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Land Use Land Cover Changes: Conversion of Agricultural Land in District Hyderabad, Sindh, Pakistan

[1]Marvi Pirzada*, [2]Kamal Hussain Turi, [3]Imtiaz Hussain, [4]Oshaque Ali Lashari

[1]Department of Geography, Government Girls Zubeda College, Hyderabad
[2]Department of Geography, Shah Abdul Latif University, Khairpur
[3]Department of Geography, Government Degree college Therhi
[4]Department of (HESCO) Computer Centre Hyderabad

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Corresponding Author:
Marvi Pirzada,
Department of Geography, Government Girls Zubeda College, Hyderabad
Email: marvipirzada@yahoo.com

ABSTRACT

Changes in land use and land cover (LULC) pose significant environmental threats, including global warming, reduced biodiversity, and increased greenhouse emissions. These changes lead to soil erosion, landslides, land degradation, and water contamination, ultimately endangering human health and food security. In countries like Pakistan, rapid urbanization and population growth are key drivers of LULC transformation, resulting in the loss of fertile agricultural land to urban development. This study examines Land Use and Land Cover (LULC) changes and their impacts on agricultural land in Hyderabad District from 1972 to 2023. Using advance Remote Sensing (RS) and Geographic Information System (GIS) techniques,Landsat satellite imagery from 1972, 1986, 2000, and 2023 was processed using the Maximum Likelihood Supervised Classification method in ArcGIS 10.8. The study analyzes LULC changes across four Talukas including Hyderabad City, Qasimabad, Latifabad, and Hyderabad (Rural). The findings reveal significant transformations in LULC classes, indicating substantial land use changes over the 51-year period. Between 1972 and 2023, Hyderabad District experienced significant land use changes, with built-up areas expanding by 184% (from 123.7 km² to 351.7 km²). This growth came at the expense of agricultural land (-30.6%), orchards (-16.8%), and barren land (-36.5%). Rapid urbanization, driven by rural-to-urban migration, is the primary cause, leading to ecological degradation and exacerbating climate change impacts.

Introduction

Land use and land cover change (LUCC) is increasingly recognized as a key driver of global change (Ellis, 2021). Land use and land cover changes (LULC) result from complex interactions between environmental and socioeconomic factors (Demissie et al., 2017; Lesschen et al., 2005). LULC changes, despite varying in nature, ultimately lead to natural resource exploitation and environmental degradation, causing issues like water pollution, landslides, soil erosion, and desertification (Mir et al., 2025). Agricultural land is being converted to built-up areas due to urban expansion and infrastructure development, threatening global food production and ecosystem services (Mohammadyari et al., 2023). LULC changes threaten food security, ecosystem functions, and climate stability. Understanding agricultural land conversion is key to sustainable development (Hailu et al., 2024). Rapid urbanization in China and South Asia has led to significant agricultural land loss near cities (Resniova & Ponomarenko, 2021). Global cropland loss to urban expansion is projected to reach 1.8-2.4% by 2030, mainly in Asia and Africa (Bren d'Amour et al., 2017). Urban areas expanded by 50% globally from 2000 to 2020, driving significant cropland loss (Potapov et al., 2022). GIS and remote sensing techniques effectively map LULC changes, especially in inaccessible areas, and track spatial patterns of agricultural land conversion at various scales (MohanRajan et al., 2020; Abebe et al., 2022; Su et al., 2022). This study examines the impact of land use and land cover (LULC) changes on agricultural land using remotely sensed data in Hyderabad District, Sindh, from 1972 to 2023. The urban area expanded from 30% to 65% over four decades, significantly decreasing agricultural land, water bodies, and barren land.

Study Area

Hyderabad district is located in the lower Indus plain, 13 meters above sea level, between 24°46′-26°06′ N latitude and 68°16′-68°59′ E longitude. It borders Matiari to the north, Tando Allahyar to the east, Badin and Tando Muhammad Khan to the south, and Thatta and Jamshoro to the west (Bux et al., 2022; GoP, 2020).

Hyderabad district's area and talukas have changed over time. By 1998, it covered 5,519 sq km, and by 2017, it was divided into four talukas (Hyderabad City, Qasimabad, Latifabad, and Hyderabad) covering 993 sq km (GoP, 1998, 2017, 2023) (figure 1).

