four water bodies using Arc Swat for 5 years. Land use Land Cover change detection analysis was carried out with LANDSAT satellite images. After acquiring a satisfactory accuracy value for each classified image, a detailed post-classification change detection analysis was executed. Waterbody, vegetation, urban land, and open land were identified as classes for change detection. For the years 1997, 2002, 2007, 2013, and 2019, the classification accuracy achieved for Amber lake was 93 to 97.33 %, for IDL Swan Lake was 92.86 to 94 %, for Peacock lake was 88.57 to 96.57 % and Buffalo lake was 89.71 to 96.10%. It has been noticed that water bodies have been encroached upon or diminished chiefly due to urban development or the eutrophication process.

Keywords —Accuracy Assessment, Change Detection, GIS, Urban, Watershed, LULC

I. INTRODUCTION

The change detection technique aims to identify Land Use/Land Cover (LULC) on digital pictures that change aspects of relevance between two or more dates [1]. Land cover change implies a change in some continuous features of the land such as plant type, soil qualities etc., whereas land-use change consists of modifying the way a particular area of land is being utilized or managed by humans [2][3]. Land use/land cover (LULC) changes are critical challenges of global environmental change [4]. Mapping and monitoring land use and land cover (LULC) are critical for long-term development, planning, and management [5]. Over the last several decades' different approaches to LULC mapping and change detection were developed and deployed all over the globe [6][7] .

Over a while, LULC has been evolving, which is more rapid currently owing to anthropogenic activities, such as industrialization and urbanization [8]. LULC changes and their consequences are more evident over regions with increased population density, industrialization, urbanization, deforestation, agricultural diversification etc [9]. According to the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC) in 2007, anthropogenic activities, such as urbanization and agriculture, accounted for 90 percent of global warming [10]. Due to this, there are rapid transformations in land-use land cover in general and in urban areas in particular. These irregular transformations in urban land are causing a significant impact on the fertile lands (green spaces) as well as it became a major reason for many environmental problems, waste disposal and water pollution (blue spaces) as specified by the U.N Conference on Human settlement. The changes in blue-green infrastructure in urban land should be regulated to maintain the balance in the urban ecosystem. Land use and land cover changes may have four main direct implications on the water quality: they can cause droughts, floods and changes in river and groundwater quality [11]. Globally, countries have been facing a change in the environment due to population growth, increased agricultural production, increasing demand for natural resources, climate change and resultant degradation of the natural environment [12]. Thus, highlighting the necessity of investigating the influence of LULC changes, which is critical to enable policy and decision-makers for sustainable planning and management and a safe ecological system [13]. One way of monitoring this changing scenario is by land use land cover change detection analysis. Change detection analysis is a preferred technique for understanding the changes in urban blue-green

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infrastructure.

1.1 Background

Around the onset of the previous decade, the word 'blue-green' or 'green/blue infrastructure developed from rising awareness of the need for more integrated planning to manage Green and Blue Infrastructure [14]. Green infrastructure networks that are interconnected can improve community resiliency by enhancing water supplies, decreasing floods, combating the urban heat island effect, and improving water quality (EPA, 2016)[15].

The land-use and land-cover pattern of urban infrastructure results from natural and socio-economic factors and their utilization by humans in time and space. Hence, for selection, urban planning and implantation of land use, information on land use land cover is essential and can be used to meet the increasing demands for basic human needs and welfare. There has been a significant change in blue-green spaces in the urban environment for the past few decades. For sustainability of the increasing urban land, there needs to be a harmonic interaction with nature. This can be possible by proper monitoring and management of natural resources that are water and land.

1.2 Role of Remote sensing and GIS in Change Detection Analysis

Remote sensing data and geographic information systems (GIS) have been recognized as efficacious techniques for identifying urban sprawl [16] [17] . When combined with a global positioning system and geographic information system, remote sensing can better detect land use and land cover changes. With various methodologies and data sets, remote sensing (RS) has been used to categorize and map land cover and land-use changes. Landsat images, in particular, have been instrumental in the classification of various topography components on a broader scale [18]. Remote sensing technology is previously used in many studies giving effective results for both land-use change detection studies and urban land use expansion modelling.

