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EXACERBATING LAND USE PATTERNS IN URBAN AREAS: A SPATIO - TEMPORAL STUDY OF URBANIZATION IN PATAN CITY, GUJARAT

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ABSTRACT

This study examines the urbanisation and alterations in land use in Patan, a city in Gujarat. Rural areas are transformed into urban areas through the process of urbanisation. The study investigates the effects of this procedure on Patan's land use. Satellite images from 2012 and 2022 are used in the study to map and track changes in the study area. The study examines the many land classifications in the region, including water bodies, built-up areas, vegetation, agriculture, agricultural fallow land, riverbeds, and barren land. It does so using tools like QGIS and ArcGIS. The study's conclusions show that Patan's land use has changed significantly during the previous ten years. While agriculture and agricultural fallow have reduced, the built-up area has expanded. These changes are attributable to the urbanisation and expanding population of the region. This study underlines the requirement for efficient land use laws and rules that support Patan's sustainable urban development. Urbanization can have detrimental effects on the ecology, the loss of agricultural land, and other factors if it is not planned for properly. The study emphasises the significance of efficiently managing urban areas through the use of GIS and remote sensing technology. These technologies can offer insightful information about how land use is changing and how urbanisation affects the environment. This study sheds light on Patan's urbanisation and shifting land use patterns and emphasises the necessity of sustainable urban planning and management.

Keywords: Patan, Urbanization, ArcGIS, QGIS, Agriculture, Built up area

INTRODUCTION

Urbanization is a multifaceted process with far-reaching consequences for societies, economies, and ecosystems. The process, by which people migrate from rural to urban areas, resulting in the growth and expansion of cities and towns, is known as urbanisation. Urbanization is a global phenomenon, and its effects can be felt all over the world, particularly in developing countries where urbanisation rates are rapidly increasing (Memon et al., 2019). More than half of the world's population lives in cities as of 2021, and this figure is expected to rise to two-thirds by 2050. (United Nations, 2021).

Individuals and society as a whole benefit greatly from urbanisation. Urban areas can provide better access to education, healthcare, and job opportunities, as well as social and cultural amenities. Cities, as hubs for innovation, trade, and commerce, can also play an important role in driving economic growth and development. Furthermore, urban areas can contribute to environmental sustainability, with densely populated cities often emitting less carbon per capita than rural areas due to more efficient resource use (McGranahan et al., 2015). However, urbanisation brings with it a number of challenges and risks.

Rapid urbanisation can put a strain on resources and infrastructure, resulting in overcrowding, pollution, and insufficient access to essential services (Kobayashi, 2017). Urban areas can also exacerbate social and economic inequality by making it more difficult for marginalized communities to access services and opportunities. Furthermore, urbanisation can have a negative impact on ecosystems and biodiversity because it frequently involves the conversion of natural habitats and biodiversity loss (Grimm et al., 2008). These challenges and risks highlight the importance of policymakers and academics developing effective strategies to address the negative effects of urbanisation while maximizing its benefits.

Scholars and policymakers have paid increasing attention to the challenges and opportunities that urbanisation presents. Efforts to promote sustainable urbanisation and mitigate its negative effects have included infrastructure investments, promotion of sustainable transportation and energy systems, and initiatives to support inclusive and equitable urban development (United Nations, 2021). A growing body of research has concentrated on the social, economic, and environmental consequences of urbanisation, as well as strategies for mitigating its negative effects and maximising its benefits.

Several studies, for example, have looked into the relationship between urbanisation and health. According to Van Dyck et al. (2019), living in cities is associated with higher levels of physical activity, but also with increased exposure to air pollution. Another study, by Vos et al. (2017), discovered that in low- and middle-income countries, urbanisation was associated with a higher prevalence of obesity and diabetes. These findings highlight the critical need to address the negative effects of urbanisation on health and well-being. Other studies have concentrated on the economic consequences of urbanisation. Henderson et al. (2019) discovered that in developing countries, urbanisation was associated with higher levels of productivity and income growth. Similarly, Ahmed and Khattak (2019) discovered that urbanisation was positively related to economic growth in Pakistan. These findings suggest that urbanisation, particularly in developing countries, can play an important role in driving economic development.

In recent years, efforts to promote sustainable urbanisation have received increased attention. Ziervogel et al. (2016) found that incorporating climate change adaptation and mitigation strategies into urban planning and development is critical. Similarly, Marcotullio et al. (2019) stressed the importance of promoting sustainable transport and land use policies in urban areas in order to reduce greenhouse gas emissions and promote more sustainable urban development. Several studies have also looked into the role of green infrastructure in promoting urban sustainability. McPhearson et al. (2017) discovered, for example, that urban green spaces can provide numerous environmental and social benefits, such as improved air and water quality, increased biodiversity, and increased community well-being.

