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Assessment of Land Use/Land Cover Dynamics in the Osman Sagar and Himayat Sagar Catchments Using Remote Sensing and GIS Techniques

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Water bodies play a critical role in sustaining human life and maintaining ecological balance, especially in urban environments. However, in recent years, many water bodies have deteriorated significantly due to pollution, rapid urbanization, and encroachment. This study focuses on the catchment areas of Himayat Sagar and Osman Sagar—two of the most prominent drinking water sources for Hyderabad city. Osman Sagar supplies approximately 25 million gallons per day (MGD), while Himayat Sagar contributes around 15 MGD, both operating through gravity flow systems.

The protection and sustainability of these water bodies are closely linked to the conservation of their catchment areas, which are increasingly being engulfed by the expanding urban agglomeration of Hyderabad. To assess the impact of urban growth on these catchments, this study analyzes Land Use and Land Cover (LULC) changes over the years 2006, 2011, 2014, 2018, and 2023 using high-resolution LISS-IV satellite imagery.

The results indicate a significant increase in built-up area within both catchments. Between 2006 and 2023, the built-up area in the Himayat Sagar catchment increased by 29.08%, while the Osman Sagar catchment witnessed a dramatic rise of 101.80%. This rapid urban expansion is occurring primarily at the expense of agricultural and barren lands, posing a direct threat to the ecological integrity and water quality of these reservoirs.

Keywords - Catchment Area. Land Use/Land Cover (LULC), , Urbanization, Water Bodies.

1. Introduction

Urban water bodies are critical for ecological sustainability and human well-being, especially amid rapid urban growth. Hyderabad's twin reservoirs Osman Sagar and Himayat Sagar constructed in the early 20th century, serve as key sources of potable water and flood mitigation. These gravity-fed reservoirs were established in response to devastating floods and remain integral to the city's water infrastructure(C.Ramachandraiah et al., 2004).

Land use classification efforts began in the mid-1970s, initiated by standardized departmental frameworks under the National Aeronautics and Space Administration (NASA), as outlined by Anderson et al. (1971). In India, the National Remote Sensing Centre (NRSC), under the Department of Space, developed a Land Use/Land Cover (LULC) classification system comprising 24 categories up to Level-II. This system is optimized for mapping at a 1:250,000 scale, and it builds upon the foundational classification schemes (NRSA, 2004).

Over recent decades, Hyderabad has undergone dramatic urban expansion, driven by IT growth, infrastructure development, and population influx. High-resolution remote sensing studies reveal that built-up land in the city more than doubled between 2005 and 2016, increasing from approximately 38,863 hectares to 80,111 hectares—a change mirrored by a significant decline in rain-fed cropland and water bodies (Gumma et al., 2017). Such rapid urbanization, especially in western and eastern sectors, has led to heightened impervious surfaces, reduced agricultural space, and shrinking water bodies. The catchment areas of Osman Sagar and Himayat Sagar face serious degradation due to encroachment and unplanned development. Notably, studies indicate that their catchments have contracted drastically—approximately 80% for Osman Sagar and 70% for Himayat Sagar. Without timely intervention, projections warn these reservoirs could dry up by 2040 (Osman Sagar) and 2036 (Himayat Sagar), seriously threatening Hyderabad's water security. (C.Ramachandraiah et al., 2008).

Furthermore, regulatory protections such as the Government Order (GO-111), which previously restricted development around these catchments, have been weakened or rescinded, exacerbating vulnerabilities to encroachment and environmental degradation(Hindhu article , 2023)

2. Materials and Method

2.1 Study Area

The artificial lakes of Osmansagar and Himayat sagar are situated close to Hyderabad in the Ranga Reddy District of Telangana, India. Hyderabad gets its drinking water from these two reservoirs. The runoff and eventually the inflows into both reservoirs will be impacted by the changes in the catchment areas.Himayatsagar Reservoir was built in 1925 on the Esa River and sits 9.6 km southwest of Hyderabad, in latitudes 17º02'00" N to 17º21'15" N and longitudes 77º53'49" E to 78º26'48" E. Located 9.6 km west of Hyderabad, at latitudes 17º14'31" N to 17º29'50" N and longitudes 77º50'30" E to 78º20'4" E, is the Osmansagar reservoir, built in 1922 on the Musi River (Akhil et al 2019).The elevation range of 516 m through 730 m is found within the 1358.53 km2 catchment area of Himayatsagar