Change detection is a significant application of remote sensing, enabling the handler to analyze the changes in LULC as it reaches consistent coverage at short intervals. Change detection systematically assesses and correlates images captured from the same area at different periods and, as a result, shows the various land transformations that have occurred. Change detection analysis permits both short and long term transformations to be depicted, and in order to accomplish this, the process employs multi-temporal datasets.

Several studies on land use land cover changes using GIS and remote sensing has been carried out. This is due to alarming rise in the population and urban regions. Heikkonen et al. (1998) used remote sensing to classify urban areas. Extraction, selection, and classification were all done using algorithms. Landsat TM and ERS-1 SA images were used to classify. The CART (classification and Regression Trees)-based system demonstrated potential in classifying images of varying sizes and orientations. Praveen et al. (2013) studied the variation in land use and land cover in Tirupati's urban area from 1976 to 2003. Classification was accomplished using GIS and remote sensing techniques. In this classification analysis, eight categories were investigated. The study examined the data and discovered a considerable growth in built-up areas. The strategy of using GIS and remote sensing resulted in a better examination of the study area located in Tirupati's mountainous hills. Rwanga and Ndambuki (2017) identified remote sensing as a significant tool for LU/LC alterations. Common LULC classification like, built-up , water bodies and barren land were categorized. The overall classification accuracy of the study was 81.7 percent, with a kappa coefficient (K) of 0.722. The kappa coefficient is considered significant. Zhang and Zhang (2020) evaluated the changes in land cover in the Lower Yangtze River basin for 30 years. Landsat remote sensing images were used in conjunction with the powerful technology Google Earth Engine. According to the study, the effects of increasing urban population and expanding industrial growth were the primary causes driving the expansion of urban built-up areas and significant decline in vegetation. Gogoi et al. (2019) demonstrated that LULC has a major impact on climate via multiple pathways. The study found that changes in LULC are linked to the increased warming that has occurred in the eastern state of Odisha during the last decade. LULC has enormous potential for detecting climatic impacts such as temperature, rainfall, and crop patterns.

The objective of this study is to detect the changes in the urban environment of blue-green spaces. The change detection is studied between two water bodies and their surrounding environment from 1997 till 2019 in Hyderabad city, Telangana state, India. Most of the studies have focussed on land use land cover changes, and this paper aims to detect and analyse the changes within the urban concerning the blue-green infrastructure.

II. STUDY AREA

The area of concern for the present study is IDL Swan lake and Buffalo lake watersheds located in the western part of Hyderabad, Telangana State. The latitude, longitude and area is shown in table 1 and figure 1 shows the study area location of the map.

III. METHODOLOGY

The detailed methodology followed for this study is discussed in the following subsection.

3.1 Data Collection

The current analysis is based on geographical remote

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sensing data as well as non-spatial data from diverse sources for various time periods. ASTER Global Digital Elevation Model (GDEM) data acquired by the ASTER satellite was used to delineate the watersheds of IDL Swan lake and Buffalo lake for which change detection analysis was performed. Satellite data from the United States Geological Survey (USGS) Earth Explorer (https://earthexplorer.usgs.gov/) for the years 1997, 2002, 2007, 2013, and 2019 (Table 2) were utilized for visual image interpretation and identifying Changes .

3.2 Preprocessing of Collected Data

3.2.1 ASTER GDEM

In this research, ASTER GDEM of the study region with the 30-meter spatial resolution was obtained for watershed delineation. Watershed delineation entails drawing a line that reflects the region that contributes to a control point or outflow. The watersheds of the study area were generated Figure 2 depicts the process flow diagram used for watershed delineation.

3.2.2. Landsat Imagery

All the downloaded images from USGS earth explorer contains multiple bands which have to be stacked to produce a composite image. The images were pre-processed for periodic noise reduction and Histogram equalization increase the quality of the pictures. Watersheds created for and are converted to shapefiles and boundary of the watersheds retrieved from the Landsat images for five different years . The extracted images from Landsat imagery are displayed in Figure 3.

