Spatio-temporal analysis through remote sensing and GIS in Hyderabad, Telangana

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ABSTRACT

Spatio-temporal analysis is a process for determining the Land Use & Land Cover(LULC) of a particular area. In this research work, three dates (2014, 2018 & 2023) satellite images were used for mapping and monitoring of Hyderabad, Telangana. This study focuses on the classification of the study area into different categories on the basis of use and association by implementing a rule-based classification system on remotely sensed data. The LULC categories which are used are -Waterbodies, Agriculture Land, Forest/Natural Vegetation, Built-up and Barren Land/Open Land). Landsat 8 and 9 satellite imagery have been used. QGIS is the software used, which is an open source software, which has a number of useful and accessible features, but also some limitations which will be made clear through this report.

INTRODUCTION

GIS stands for Geographic Information System. It is a computer-based system used to capture, store, analyze, manage, and present geospatial data. In simpler terms, GIS is a tool for visualizing, analyzing, and interpreting data that has a location component. GIS combines different types of data such as maps, aerial photographs, satellite imagery, and other geographic data with non-spatial data such as demographics, weather, and economic data. This integration allows users to understand relationships, patterns, and trends that are not easily visible with traditional methods.GIS has a wide range of applications in various fields such as environmental management, urban planning, public health, natural resource management, transportation planning, and many others.

Remote sensing enables the collection of data on the Earth's surface that may be difficult or impossible to obtain using traditional ground-based methods. Remote sensing data can be used to study a wide range of phenomena, including land cover, vegetation, soil moisture, ocean temperature, atmospheric conditions, and natural hazards such as wildfires and floods. Remote sensing data is typically collected in the form of digital images, which can be processed and analyzed using specialized software to extract information about the Earth's surface and environment. Remote sensing data is used in a variety of applications, including environmental monitoring, land use planning, agriculture, forestry, natural resource management, urban planning, and disaster response. Remote sensing technology has revolutionized the way we study and understand the Earth's systems and has enabled the development of a wide range of applications that benefit society.

STUDY AREA

Hyderabad is located in the southern part of India, in the state of Telangana. It is situated on the Deccan Plateau, along the banks of the Musi River. The coordinates of Hyderabad are 17.3850° N, 78.4867° E. Hyderabad is located in the state of Telangana, India. However, it is also the capital city of the neighbouring state of Andhra Pradesh until 2014, after which Telangana was formed as a separate state with Hyderabad as its capital. Hyderabad is located in the southern part of India, on the Deccan Plateau. The city is situated at an elevation of about 505 meters (1,657 feet) above sea level. The Musi River flows through the city from west to east. The climate of Hyderabad is classified as tropical savanna with hot summers and mild winters. The surrounding geography of Hyderabad is dominated by rocky terrain with low hills and plateaus. The region is rich in minerals, including iron ore, coal, and limestone. The area surrounding Hyderabad is predominantly agricultural, with crops such as rice, wheat, and sugarcane grown in the surrounding districts. Hyderabad is also known for its man-made lakes, including the Hussain Sagar Lake, which is located in the heart of the city. The lake was built in the 16th century to provide irrigation water and was later expanded to become a recreational spot for the city's residents. Today, it is a popular tourist destination and a major landmark of Hyderabad.