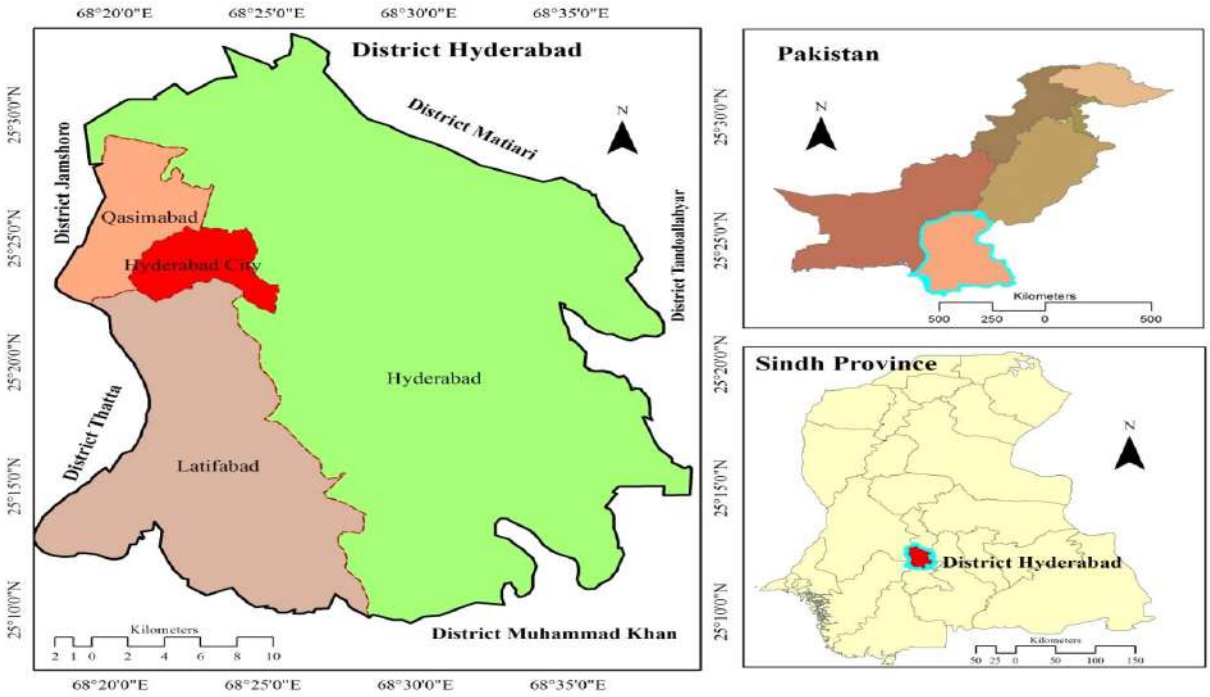

Figure 1 Location map of District Hyderabad

Source: Prepared in ArcGIS 10.8

Hyderabad district is a vast alluvial plain with no major hills or mountains, except for small hillocks and the Ganjo Takkar limestone range. The area is primarily composed of fertile, sandy, and loamy soil. The Indus River flows along its western border, with canals like Pinyari and Phuleli passing through the district (GoP, 1998; Mahessar et al., 2015). Hyderabad has a subtropical desert climate with extreme temperatures, reaching 44°C in May and averaging 25°C in winter. It experiences intense heat waves (April-June) and foggy winters, with most rainfall from cyclonic winds (GoP, 1998). The population of Hyderabad district has grown significantly from 1951 to 2023, closely linked to environmental changes, urbanization, and land use patterns (Otu et al., 2011).

Methodology

This study used Remote Sensing and GIS to analyze LULC changes from 1972 to 2023, utilizing USGS satellite imagery for four specific years (1972, 1986, 2000, and 2023) to assess temporal changes in land use and land cover.

Image Processing and Analyzing

A multi temporal dataset of Landsat satellite imagery was utilized to analyze land use and land cover (LULC) changes in District Hyderabad between 1972 and 2023 (Table 1). The imagery was selected for four benchmark years: 1972, 1986, 2000 and 2023, representing approximately five decade intervals. ArcGIS 10.8.2 was used to analyze the satellite data. Four spectral bands of Landsat 1, 5 and 7 were utilized, while seven bands were employed for Landsat 7 and Landsat 8. The earliest image, acquired on 15 October 1972 by the Multispectral Scanner (MSS), contains four spectral bands with a spatial resolution of 60 meters, providing broad-scale land cover information. The subsequent image from 5 November 1986, acquired by the Thematic Mapper (TM), improved resolution to 30 meters and expanded spectral coverage to seven bands, allowing for more accurate classification. The 18 October 2000 image was obtained from the Enhanced Thematic Mapper (ETM+), which offered similar spectral properties with the added

advantage of a panchromatic band for enhanced spatial detail (Hemati, Hasanlou, Mahdianpari, & Mohammadimanesh, 2021; Markham & Helder, 2012; Zhu et al., 2020). Finally, the most recent image, dated 26 October 2023, was acquired from the Operational Land Imager (OLI) with improved radiometric quality and additional spectral bands suitable for detailed (Lillesand, Kiefer, & Chipman, 2015). LULC mapping. All images correspond to Path 152, Row 042 of Landsat World Reference System (WRS-2), and ensuring spatial consistency across the time series.

Table: 1 Detail information of Satellite data

Year	Date of Acquisition	Bands	Row	Path	Spatial Resolution	Sensor	Source
1972	15/10/1972	4	042	163	60m	MSS	USGS
1986	05/11/1986	4	042	152	30m	TM	USGS
2000	18/10/2000	7	042	152	30m	ETM+	USGS
2023	26/10/2023	7	042	152	30m	OLI	USGS

Source: USGS 1972, 1986, 2000 and 2023

Thus, two scenes covered the district Hyderabad, both were downloaded, preprocessed and mosaicked to generate a cohesive image of the study area. Image processing included the creation of false color composites and the extraction of the area of interest (AOI) using the extract by mask operation. Training samples were collected for five major LULC classes and corresponding signature files were generated. Each image was classified using the Maximum Likelihood Classifier (MLC). Following classification, shapefiles of individual Talukas were used to extract LULC information separately, and the area of each class was calculated in square kilometers using the field calculator tool.