In recent years, research and policy have focused on efforts to promote inclusive and equitable urban development. Buntaine et al. (2019) highlighted the importance of engaging communities and promoting participatory planning processes in urban development to ensure that all stakeholders' needs and perspectives are considered. Similarly, Chapple et al. (2019) stressed the significance of addressing gentrification and displacement in urban areas in order to promote equitable development.

To summarize, urbanisation is a complex and multifaceted process that has both benefits and drawbacks. While urbanisation can improve access to education, healthcare, and employment opportunities, it can also cause overcrowding, pollution, and insufficient access to basic services, exacerbates social and economic inequality, and harm ecosystems and biodiversity.

In recent years, the urbanisation process has resulted in significant changes in land use patterns in many cities around the world, with negative consequences for the environment and human well-being. Patan, located in the Indian state of Gujarat, is no exception. Patan has experienced rapid urbanisation in recent decades, resulting in significant changes in land use patterns and associated environmental and social impacts. The need for a spatiotemporal study of urbanisation in Patan city is thus obvious, in order to understand how land use patterns change over time and their underlying drivers, and to inform the development of more sustainable urban development policies and practices

Patan was chosen as the study site because of its rapid urbanisation and associated land use changes, as well as its strategic location in Gujarat, one of India's most urbanized states. Furthermore, Patan has a diverse population and a rich cultural heritage, making it a unique case study for understanding the complexities of urbanisation in the context of a developing country..

MATERIALS AND METHODOLOGY

Study Area

Patan is a city in the western Indian state of Gujarat. It is located in Patan, about 124 kilometres north of Ahmedabad, and is 53 metres above sea level. The city is in the semi-arid zone, which means it has a hot and dry climate all year. Patan's average temperature ranges from 25.7°C in the winter to 34.7°C in the summer. The monsoon season, which lasts from

June to September, is responsible for the majority of the rainfall in the region. The Saraswati River, which flows to the north of Patan, surrounds the city. The river has a large impact on the geography of the area, and its waters are frequently used for irrigation and farming. The region's soil is predominantly alluvial, which means it is fertile and suitable for agriculture. As a result, farming is an important part of the local economy, with cotton, wheat, and vegetables grown in the area. Patan's economy is primarily based on textile industries. Aside from the textile industry, handicrafts are a significant contributor to Patan's economy. Agriculture and dairy farming are also important contributors to the city's economy. Patan is well-connected to major Gujarat cities via road and rail networks. The nearest airport is in Ahmedabad, which is around 120 km away from Patan.

Data Collection

Remote sensing techniques were used to collect data on urbanisation trends in the study area. Google Earth Pro was specifically used to obtain high-resolution satellite imagery of the study area. The imagery was then analysed using image processing software such as ArcGIS and QGIS to identify changes in the urban landscape over time.

Pre-Analysis Steps

Several pre-analysis steps were used to prepare the study area before analysing the satellite imagery. These steps were as follows :

1. Saving Images from Google Earth Pro: Google Earth Pro was used to obtain high-resolution satellite images of the study area from 2012 (September) to 2022 (February). These images were saved as high-resolution JPEG files, allowing for a 10-year comparative view of the area and providing a visual representation for identifying changes and patterns. Because of the high-resolution format, the images were clear and high-quality, making them suitable for spatial and visual analysis.