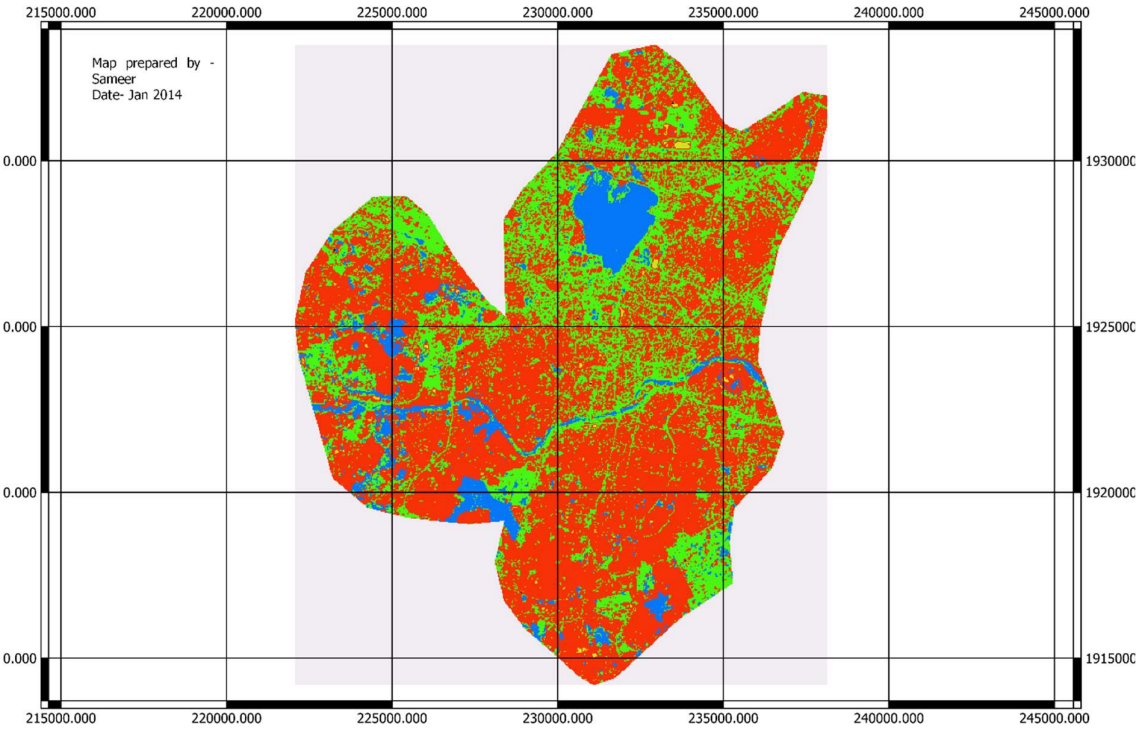
SOFTWARE AND METHODS USED

The Landsat program is a series of Earth-observing satellite missions jointly operated by the United States Geological Survey (USGS) and NASA. The program was established in 1972 and is the longest-running satellite program for Earth observation. The Landsat program has launched several satellites since its inception, each with improved capabilities and technological advancements. The most recent satellite in the series is Landsat 9, which was launched in September 2021. Landsat 9 is equipped with two main sensors, the Operational Land Imager 2 (OLI-2) and the Thermal Infrared Sensor 2 (TIRS-2), which enable high-quality data collection in the visible, near-infrared, and thermal infrared spectral regions. For the purposes of this study the LANDSAT 8 and 9 data is used. The software used for analysis is QGIS. QGIS (short for Quantum Geographic Information System) is a free, open-source geographic information system (GIS) software application that allows users to analyse and visualize geospatial data. QGIS is used for a wide range of tasks related to geospatial data, including data visualization, mapping, spatial analysis, and data management.