A small amount of the research area is located in the Indian state of Telangana's districts of Medak, Mahabubnagar, and Vikarabad. The Musi River, which has its source in the hills of Ananthagiri near Vikarabad in the Rangareddy District of Telangana, is a significant river that feeds the Himayatsagar and Osmansagar catchments shown in fig.1. It passes through Hyderabad city and then merges with the Aleruriver, primarily running west to east. It flows south and enters the Krishna river close to Wadapally at an elevation of roughly 61 meters. The Musi River has already traveled 267 kilometers when it meets the Krishna River. The watershed of study area spans 11268.6 km^2.

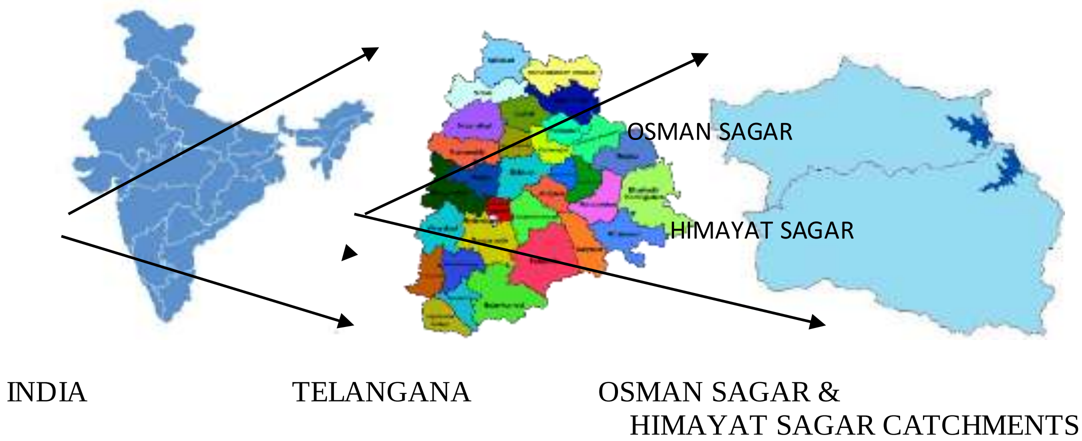

Fig. 1:Study Area Map

2.2 Satellite Data

Remotely sensed false color composite (FCC) prints of the research region obtained from IRS P6, Resourcesat-1, Resourcesat-2, and Resourcesat-2a LISS IV data. Four scenes of Resourcesat-1, Resourcesat-2, and Resourcesat-2a LISS IV data span the whole research area. The satellite data sets are used in the experiment are given below in table.1

Table: 1. Satellite data sets used in the study area

Sl. No.	Satellite	Sensor	Path-Row	Date of Pass
1	IRS P-6	LISS-IV 5.8 meter	99-60-D, 99-61-A, 100-60-C and 100-61-A	12-February-2006
2	IRS RS-2	LISS-IV 5.8 meter	99-60-D, 99-61-A, 100-60-C and 100-61-A	22-December-2011
3	IRS RS-2	LISS-IV 5.8 meter	99-60-D, 99-61-A, 100-60-C and 100-61-A	17-March-2014
4	IRS RS-2A	LISS-IV 5.8 meter	99-60-D, 99-61-A, 100-60-C and 100-61-A	13-April-2018
5	IRS RS-2A	LISS-IV 5.8 meter	99-60-D, 99-61-A, 100-60-C and 100-61-A	16-April- 2023

2.3 Image Processing

Layer-stacked images often exhibit weak spectral reflectance, leading to frequent misclassification by automated classification algorithms. This is primarily because several land-use types share similar spectral characteristics, making them difficult to distinguish (D Lu, 2017). Urban areas, in particular, present a complex mix of spectral signatures, which poses significant challenges for classification especially when using pixel-based methods on medium- and low-resolution satellite imagery(Ravi et al 2023).

