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EVOLVING THE CAPITAL OF PAKISTAN, ISLAMABAD: A COMPREHENSIVE ANALYSIS OF URBANIZATION TRENDS AND LAND USE LAND COVER CHANGES (2018-2022) THROUGH GIS

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ABSTRACT

This study deals with land use land cover changes (LULC) in Islamabad, the capital city of Pakistan, between 2018 and 2022. This study exploits satellite-based remote sensing and geographic information system (GIS) technology as tools to gain a deeper understanding of the complex LULC dynamics in the area in question and present an accurate picture of it over time. The findings are seen to be significant in many ways as these have major alterations in water bodies, tree covers, flooded areas, crops, built-ups, and rangelands. This also shows the continuous development of the city from an urbanization perspective. Very obvious are the noteworthy increase in built-up areas which suggest urbanization is an ongoing trend. Apart from this, the research proposes feasible strategies for sustainable urban development, conserving natural resources, smart growth, flood management, agricultural land conservation, public transportation improvements, green property projects, and policy integration. These data provide a key consideration in conversations on urban planning for the period 2023, ensuring that we build on a strong, evidence-based background for detailed, sustainable urban development in Islamabad and many other comparable rapidly growing urban settings around the world.

Keywords: Islamabad, Policy Recommendation, Urbanization Trend, Forest Cover Change, Land Use Change, Environmental Impacts, GIS

INTRODUCTION

Fundamental elements of the dynamic interaction between human activities and the natural environment are changes in land use and land cover (LULC). While land use includes the human arrangements, actions, and interventions that shape and modify different land cover types, land cover represents the physical qualities and bio-physical cover on the Earth's surface (Rawat and Kumar, 2015). Understanding LULC changes is crucial to understanding how human-environment interactions affect them and what they mean for ecosystems and societal structures.

LULC changes are crucial in determining the landscape, affecting environmental health, and preserving ecological balance in both urban and rural contexts. Deforestation, urban development, agricultural growth, and industrialization are only a few examples of the

various modifications caused by the interaction between human activity and the Earth's surface. These changes may have a significant impact on biodiversity, water supplies, natural habitats, and the climate system.

In addition to being important for comprehending a region's past and present conditions, the study of LULC changes is essential for predicting future trends and developing sustainable land management plans. The demand for resources and land increases as human populations rises and spread, placing enormous strain on the vulnerable ecosystems that sustain life on our planet.

LULC alterations can lead to the loss of green spaces, disruption of natural corridors, and altered microclimates in urban environments like Islamabad where development is fast altering the cityscape. These changes may then affect regional weather patterns, increase the urban heat island effect, and have an impact on the general welfare and standard of living of its residents.

Urbanization has a significant impact on the dynamics of land use and land cover. The transformation of rural areas into urban areas, which are defined by housing, industrialization, and infrastructural growth, disturbs the ecological balance and modifies regional climatic patterns. Urban growth frequently causes concerns like urban heat islands by causing the fragmentation of green spaces, a loss of biodiversity, and an increase in surface runoff (Seto et al., 2012; Zhou et al., 2020).

Studies on LULC alterations have demonstrated that these changes can have both favorable and unfavorable effects. Urbanization promotes economic progress and raises living standards, but it can also lead to social inequality, resource depletion, and environmental deterioration (Foley et al., 2005). To achieve sustainable urban expansion, it is crucial to comprehend the intricate trade-offs between urban development and environmental preservation.

The analysis of LULC changes has been transformed by the use of cutting-edge technology like remote sensing and Geographic Information Systems (GIS). As a result of the capture and processing of enormous geographic data made possible by satellite imaging and spatial analytic tools, valuable insights into the patterns and trends of land use shifts can be gained (Lambin and Geist, 2006). Decision-makers and urban planners now have a scientific foundation for well- informed policy creation and spatial planning thanks to these data-driven techniques.

Planning for the environment, sustainable development, and resource management can all benefit from research on LULC changes in Islamabad. Understanding the scope of these changes and how they will affect the neighborhood environment, local biodiversity, and overall ecological balance is crucial as the city continues to expand and urbanize.

Policymakers and urban planners may develop evidence-based solutions to reduce the negative effects of urbanization, safeguard important ecosystems, and promote sustainable land use practices by understanding the factors that are causing LULC changes. Furthermore, knowing how human activities affect how the land changes can help in the formulation of policies that promote inclusive and fair urban growth.

The results of this study will add to the body of knowledge already available on LULC alterations in urban settings, particularly in fast-growing cities like Islamabad. The study's findings will help guide future urban planning initiatives and decision-making procedures involving land use management and environmental protection.

This thesis seeks to advance knowledge of the effects of urbanization on the environment and society by a thorough analysis of the LULC trends in Islamabad in the years 2018, 2020, and 2022. In order to create precise maps of the land cover and spot noteworthy changes throughout the course of the study, the research will use remote sensing methods and GIS analysis. The results will give policymakers crucial knowledge they need to promote sustainable urban growth, safeguard natural ecosystems, and improve the city's overall resilience.

In conclusion, research on LULC changes in fast-growing cities like Islamabad is essential for enlightened decision-making and environmentally friendly urban design. This research aims to contribute to a more balanced and inclusive approach to urban growth, maintaining a peaceful cohabitation between people and the environment in Islamabad and beyond, by understanding the complex interaction between human activities and land alterations.

Study Area

The study area, Islamabad, which acts as the focus of this thesis, is thoroughly described in this chapter. The nation of Pakistan's capital, Islamabad, is located in the north of the continent. It is a planned city with strategic value as the national political, administrative, and economic hub. This section explores Islamabad's historical growth and significant land use changes over time, as well as its physical, climatic, and demographic aspects.

Islamabad is situated at the base of the magnificent Margalla Hills, which serve as the city's natural northern border. The city is located between 33.6844° N and 73.0479° E in terms of latitude and longitude. The city is one of Pakistan's major urban regions, with a total size of about 906.5 square kilometers.

Islamabad's geography is characterized by undulating terrain with a range of heights between 457 meters (1,500 feet) and 609 meters (2,000 feet). The Margalla Hills' presence enhances the city's natural attractiveness and is essential for both providing open places for recreation and safeguarding the environment.

METHODOLOGY

Data Collection:

In this study, the shifting Land Use and Land Cover (LULC) in Islamabad, Pakistan, is examined. The data was collected from https://livingatlas.arcgis.com/landcoverexplorer/#mapCenter=-154.873%2C19.477%2C11&mode=step&timeExtent=2017%2C2022&year=2022. The dataset was created using the deep learning AI land categorization model from Impact Observatory and consists of images with a 10-meter resolution. It is crucial to remember that this algorithm successfully divides LULC into seven different groups. The information included observations for September in the years 2018, 2020, and 2022.