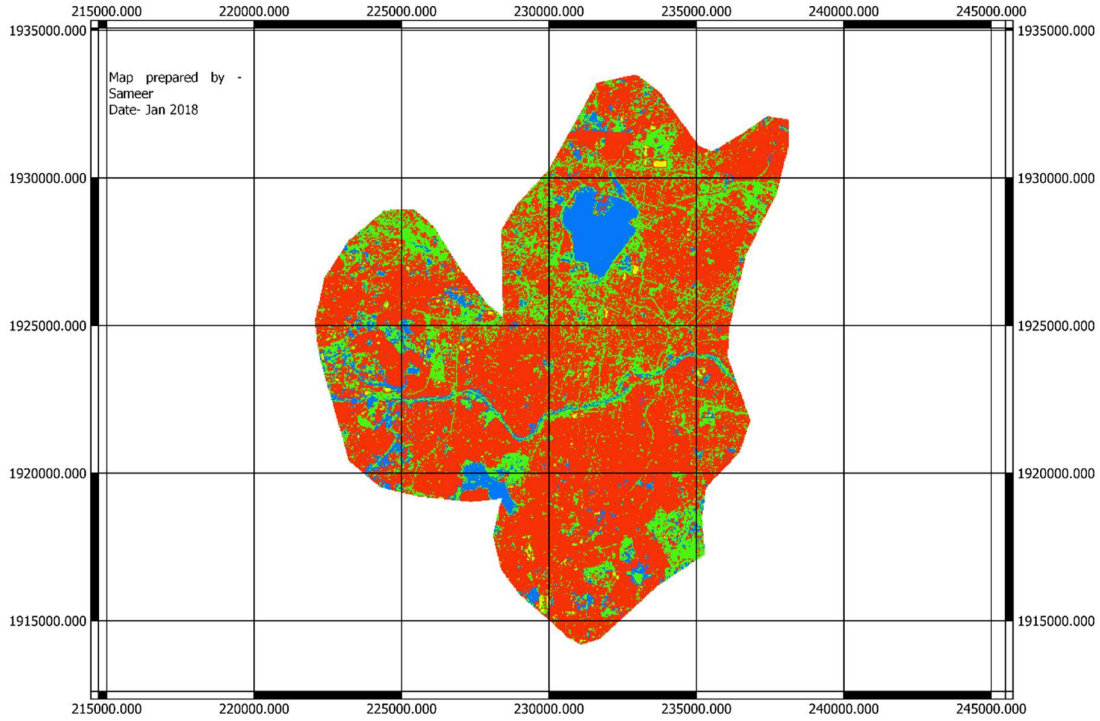
IMAGE CLASSIFICATION

For the purposes of this study only unsupervised classification of pixels is done.The overall objective of the image classification procedure is to automatically categorize all pixels in an image into land-cover classes or themes and the maximum likelihood classifier quantitatively evaluates both the variance and covariance of the category’s spectral response patterns whenever it classifies an unknown pixel. Although easy to perform, the unsupervised classification is not perfect and some areas get wrongly classified, regardless of the number of iterations run as the data fed to the algorithm is limited in scope and mere spectroscopic analysis does not produce completely accurate results. Still the use of spectral analysis allows us to observe broad LULC patterns for a certain area.

Land Use/Cover change detection and analysis-

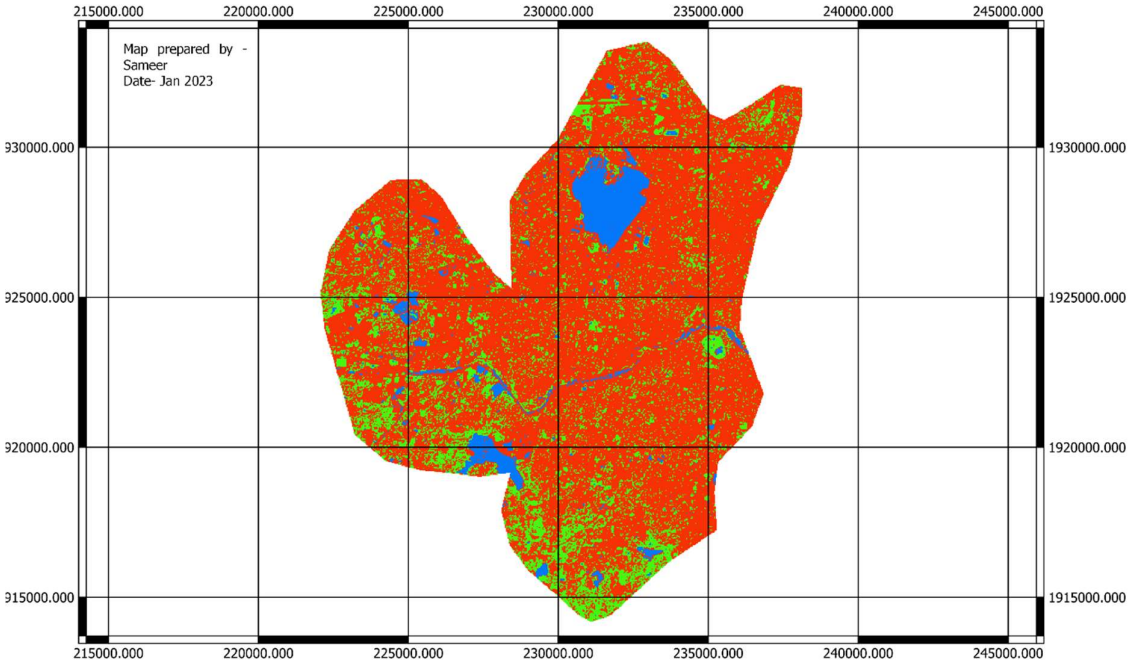


The above map is generated through unsupervised classification, initially the K- means method was used to cluster the data. But, the method was found lacking as it failed to distinguish between built up areas and water bodies in areas where they were closely situated. To rectify this the ISODAT method was used. Still, the QGIS system was not able to perfectly classify the system as it failed to distinguish between agricultural land and natural vegetation.



legend
- water bodies
- built up area
- barren land
- natural vegetation

The number of iterations used to obtain the initial classification was 25, with 10 classes. They were further reclassified into 4 classes as a separate agricultural class could not be obtained even if the number of iterations was further increased.



