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Landuse & Land Cover Change Detection of Hindupur Mandal in Sri Sathya Sai District, Andhra Pradesh

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Abstract: ***Understanding land use and land cover is vital for regional planning authorities as it helps in recognizing significant changes and grasping the dynamics of land use. Knowledge of land use and land cover maps is crucial for understanding drought - prone environments, conservation, and management. Human activities globally are the main drivers of changes in land cover, resulting in land degradation due to population pressure and unregulated land use practices. These alterations disrupt ecosystems, impacting ecology and development outcomes. This research focuses on analyzing LULC pattern changes in Hindupur mandal of Sri Sathya Sai district from 2017 to 2023 using Remote Sensing and Geographic Information System technologies.***

Keywords: Landuse, Land cover, water, Trees, Built Area & Crops

1. Introduction

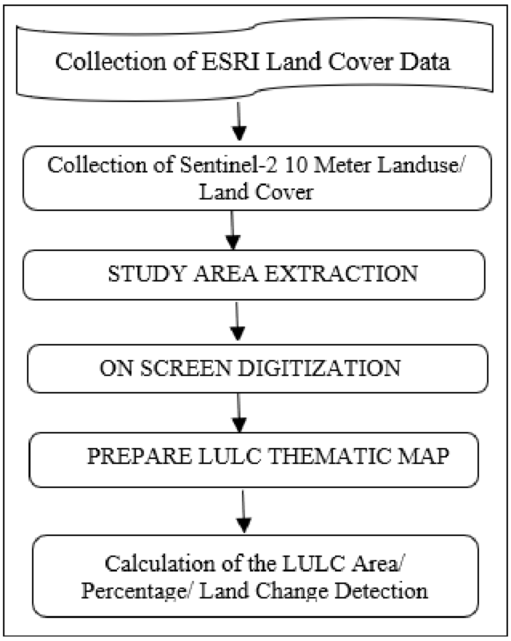
Land use is closely tied to human activities or economic functions on a specific piece of land, while land cover refers to the composition and characteristics of the land surface elements. Initially, land cover focused on vegetation types, but it now encompasses human - made structures such as buildings and pavement, in addition to other natural environment aspects. It is essential to comprehend changes in LULC for effective natural resource management. The interaction between a society's cultural background, physical needs, and the land's natural potential influences land use. Changes in land use often result in alterations in land cover. Globally, very fast changes in land cover are caused by human activities and natural events, with human activities currently being the primary driver. Technological advancements have enabled the visualization of changes in the Earth's surface through satellite imagery, making remote sensing the most efficient tool for monitoring these transitions. Satellite remote sensing is a crucial data source for change detection due to its temporal data acquisition, digital format suitability, and cost - effectiveness compared to traditional methods. Macleod and Congation (1998) emphasize four key aspects of change detection in monitoring natural resources: detecting changes, identifying their nature, measuring their extent, and assessing their spatial pattern

2. Study Area

Hindupur, situated in the Sri Sathya Sai district (Anantapur District) of Andhra Pradesh, India, lies near the Andhra–Karnataka border and serves as the administrative center of Hindupur mandal (Fig: 1). Positioned at coordinates 13° 49' 41" N latitude and 77° 29' 29" E longitude, the Hindupur mandal covers an area of 198 km2, encompassing around 14 villages. Nestled on the arid banks of the Penna River, Hindupur is perched at an elevation of 2, 037 feet (621 meters). According to the 2011 Census of India, the city's population was recorded at 151, 677, marking an increase from 125, 074 in the 2001 census. The population breakdown in 2011 comprised 76, 625 males and 75, 210 females, resulting in a sex ratio of 982 females per 1000 males, surpassing the national average of 940 per 1000. The city boasted an average literacy rate of 76.40%, with 103, 538 literates, notably higher than the state's average of 67.41%. Telugu serves as the official language, while Urdu and Kannada are the second and third most spoken languages, respectively, with Kannada being prevalent due to its proximity to the Karnataka State Border.

3. Aims & Objectives

The objective is to analyze the land use and land cover categories in Hindupur mandal, located in Sri Satya Sai District, for the years 2017 and 2023, with a focus on identifying any alterations that occurred during this period.
Methodology:



Data: The Sentinel - 2 scene collection, which includes over 2 million Earth observations captured in 6 spectral bands, was analyzed using data models to create detailed maps.