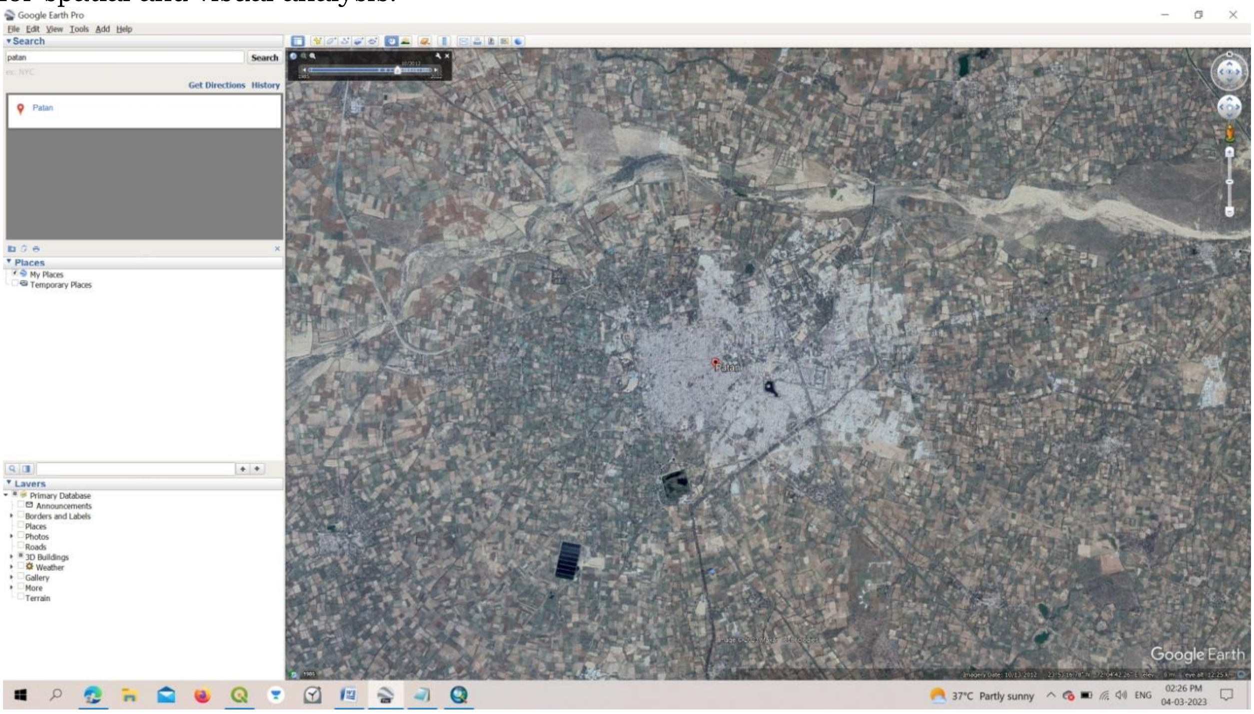

Figure 1 : Selection of study area from Google earth pro

2. Preparing the Study Area: To prepare the study area, a base map was created using image processing software such as ArcGIS or QGIS. The satellite images were georeferenced to a known coordinate system as the first step in creating the base map. This entailed locating control points on the satellite image and matching them to coordinates on a reference map. After georeferencing the images, adjustments were made to match the location of the study area. Scaling, rotating, and translating the images to align them with the reference map was required. The resulting base map depicted the study area accurately and provided a framework for conducting spatial analyses.

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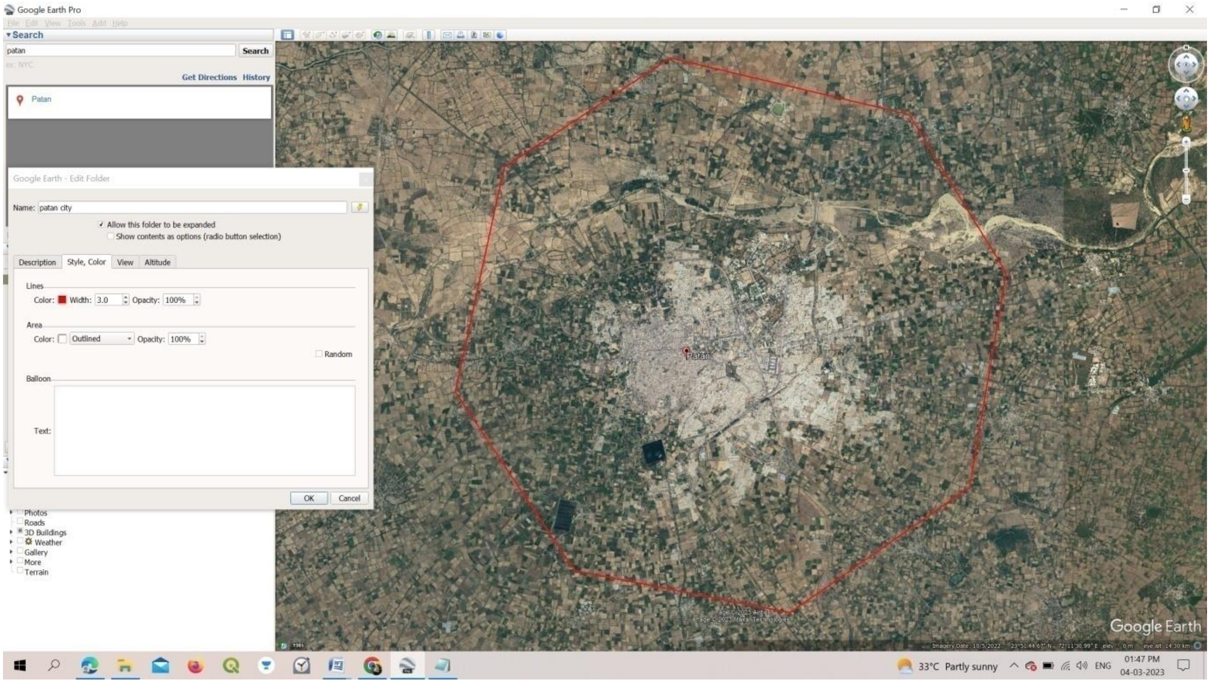

Figure 2 : Study area

3. Georeferencing the Study Area: To georeference the study area, satellite images were matched to a known coordinate system (e.g., WGS 84) using control points from the study area's topographic map. This entailed locating common points on the satellite images and topographic map and then connecting them with a transformation function. The control points were carefully chosen to ensure that they appeared correctly on both the satellite images and the topographic map. Following the completion of the georeferencing process, the satellite images could be overlaid on other spatial data layers and used for spatial analysis, such as identifying changes and patterns over time.