Classification of Classes:

The imagery dataset underwent a meticulous classification process, wherein each distinctive class was assigned a unique value and name:

Table 1: Classification of Classes

Value	Name	Description
1	Water	Represents consistently wet areas (e.g., rivers, lakes, oceans)
2	Trees	Encompasses densely packed, tall vegetation
4	Flooded Vegetation	Characterizes seasonal floodplains with mixed vegetation
5	Crops	Pertains to cultivated cereals and grasses
7	Built-up Area	Refers to man-made structures and urban areas
8	Bare Land	Signifies environments with minimal vegetation
11	Rangeland	Denotes areas with little to no vegetation

Classification Results and Area Calculation:

The "Global land use/land cover with Sentinel-2 and deep learning" dataset's pre-classified photos were painstakingly used to produce the classification findings. The extent of each land use class in Islamabad was determined from these classed photos in both hectares and square kilometers.

The formula used for calculating the area in hectares from the number of pixel cells (count) is as follows:

$$\text{Area in Hectares} = \frac{\text{Count of Pixel Cells} \times \text{Pixel size}}{10{,}000}$$

The formula used for calculating the area (in square kilometers) is adjusted as follows:

$$\text{Area in Sq.Km} = \frac{\text{Count of Pixel Cells} \times \text{Pixel size}}{1{,}000{,}000}$$

The formula used for calculating the percentage of an area was:

$$\text{Percentage of Areas} = \frac{\text{Total Area}}{\text{Area of a Specific Class}} \times 100$$

The formula employed for the calculation of change detection in hectares between two years was:

$$\text{Change Detection} = \text{Final Area} - \text{Initial Area}$$

The formula used for the calculation of Percentage change detection was:

$$\text{Percentage of Change Detection} = \frac{\text{Change Detection}}{\text{Initial Area}} \times 100$$

In All formulas, "Count of Pixel Cells" represents the number of pixel cells allocated to the specific land use class, and "Pixel Size" represents the size of each pixel, which is 10x10 meters. For hectares, we divide the count of pixel cells and pixel size by 10,000 to convert square meters to hectares, and for square kilometers, we divide the count of pixel cells and pixel size by 1,000,000 to convert square meters to square kilometers.

RESULTS AND DISCUSSION

Land Use Land Cover Classification of Islamabad 2018

The current study provides a thorough summary of Islamabad's Land Use Land Cover (LULC) distribution for the calendar year 2018. Water (W), Trees (T), Flooded Vegetation (FV), Crops (C), Built Area (BA), Bare Ground (BG), Rangeland (RL), and Total Area (TA) are the several divisions into which the LULC categories have been divided. Insightful information about the scope and distribution of each land use category is revealed by the data analysis.

Table 2: Land Use Land Cover Classification of Islamabad – 2018

Land Use Land Cover Overview of Islamabad - 2018						
S. No.	**LULC type**	**Cell Count**	**Cell Size**	**Area in Sq. km**	**Area in Hectare**	**Area Percentage (%)**
1	W	73356	10 × 10	7.34	733.56	0.87
2	T	1256639		125.66	12566.4	14.86
3	FV	2921		0.29	29.21	0.03
4	C	2063195		206.32	20632	24.403
5	BA	3797496		379.75	37975	44.92
6	BG	7720		0.77	77.2	0.09
7	RL	1253429		125.34	12534.3	14.83
8	TA	8454756		845.47	84547.67	100

LULC = Land Use Land Cover, W = Water, T = Trees, FV = Flooded vegetation, C = Crops, BA = Built Area, BG = Bare Ground, RL = Rangeland, TA = Total Area

According to the findings, Water makes up about 0.87% of the region's total area or 7.34 square kilometers. With 125.66 square kilometers, or 14.86% of the total area, trees dominate the environment. 0.03% of the area, or 0.29 square kilometers, is marginally covered by flooded vegetation. Crops cover 206.32 square kilometers, or 24.40% of the land, and are a crucial part of the agricultural landscape of the area.

It should be noted that the Built Area, with 379.75 square kilometers, or 44.92% of the total area, has the biggest spatial extent. Additionally, Rangeland encompasses 125.34 square kilometers (14.83%) and Bare Ground comprises 0.77 square kilometers (0.09%). Islamabad's total area, which includes all of the aforementioned LULC kinds,is calculated to be 845.47 square kilometers. These results provide important new information about Islamabad's land use patterns and lay a solid foundation for the city's future planning and sustainable development activities.

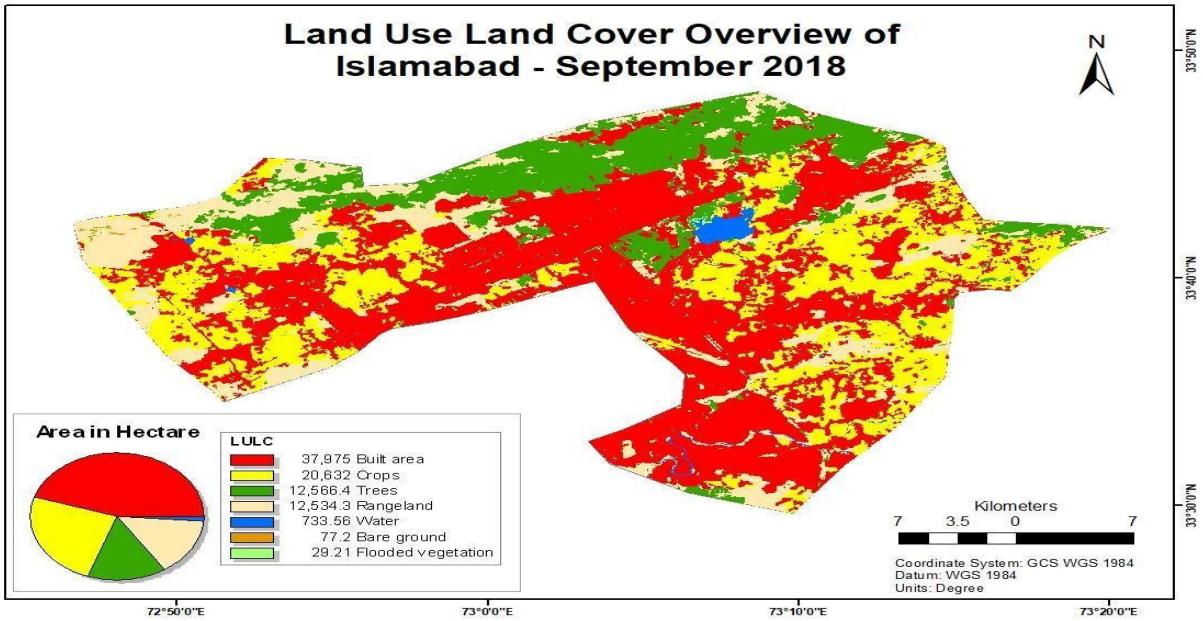


Figure SEQ Figure * ARABIC 1 Land Use Land Cover Classification Map of Islamabad - 2018

Land Use Land Cover Classification of Islamabad 2020

An updated and thorough analysis of the Land Use Land Cover (LULC) distribution in Islamabad was conducted in the year 2020, providing crucial insights into the changing spatial patterns. Water (W), Trees (T), Flooded Vegetation (FV), Crops (C), Built Area (BA), Bare Ground (BG), Rangeland (RL), and Total Area (TA) are the methodically categorized LULC kinds.