Image Classification

The study area comprised of four Talukas/Tehsils of district Hyderabad. The supervised image classification was carried out using the Maximum Likelihood Classification (MLC) technique in ArcGIS 10.8.2. A total of five LULC classes were developed: Agriculture, Orchard, Water, Built-up area and Barren land (Table 2). For each LULC category, 200-300 samples were selected to enhance the accuracy of classification. The spectral signatures of theses training sites were extracted and analyzed for class separation. Once the classification process was completed, the LULC areas of four Talukas/Tehsils were calculated in square kilometers.

Table: 2 Descriptions of Land Use Land Cover Classes

LULC Classes	Description
Agriculture	All types of cultivated area/agricultural fields and other vegetation.
Orchards	Different fruit orchards like banana, mango, guava, sugarcane, etc…
Water	River, canal, ponds, seasonal wetlands
Barren Land	Uncultivated or unused land, bare soil or land
Built-Up Area	Residential, industrial and commercial services

Results

Overall LULC change in District Hyderabad

The LULC change in district Hyderabad from 1972 to 2023 reveals a clear shift from an agrarian landscape to an increasingly urbanized environment. By 2023, the transformation became more

pronounced. Built-up area covered 34% of the district, compared to only 12% in 1972. In contrast, agriculture declined from 23% in 1972 to 16% in 2023, while orchards decreased from 38% to 32% (figure 2).

Overall trend in LULC classes clearly illustrates that built-up area expanded dramatically, with a total gain of 184.3 km², making urban land the fastest-growing category. Agriculture declined consistently across all periods, losing –30.7 km². Overall, showing steady land conversion into urban and other uses. Orchards decreased by –16.8 km², reflecting a reduction in traditional plantation areas. Whereas barren land fluctuated heavily, but overall declined by –36.5 km², suggesting land reclamation or conversion into settlements (Table 3).

It clearly highlights the trend of urban expansion at the expense of agriculture, barren land and orchards. While orchards and barren land fluctuated, agriculture showed a steady decline and built-up area consistently expanded. The sharp growth of built-up land over the past five decades indicates not only population-driven urban sprawl but also socio-economic transformation in the district. The loss of agricultural land and orchards raises concerns regarding food security, environmental sustainability and ecological balance in the region.