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Software used: ArcGIS 10.3 & M. S. Office

4. Result & Discussion

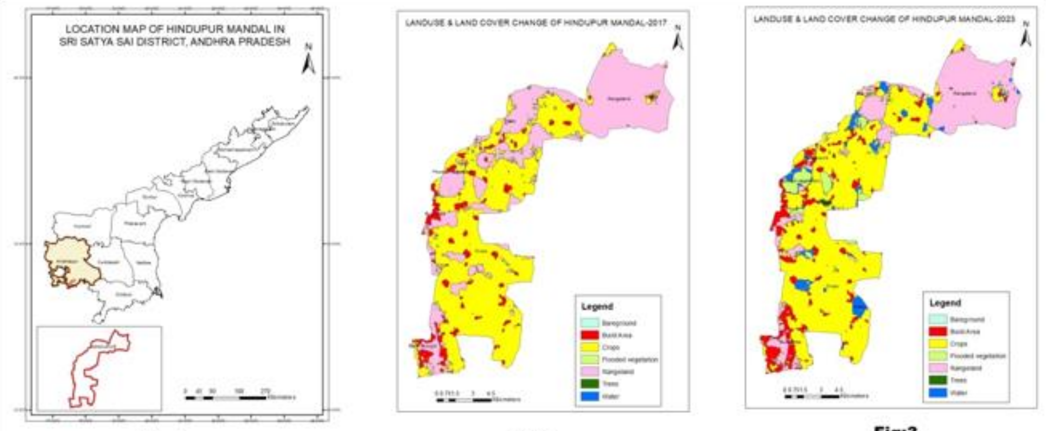

Fig:1 Fig:2 Fig:3

Table 1: LULC of Hindupur Mandal- 2017

S. no	Name of the Classes	Area Sq km	Area Percent
1	Water	0.025042	0.012937
2	Trees	0.082241	0.042488
3	Flooded vegetation	0.012223	0.006315
4	Crops	103.513181	53.47749
5	Built Area	11.642983	6.015055
6	Bare Ground	0.033242	0.017174
7	Rangeland	78.255113	40.42854

Table 1 displays the land use and land cover (LULC) data for Hindupur Mandal in 2017 (refer to Fig.2), illustrating the distribution of various land classes in terms of area in square kilometers and percentage. The identified LULC classes include Water, Trees, Flooded vegetation, Crops, Built Area, Bare Ground, and Rangeland. Water covers the smallest area at 0.025042 sq km, representing 0.012937% of the total area. Trees occupy 0.082241 sq km, accounting for 0.042488% of the area. Flooded vegetation covers 0.012223 sq km, making up 0.006315% of the total area. Crops dominate the landscape with an area of 103.513181 sq km, constituting 53.47749% of the total area. Built Area covers 11.642983 sq km, representing 6.015055% of the area. Bare Ground and Rangeland cover 0.033242 sq km (0.017174%) and 78.255113 sq km (40.42854%), respectively. This data offers a detailed insight into the land use distribution in Hindupur Mandal, emphasizing the significant presence of agricultural land (Crops) and Rangeland in the region.

Table 2: LULC of Hindupur Mandal - 2023

S. no	Name of the Classes	Area Sq km	Area Percent
1	Water	7.791027	4.025051
2	Trees	0.908171	0.469185
3	Flooded vegetation	6.808374	3.517386
4	Crops	108.777795	56.197484
5	Build Area	17.419016	8.999124
6	Bareground	0.001645	0.00085
7	Rangeland	51.857434	26.790921

Table 2 displays the land use and land cover (LULC) data for Hindupur Mandal in 2023 (Fig: 2). The Mandal's area is categorized into seven classes, each with its respective area in square kilometers and percentage of the total area. These classes consist of Water, Trees, Flooded vegetation, Crops, Build Area, Bareground, and Rangeland.

Water covers 7.791027 square kilometers, representing 4.025051% of the total area. Trees occupy 0.908171 square kilometers, accounting for 0.469185% of the total area. Flooded vegetation covers 6.808374 square kilometers, making up 3.517386% of the total area. Crops have the largest coverage with 108.777795 square kilometers, accounting for 56.197484% of the total area. Build Area covers 17.419016 square kilometers, representing 8.999124% of the total area. Bareground is the smallest class with an area of 0.001645 square kilometers, making up 0.00085% of the total area. Rangeland covers 51.857434 square kilometers, accounting for 26.790921% of the total area.

This data offers valuable insights into the land cover distribution in Hindupur Mandal in 2023, essential for understanding the region's environmental and ecological dynamics. The prevalence of crop lands and rangelands indicates agricultural and pastoral activities, while the presence of water bodies and trees underscores the significance of natural resources in the Mandal. This information can guide land management, conservation initiatives, and sustainable development planning in the area.