Table 3 Land Use Land Cover Overview of Islamabad 2020

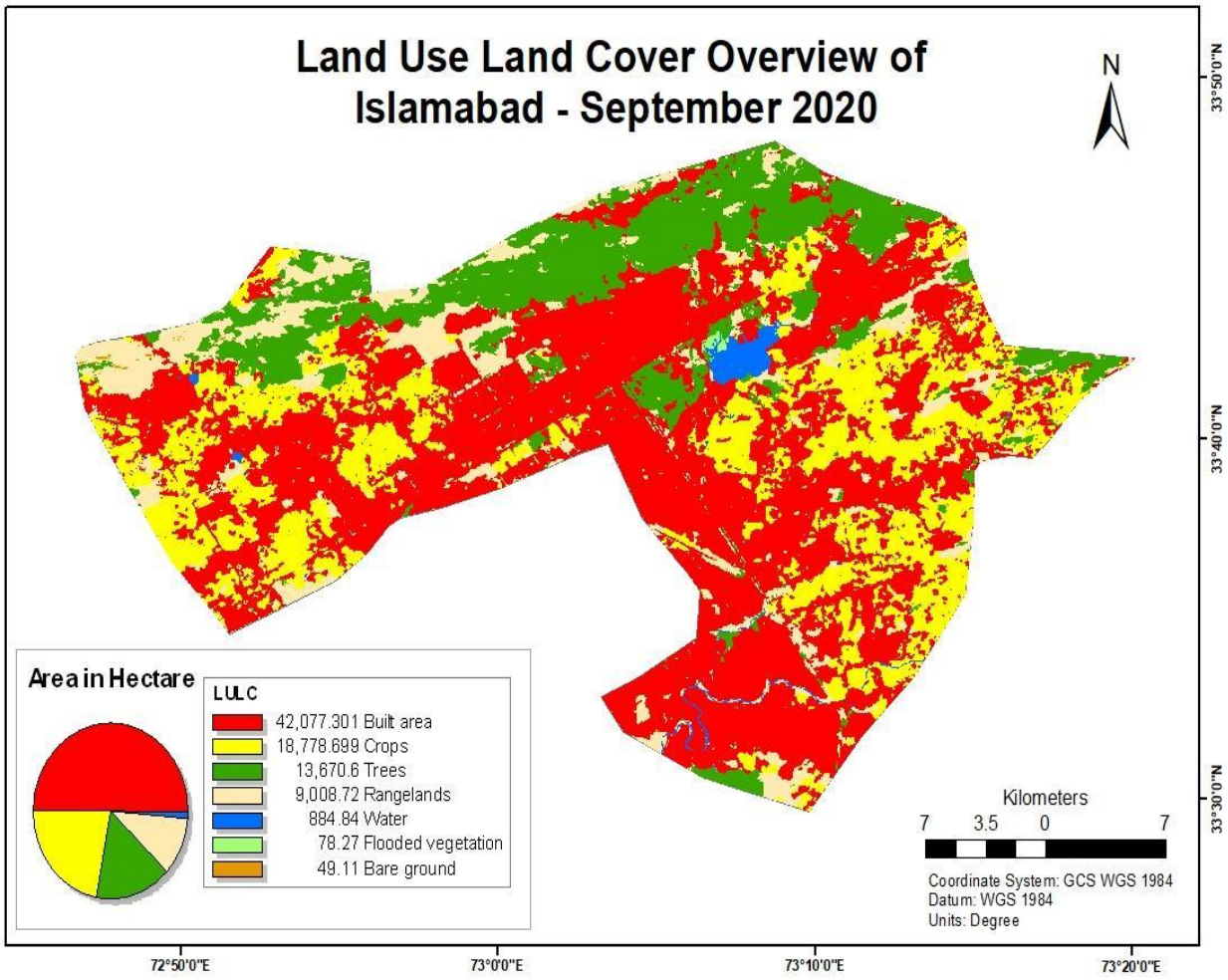
Land Use Land Cover Overview of Islamabad - 2020						
S. No.	**LULC type**	**Cell Count**	**Cell Size**	**Area in Sq. km**	**Area in Hectare**	**Area Percentage (%)**
1	W	88484	10 × 10	8.85	884.84	1.05
2	T	1367059		136.71	13670.6	16.17
3	FV	7827		0.78	78.27	0.09
4	C	1877868		187.79	18778.7	22.21
5	BA	4207735		420.77	42077.3	49.77
6	BG	4911		0.49	49.11	0.06
7	RL	900872		90.09	9008.72	10.66
8	TA	8454756		845.48	84547.54	100

LULC = Land Use Land Cover, W = Water, T = Trees, FV = Flooded vegetation, C = Crops, BA = Built Area, BG = Bare Ground, RL = Rangeland, TA = Total Area

The results show significant changes from the 2018 data, illuminating the dynamic character of land use in the area. A total of 8.85 square kilometers, or around 1.05% of the entire landscape, is covered by water. A significant amount of the territory, at 16.17%, or 136.71 square kilometers, is still heavily covered by trees. 0.09% of the area, or a tiny 0.78 square kilometers, had vegetation that had been flooded.

The agricultural sector of the area is heavily dependent on crops, which cover an area of 187.79 square kilometers, or 22.21% of the land. The Built Area, which includes urban and developed zones, has significantly increased and now occupies 420.77 square kilometers, or 49.77% of the total area, suggesting that urbanization and development activities in Islamabad have become more intense.

Bare Ground also covers 0.49 square kilometers (0.06%), whereas Rangeland covers 90.09 square kilometers (10.66%). Islamabad's total area, which includes all of the aforementioned LULC kinds, is still 845.48 square kilometers. For strategic planning, informed decision-making, and sustainable development activities in the city, these revised findings offer useful and current information.



