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# REMOTE SENSING AND GIS APPLICATION IN ANALYSIS OF LAND USE LAND COVER AND CHANGE ANALYSIS OF IN AND AROUND HYDERABAD CITY.

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**Abstract**

The discourse over environmental sustainability revolves around changes in land use and land cover because they are major contributors to global environmental change. As cities grow, they consume more and more farmland, forest, and water sources. Several urban environmental problems, including worsening air quality, more frequent and severe flooding due to enhanced runoff, higher average temperatures, a decline in water quality, and so on, can be traced back to unchecked urban sprawl. In this paper, we use the city of Hyderabad as a case to examine urban growth and land cover change from 2011 to 2021. Geographical land use variations that transpired during the study period are investigated using remote sensing techniques. Change detection analysis shows that Built-up area has been increased by 0.87%, Open scrub land has been increased by 1.93%, waste lands are decreased by 1.08%, Agricultural area land in Kharif crop has been increased by 0.14%, at the time of Rabi crop it was decreased by 93.35% and at the time of Double cropped area it was decreased by 2.06%; water bodies are reduced by 0.32%. The government of Telangana may have been responsible for the massive increase in new plantation (69%) with their Haritha haram programme. Local governments and urban planners can use the results of studies on urban development, land use, and land cover change to frame the city's long-term, environmentally friendly growth.

## INTRODUCTION

For centuries, humans have been changing the planet's appearance, but it was only in the last three that machines made significant inroads into the planet's landmass. More than two centuries have passed since Malthus (1798) first proposed the idea that rising populations would eventually exhaust the Earth's ability to sustainably produce food for everyone. As the Malthusian projection became more likely in the second half of the 20th century, serious efforts were made to investigate the connection between human population and environmental factors.

The term "land use" refers to how the land is put to work by humans, and it varies depending on the land's biophysical characteristics, the needs of humans for food, shelter, recreation, resource excavation and refining, and so on.

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The deterioration of tropical ecosystems and their environmental assets as a result of ongoing organic and chemical pollution from agriculture and industries is cause for grave concern (Benidick, 1999).

What we call "land cover" describes the variety of materials that can be found on the planet's surface, from water to plants to bare soil to manmade structures (Ellis, 2007). The effects of degradation on land cover are often more severe in developing countries than in developed ones because of population growth and the desire to maximise profit from scarce resources.

Accurate recognition of LULC types, precise data on current and historical land cover, assessment of the dynamics of these modifications, and the revelation of spatial structures of urban sprawl over time are all made possible by combining remote sensing data with geographic information systems (GIS) (Ioannou, K et al. 2021; Olorunfemi, I.E et al. 2020; Zhang, X et al. 2020; Bielecka, E. et al. 2020).

Contentment and quality of life in cities are negatively impacted by urbanization's many negative effects on the environment, such as pollution, warming, increased energy needs, and deterioration (Chen et al. 2006). Large shifts in the surface energy alignment of urban areas are brought on by these changes to the qualities of numerous land surfaces (Stewart and Oke 2012).

In the future, an even larger share of the world's population is projected to reside in urban areas, which are already home to more than half of the current population (World Health Organization 2010). Human-induced alterations to the planet's land use and cover (LU-LC) have compounded the effects of rapid urbanization on the climate (Jin et al. 2005).

The metrics of the degree of urbanisation that portray the environmental quality of urban regions are the impervious areas, like buildings, roads, parking lots, technical infrastructure, etc., and these increase as a result of urban sprawl. A city's structure and functionality (Sodczyk et al. 2020; Triantakonstantis et al. 2015), for example, are all influenced by the amount of land that has been developed. This includes the creation of urban heat islands (Hu X et al. 2017; Padmanaban R et al. 2019; Mitz E et al. 2021). Consequently, the variety of land cover and the arrangement of its components in area influence people's standard of living (Larondelle et al. 2014).

Growth in urban areas, whether due to demographic, economic, social, or political factors, is a dynamic and complex process that can have negative effects on LULC shifts (Sapena, M et al. 2019). The transition of natural vegetation cover and the fully operational of urban ecosystems are all impacted by these shifts, which are in large part ascertained by continuing processes of urban sprawl (Kiełkowska, J et al. 2018; Yu, Y et al. 2018; Ramachandra, T.V et al 2012).