3.3 Image Classification

Satellite image pre-processing prior to detecting change is immensely essential and has a distinct primary aim of establishing a more direct affiliation between the obtained data and biophysical phenomena [19]. All satellite data was analyzed by assigning pixel signatures and dividing the watershed into five groups based on distinct terrain features. A suitable spectral signature guarantees that there is 'minimal confusion' among the land covers to be mapped [20]. The recognized classifications for this study are Vegetation land, water bodies, Urban land and Open land. Following that, the maximum likelihood method was employed to perform supervised image classification.

3.4 Accuracy Assessment

Accuracy Assessment falls under post classification method after executing the fundamental digital classification process, conducting accuracy assessment is the next crucial stage in LULC change research. It is used primarily to describe the degree to which a classification is viewed as accurate. It is used mainly to express the degree to which classification is considered correct. Accuracy assessments with quantitative are based on the quantified parameters, which are comparable, while assessment of qualitative features is based on visually comparing results found to that are seen on the surface of the ground.

IV. RESULTS AND DISCUSSIONS

The classified images obtained after pre-processing and supervised classification illustrating the IDL swan and Buffalo lake watershed region are presented in the figure 4. These categorized images are presenting the changes in the physical features of the study area for the year 1997, 2002, 2007, 2013 and 2019. The blue colour denotes the water bodies, the green colour symbolizes the vegetation land, the red colour urban land, and the cream colour displays the open area. Accuracy assessment and change detection analysis were performed.

4.1. Accuracy Assessment Report

The land use land cover map of the study area generated for 1997, 2002, 2007, 2013 and 2019 using supervised classification. The accuracy assessment was carried out to get the user's accuracy. Accuracy evaluation was based on the ground truth signatures of the study area. The ground truth was gathered through field survey and google earth for interpretation. The highest user and producers accuracy was attained for the water body class in all four watersheds.

Nevertheless, the accuracy attained for all the classes is satisfactory and coincides with the change in the visual classification. Overall, the kappa coefficient achieved for each class were satisfactory. Below are the accuracy report received after classification for different years displayed in tables 3 and 4.

4.2. Land Use Land Cover Change Detection Analysis Results

Land use land cover change detection analysis has been conducted for the years 1997, 2002, 2007, 2013 and 2019 and shown in tables 7 to 10. The changes in the area for each classification for different years are analyzed and compared.

In IDL Swan Lake, the end results from 1997 to 2019 reveals that vegetation land declined by 25.60 percent, and waterbody has grown by 8.7 percent. The growth in the water body does not reflect the aerial extent, but it is due to the existence of a sewage treatment plant at its upstream, which provides a constant flow of domestic wastewater throughout the year, therefore, giving a water body appearance. The Built-up area rose from 36 to 70.56 hectares and vegetation has declined considerably from 261.40 hectares to 103.10 hectares. It was observed at IDL Swan Lake watershed, there is a continuous decrease of vegetation from 1997 to 2019. The substantial reduction in vegetation is attributable to the removal of trees in that region to make way for high-rise apartments. The transition

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to urban land is characterized by a shift in vegetation and open space. The acreage of water bodies increased in 2007, but subsequently dropped by 2019. Algae and water hyacinth have colonized the water body, resulting in a change in vegetation. This lake has also been a hotspot for biodiversity including birds, ducks, and fishes. Swan Lake served as a recreation area for the residents of the area. However, the water body has degraded, and the majority of the watershed has been changed from vegetation to urban area.

The statistics showed the deterioration of Buffalo lake waterbody from 1997-2019 by 9.77 percent . Vegetation land has reduced by 23.07 percent and 12.88 percent correspondingly. Compared to the above IDL Swan lake, the transformation was not that great since these Buffalo lake is situated inside the Hyderabad Central University, due to a regulated environment. Water bodies and vegetation in the Buffalo watershed indicate little change. The development of urban land has caused a change in open land and vegetation. Due to the existence of freshwater algae, the area of the water body has changed minimally. The biodiversity of these watersheds' flora, wildlife, birds, fishes, and insects has not been impacted. Unlike IDL Swan Lake, which are located within urban infrastructure, these water bodies are located within the university, a controlled setting with limited change.