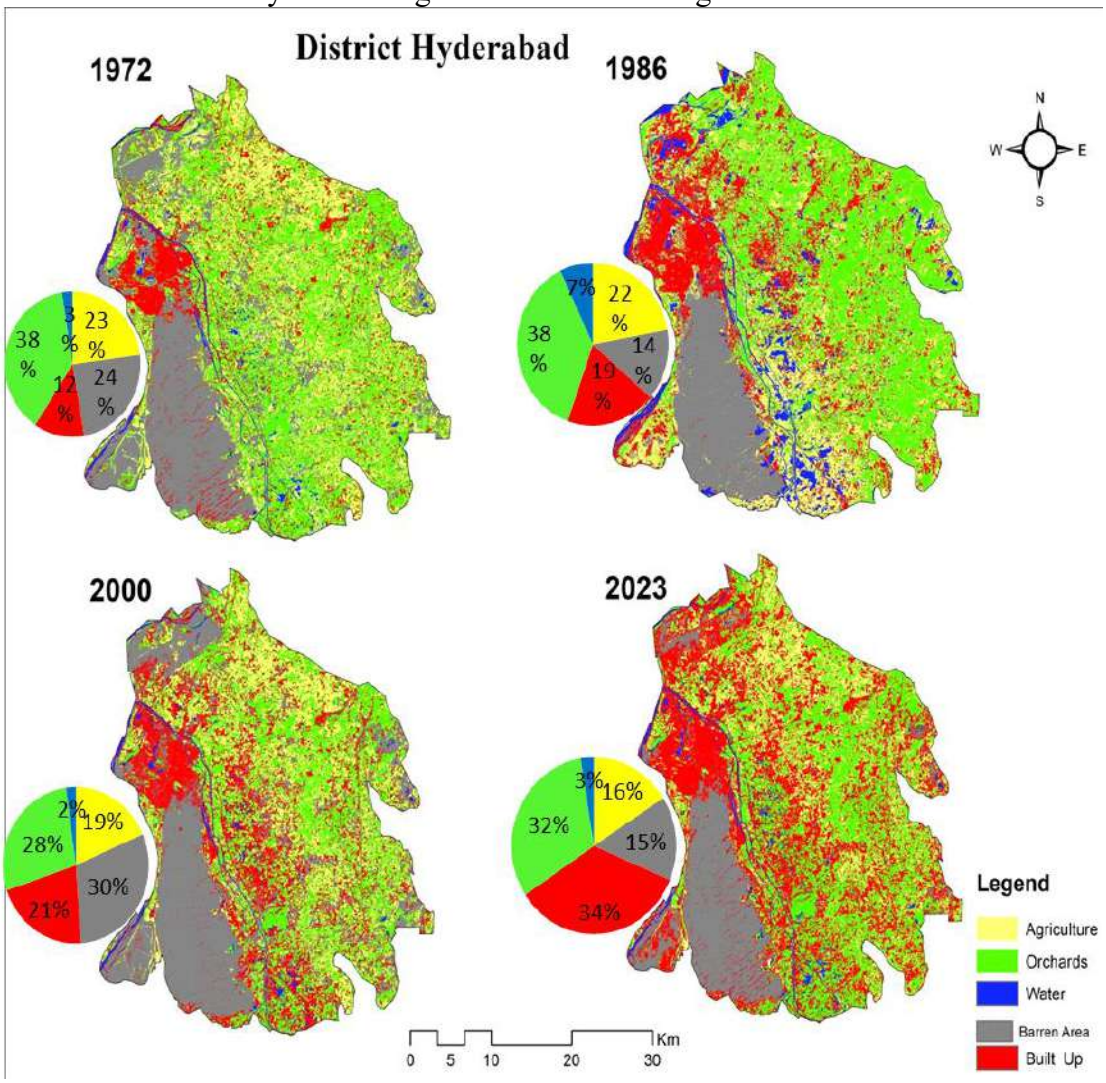

Figure 2: Temporal comparison of LULC Classes of District Hyderabad (1972-2023)
Source: Classified images of 1972, 1986, 2000 and 2023

Change in LULC classes in Taluka Hyderabad City (1972-2023)

- Agricultural land declined by 66.3% due to urbanization
- Built-up areas grew by 69.1% driven by population growth and infrastructure development
- Water bodies increased by 120% due to urban waterlogging and reservoir development
- Barren land decreased by 78.7% due to urban expansion
- Orchards showed a modest gain of 7.1% despite fluctuations

The changes reflect rapid urbanization, shifting from agriculture to built-up areas and altered hydrological patterns. (Figure 3).

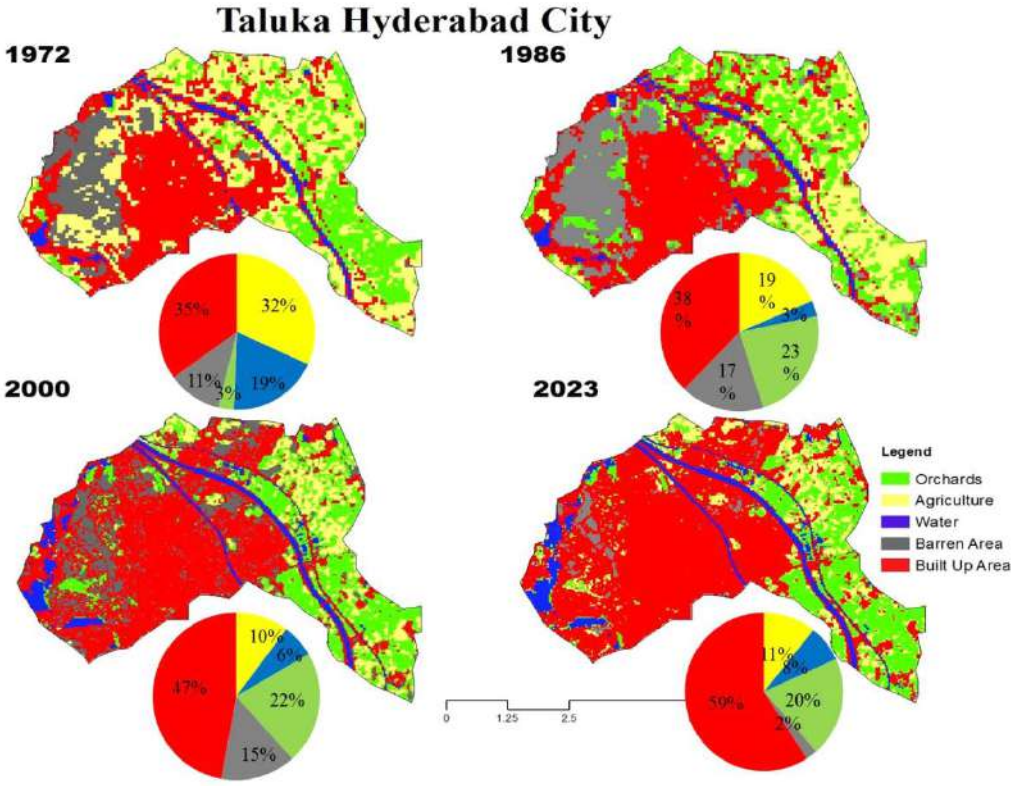

Figure 3: Temporal comparison of LULC of Taluka Hyderabad city (1972-2023). Source: Classified Images of 1972, 1986, 2000 and 2023

Change in LULC classes in Taluka Hyderabad (1972-2023)

Taluka Hyderabad's land use changes from 1972 to 2023 show:

- Agricultural land declined by 38.2%
- Built-up areas increased by 128.7%
- Water bodies expanded by 107.0%
- Barren areas increased by 15.9%
- Orchards declined by 16.7%

The changes reflect urbanization and infrastructure development, transitioning the area from agricultural dominance to increased urban and water-covered areas.