Goal 11.3.1 of the Sustainable Development Goals (SDGs) emphasizes the importance of effectiveness of "the land consumption rate to the population growth rate" for the advantage of the sustainable urbanisation and improvement of possibilities for

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participatory, incorporated and sustainable urban planning and management (Sleszy'nski et al., 2020; Sleszy'nski et al., 2016).

Because urbanisation occurs at a faster rate than the overall population, this lag can't be detected by looking at numbers alone. The need to precisely recognise and consistently evaluate spatial variation in LULC over the long term is evident from the fact that this is a prerequisite for evaluating urban growth (Castanho, R.A et al 2019; El Mendili, L et al. 2020; Gibas, P et al. 2020).

According to the research of K. Sundara kumar et al. (2012), who used the city of Hyderabad as a case study spanning the 22 years from 1989 to 2011, both urbanisation and land cover change occurred during that time. Changes in land use across the study area are analysed using satellite imagery acquired via remote sensing. Built-up area is up 86.35 percent, open land is up 139.6 percent, agricultural land is down 24.5 percent, and water bodies are down 53.41 percent, according to the change detection analysis.

Satellite data can focus on providing precious data concerning land cover change, as demonstrated by the research of Vittek, Brink, et al., 2014, who used a structured specimen of satellite imagery to analyse land cover changes in West Africa between 1975 and 1990.

Demissie et al. 2017 is another groundbreaking study that uses classified Landsat satellite data to investigate the causes of land use change in Gonder, Ethiopia. Sixty-one percent of the area analysed in the study had land use shifts during the time period of the study.

The author referred to a thorough study of the causes of urban sprawl, including factors such as local geography, zoning laws, population density, job availability, and Euclidean distance from major thoroughfares, train stations, shopping centres, religious landmarks, and more. For the city of Ahmedabad, a composite design is utilised to anticipate LULC by incorporating strategic reasoning and deterministic development designs. The results show that the increase in population is the primary driver of LULC changes due to the need for more space to accommodate residents (Mustafa et al. 2018).

The current research endeavours to utilise multi-temporal data to track and evaluate LU/LC shifts in Hyderabad. Using remote sensing data, this study aims to assess LULC changes from 2011 to 2021.

## MATERIALS AND METHODS

### Study Area:

Hyderabad (coordinates: 17°21′42″N 78°28′29″E), the capital and most populous city of the Indian state of Telangana. With 6.9 million residents (from within the city limits and the surrounding municipal zone) and 9.7 million (from within and the surrounding metropolitan region), the 2011 Indian Census ranked Hyderabad as the fourth most

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populous city in India. Hyderabad has the fifth-largest economy in India, producing a GDP of US$74 billion in 2016.

### Study Objectives

The purpose of this research work is to utilise satellite data, collateral data, and field data to create digital thematic maps on the ARC/INFO GIS platform. The spatial database is made up of these elements.

## METHODOLOGY

### Base Map

Base Map of the Study Area Satellite Data: The 1:50000 scale Survey of India Toposheet was used to create the base map for the research area. All cities, roads, bodies of water, and wooded areas are considered. All the towns' sizes are revised and expanded after a comparison between the Survey of India's topographic maps and the satellite image (Figure 1).

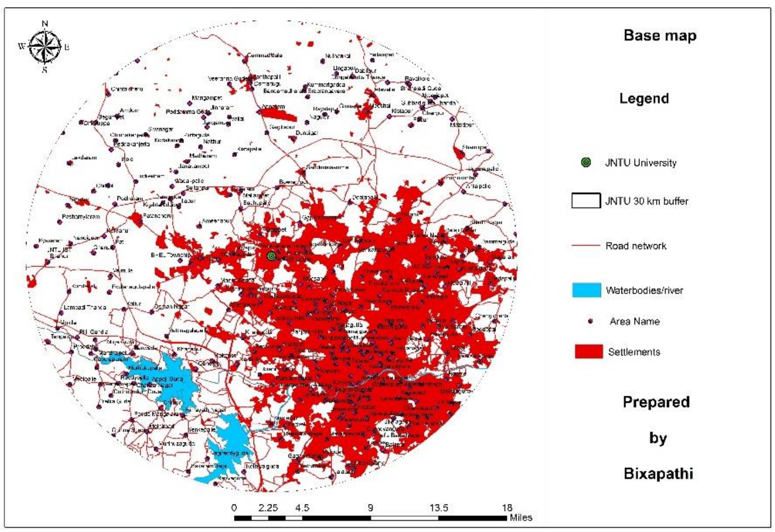


**Figure 1: Base map of the study area**

### Drainage Map

A clear demarcation between the arid and humid zones exists across all the water bodies. Over time, these wet (water-spread) regions shift, and new tanks appear in satellite imagery. Therefore, satellite imagery is used to create an upgraded drainage map (Figure 2). Current drainage follows a Dendritic Drainage pattern.