Based on the satellite data summarized in Table 1, only the essential spectral bands Red, Green, Near Infrared (NIR), and Short-Wave Infrared (SWIR**)** were selected for band combinations. The remaining bands were used as reference layers for creating color composites to assist in identifying spatial and spectral characteristics (Anji Reddy, 2008). The administrative boundaries of the study area were digitized using topographic maps within ArcGIS 10.2.2**,** and a shapefile generated from this boundary was used to subset the satellite imagery in ERDAS Imagine 2015. False Color Composites (FCCs) for each satellite image were generated using consistent band combinations NIR, Red, and Green to accurately interpret the spectral signatures of different land cover types.

3. Results

3.1 Drainage Map

This geographic area provides groundwater flow, its saturated equivalent, runoff, and through flow to streams.

There are differences in the quantity, dimensions, and forms of the drainage basins, and more information is accessible with larger and more intricate topographic maps.

This map consists of all water bodies, rivers, tributaries, perennial & ephemeral streams, reservoirs, tanks, ponds and the entire drainage network from first order originating in the area to the last order joining the rivers, tributaries and tanks based on topography. Understanding the importance of drainage depends on the purpose and the objective of the project.

The study of the drainage is to determine how much the pollutants in the water would impact the ground water. The primary input data used to construct the drainage map are the toposheets from the Survey of India and summertime satellite imagery. The drainage map in fig. 2 is created at a 1:50,000 scale using Survey of India toposheets, and it is updated if deviations or new developments are noticed using the most recent satellite data.

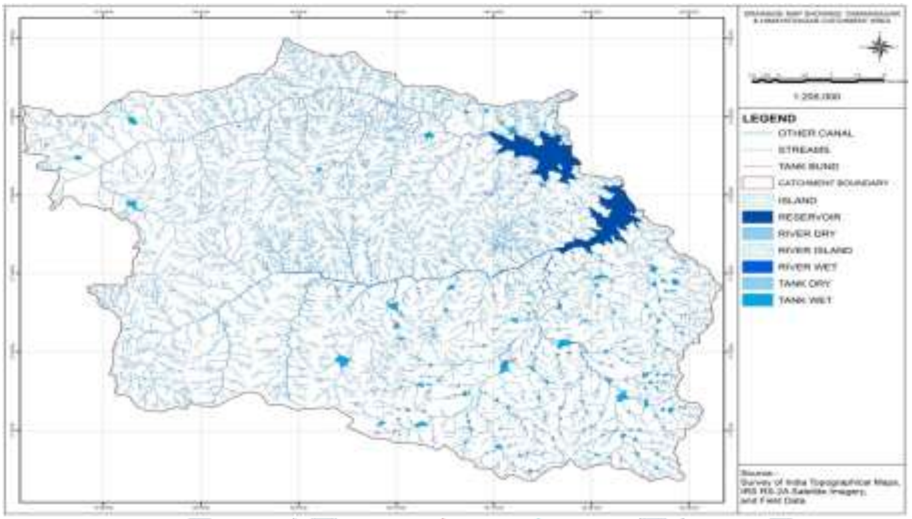

Fig.2.Map of Study Area

3.2 Land use / Land cover

Land use refers to man's activities and various uses, which are carried on land. Land cover refers to natural vegetation, water bodies, rock/soil, artificial cover and others resulting due to land transformation. Although land use is generally inferred based on the cover, yet both the terms land use and land cover are closely related and interchangeable. Information on the rate and kind of change in the use of land resources is essential to the proper planning, management and regulation of the use of such resources.