Land Use Land Cover Classification of Islamabad 2022

An extensive Land Use Land Cover (LULC) assessment that provided up-to-date data on the distribution and scope of several land use categories was carried out in Islamabad in 2022. Water (W), Trees (T), Flooded Vegetation (FV), Crops (C), Built Area (BA), Bare Ground (BG), Rangeland (RL), and Total Area (TA) are the different LULC kinds.

Table 4: Land Use Land Cover Overview of Islamabad-2022

Land Use Land Cover Overview of Islamabad - 2022						
S. No	**LULC Type**	**Cell Count**	**Cell Size**	**Area in Sq.Km**	**Area in Hectare**	**Area Percentage (%)**
1	W	79597	10 × 10	7.9597	796	0.941488
2	T	1204804		120.48	12048	14.2501
3	FV	5410		0.541	54	0.06387
4	C	1467647		146.765	14676	17.3584
5	BA	4603184		460.318	46032	54.4455
6	BG	4749		0.4749	47	0.05559
7	RL	1089365		108.937	10894	12.8851
8	TA	8454756		845.4756	84547	100

LULC = Land Use Land Cover, W = Water, T = Trees, FV = Flooded vegetation, C = Crops, BA = Built Area, BG = Bare Ground, RL = Rangeland, TA = Total Area

According to the data, Water has an area of 7.9597 square kilometers, or roughly 0.941% of the entire territory. Trees still make up a large portion of the landscape, covering 120.48 square kilometers or 14.25% of it. 0.06387% of the area, or 0.541 square kilometers, is covered by Flooded Vegetation.

The agricultural sector of the area is heavily dependent on crops, which cover 146.765 square kilometers, or 17.36% of the land. The Built Area, which includes developed and urban areas, has grown dramatically and presently occupies 460.318 square kilometers, or 54.45% of the total area, suggesting that Islamabad's urbanization and growth are still ongoing.

Rangeland covers 108.937 square kilometers (12.89%) whereas Bare Ground covers 0.4749 square kilometers (0.05559%). The total area of Islamabad, which includes all the LULC categories listed, stays at 845.4756 square kilometers.

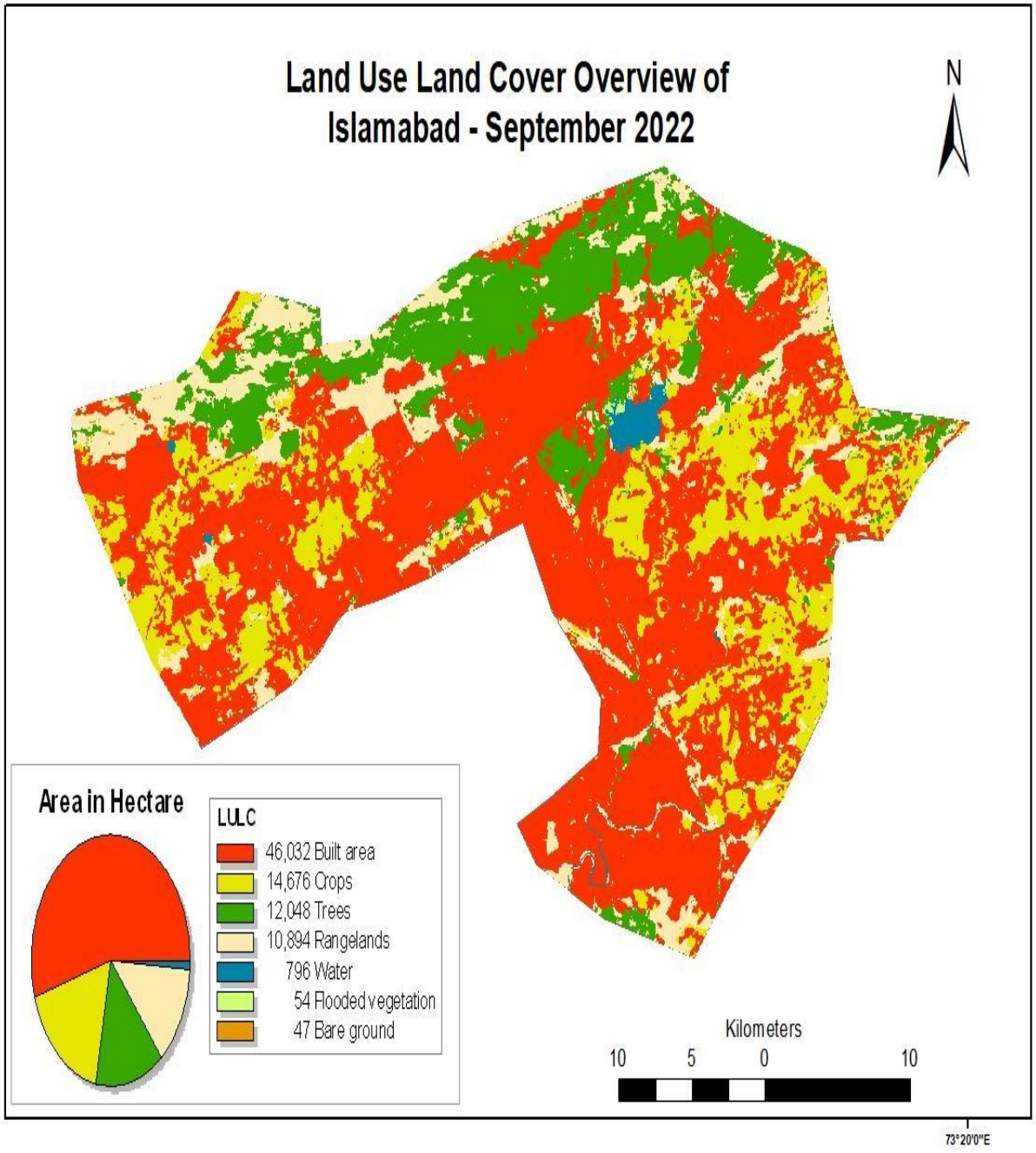


Figure 3 Land Use Land Cover Overview of Islamabad - September 2022

Land Use Land Cover Trend and Analysis:

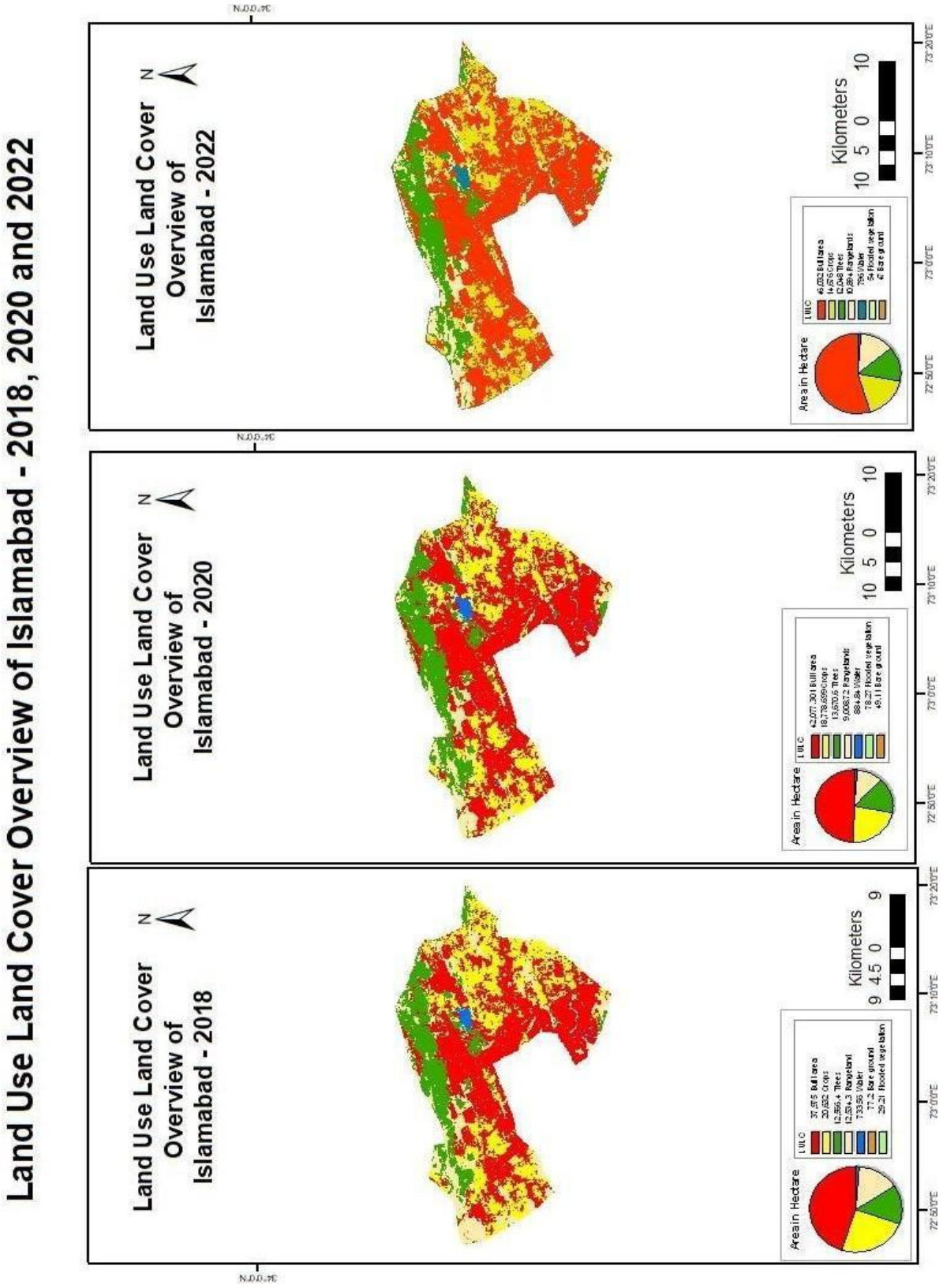


Figure SEQ Figure * ARABIC 4 Land Cover Land Use Overview of Islamabad 2018, 2020 and 2022

Land Use Land Cover Analysis and Trend between 2018-2020

Significant changes in the distribution and extent of different land cover types are seen in Islamabad between the years of 2018 and 2020, according to an analysis of land use and land cover (LULC) changes. In accordance with the starting area (IA) in 2018, the analysis displays the change discovered (CD) in hectares and the accompanying percentage change (%).

Percentage Change (2018-2020)

S.No	LULC Type	Area in 2018 (Hectare)	Area in 2020 (Hectare)	Change Detected (Hectare)	Percentage Change (%) (CD/IA)×100
1	W	733.56	884.84	151.28	↑21%
2	T	12566.4	13670.6	1104.2	↑9%
4	C	20632	18778.7	-1853.3	↓9%
5	BA	37975	42077.3	4102.3	↑11%
6	BG	77.2	49.11	-28.09	↓36%
7	RL	12534.3	9008.72	-3525.58	↓28%
8	TA	84547.67	84547.54	0	↑0%

LULC = Land Use Land Cover, W = Water, T = Trees, FV = Flooded vegetation, C = Crops, BA = Built Area, BG = Bare Ground, RL = Rangeland, TA = Total Area, CD = Change Detected, IA = Initial Area (Area in 2018)

Water (W): Water bodies had significant growth, growing from 733.56 hectares in 2018 to 884.84 hectares in 2020. This expansion reflects a remarkable change observed of 151.28 hectares, marking a noteworthy change discovered of 21%. This shows a rise in the region's water area, which is a good trend.

Trees (T): The tree cover increased from 12,566.4 hectares in 2018 to 13,670.6 hectares in 2020, yielding a change observed of 1,104.2 hectares, equal to a remarkable percentage rise of 9%. This represents positive progress. This points to a persistent pattern of growing tree cover.

Flooded Vegetation (FV): From 29.21 hectares in 2018 to 78.27 hectares in 2020, reflecting a major shift of 49.06 hectares and an impressive percentage rise of 168%, the area of flooded vegetation underwent a remarkable increase. This shows a clear tendency toward more flooded vegetation in the area.

Crops (C): The crop area, however, showed a loss, falling from 20,632 hectares in 2018 to 18,778.7 hectares in 2020, demonstrating a change detected of -1,853.3 hectares, resulting in a 9% decrease in percentage. This points to a regional pattern of declining cropland.

Built Area (BA): The size of urban and developed areas significantly increased, rising from 37,975 hectares in 2018 to 42,077.3 hectares in 2020. This is a shift of 4,102.3 hectares, or a significant increase of 11%. This shows that Islamabad's urbanization and growth are still on the rise.

Conversely, the amount of bare ground (BG) declined from 77.2 hectares in 2018 to 49.11 hectares in 2020, showing a change detected of -28.09 hectares, or a 36% reduction in area. This shows that the region is experiencing a trend of less bare terrain.

Rangeland (RL): The area of rangeland decreased from 12,534.3 hectares in 2018 to 9,008.72 hectares in 2020, showing a change observed of -3,525.58 hectares, or a 28% decrease in percentage. This shows that Islamabad's rangeland area is continuing to decline.