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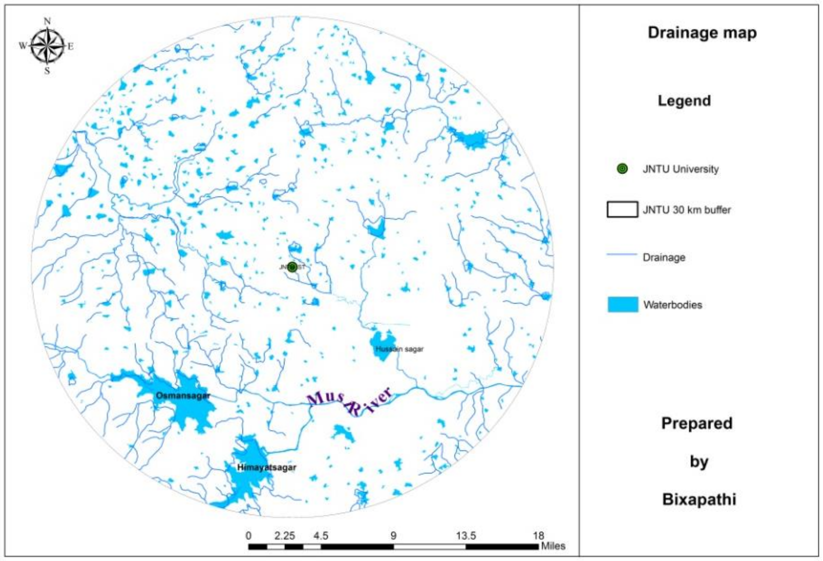


**Figure 2: Drainage map of the study area**

## Road network map

Research investigating the impacts of air pollution on the environment. In the past, researchers have measured their traffic areas exposure to air pollution in a variety of ways. Exposure assessment must consider the large amount of spatial variation within cities caused by traffic. Exposures from vehicular traffic are represented on a road network map (Figure 3) based on how close a home is to major thoroughfares.

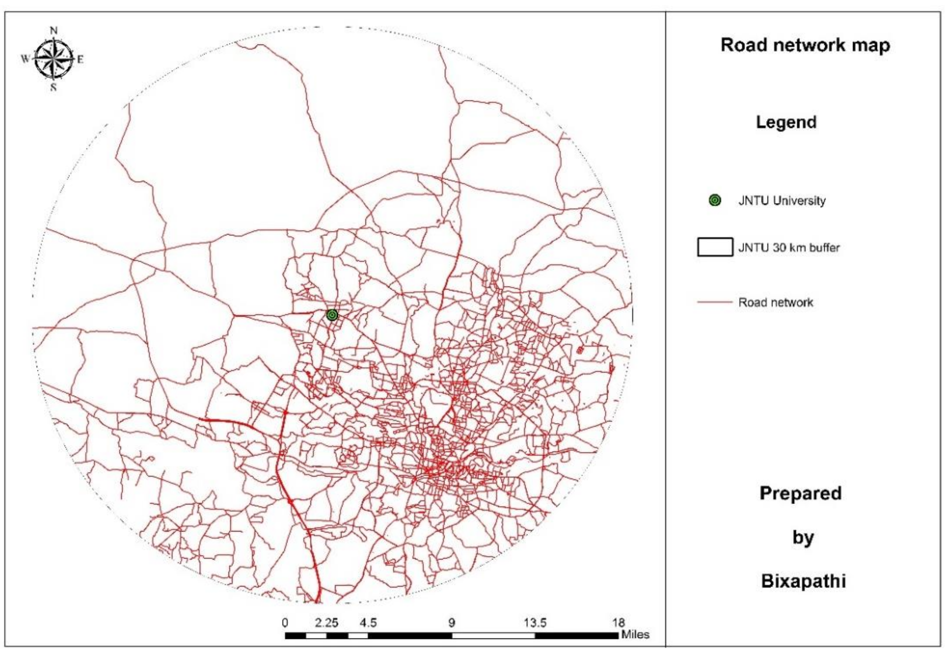


**Figure 3: Road network map of the study area**

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### Techniques for Land use land cover mapping:

Defining the strategy employed to map land use and land cover. Both basic and ground information are required for delving into the data and drawing inferences.