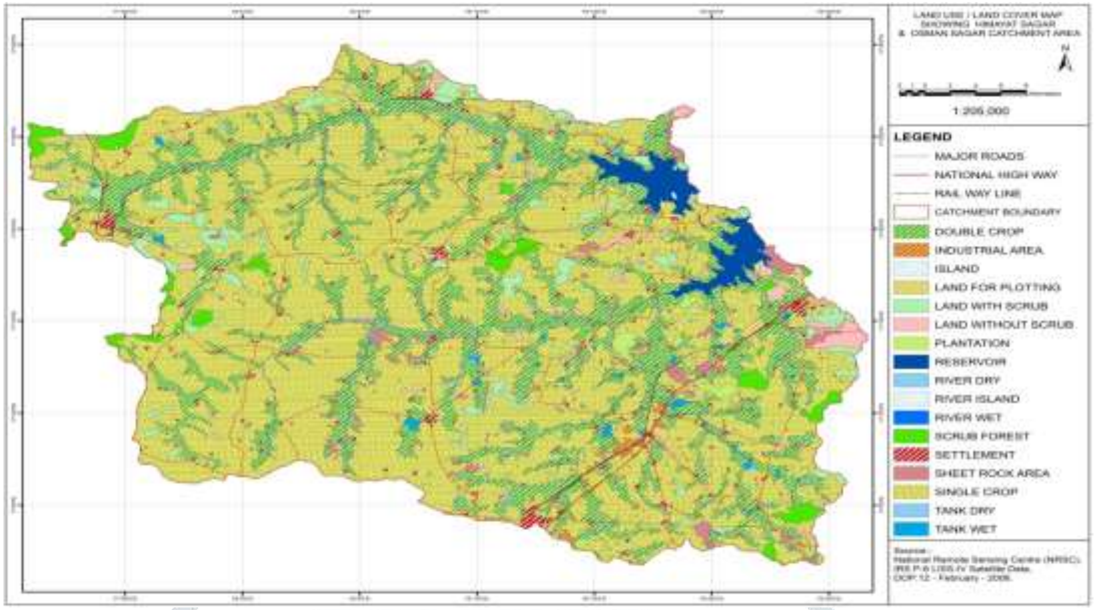

Fig.3 :Land Use/Land cover of study area - 2006

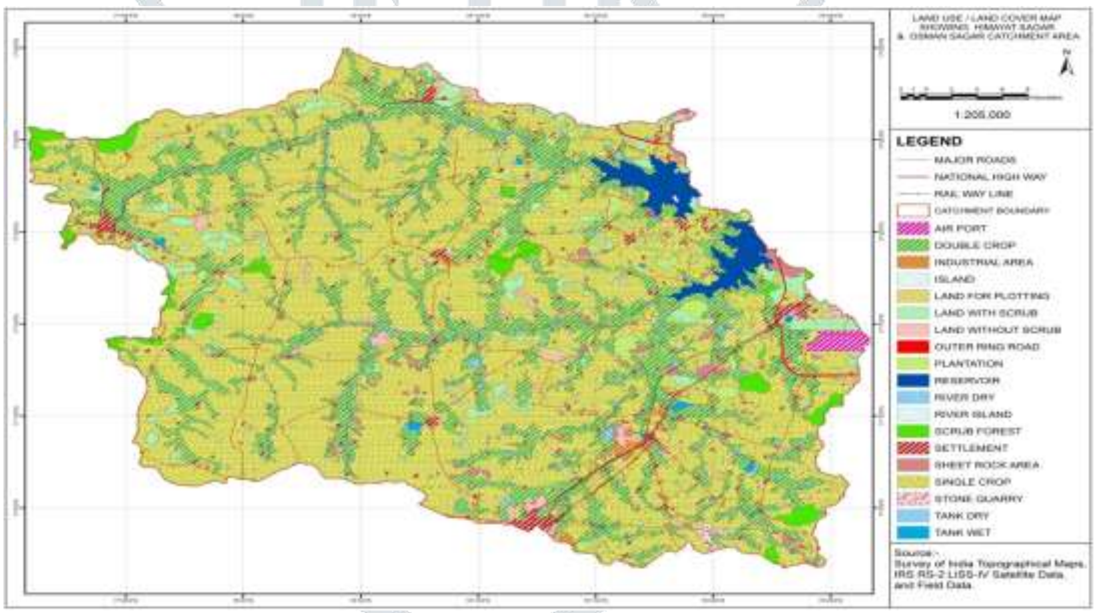

Fig.4 :Land Use/Land cover of study area - 2011

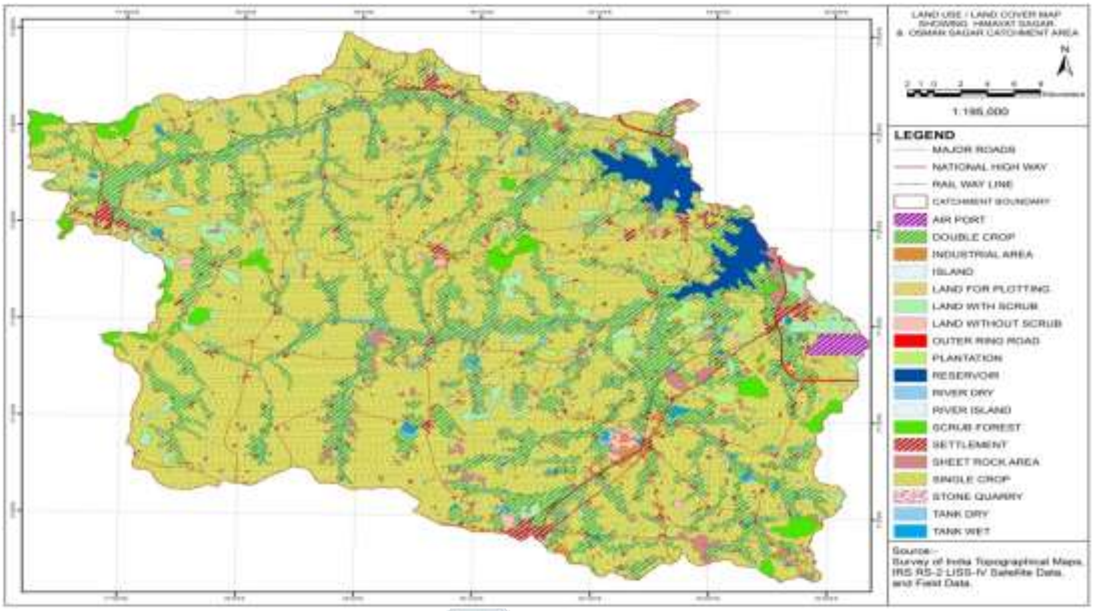

Fig.5 :Land Use/Land cover of study area - 2014

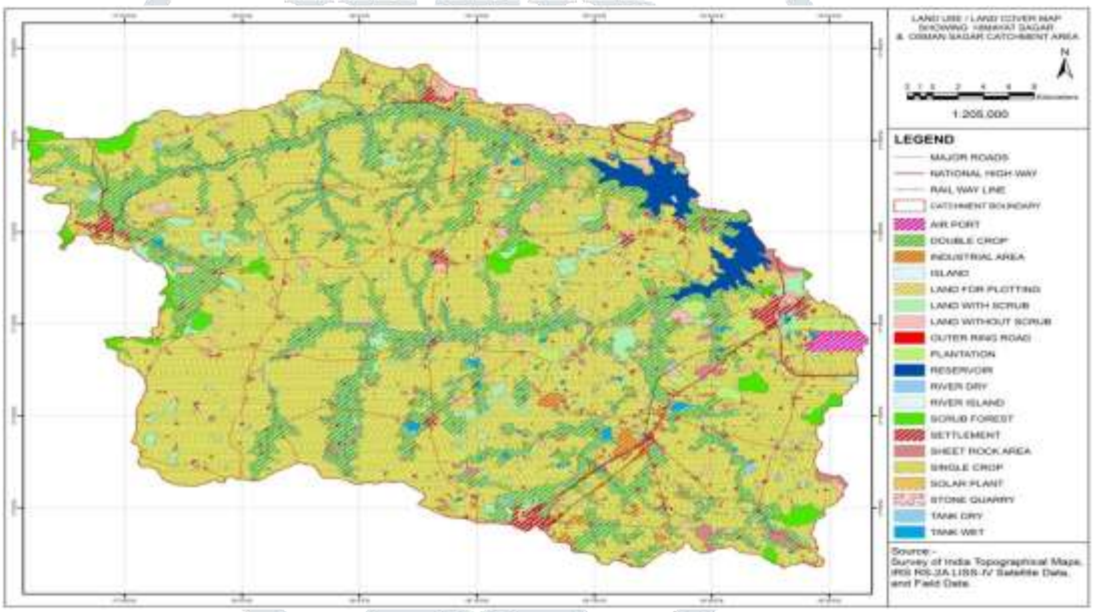

Fig.6 :Land Use/Land cover of study area - 2018

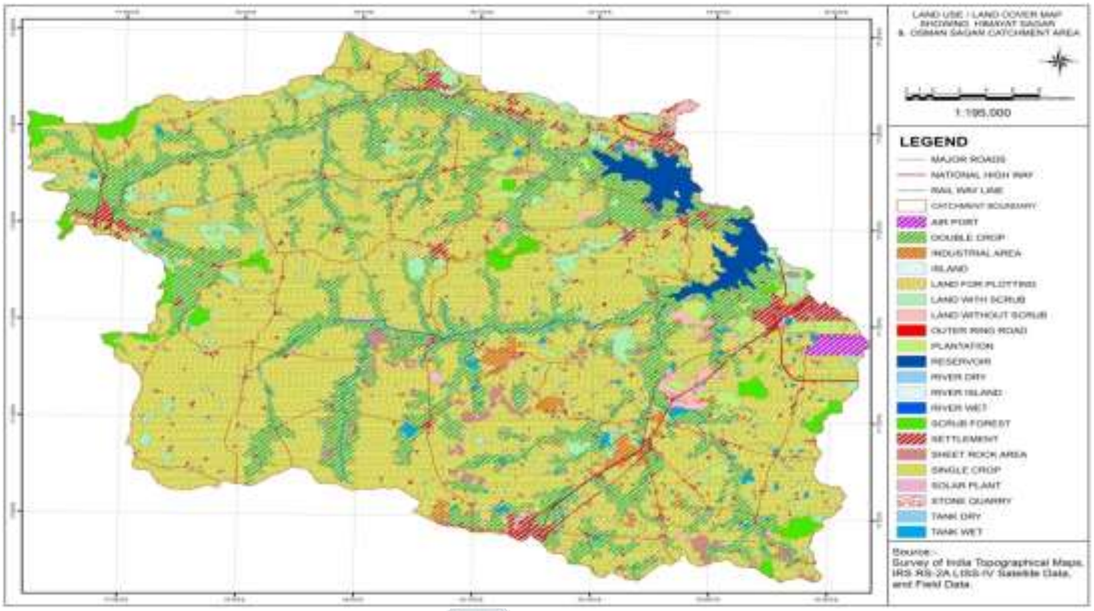

Fig.7 :Land Use/Land cover of study area - 2023

Based on the LULC map legend for the Himayat Sagar and Osman Sagar catchment areas, the land cover classes can be broadly categorized into five major groups: Agricultural Land, Forest, Built-up Land, Water Bodies, and Wastelands. The Agricultural Land category includes areas under cultivation and farming activities such as single crop, double crop, and plantation. In some contexts, land for plotting may also fall under this category if intended for agricultural use in the future. The Forest category is primarily represented by scrub forest, outer ring road scrub, and river wet zones, which indicate degraded forest or semi-natural vegetative cover rather than dense forests. The Built-up Land class includes infrastructure and developed areas such as industrial areas, solar plants, stone quarries, and land designated for plotting (in cases where it is used or intended for residential, commercial, or urban development). Supporting infrastructure such as major roads, national highways, railway lines, and airports also fall within this category. Water Bodies are distinctly marked and include features such as reservoirs, rivers, and wet tanks, representing active surface water zones crucial for the hydrology of the catchment. Finally, Baarenlands include ecologically degraded or unproductive areas such as sheet rock areas, tank dry (indicating abandoned or dried-up tanks), and in some cases islands or degraded scrub wetlands. This classification helps simplify and standardize the diverse land cover types present in the region for further analysis of land use change, environmental degradation, and catchment sustainability.