V. CONCLUSIONS

This research aims to examine changes in land use and land cover and their impact on blue-green infrastructure in urban environments from 1997 to 2019. The identification of change has been detected in two separate watersheds located in two different locales. The study highlighted the effects of LULC alterations on vegetation and water bodies due to urban growth. The IDL Swan Lake watershed in the urban infrastructure, exhibited a significant rise in urban land of 36 to 70.56 hectares. According to the findings, the expansion of metropolitan areas has resulted in a significant decline in vegetation, water bodies, and open land. Whereas the watersheds in controlled environments, such as Buffalo, have seen minor changes in blue-green regions. As a result, unplanned, fast urbanization endangers the long-term viability by compromising crucial environmental components.

Continuous long term land use land cover change detection is essential as it assists in land management and decision making in the account of ecosystem’s organisms and natural processes. The green and blue spaces in the urban infrastructure are the most fundamental in urban ecology. The increasing urbanization decreases these water-vegetation areas, therefore, affecting the urban landscape. Disturbances in the environment like urbanization, pollution discharge into the water body and green cover loss may lead to the proliferation of non-invasive species like water hyacinth, impacting the lake ecology. In order to design and execute relevant policies and effective programs for sustainable regional development, there is a critical requirement to know the land use/land cover patterns in a specific region, which enables the urban planners to maintain sustainable development. Urban confinement policies are essential tools for control of urban growth, which are extensively used to limit unplanned urban expansion, shape the growth of urban areas, conserve open spaces, and safeguard the lakes. There should be distinct monitoring agencies and committees to ensure a sustainable environment.

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Figures and Tables

Figures:

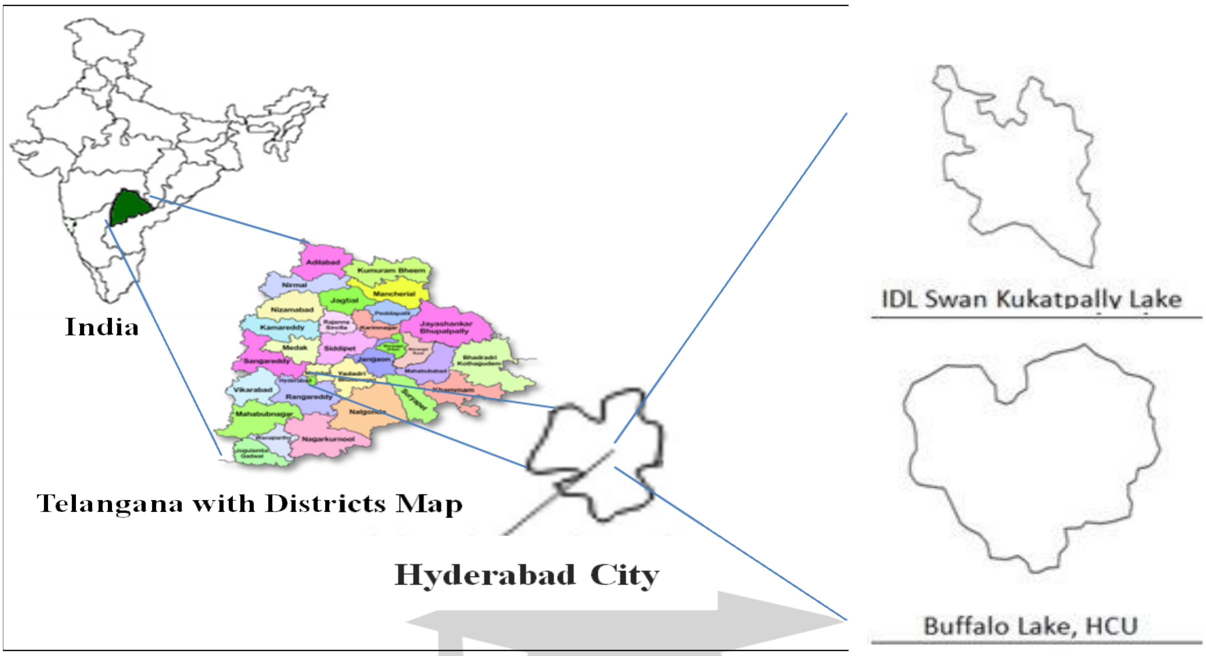

Fig. 1 Location of the study area

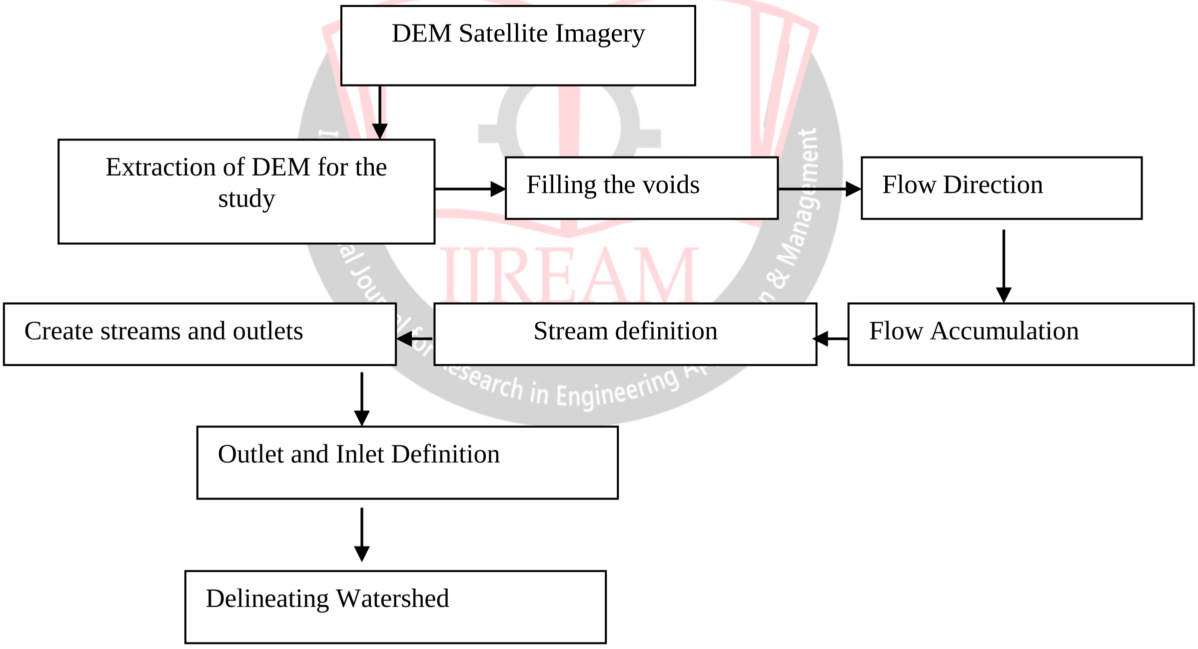

Fig. 2 Flowchart for watershed delineation

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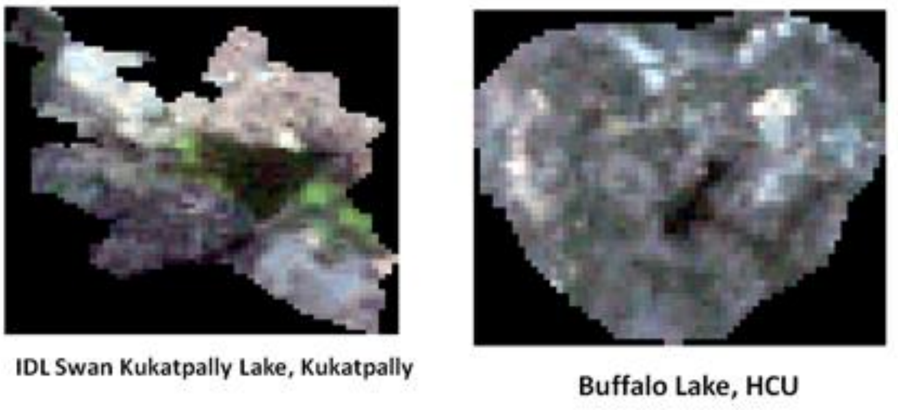