Basic data include:

Satellite-derived topographical sheets Local insight Reports and other materials pertaining to the study area Maps of the area at various scales to facilitate detail transfer

**a. On-the-Ground Information:** On-the-Ground Information is Critical for Validating and Improving the Accuracy of the Interpreted Classes, while also reducing the Need for Field Work.

**b. Data analysis:** The study can be broken down into three sections for analysing and interpreting satellite data: Planning and Preparation; Field Research; Analysis and Reporting.

**c. Preliminary work consists of the goals of this study are:** To understand the constraints of satellite data; To specify the criteria for the land use classification to be adopted; To determine the size of mapping units, which is scale-dependent; Classification of land uses and land covers and their interpretation; Outlining areas of uncertainty; Making a land use/land cover map of the field.

**d. Fieldwork:** What kind of ground data needs to be collected; How to pick a section to classify; Verifying questionable spots; Misclassification, new construction, and renaming all contributing to a shift in land use and land cover; Commonplace Assurance.

Following data collection, we perform the following steps to create a final land use/land cover map; reinterpretation and analysis or correction of doubtful areas; transfer of details on base map; marginal information.

## RESULTS AD DISCUSSION:

### Land use / Land cover Classification

Classification methods based on satellite data should provide a framework to meet the requirements of most users; therefore, it is important to take into account specific requirements and constraints of satellite data and research area, especially as they pertain to Indian conditions, in the specific situation of creating a new classification system. There needs to be a set of rules and standards by which these can be judged.

- Classifications of land use and land cover should be thorough, supported by solid science, useful in a variety of contexts, and applicable over large areas. The classification system needs to be adaptable so that it can be used at various scales and set of numerical.

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- In order to explain land use and land cover categorizations with the fewest possible classification models (less the classifiers used in the definition, less the errors expected and less time and resources necessary for field validation). Multi-seasonal satellite data use should be supported by the classification system
- A subjective judgement is required to determine the most suitable classification or data level within a classification. A choice must be made between the granularity of the images and the specificity of the data representation. Level-I information will be represented by data at a scale of 1:250,000; Level-II information at a scale of 1:50,000; Level-III information at a scale of 1:10,000; and Level-V information at a scale of 1:5,000.
- Based on the scale of mapping, the minimum inference precision and consistency for identifying land use/land cover classifications from satellite data should be at least 85-95 percent. Some of the related classifications may be extrapolated due to certain constraints of satellite data; for instance, forest and wooded land can be put under the primary position "Forest."

**Assessment of Land Use and Land Cover Changes between 2011 to 2021**

The classified image from 2011 and 2021 is displayed in the figures 4&5. Cities, grass, forests, farms, deserts, and bodies of water are all represented by different shades of red, green, yellow, orange, white, and blue. The percentage of land that is open, agricultural, or grassland is decreasing from the 2011 classified image to the 2021 classified image, while the percentage that is built up or covered by trees is gradually increasing. Greater urbanisation is occurring primarily in already-developed metropolitan areas, which are rapidly expanding into surrounding countryside. Within the last decade, we have seen a reduction in farmland and grassland. Because of human interference, the patterns are shifting randomly. Formerly farmable and forested land is being developed into urban centres. There has been an exponential growth in the concrete jungle. The figure illustrates the unbalanced nature of uraban's expansion and development. Despite the apparent expansion of forest cover, the size of the body of water appears to have shrunk. As a result of a lack of farmers and internal migration, it appears that some formerly arable land has been converted into forest. Some of the arid regions have also been developed into forests and human communities. Land use has changed dramatically between 2011 and 2021, as seen in an analysis of satellite images. Also, the rate at which people are settling new areas and building new things has increased dramatically, though it seems to be happening more at random.