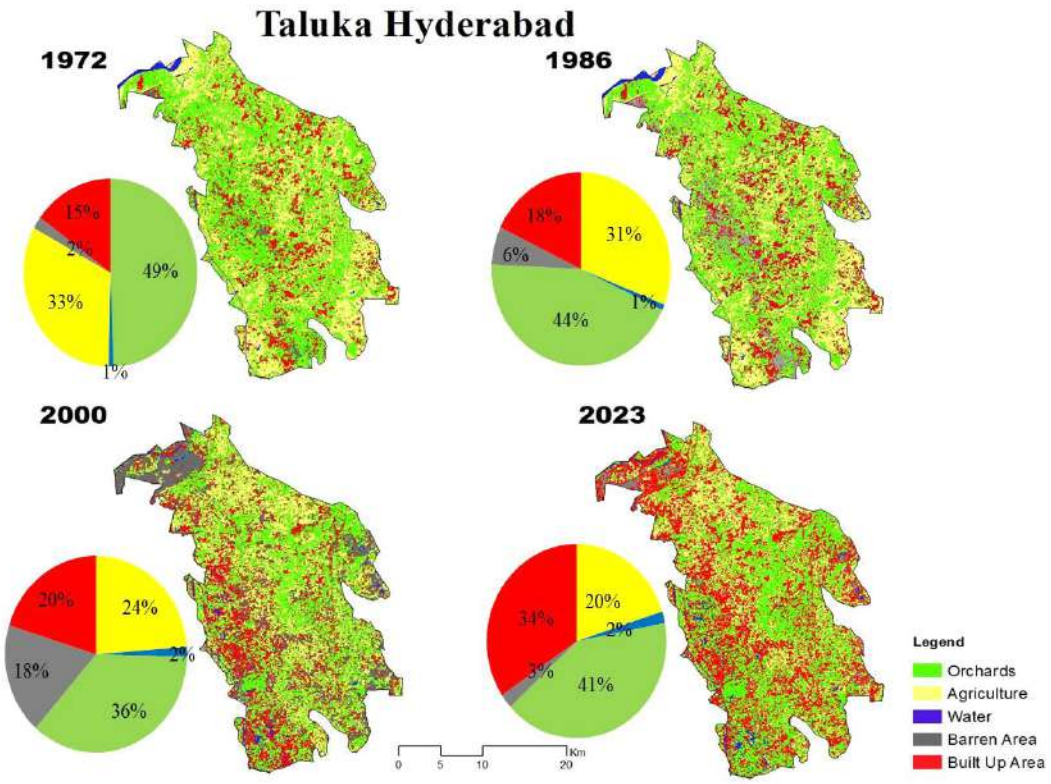

Figure: 4 Temporal comparison of LULC Classes of Taluka Hyderabad (1972-2023)
Source: Classified images of 1972, 1986, 2000 and 2023

Change in LULC classes in Taluka Latifabad (1972-2023)

- Agricultural land declined by 24.18%
- Orchards decreased by 55.0%
- Built-up land increased by 95.6% due to urbanization
- Barren land decreased by 1.1%
- Water bodies decreased by 2.8%

The changes reflect rapid urbanization, with agricultural and orchard lands being converted to built-up areas.

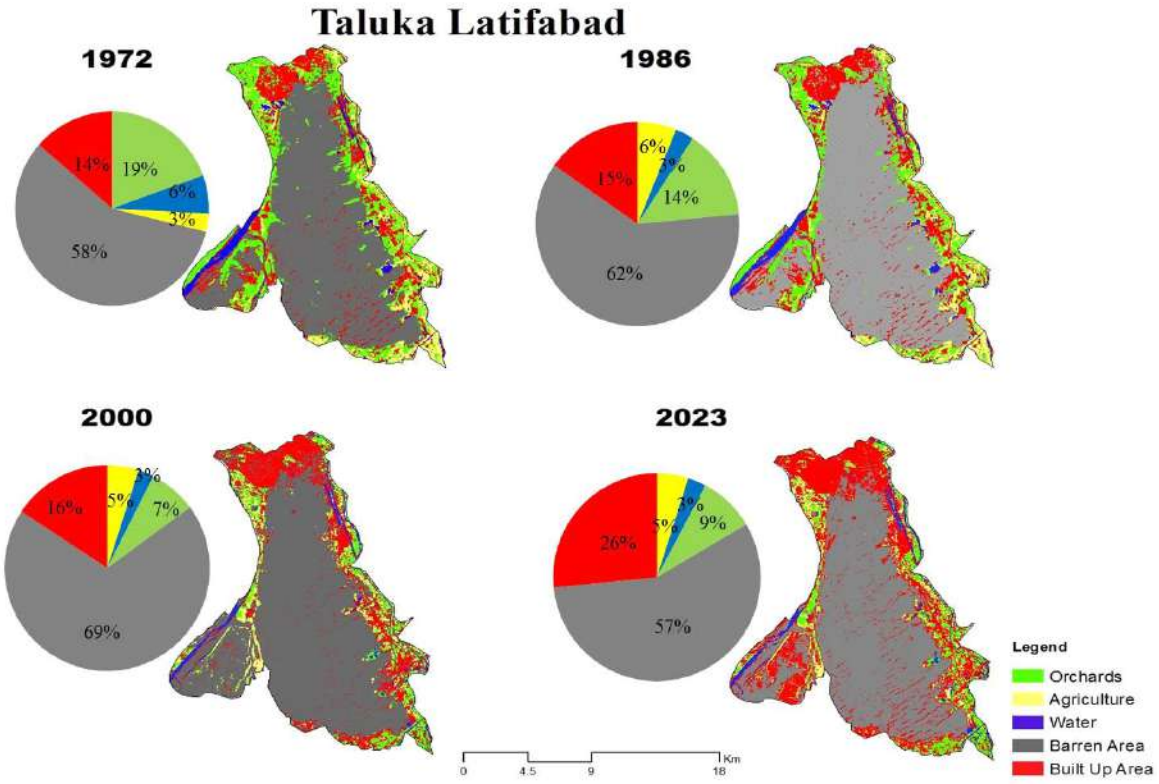

Figure:5 Temporal comparison of LULC Classes of Taluka Latifabad (1972-2023)
Source: Classified images of 1972, 1986, 2000 and 2023

2.5 Change in LULC classes in Taluka Qasimabad (1972-2023)

- Agricultural land increased by 160.8 km²
- Built-up areas expanded by 110.07 km² due to urban growth
- Orchards declined by 67.1 km²
- Water bodies decreased by 36.3 km²
- Barren land showed a modest gain of 12.2 km²

The changes reflect agricultural intensification and urbanization, occurring at the expense of orchards and water resources.