Table 3: Land Use & Land Cover Change Detection of Hindupur Mandal: 2017 - 2023

LULC change Detection 2017 - 2023	Area change (sq)
Bare Ground - Build Area	0.00329
Bare Ground - Crops	0.006699
Bare Ground - Flooded vegetat*	0.002227
Bare Ground - Rangeland	0.019392
Bare Ground - Water	0.001634
Built Area - Build Area	10.800092
Built Area - Crops	0.598432
Built Area - Flooded vegetati*	0.054704
Built Area - Rangeland	0.084309
Built Area - Trees	0.00578
Built Area - Water	0.096521
Crops - Bareground	0.001645
Crops - Build Area	3.561033
Crops - Crops	94.146762
Crops - Flooded vegetation	0.508759
Crops - Rangeland	2.316215
Crops - Trees	0.062073
Crops - Water	2.905906
Flooded vegetation - Flooded *	0.009841

Flooded vegetation - Water	0.002382
Rangeland - Build Area	3.04502
Rangeland - Crops	14.001816
Rangeland - Flooded vegetation	6.22272
Rangeland - Rangeland	49.418848
Rangeland - Trees	0.821511
Rangeland - Water	4.729906
Trees - Build Area	0.004475
Trees - Crops	0.010629
Trees - Flooded vegetation	0.009052
Trees - Rangeland	0.012176
Trees - Trees	0.018286
Trees - Water	0.027595
Water - Water	0.025042

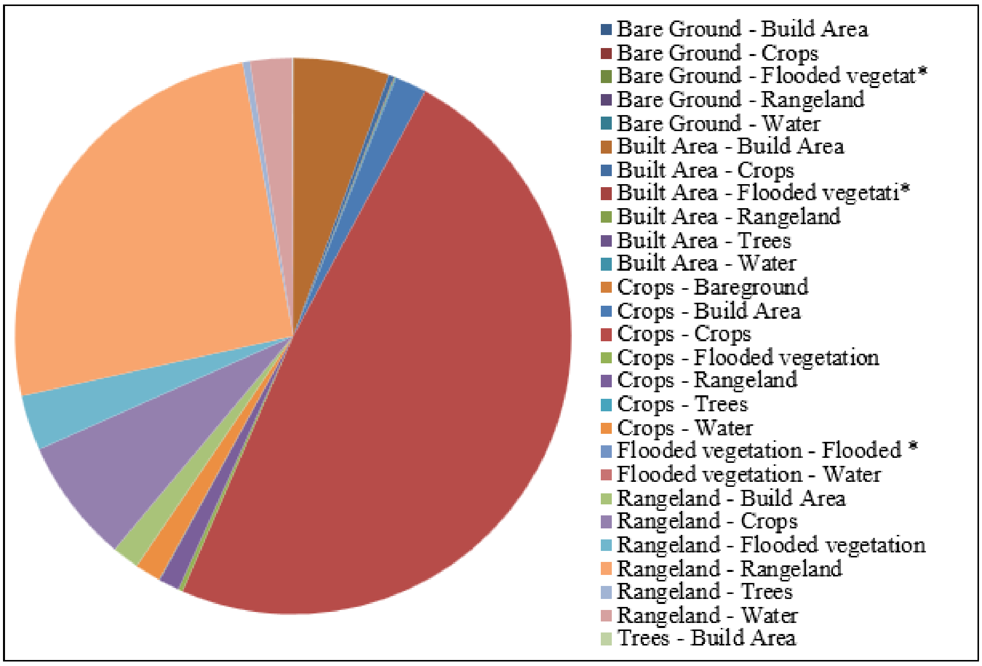

Figure 4: Change Detection of LULC

Table 2 displays the land use and land cover (LULC) data for Hindupur Mandal in 2023, divided into seven classes: Water, Trees, Flooded vegetation, Crops, Build Area, Bareground, and Rangeland. Water covers 7.791027 square kilometers (4.025051% of the total area), Trees occupy 0.908171 square kilometers (0.469185%), Flooded vegetation covers 6.808374 square kilometers (3.517386%), Crops have the largest area with 108.777795 square kilometers (56.197484%), Build Area covers 17.419016 square kilometers (8.999124%), Bareground is the smallest at 0.001645 square kilometers (0.00085%), and Rangeland covers 51.857434 square kilometers (26.790921%).