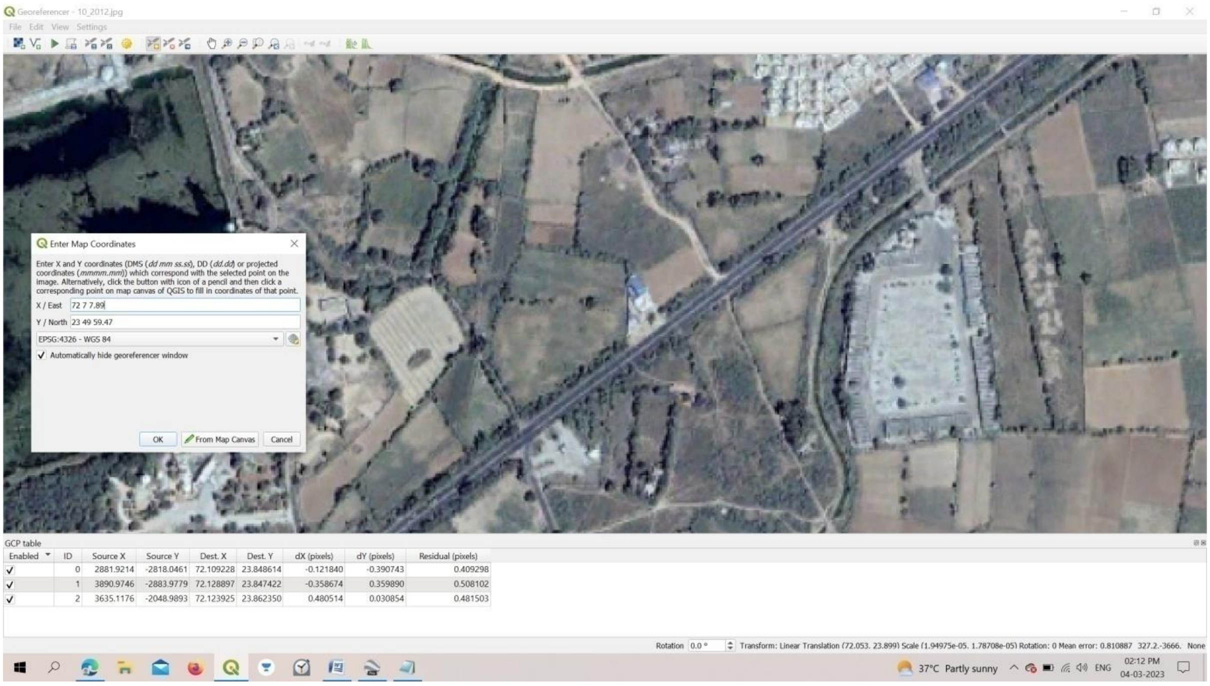

Figure 3 : Addition of control point in QGIS

4. Clipping the Study Area: The study area was clipped from the entire satellite image to create a smaller and more manageable area for analysis. This was accomplished with image processing software like ArcGIS or QGIS. Using a defined boundary or shapefile that accurately represented the study area, the clip function was applied to the satellite image.

Once the study area was clipped, it could be used for further analysis without requiring the entire satellite image to be processed. Working with a smaller area of interest improved efficiency and reduced computational time.