Total Area (TA): Islamabad's total size was the same in 2018 and 2020 at 84,547.67 hectares, resulting in a change recorded of 0 hectares, indicating no % change. This shows that the overall trend for the region is stable.

The results offer a thorough grasp of the dynamic shifts in land use and cover over the designated two-year period and show the patterns influencing Islamabad's urban landscape.

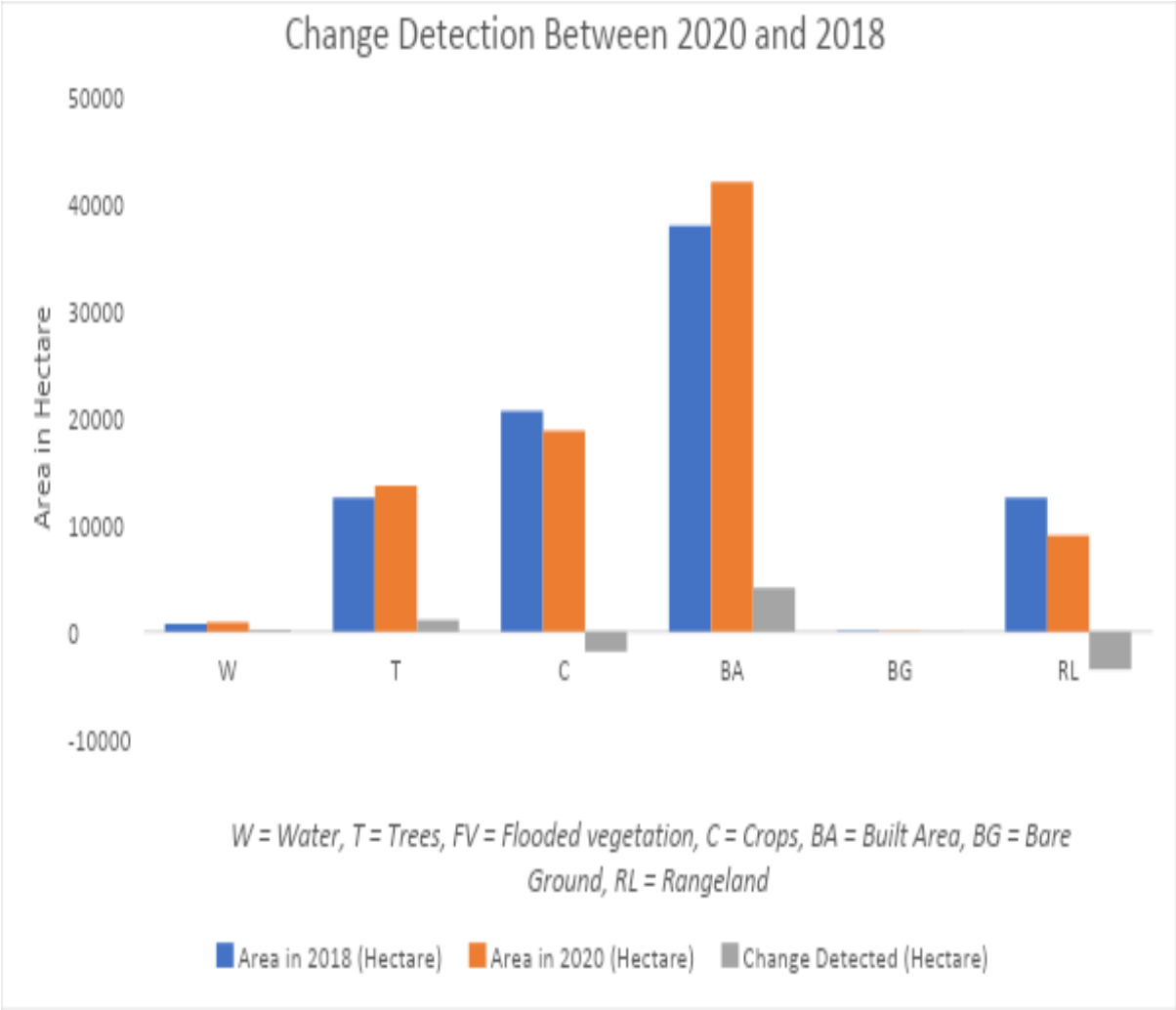


Figure 5: Change Detection between 2018 and 2020

Land Use Land Cover Analysis and Trend between 2020-2022

Significant changes in the distribution and extent of different land cover types are seen in Islamabad between 2020 and 2022, according to an examination of LULC changes. The analysis shows the amount of change that was found (CD) in hectares and the percentage change that was found (%) relative to the initial area (IA) in 2020.

Percentage Change (2020-2022)					
S.No	**LULC Type**	**Area in 2020 (Hectare)**	**Area in 2022 (Hectare)**	**Change Detected (Hectare)**	**Percentage Change (CD/IA) ×100**
1	W	884.84	796	-88.84	↓10%
2	T	13670.6	12048	-1622.6	↓12%
3	FV	78.27	54	-24.27	↓31%
4	C	18778.7	14676	-4102.7	↓22%
5	BA	42077.3	46032	3954.7	↑9%
6	BG	49.11	47	-2.11	↓4%
7	RL	9008.72	10894	1885.28	↑21%
8	TA	84547.54	84547	0	↑0%

LULC = Land Use Land Cover, W = Water, T = Trees, FV = Flooded vegetation, C = Crops, BA = Built Area, BG = Bare Ground, RL = Rangeland, TA = Total Area, CD = Change Detected, IA = Initial Area

Water (W): Water bodies saw a decline from 884.84 hectares in 2020 to 796 hectares in 2022, showing a change observed of -88.84 hectares, resulting in a 10% decrease in percentage. This illustrates a clear decline in the amount of water in the area.

Trees (T): The amount of land covered by trees decreased from 13,670.6 hectares in 2020 to 12,048 hectares in 2022, indicating a change that was detected of -1,622.6 hectares, or a 12% drop in the area. This shows that the number of trees is continuing to decline.

Flooded Vegetation (FV): From 78.27 hectares in 2020 to 54 hectares in 2022, the area of flooded vegetation dropped, with a shift of -24.27 hectares, or a 31% decrease in percentage. This suggests that the area's waterlogged vegetation has been trending noticeably downward.

Crops (C): From 18,778.7 hectares in 2020 to 14,676 hectares in 2022, the crop area had a significant fall, showing a change detected of -4,102.7 hectares, resulting in a 22% decrease in percentage. This points to a regional pattern of declining cropland.

Built Area (BA): Urban and developed areas grew, going from 42,077.3 hectares in 2020 to 46,032 hectares in 2022. This is a shift of 3,954.7 hectares, or a 9% increase in area. This shows that Islamabad's urbanization and growth are still on the rise.