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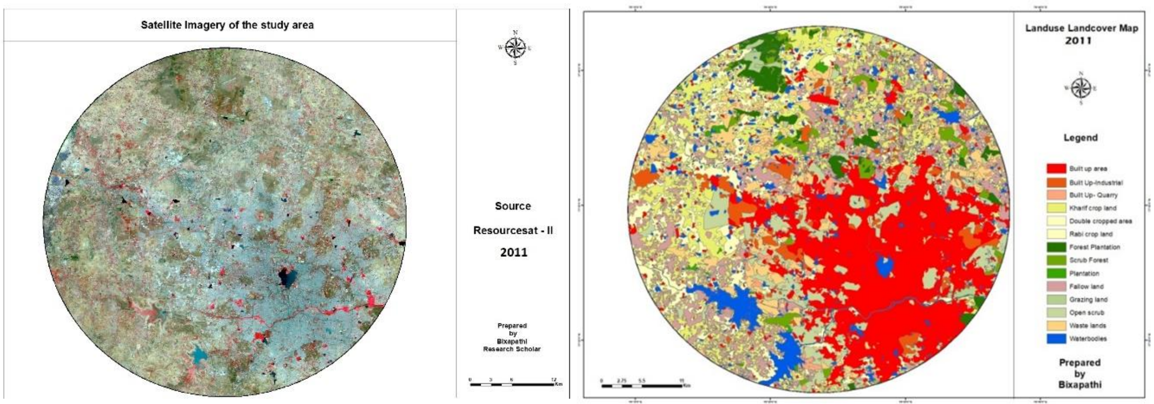


**Figure 4: Land Use Land cover map of study area for the year 2011**

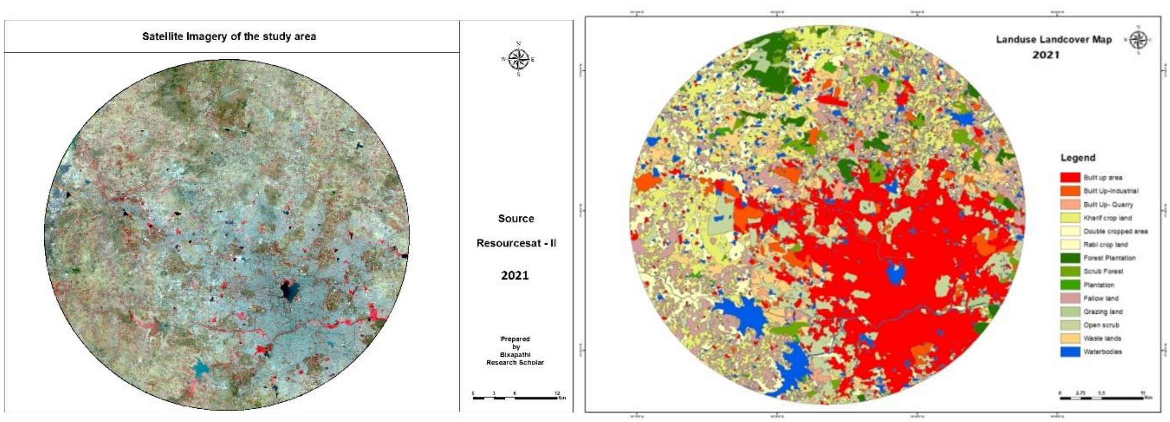


**Figure 5: Land Use Land cover map of study area for the year 2021**

## Land Use and Land Cover Change through LULC Transition Matrix

The last step in this analysis is the creation of the LULC transition matrix (Table 1), which shows the changes that occurred between each class and how they relate to one another. This could show, for instance, how much land in the dunes was transformed into places with sparse vegetation (Olofsson, P et al. 2014). The changes confirmed by the precision matrix are summed up here in terms of actual surface area in this matrix. The analysis has one drawback in that it ignores what occurred during the gap between the two years. It does, however, highlight an excellent tool for studies in which LULC changes and the potential drivers forcing those changes are the focus of interest. Reference areas for classes across all years under consideration are shown along the main diagonal. For each group, there are two columns "loss" and "gain" that show how much land was sacrificed or gained. Every category's total gain or loss is determined by adding up the corresponding columns and rows of the reference area. In particular, the study focused on the bookends of the time frame, between 2011 and 2021. This matrix can be easily analysed. For instance, -40.72 km2 of water surface area was lost. There were positive effects from the conversion of waste land (-170.63 km2), shrubland (13.12 km2), mixed

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forest (0.0005 km2), and bare surfaces (0.0081 km2) to water bodies. However, these gains are being lost because of a variety of transitions, such as those from open scurb vegetation (319 km2) to bare surfaces (0.009 km2) and wetlands (0.0017 km2). These changes occurred exclusively between the two categories that were chosen.