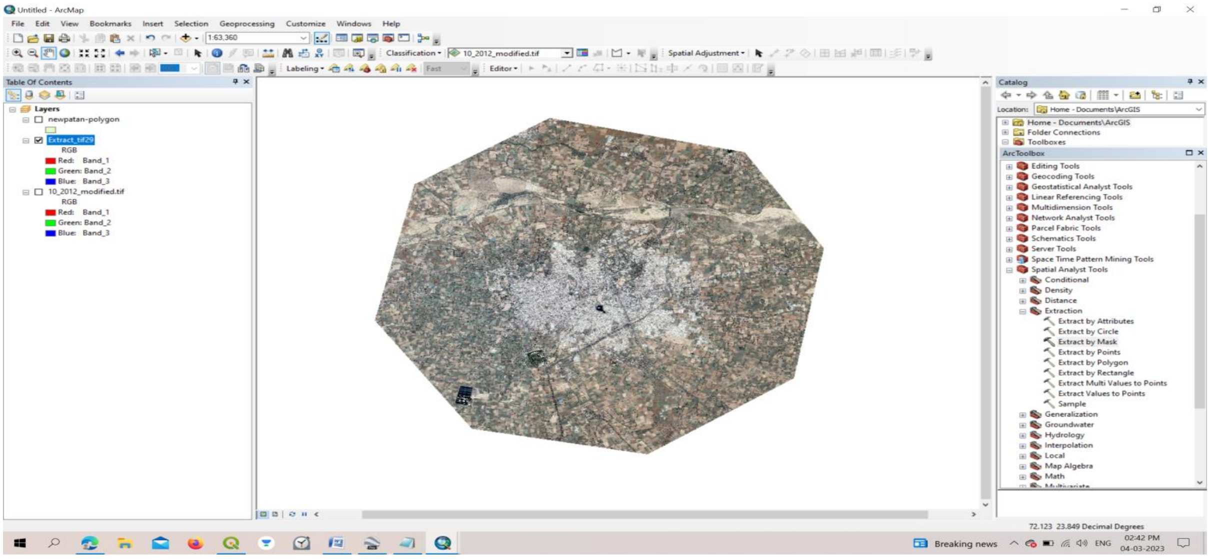

Figure 4 : Clipped study area

Image Analysis

Following the preparation of the study area, image analysis was carried out to identify changes in the urban landscape over time. Satellite images were classified into different land use/land cover categories using supervised classification techniques (e.g., built-up areas, vegetation, water bodies).

The steps which were used for the supervised classification included:

1. Defining Training Areas: To train the image classification algorithm, training areas were defined in the satellite images for each land use/land cover category. Based on prior knowledge of the study area and visual interpretation of satellite images, representative areas of each category, such as built-up areas, vegetation, water bodies, were chosen. The chosen areas were then used to train the algorithm to recognize various land use/land cover categories in satellite images. The process of defining training areas is critical to ensuring the accuracy of image classification results because it provides a foundation for the algorithm to identify and distinguish different land use/land cover categories.

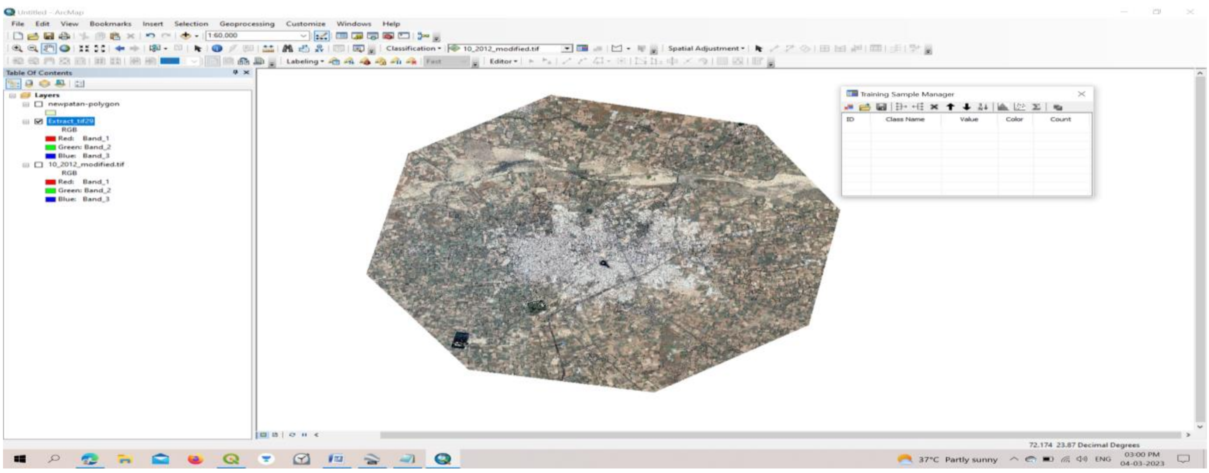

Figure 5 : Image before training sample

2. Assigning Classes: Each pixel in the satellite images was assigned to one of the classes based on the training information after the training areas for each land use/land cover category were defined. This was accomplished by using an image classification algorithm that classified every pixel in the image using the information learned from the training areas. The algorithm compared each pixel's spectral characteristics to the training data to assign the pixel to a specific land use/land cover class. The assignment process was automated and

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efficient, allowing large areas of satellite images to be classified in a short period of time. The resulting land use/land cover map was useful for a variety of applications, including land management, urban planning, and environmental monitoring.