Bare Ground (BG): The area of bare ground declined from 49.11 hectares in 2020 to 47 hectares in 2022, suggesting a change detected of -2.11 hectares and a 4% decrease in percentage. This shows that the region is experiencing a trend of less bare terrain. Rangeland (RL): The area of rangeland increased from 9,008.72 hectares in 2020 to 10,894 hectares in 2022, with a change of 1,885.28 hectares, or a 21% rise in percentage. This suggests a noticeable rising tendency in Islamabad's rangeland area.

Total Area (TA): Islamabad's total size stayed the same in 2020 and 2022 at 84,547.54 hectares, resulting in a change observed of 0 hectares, indicating no % change. This shows that the overall trend for the region is stable.

The results offer a thorough understanding of the dynamic changes in land use and land cover during the stipulated two-year period and show the trends influencing Islamabad's urban landscape, which would be helpful for the city's initiatives for sustainable development and urban planning.

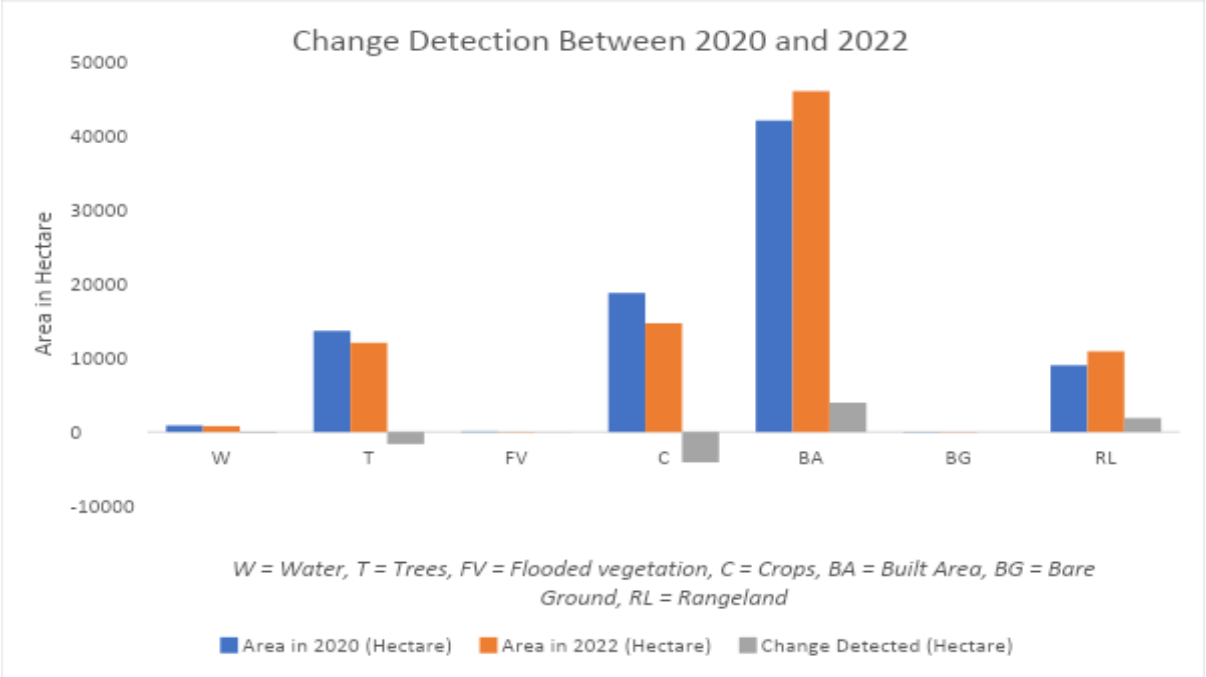


Figure 6: Change Detection Between 2020 and 2022

Urbanization Trend:

Urbanization Trend		
S.No	Year	Percentage of built Area
1	2018	44.92%
2	2020	49.77%
3	2022	54.45%

Investigating the urbanization trend from 2018 to 2022 reveals a noteworthy progression in the percentage of built area. The percentage increase from 2018 to 2020 can be calculated as follows:

$$\text{Percentage Increase (2018 to 2020)} = \frac{44{\cdot}77 - 44{\cdot}92}{44.92} \times 100$$
$$= 10.75\ \%$$

Similarly, the percentage increase from 2020 to 2022 is determined by:

$$\text{Percentage Increase (2020 to 2022)} = \frac{55{\cdot}45 - 49.77}{49.77} \times 100$$
$$= 9.46\ \%$$

The average urbanization trend, representing the overall growth in built area over this period, is calculated as the mean of these two percentages:

$$\text{Average Urbanization Trend} = \frac{10.75 - 9.40}{2} \approx 10.10\%$$

These calculations underscore a consistent and significant upward trajectory in urban development, highlighting the ongoing process of urbanization and its transformative impact on the built environment in Islamabad.

CONCLUSION

The results of the examination of Islamabad's land use, land cover (LULC), and urbanization patterns provide important new insights into the dynamics of the city's urban development throughout the three-year period from 2018 to 2022. The study provides a thorough overview of the city's changing land use patterns by highlighting the spatial distribution and extent of distinct land cover categories.

The findings show that the Built Area (BA), which represents urban and developed zones, grew significantly between 2018 and 2022, rising from 44.92% of the total area to 54.45%. This suggests a noticeable growth in urbanization, which reflects the city's reaction to rising economic and demographic needs. Urban planning and sustainable development in Islamabad face both possibilities and difficulties as a result of the city's growing urbanization.

Trees (T), Water (W), Flooded Vegetation (FV), Crops (C), Bare Ground (BG), and Rangeland (RL) are examples of land cover types where trends have been noticed. These kinds also help to comprehend the biological and environmental dynamics of the city. While certain land cover categories witnessed development, others underwent changes or decreased, demonstrating the dynamic interaction between anthropogenic and natural causes.

The pace of urbanization, which grew gradually over the course of three years, represents the city's continual landscape modification and urban growth. Understanding and controlling the urbanization process is essential for maintaining a balance between economic development, environmental protection, and the quality of life for Islamabad's citizens as the city continues to change.

In conclusion, the thorough examination of Islamabad's urbanization, land use, and cover patterns offers vital information for urban planners, decision-makers, and policy-makers to guide sustainable development initiatives. Adopting policies to protect green spaces, advance sustainable land use, and lessen environmental effects is essential as the city develops. The findings of this study provide a useful basis for making informed decisions and will help Islamabad create a resilient and prosperous urban future.