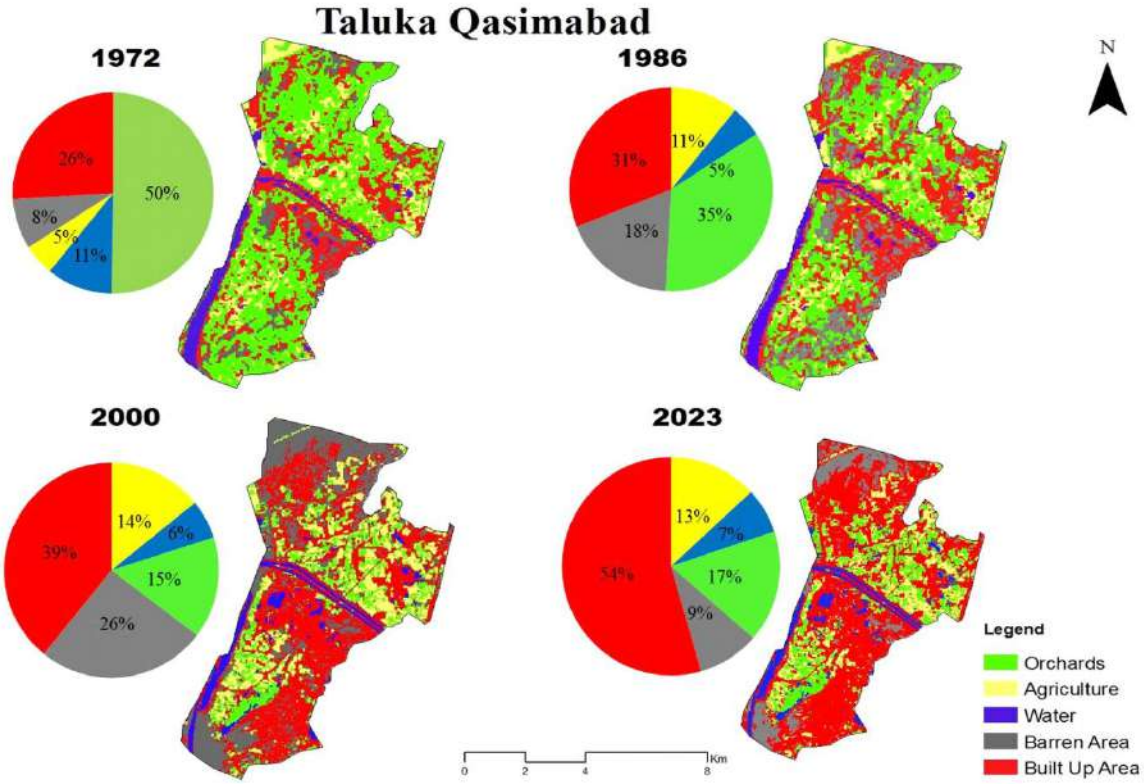

Figure:6 Temporal comparison of LULC Classes of Taluka Qasimabad
Source: Classified images of 1972, 1986, 2000 and 2023

Table:3 Taluka/Tehsil wise Land Use Land Cover change in District Hyderabad from 1972 to 2023 (Source: Classified images of 1972, 1986, 2000 and 2023)

Talukas	Years	LULC Classes				
		Agriculture	Orchards	Built-Up Area	Barren Land	Water body
Hyderabad City	1972	31.8	3.2	34.9	11.2	18.8
	1986	18.5	23.3	37.8	17.2	3.3
	2000	10.2	21.8	47.2	14.5	6.4
	2023	10	20.3	59.1	2.4	7.4
Latifabad	1972	3	19.5	13.6	57.5	6.4
	1986	6.2	14.3	15.2	61.3	3
	2000	5	7.5	15.7	69.4	2.5
	2023	4.9	8.7	26.6	56.9	2.9
Qasimabad	1972	5	50.3	25.9	8.1	10.6
	1986	10.8	35.1	31	18.1	5
	2000	14.2	15.2	39.2	25.5	5.9
	2023	13.1	16.6	54.5	9.1	6.7
Hyderabad	1972	32.5	49.4	15	2.1	0.9
	1986	31	43.8	17.9	6.3	0.9
	2000	23.8	36.2	20.2	18.2	1.6