**Table 1: Results of change detection analysis of study area during 2011-2021.**

| **Land Use Land Cover** | | | |
|---|---|---|---|
| Land Use-Level - I | Land Use-Level - II | 2011 | 2021 |
| Built up area | Built Up- Quarry | 1611.3 | 1611.32 |
| | Built Up-Industrial | 7851.1 | 7842.36 |
| | Built up area | 50147 | 50527.71 |
| Agricultur Area | Double cropped area | 24391 | 23888.84 |
| | Kharif crop land | 32382 | 32427.89 |
| | Rabi crop land | 724.38 | 48.15 |
| Forst Area | Fallow land | 22263 | 22254.93 |
| | Forest Plantation | 5598.1 | 5598.13 |
| | Plantation | 934.73 | 1581.73 |
| | Scrub Forest | 4526.2 | 4539.34 |
| Waste Lands | Open scrub | 16518 | 16837.48 |
| | Grazing land | 1628.3 | 1628.25 |
| | Waste lands | 15798 | 15627.04 |
| Water Bodies | Waterbodies | 12817 | 12776.44 |

Only the biggest shifts are covered here so as not to overwhelm the reader. Although residential land use has increased dramatically over the past decade, this increase pales in comparison to the characterised annual growth rate of about 5% in Hyderabad's industrial cities. Plantation areas increased by 647 $km^2$ and decreased by 0.003 $km^2$, respectively, reflecting both deforestation and reforestation practises, as well as more sustainable urbanisation development in some newly constructed residential, industrial, and commercial areas. However, a loss of 0.003 $km^2$ was recorded in the swamps. Since wetlands absorb some of the city's non-point pollution, their disappearance is a warning of the impending loss of ecological services such as biochemical processes and water purification. Finally, grassland and low-vegetation-density areas changed to bare surfaces, which was the most extreme example of this phenomenon. Eighty percent of the total gain in bare surfaces came from this third group, which gained 9.12 $km^2$, while the first two groups lost a combined total of 2.48 and 4.66 $km^2$.

## CONCLUSIONS

This study analysed data from 2011 to 2021 to determine changes in land use and land cover (LULC) in the metropolitan area surrounding Hyderabad, the capital city of the Indian state of Telangana. The annual land use variability was created using up-to-date data that is reliable for decision making and ecosystem preservation by utilising data from

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Geographic Information Systems (GIS) images, the NVDI spectral index, and field data. This research was conducted to update existing course resolution maps and provide details on the spatial distribution of land use in Hyderabad over the past decade. The positive outcomes can be summed up in four key areas: Vegetation types like mixed forest and low-density vegetation (bare surfaces, sparse vegetation, and grassland) have been maintained and enhanced over time thanks to reforestation or transition from other categories; (3) swamps have encountered significant deterioration over the past ten years; and (4) hiatuses have declined significantly.

Furthermore, this research showed how to use open-source tools to process publicly available Landsat data. It provided a reliable method for charting and evaluating changes in LULC over time. This methodology improves the use of remote sensing and scientific studies in Hyderabad and other parts of India, and it can be implemented in a similar fashion to larger datasets and other satellite products.

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- To locate sampling locations on the Topo sheets developed by the survey of India.
- To assess the air quality trends in different zones of the study area (Like. Traffic-Related, residential, commercial/mixed areas, roadside, and industrial zones, etc).
- To prepare inventory for different air pollutants and their pollution loads from various sources along with spatial and temporal distribution in the study area.
- To calculate Air Quality Index for the various monitored locations and preparation of spatial distribution maps for the air pollutants on the study area.
- Health Risk assessment of different age groups due to the inhalation dose of the various ambient air quality pollutants using well defined USEPA methods.
- Multivariate statistical analysis will be carried out for the obtained results to find the significance.
- To assess the effects of sources on ambient air quality under various Management/intervention/control options, and to outline a set of short-term and long-term steps that can be taken as acceptable and cost-effective air pollution mitigation strategies/plans to guarantee "Cleaner air in metropolitan areas."