Table 3 and Fig 4 present the land use and land cover change detection results in Hindupur Mandal from 2017 to 2023. Categories analyzed include Bare Ground - Build Area, Bare Ground - Crops, Bare Ground - Flooded vegetation, Bare Ground - Rangeland, and Bare Ground - Water, showing specific area changes over the six - year period. For instance, Bare Ground - Build Area changed by 0.00329 square units, Bare Ground - Crops by 0.006699 square units, Bare Ground - Flooded vegetation by 0.002227 square units, Bare Ground - Rangeland by 0.019392 square units, and Bare Ground - Water by 0.001634 square units. These values offer insights into land use changes over time.

The relationship between built areas and various land cover types is detailed in the table, indicating the proportion of each land cover type within the built area. The majority of the built area consists of built structures (10.800092), with smaller proportions covered by crops (0.598432), flooded vegetation (0.054704), rangeland (0.084309), trees (0.00578), and water (0.096521). This data aids in understanding the impact of urbanization on the landscape and can guide land use planning and environmental management strategies.

The analysis presented illustrates the distribution of land cover types in a specific area, focusing on various categories related to crops. The data reveals that the majority of the land, 94.146762%, is dedicated to "Crops, " indicating extensive agricultural use. Other categories include "Crops - Rangeland" at 2.316215%, "Crops - Water" at 2.905906%, "Crops - Build Area" at 3.561033%, "Crops - Flooded vegetation" at 0.508759%, "Crops - Trees" at 0.062073%, and "Crops - Bareground" at 0.001645%. These figures offer insights into the spatial distribution of land cover types, emphasizing the dominance of agricultural activities. The data is essential for analyzing land use patterns, evaluating environmental impacts, and guiding land management strategies in the region.

The data represents the proportion of flooded vegetation under two conditions: fully submerged in water and partially submerged. The first column denotes the flooded vegetation category, while the second column specifies the condition of the vegetation—fully or partially flooded. The numerical values in the third column indicate the proportion of flooded vegetation in each condition. A value of 0.009841 corresponds to fully submerged vegetation, while 0.002382 represents partially submerged vegetation. These values suggest a higher proportion of flooded vegetation when completely submerged compared to partial submersion. This information is valuable for understanding the effects of varying flood levels on vegetation and ecosystem dynamics in flood - prone regions.

The distribution of various land cover types within a rangeland area, showcasing the percentage of each type in relation to the total area. Rangeland dominates the landscape, covering 49.42% of the total area, indicating its prevalence. Crops occupy 14.00%, hinting at agricultural activities. Flooded vegetation covers 6.22%, suggesting wetland presence. Water encompasses 4.73%, likely representing water bodies. Trees make up 0.82%, indicating scattered tree cover. The Build Area category represents 3.05%, indicating human - made structures. This data offers valuable insights into the land cover composition, crucial for understanding ecological dynamics and land use patterns in the region.

The quantitatively represents the relationships between different land cover types through provided values. For example, the value of 0.010629 for "Trees - Crops" indicates that around 1.06% of tree - covered areas are near crop fields. Similarly, the value of 0.009052 for "Trees - Flooded vegetation" suggests 0.91% of tree - covered areas are adjacent to flooded vegetation. Values like "Trees - Rangeland, " "Trees - Trees, " and "Trees - Water" at 1.22%, 1.83%, and 2.76% respectively, show the proportions of tree - covered areas near rangeland, other tree - covered areas, and water bodies. Additionally, the value of 0.025042 for "Water - Water" signifies water bodies near each other. These values offer insights into spatial relationships between land cover types, aiding in landscape analysis, ecological understanding, and land use planning in the area.

5. Conclusion

The report presents detailed information on the changes in land use and land cover in the Hindupur Mandal from 2017 to 2023, focusing on categories like Bare Ground - Build Area, Crops, Flooded vegetation, Rangeland, and Water. It illustrates the specific changes in area for each category over a six - year period, shedding light on the dynamics of land use alterations. One table emphasizes the prevalence of built structures in the area, while another highlights the dominance of agricultural land cover types, particularly "Crops. " The data also delves into flooded vegetation under varying conditions, rangeland composition, and the spatial relationships between different land cover types. The study utilized Satellite data to map and quantify the area's extent within a specific timeframe. Geographical Information System (GIS) and Satellite data were crucial in providing spatial inputs and evaluating the statistical model representing growth. The research area is located in the central part of the peninsula, away from coastal regions and riverbanks. Due to the hindrance caused by the high Western Ghats in receiving rainfall, the area does not fully benefit from the southwest monsoon. These findings offer valuable insights for analyzing trends, understanding environmental impacts, and devising effective land management strategies in the study area.

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