	2023		20.1	41.2	34.4	2.4	1.9
District Hyderabad	1972		22.9	38.2	12.1	24.3	2.5
	1986		22.2	37.5	19.1	14.1	7.1
	2000		18.5	28	21	30.3	2.2
	2023		15.9	31.7	34.3	15.4	2.6
Hyderabad City	**% Change among Periods**	**P1**	-41.8	618.7	8.1	53	-82.6
		P2	-44.9	-6.7	24.9	-15.5	95
		P3	5.3	-6.8	25.3	-83.5	17
Latifabad		**P1**	108.8	-26.6	12.1	6.5	-53.8
		P2	-19.8	-47.7	3.3	13.1	-16.2
		P3	-1.5	17.1	68.9	-17.9	15.7
Qasimabad		**P1**	115	-30.3	19.5	123.1	-52.4
		P2	31.5	-56.6	26.4	40.8	16.1
		P3	-7.8	8.8	39.1	-64.3	15
Hyderabad		**P1**	-4.5	-11.4	19.3	200.4	0.6
		P2	-23.4	-17.3	12.8	189.3	70.8
		P3	-15.6	13.8	69.9	-86.7	20.5
District Hyderabad		**P1**	-3.3	-1.6	58	-41.9	181.2
		P2	-16.6	25.4	9.8	115.1	-69.1
		P3	-14	13.4	100	-49.2	18.1
Hyderabad City	**Overall Change %**		-66.3	526	69.1	-78.7	-60.4
Latifabad			65	-55	95.6	-1.1	-55.3
Qasimabad			160.8	-67.1	110.1	12.2	-36.3
Hyderabad			-38.2	-16.7	128.7	15.9	107
District Hyderabad			-30.7	-16.8	184.3	-36.5	2.5

Note: P1 stands for Period 1 indicates the duration from 1972 to 1986, P2 stands for Period 2 from 1986 to 2000 and P3 stands for period 3 from 2000 to 2023.

Discussions

Impact of LULC change on Agricultural land in District Hyderabad (1972-2023)

The study depicts the progressive decline of agricultural and orchard lands in District Hyderabad from 1972 to 2023, concomitant with a marked increase in built-up area, and minor fluctuations in barren and water bodies. These trends are consistent with findings from (Ul Din & Mak, 2021), who report significant urban expansion in Hyderabad, Pakistan, driven by population growth and expansion of infrastructure at the expense of agricultural lands. Similarly, (Gumma, Mohammad, Nedumaran, Whitbread, & Lagerkvist, 2017) document the "urban sprawl" in peri-urban Hyderabad, India, showing that agricultural land is being converted rapidly into built infrastructure, often replacing orchard and green cover. The decline in water bodies and the pressure on irrigation resources mirrors observations by (kumar Nayan, Das, Mukerji, Mazumder, & Bera, 2020), who show substantial decrease in surface water area in the metropolitan region due to LULC transformations. (Peerzado et al., 2019) also emphasize land use conflicts in which agricultural lands are increasingly converted for non-agricultural uses under urban pressures. The consistent pattern across these studies reinforces the conclusion that in Hyderabad, urbanization is exerting strong, cumulatively adverse impacts on agricultural and orchard land, which may

have important implications for food security, land management, and environmental sustainability (Figure 7).

Figure: 7 Interconnection of LULC change and agricultural land in District Hyderabad
Source: Classified images 1972-2023

Comparative Impact of LULC on Agricultural Land in Taluka Hyderabad City, Taluka Latifabad, Taluka Qasimabad and Taluka Hyderabad from 1972 to 2023

The analysis of Land Use and Land Cover (LULC) changes across Taluka Hyderabad City, Latifabad, Qasimabad and Taluka Hyderabad between 1972 and 2023 reveals significant urban expansion at the cost of agricultural and orchard lands. In Taluka Hyderabad City, agricultural land decreased drastically from 9.5 sq. km in 1972 to 3.2 sq. km in 2023 (−66%), while built-up areas expanded from 10.4 sq. km to 17.6 sq. km (+69%). This sharp decline highlights that fertile land in the urban core has been most vulnerable to encroachment. The steady fall of agricultural land corresponds directly to the consistent rise in built-up areas, reflecting how rapid population growth and infrastructure development have reshaped land use within the city center. Whereas the Land Use Land Cover (LULC) change in Taluka Hyderabad between 1972 and 2023 demonstrates a significant transformation of land use patterns. Agricultural land shows a continuous decline, reducing from about 230 sq. km in 1972 to nearly 140 sq. km in 2023, primarily due to conversion into built-up areas. In contrast, the built-up area expanded markedly, particularly after 2000, increasing from around 105 sq. km in 1972 to nearly 240 sq. km in 2023, reflecting rapid urbanization. Orchards, which initially covered approximately 350 sq. km, experienced a steady decline until 2000, followed by a slight recovery to about 290 sq. km in 2023. The barren area expanded until 2000 but later contracted, likely due to its transformation into urban and cultivated land. Water bodies remained limited but displayed gradual growth over the study period. Overall, the results emphasize the strong interconnection between the expansion of built-up areas and the decline of agricultural land, underscoring the profound effects of urban growth on the rural and peri-urban landscape of Taluka Hyderabad.

In Taluka Latifabad, agricultural land showed only a slight reduction (−6%), remaining close to 12 sq. km over the five decades. However, built-up areas more than doubled, from 30.6 sq. km in 1972 to 62.8 sq. km in 2023 (+105%), accompanied by a significant decline in orchards from 45.9 sq. km to 21.3 sq. km (−54%). This suggests that while core agricultural land was somewhat preserved, orchards and open spaces were extensively converted into residential and commercial uses. Similarly, Taluka Qasimabad experienced moderate agricultural land loss but severe orchard decline, from 27.1 sq. km in 1972 to 9.0 sq. km in 2023 (−67%), alongside a substantial rise in built-up areas from 13.9 sq. km to 29.4 sq. km (+112%). The evidence shows that orchards in Latifabad and Qasimabad served as transitional zones, providing land for housing schemes and urban sprawl.