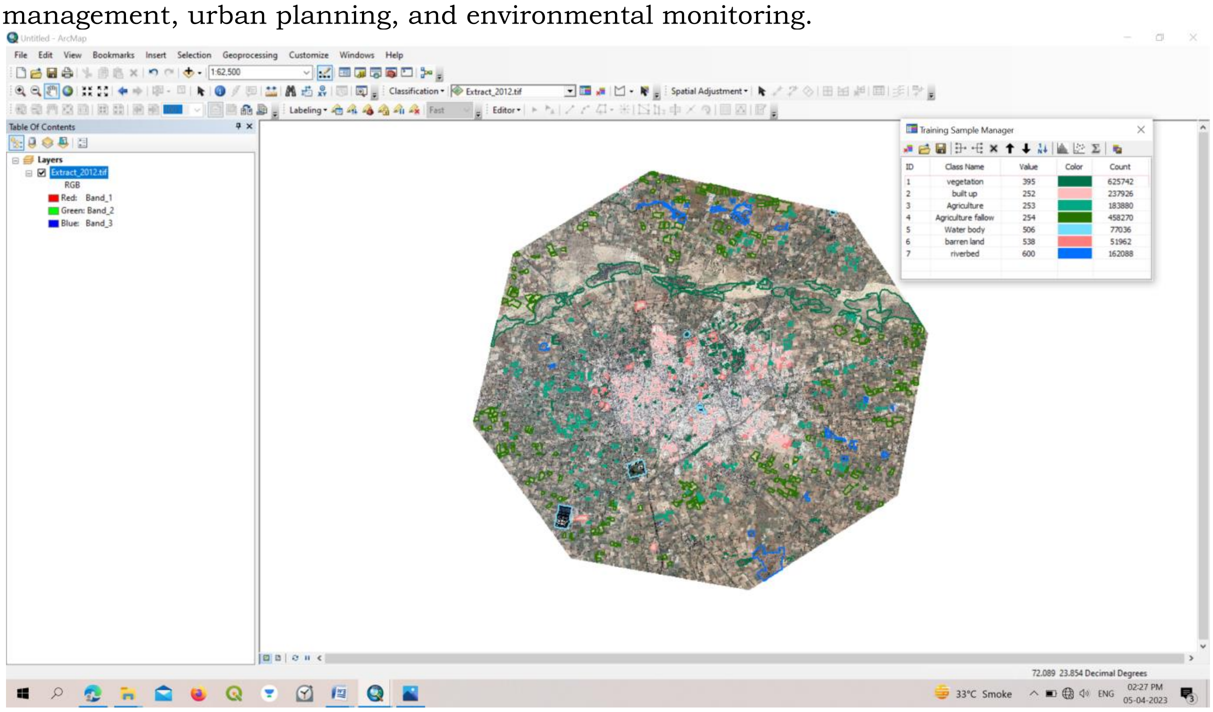

Figure 6 : Image after creating training sample.

3. Checking Classification Accuracy: The classified images were compared to reference data such as high-resolution satellite images to ensure the accuracy of the land use/land cover classification. This procedure involves randomly selecting points within the study area and using reference data to confirm the land use/land cover class at each point. The accuracy assessment results were used to evaluate the classification method's effectiveness and to identify any errors or misclassifications that needed to be corrected. The accuracy checks improved the reliability of the land use/land cover classification, which increased confidence in the data's subsequent analyses and applications.