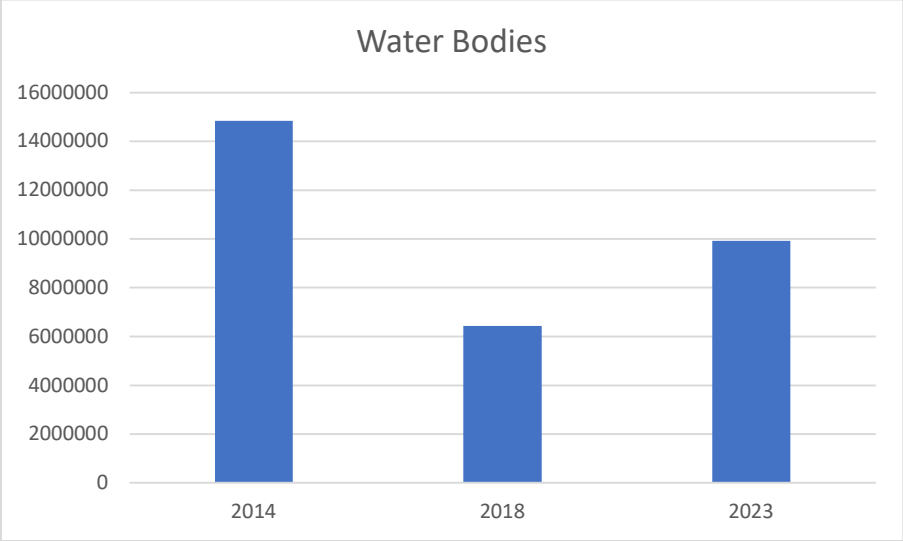
legend
- water bodies
- built up area
- barren land
- natural vegetation

The 4 classifications were further reduced to 3 as QGIS failed to detect barren land as a separate category in the 2023 map. Even from an initial look comparing the three maps we can see that there is a noticeable change in the Land Use/Cover change. There is a decrease in area of natural vegetation and a corresponding increase in area of built up area.

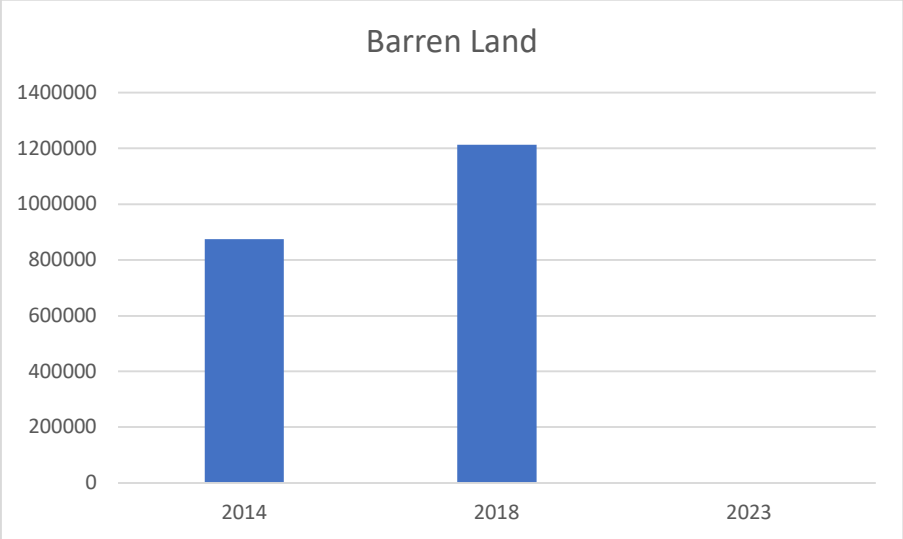
Results and Discussion

	2014	2018	2023
Natural Veg.	53811000	39194100	31360500
Water Bodies	14839200	6442200	9932400
Barren Land	874800	1213200	N.A
Built up area	10,86,25,500	121491900	136890000