Fig. 3 Subset Satellite Images of the two Watersheds

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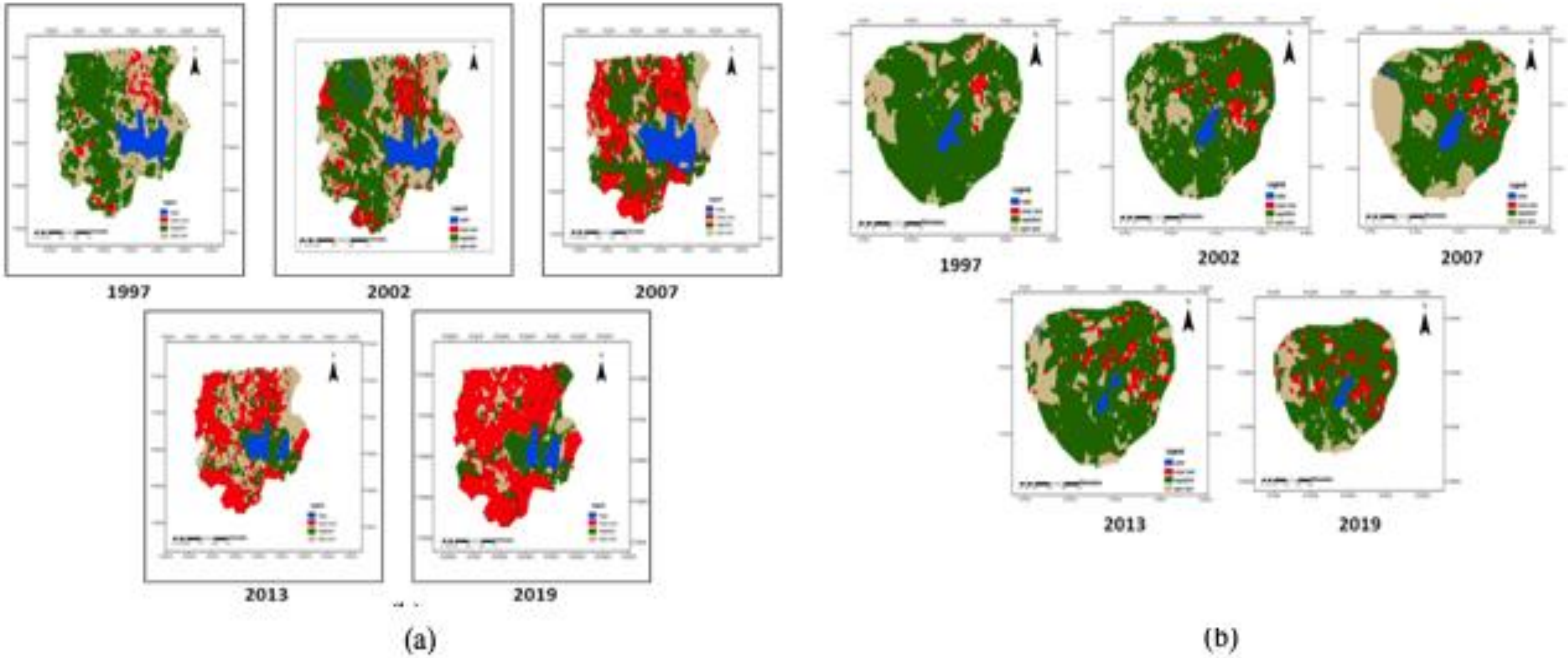

Fig. 4 Land Use Land Cover Change Detection Analysis for (a) IDL Swan Lake and (b) Buffalo Lake

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Tables:

Table 1. Geographic cordinates, area and location of the watersheds.