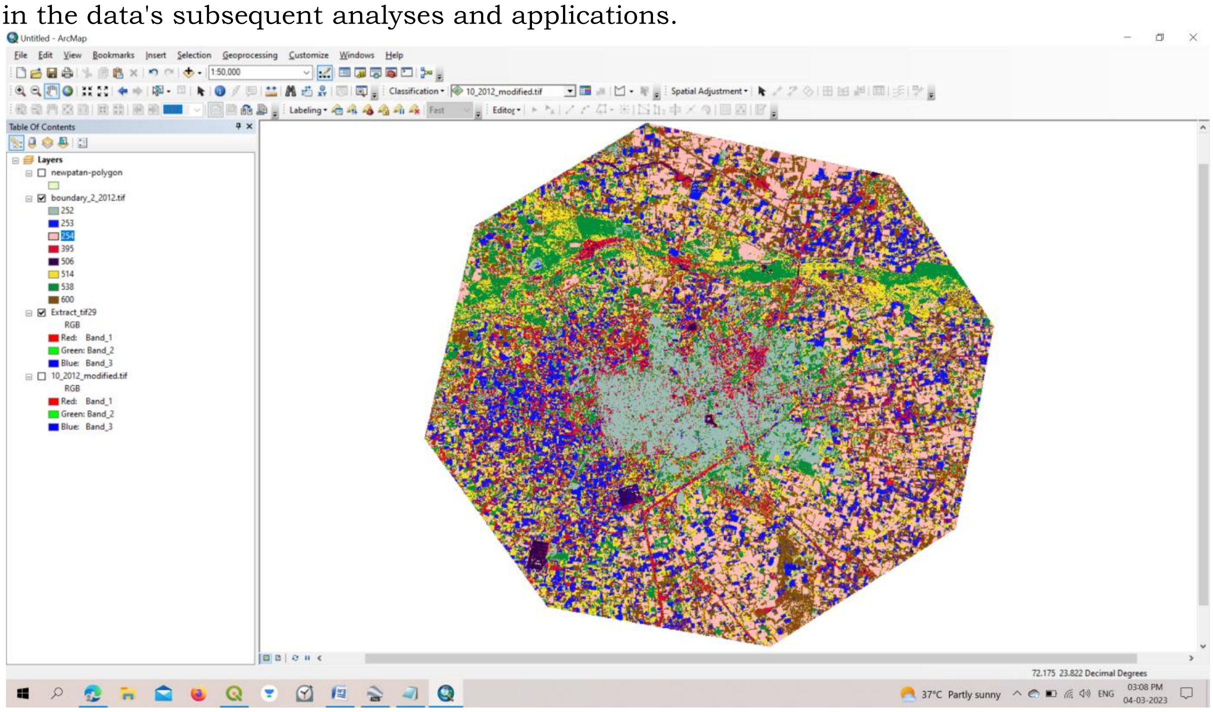

Figure 7 : Classified image of study area

4. Creating Land Use Maps: Land use maps were generated for each year by visualizing the distribution of the different classes within the study area after assigning the land use/land cover classes to each pixel in the satellite images. This involves converting the

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classified images into thematic maps displaying the spatial distribution of land use/land cover types such as agriculture, agricultural fallow, water bodies, barren land, built-up area, riverbed, and vegetation. The land use maps were used as inputs for further analyses such as urban growth modeling, environmental impact assessment, and land use planning, and provided valuable information on changes in land use patterns over time.