RECOMMENDATIONS

Several important recommendations are put forth to direct future planning and support sustainable development activities in the city based on the analytical findings from the land use land cover (LULC) research and urbanization patterns in Islamabad for the Policy Makers:

Sustainable Urban Planning: Include in the city's growth plans sustainable urban planning strategies that give priority to the provision of green spaces, parks, and recreational places. This strategy will improve the quality of life for locals while preserving natural harmony amid urban growth.

Natural Resource Conservation: Put your attention on initiatives to save vital natural resources. Programs for reforestation and afforestation should be implemented to improve tree cover and protect water bodies from further deterioration.

Smart Growth Strategies: Promote the employment of smart growth tactics that support dense, mixed-use urban development. By concentrating urban expansion within current regions, sprawl will be reduced, open spaces will be preserved, and overall urban efficiency will increase.

Establish thorough flood control techniques and climate resilience measures in light of the existence of Flooded Vegetation (FV) and possible climate change implications. Increase urban resilience by using natural solutions and flood mitigation infrastructure.

Agricultural Land Preservation: Promote sustainable agricultural methods to protect and maintain agricultural land (Crops - C) on the edges of cities. Prevent the development of built-up areas on productive agricultural land.

Public Transportation and Mobility: Promote effective public transportation networks and environmentally friendly forms of transportation to combat the problems associated with urbanization. Encourage the use of public transportation, cycling, and walking to lessen the need for private automobiles and clear up traffic.

Establish a reliable method for monitoring land usage by utilizing remote sensing technology and Geographic Information method (GIS) mapping.

Update and monitor land cover changes often to support decision-making based on facts.

Public Involvement and Awareness: Through public involvement and awareness initiatives, include the community in urban planning procedures. Encourage the implementation of sustainable land use methods and seek out the opinions of locals to promote inclusive urban development.

Green Building and Sustainable Infrastructure: Encourage the use of green building practices and the creation of sustainable infrastructure. Encourage the construction of energy-efficient structures, the use of renewable energy sources, and the creation of environmentally friendly infrastructure.

Adaptive Management and Policy Integration: Embrace adaptive management approaches and integrate land use policies with environmental, social, and economic policies. Adopt an integrated approach to address urbanization challenges holistically.

These suggestions might be included into Islamabad's planning and development initiatives to create a more resilient and sustainable urban environment. The city may start on a route to a peaceful and successful future by combining urban growth with environmental preservation and community well-being.

REFERENCES

[1] Rawat, J. S., & Kumar, M. (2015). Monitoring land use/land cover using remote sensing and GIS techniques. International Journal of Computer Applications, 117(18), 11-17.
[2] DeFries, R. S., & Townshend, J. R. (1994). Global land use patterns and their impact on atmospheric carbon dioxide. Global Biogeochemical Cycles, 8(4), 495-512.
[3] Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., ... & Helkowski, J. H. (2005). Global consequences of land use. Science, 309(5734), 570-574.
[4] Lambin, E. F., & Geist, H. J. (2006). Land-use and land-cover change: Local processes and global impacts. Berlin, Heidelberg: Springer-Verlag.
[5] Mellander, P. E., Alexander, C., & Seibert, J. (2018). Land cover change effects on floods at different spatial scales and frequencies. Hydrology and Earth System Sciences, 22(1), 573-586.
[6] Seto, K. C., Fragkias, M., Güneralp, B., & Reilly, M. K. (2012). A meta-analysis of global urban land expansion. PLoS One, 7(6), e45780.
[7] Zhou, D., Zhao, X., Zhang, L., Huang, X., Xie, W., & Liu, Y. (2020). The response of urban heat islands to urbanization in different climates over China from 2003 to 2015. Climate Dynamics, 54(3-4), 1413-1432.
[8] Angel, S., Parent, J., Civco, D. L., Blei, A. M., & Potere, D. (2011). The dimensions of global urban expansion: Estimates and projections for all countries, 2000–2050. Progress in Planning, 75(2), 53-107.
[9] Bai, Z. G., Dent, D. L., Olsson, L., & Schaepman, M. E. (2008). Global assessment of land degradation and improvement 1: Identification by remote sensing. International Journal of Remote Sensing, 29(3), 697-709.
[10] Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., ... & Helkowski, J. H. (2005). Global consequences of land use. Science, 309(5734), 570-574.
[11] McDonald, R. I., Mansur, A. V., Ascensão, F., Crossman, K., Elmqvist, T., Guneralp, B., ... & Seto, K. C. (2018). Research gaps in knowledge of the impact of urban growth on biodiversity. Nature Sustainability, 1(9), 377-385.
[12] Oke, T. R. (1982). The energetic basis of the urban heat island. Quarterly Journal of the Royal Meteorological Society, 108(455), 1-24.
[13] Tiwari, A. K., & Khanduri, V. P. (2011). Detection of Land Use Changes in Doon Valley (DehradunTehsil) Using Multi-Temporal Satellite Data. Journal of the Indian Society of Remote Sensing, 39(2), 189-200.
[14] Barman, B., & Goswami, D. C. (2015). Multi-temporal Remote Sensing Based Land Use and Land Cover Change Detection in Kaziranga National Park and Its Adjacent Areas, Assam, India. Journal of the Indian Society of Remote Sensing, 43(2), 363-371.
[15] Manonmani, V., & Suganya, M. (2010). Spatio-Temporal Land Use Land Cover Change Detection and Prediction in Trichirappalli District Using Multi-Temporal Satellite Data. Journal of the Indian Society of Remote Sensing, 38(2), 263-276.
[16] Samanta, S., & Hazra, S. (2012). Spatio-Temporal Land Use Land Cover Changes in the Sagar Island, India, Using Multi-Temporal Satellite Data. Journal of the Indian Society of Remote Sensing, 40(4), 585-592.
[17] Juliev, A. V., Asyakul, M. A., & Aviasov, V. A. (2019). Land-Use and Land-Cover Change Analysis Using Remote Sensing and GIS in the Bostanlik District, Tashkent, Uzbekistan. Egyptian Journal of Remote Sensing and Space Science, 22(3), 405-416.
[18] Abebe, A. D., Assen, M., & Teferi, E. (2022). Land Use Land Cover Change Analysis in the Gubalafto District, Northeastern Ethiopia: A Combined Remote Sensing and Community Survey Approach. International Journal of Environmental Research and Public Health, 19(4), 1923.

[19] Rwanga, S. S., & Ndambuki, J. M. (2017). Mapping Land Use and Land Cover Changes in the Lake Naivasha Basin, Kenya Using Remote Sensing and GIS. International Journal of Geosciences, 8(8), 1021-1045.
[20] Food and Agriculture Organization (FAO). (2010). Global Forest Resources Assessment 2010. Food and Agriculture Organization of the United Nations.