3.3 LULC Change Analysis (2006–2023)

a) Himayat Sagar

The temporal analysis of Land Use/Land Cover (LULC) changes in the Himayat Sagar and Osman Sagar catchment areas from 2006 to 2023 reveals significant shifts in land use patternsare shown in the below table 2

Table 2: LULC information of Himayatsagar Catchment Area

S.No.	Class	2006	2011	2014	2018	2023
1	Agricultural land	1154.14	1148.1	1135.8	1128.8	1121.7
2	Forest	24.09	24.05	24.09	24.09	24.23
3	Built-up land	52.09	56.98	58.72	65.72	67.24
4	Water bodies	47.03	47.17	47.12	47.12	47.47
5	Wastelands	77.01	77.85	88.69	88.69	93.8

Agricultural land, which occupies the largest area, has shown a consistent decline from 1154.1 sq.km in 2006 to 1121.7 sq.km in 2023 reflecting a net loss of 32.4 sq.km (approximately 2.8% decrease), likely due to conversion to built-up or wasteland categories. The built-up land category exhibits a clear and steady increase over the study period, expanding from 52.09 sq.km in 2006 to 67.24 sq.km in 2023, indicating a net increase of 15.15 sq.km or a growth of approximately 29%. This trend is a strong indicator of ongoing urbanization and development pressure within the catchment area.
Meanwhile, the barren land area has also increased significantly from 77.01 sq.km in 2006 to 93.8 sq.km in 2023, a 21.8% increase, suggesting land degradation or abandonment of previously productive land. Interestingly, the forest cover has remained relatively stable, with only marginal fluctuations from 24.09 sq.km in 2006 to 24.23 sq.km in 2023, indicating either successful conservation or minimal pressure in forested zones. Water bodies, which are crucial for the catchment's hydrological function, have remained largely unchanged, increasing slightly from 47.03 sq.km in 2006 to 47.47 sq.km in 2023, suggesting that major reservoirs have been maintained over time despite surrounding land-use pressures.
Overall, the data reflects a pattern of urban expansion at the cost of agricultural land and an increase in wastelands, emphasizing the need for strategic planning and sustainable land management practices in and around critical water catchment areas.

b) Osman Sagar

The temporal analysis of Land Use/Land Cover (LULC) changes in the Osman Sagar catchment area from 2006 to 2023 reveals significant shifts in land use patternsare shown in the below table 3

S.No.	Class	2006	2011	2014	2018	2023
1	Agricultural land	619.75	615.14	623.18	606.19	605.53
2	Forest	16.93	16.61	16.61	16.00	16.17
3	Built-up land	18.34	24.73	27.09	29.35	37.01
4	Water bodies	31.11	30.63	31.04	31.08	31.38
5	Wastelands	57.52	56.51	45.8	61.07	49.99

Over the 17-year period, agricultural land has remained the dominant land cover type, fluctuating between a maximum of 623.18 sq.km in 2014 and a minimum of 605.53 sq.km in 2023. Although relatively stable, this indicates a net loss of 14.22 sq.km, possibly due to conversion to urban or wasteland areas.
Built-up land has shown a significant and steady increase, reflecting urban expansion and infrastructure development within the catchment. The area under built-up land rose from 18.34 sq.km in 2006 to 37.01 sq.km in 2023, marking a net increase of 18.67 sq.km, which represents more than a 100% increase. This growth directly indicates the pressure of urbanization on land resources within the catchment zone.
Forest cover has experienced a marginal decrease, dropping from 16.93 sq.km in 2006 to 16.17 sq.km in 2023. Though the change is minimal (about 0.76 sq.km), it reflects a slight decline in natural vegetation, possibly due to human intervention or edge degradation.
The extent of water bodies has remained largely consistent, ranging from 30.63 sq.km in 2011 to 31.38 sq.km in 2023, showing only a slight increase. This suggests that the major water sources like the reservoirs and tanks have not experienced significant encroachment or shrinkage during the study period.
Barrenlands, however, show inconsistent trends. The area decreased notably from 57.52 sq.km in 2006 to 45.80 sq.km in 2014, possibly due to reclamation or conversion to other land uses. However, it then increased again to 61.07 sq.km in 2018, followed by a reduction to 49.99 sq.km in 2023. These fluctuations may be attributed to seasonal factors, land degradation, or shifts in classification accuracy over time.