S.No	Watershed	Geo-cordinates	Area in Hecatres	Location
1	IDL Swan lake	17°29'12.98"N latitude -78°2411.08E longitude and 17°28'11.93"N latitude -78°25'06.22"E longitude	192	Kukatpally
2	Buffalo lake	17°27'27.78"N latitude -78°19'06.96"E longitude and 17°26'47.17"N latitude -78°19'42.16"E longitude	224	Hyderabad Central University

Table 2 Details of Landsat Data Collected

S. No	Date of Pass	Satellite/Sensor	Reference System/Path/Row
1	12-02-1997	Landsat5/TM	WRS-2/144/48
2	17-01-2002	Landsat7/ETM+	WRS-2/144/48
3	08-02-2007	Landsat7/ETM+	WRS-2/144/48
4	15-01-2013	Landsat7/ETM+	WRS-2/144/48
5	15-02-2019	Landsat7/ETM+	WRS-2/144/48

Table 3 Accuracy Report for IDL Swan lake watershed for the years 1997, 2002, 2007, 2013 and 2019

IDL Swan lake	1997		2002		2007		2013		2019	
Class	Producer's Accuracy	User's Accuracy	Producer's Accuracy	User's Accuracy	Producer's Accuracy	User's Accuracy	Producer's Accuracy	User's Accuracy	Producer's Accuracy	User's Accuracy
Water bodies	100%	100%	100%	100%	100%	100%	100%	75%	100%	100%
Vegetation	100%	95.65%	88.24%	100%	84.62%	90%	92.31%	85.71%	90%	100%
Urban land	100%	83.33%	85.71%	75%	100%	85.71%	90%	100%	100%	91.67%
Open land	66.67%	100%	100%	100%	100%	100%	75%	100%	80%	80%
Overall Classification Accuracy	94.59%		91.43		94.44		90		92.86	
Overall Kappa Statistics	0.90		0.87		0.92		0.85		0.89	

Table 4 Accuracy Report for Buffalo lake watershed for the years 1997, 2002, 2007, 2013 and 2019

Buffalo lake	1997		2002		2007		2013		2019	
Class	Producer's Accuracy	User's Accuracy	Producer's Accuracy	User's Accuracy	Producer's Accuracy	User's Accuracy	Producer's Accuracy	User's Accuracy	Producer's Accuracy	User's Accuracy
Water bodies	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Vegetation	100%	93.44%	98.36%	93.75%	94.74%	87.80%	97.67%	95.45%	96.23%	98.08%
Urban land	100%	100%	100%	100%	100%	100%	100%	88.89%	88.89%	88.89%
Open land	76.47%	100%	71.43%	90.91%	80.77%	91.30%	76.92%	90.91%	100%	92.86%
Overall Classification Accuracy	94.81%		92.50		89.71		94.12		96.10	
Overall Kappa Statistics	0.86		0.79		0.80		0.89		0.92	

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Table 5 Land use land cover change detection IDL Swan lake watershed for the years 1997, 2002, 2007, 2013 and 2019

IDL Swan lake		1997	2002	2007	2013	2019
S.No	**Name of the class**	**Area in ha**	**Area in ha**	**Area in ha**	**Area in ha**	**Area in ha**
1	Water body	11.34	17.30	16.47	10.44	12.33
2	Vegetation	89.28	83.76	77.58	89.1	66.42
3	Urban land	36	45.29	54.27	65.88	70.56
4	Open land	55.62	43.90	43.92	26.82	42.83

Table 6 Land use land cover change detection Buffalo lake watershed for the years 1997, 2002, 2007, 2013 and 2019

Buffalo lake		1997	2002	2007	2013	2019
S.No	**Name of the class**	**Area in ha**	**Area in ha**	**Area in ha**	**Area in ha**	**Area in ha**
1	Water body	5.32	5.46	7.80	3.69	4.8
2	Vegetation	173.62	159.75	135.63	156.95	151.25
3	Urban land	4.78	12.81	13.12	16.21	27.24
4	Open land	40.30	42.15	67.67	45.24	40.62

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