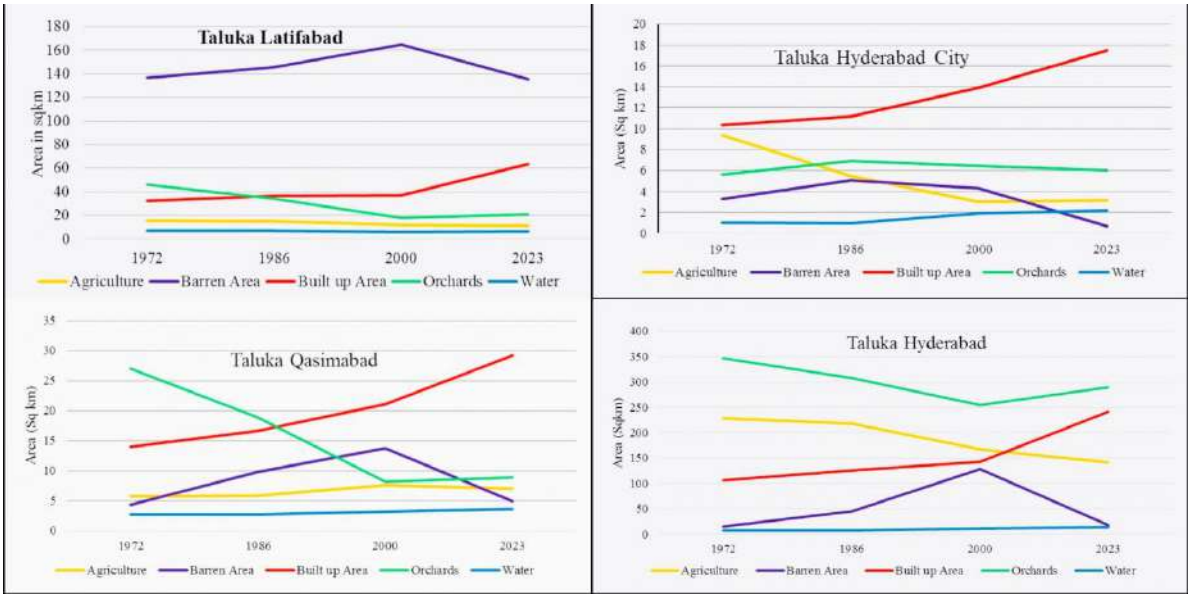

Figure: 8 Interconnection of LULC change and agricultural land in Taluka Latifabad, Taluka Qasimabad, Taluka, Taluka Hyderabad City and Taluka Hyderabad (1972-2023)
Source: Classified maps 1972-2023

Overall, the comparative figures (Figure 8) indicate that Taluka Hyderabad City and Taluka Hyderabad suffered the highest proportional loss of agricultural land, while Latifabad and Qasimabad saw widespread conversion of orchards and open lands into urban settlements. Together, these changes reflect the district-wide pressure of urbanization, where the demand for housing, infrastructure, and economic activity has continuously reshaped the landscape. The findings underline a critical policy concern: the conversion of productive agricultural land into built-up areas not only reduces local food production capacity but also alters the ecological balance of the region (Amini, Saber, Rabiei-Dastjerdi, & Homayouni, 2022; Rong & Fu, 2023). Strategic urban planning and land management are therefore essential to protect the remaining agricultural and orchard lands in Hyderabad District.

Conclusion

The analysis of Land Use Land Cover (LULC) changes across the four Talukas of District Hyderabad—Hyderabad City, Qasimabad, Latifabad, and Hyderabad Taluka—between 1972 and 2023 reveals profound shifts in land use dynamics, largely driven by urban expansion, demographic growth, and socioeconomic transformations. A consistent pattern across all Talukas is the steady decline of agricultural land, reflecting the pressures of urbanization and the conversion of fertile land into built-up areas.

In Taluka Hyderabad City, agriculture decreased substantially, while built-up areas expanded sharply, signifying the core urbanization hub of the district. Taluka Latifabad showed a similar trend, where agricultural decline and rapid growth of built-up land highlight its role as an extension of the city's urban sprawl. Taluka Qasimabad experienced notable transformations as well, with orchards and agriculture contracting significantly, while residential and commercial expansion accelerated in response to population pressures. In Taluka Hyderabad, the peri-urban and rural landscape was also reshaped: agricultural land and orchards declined, barren areas fluctuated, and built-up areas grew substantially, though at a slower pace compared to the central city.

Across the district, orchards and water bodies generally declined or fluctuated, with only partial recovery in some areas, indicating environmental stress and shifts in land management. Barren land expanded temporarily in certain Talukas but was later absorbed into urban and agricultural uses. Overall, the dominant trend is the rapid and continuous increase in built-up areas at the expense of agriculture and orchards, reshaping the traditional rural-urban balance of District Hyderabad.

This comprehensive assessment underscores the critical need for sustainable urban planning and land management policies. Without strategic interventions, the unchecked conversion of agricultural and green spaces into built-up land may undermine food security, ecological balance, and the long-term livability of Hyderabad district.

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