4. Conclusion

The spatio-temporal analysis of land use and land cover (LULC) in the Himayat Sagar and Osman Sagar catchment areas over a 17-year period (2006–2023) highlights significant landscape transformation driven by urban expansion and land degradation. The most notable change is the consistent increase in built-up land, which doubled in both catchments—rising from 18.34 sq.km to 37.01 sq.km in one, and from 52.09 sq.km to 67.24 sq.km in the other—indicating a rapid pace of urbanization. This expansion has occurred largely at the expense of agricultural land, which declined by approximately 32.4 sq.km and 14.22 sq.km respectively across both catchments.

While forest cover remained relatively stable with only marginal reductions, it reflects increasing pressure on ecological buffers in the region. Water bodies also remained largely consistent in area, suggesting that the physical extent of reservoirs has not been drastically affected, although the surrounding buffer zones and catchment health may still be under stress. Conversely, wastelands displayed fluctuating patterns, with a general increase in area in one catchment, indicating processes of land degradation or conversion of fallow and barren lands.

These trends underline a critical challenge: the increasing strain on natural and agricultural landscapes due to urban sprawl within vital catchment areas. The continued expansion of built-up land within these ecologically sensitive zones threatens the sustainability of water resources that are essential for the Hyderabad metropolitan region. Therefore, it is imperative to adopt sustainable land management strategies, enforce buffer zone protections, and implement policy-level interventions to control unregulated development. Regular monitoring through high-resolution remote sensing data, combined with ground validation, can aid in timely policy formulation to conserve these catchments and ensure long-term water security for the region

References

Akhil Gurijala, S.S.Asadi, D.Satish Chandra, Estimation of Water Excellence of Himayatsagar and Osmansagar Lakes in Hyderabad– A Model study, International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-7, Issue-6C2, April 2019.

Anderson, James R., Hardy, Ernest E., and Roach, John T.,1972. A land-use classification system for use with remote-sensor data: U.S. Geol. Survey Circ. 671, 16 p.

Anjireddy.M.,2008. Textbook of Remote Sensing and Geographical Information Systems Third Edition, ISBN : 81-7800-135-7.

C. Ramachandraiah, Sheela Prasad ,2004 Impact of Urban Growth on Water BodiesThe Case of Hyderabad , Working Paper No. 60September 2004.

Chigurupati, Ramachandraiah & Prasad, Sheela. (2008). Impact of Urban Growth on Water Bodies The Case of Hyderabad. esocialsciences.com, Working Papers.

D. Lu Corresponding author , P. Mausel , E. Brondízio & E. Moran (2004). Change detection International Journal techniques of , Remote

Gumma, M.K.; Mohammad, I.; Nedumaran, S.; Whitbread, A.; Lagerkvist, C.J. Urban Sprawl and Adverse Impacts on Agricultural Land: A Case Study on Hyderabad, India. Remote Sens. 2017, 9, 1136. https://doi.org/10.3390/rs9111136

Gumma, Murali & Mohammad, Irshad & Swamikannu, Nedumaran & Whitbread, Anthony & Lagerkvist, Carl. (2017). Urban Sprawl and Adverse Impacts on Agricultural Land: A Case Study on Hyderabad, India. Remote Sensing. 9. 1136. 10.3390/rs9111136.

https://www.thehindu.com/news/national/telangana/realty-at-a-cost/article67175448.ece?

National Remote Sensing Agency., 2004,.Manual on National Land use /land Cover mapping on 1:250,000 scale using multi-temporal IRS P6-AWiFS data, NRSA, Dept. of Space, Govt. of India,
Balanagar, Hyderabad.

Ravi Loudya, Manjula Vani Kunchepu and Anji Reddy Mareddy ,Spatio-Temporal Optical Image Analysis for LULC Classification and Change Detection Mapping- A Case Study of Hyderabad City, Indian Journal of Geosciences, Volume 77, No. 2 April - June, 2023; pp. 183-196