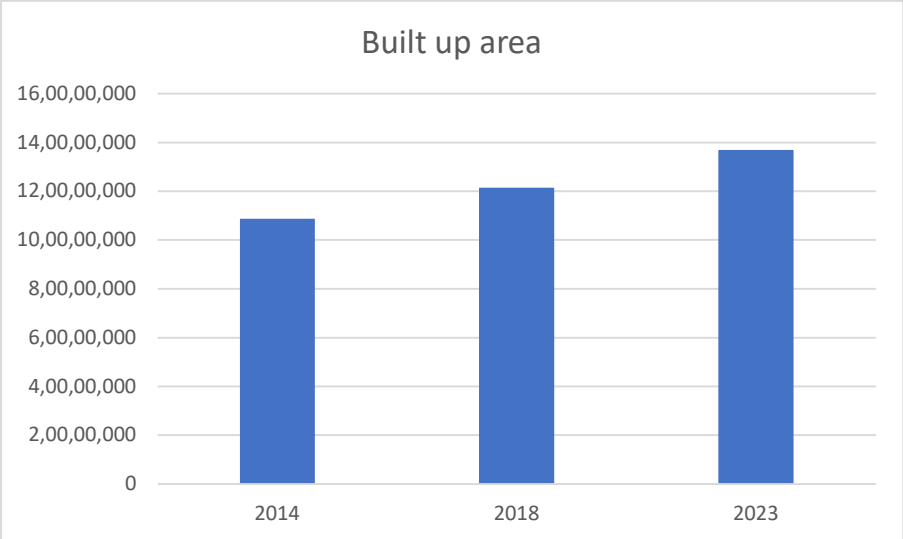
The above table, has been compiled by generating unique values report of raster. Tabulating data provides a way to store all the data in one place. But visualizing data allows us to look at a glance and draw inferences.



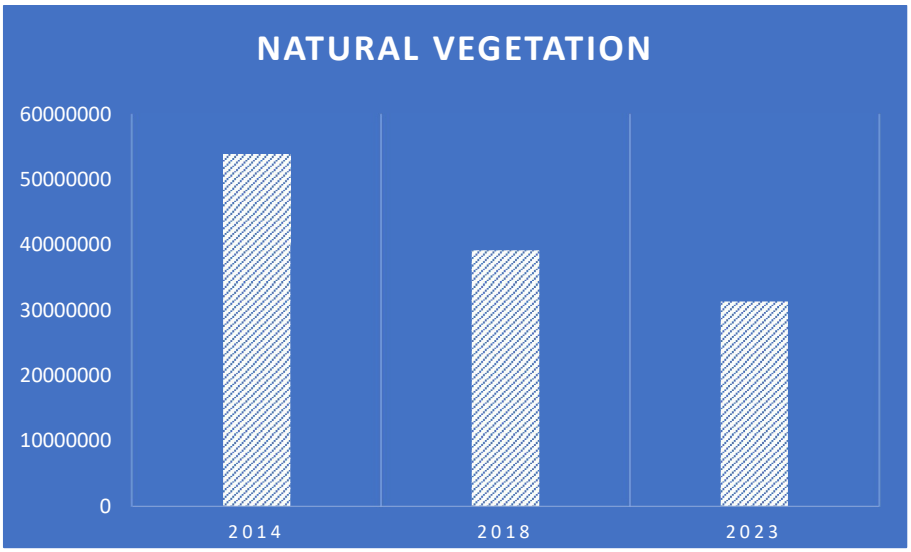
Water bodies saw a decrease from 2014 to 2018 but saw rejuvenation from 2018 to 2023.



Barren Land saw an increase from 2014 to 2018, but no inference can be drawn as barren land data was not available for 2023.



Built up area saw a continuous increase from 10,86,25,500 sq m in 2014 to 121491900 sq m in 2018 to 136890000 sq m in 2023.



The trend of natural vegetation is the most concerning, as natural vegetation fell from 53811000 sq m in 2014 to 121491900 sq m in 2018 to 31360500 sq m in 2023.