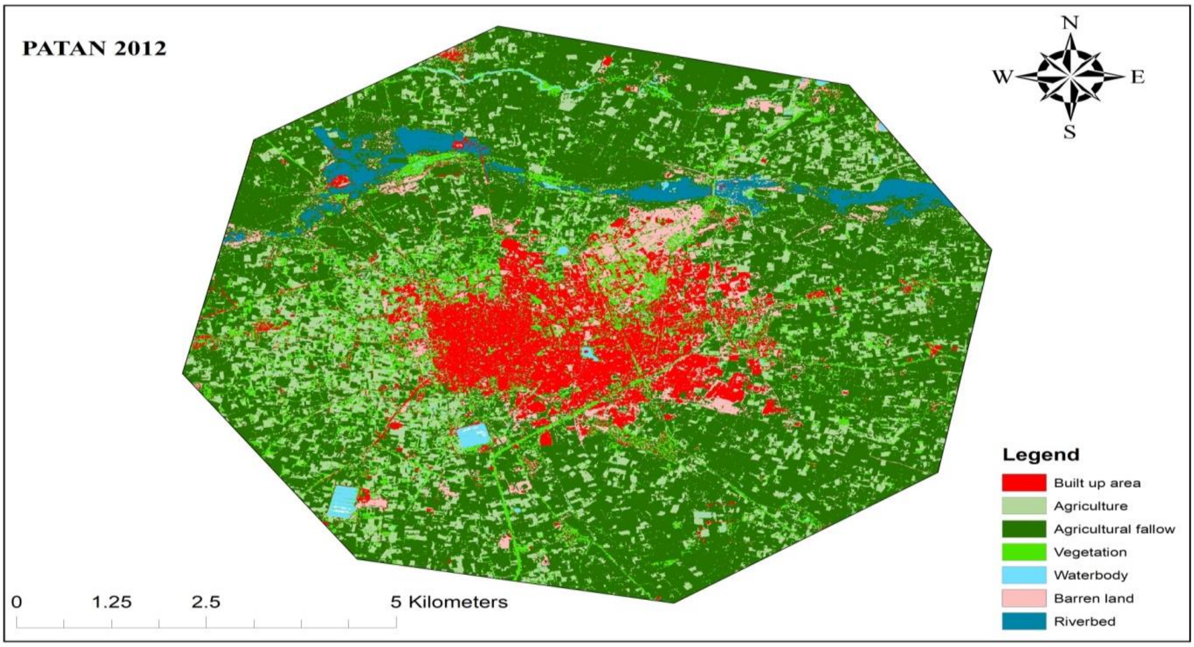

Figure 8 : Land use mapping of year 2012

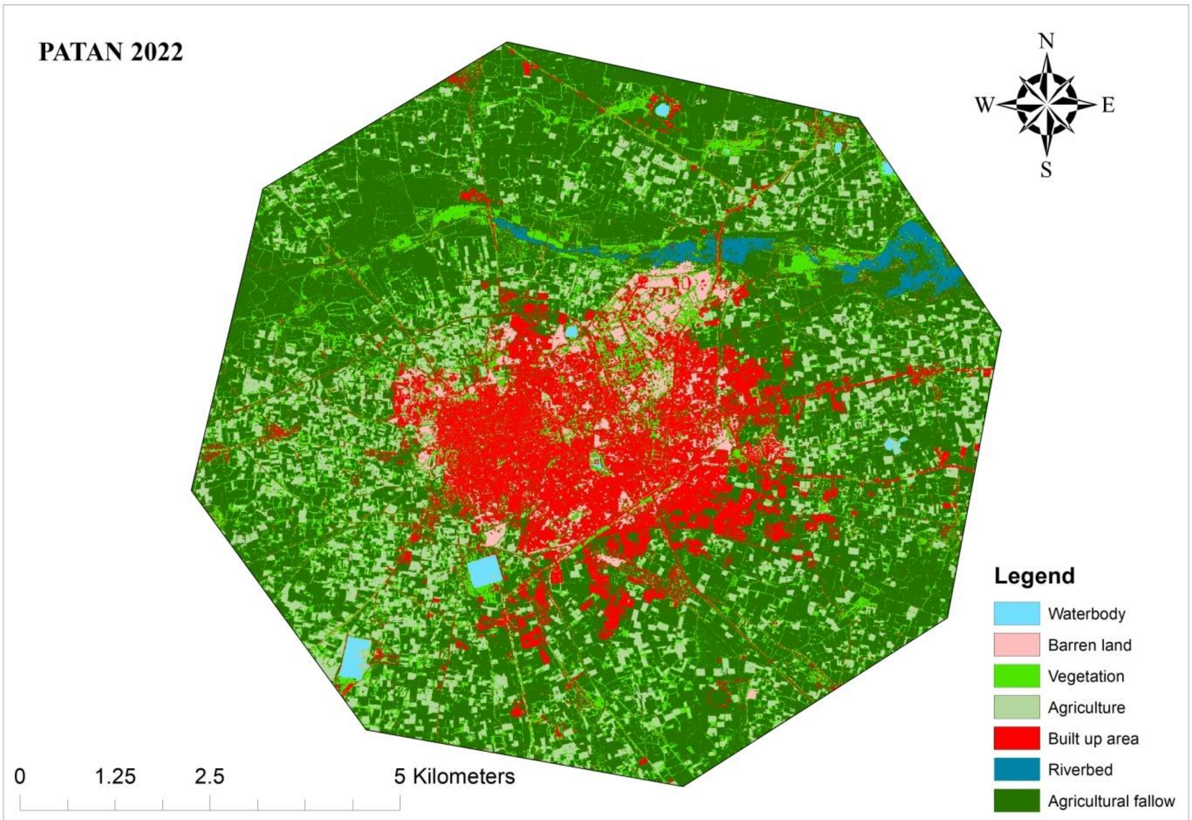

Figure 9 : Land use mapping of year 2022

5. Analyzing Urbanization Trends: The land use map analysis sought to identify urbanisation trends in the study area. This entailed looking at how the distribution and extent of built-up areas changed over time. Trends in urban expansion and growth were identified by comparing land use maps from different years. The spatial and temporal patterns of urbanisation were then examined to gain a better understanding of the drivers and consequences of urban development in the study area.

RESULTS

Between 2012 and 2022, there were noticeable changes in the land use patterns in the area. Water bodies decreased significantly from 0.96 sq km. in 2012 to 0.35 sq km. in 2022, while built-up areas increased from 6.85 sq km. to 10.18 sq km. The area covered by vegetation also increased from 6.40 sq km. to 10.31 sq km. While the area of land used for agriculture decreased from 10.66 sq km. to 8. Sq km. Agricultural fallow slightly decreased from 39.95 Sq km. to 38.54 sq km. The area covered by riverbed decreased from 1.83 sq km. to 0.79 square sq km. while the area covered by barren land decreased from 4.06 sq km. to 1.98 sq km. Overall, the data indicates a significant shift towards urbanization and development in the area, with an increase in built-up areas and a decrease in water bodies, agriculture, and barren land, along with an increase in vegetation.

The significant reduction in water bodies in Patan from 0.96 square kilometres in 2012 to 0.35 square kilometres in 2022 can be attributed to a number of factors, including rapid urbanisation, population growth, and climate change. As Patan's population has grown, so has the demand for land for housing, commercial development, and infrastructure, resulting in the conversion of water bodies into built-up areas. Furthermore, climate change has altered rainfall patterns and water availability, resulting in a reduction in the size and number of water bodies.

The rapid urbanisation and population growth in the area can be attributed to the increase in built-up areas in Patan from 6.85 sq km in 2012 to 10.18 sq km in 2022. As more people move to cities, the demand for housing, commercial development, and infrastructure grows. As a result, agricultural land, barren land, and other types of land have been converted into built-up areas.

The increase in Patan's vegetation from 6.40 square kilometres in 2012 to 10.31 square kilometres in 2022 can be attributed to a variety of factors, including reforestation efforts, afforestation, and natural regeneration of vegetation on abandoned agricultural land. Furthermore, over time, abandoned agricultural land may have been naturally reclaimed by vegetation.

The reduction in agricultural land in Patan from 10.66 square kilometres in 2012 to 8 square kilometres in 2022 can be attributed to a variety of factors, including urbanisation, migration, and changes in land use practices. As more land is developed, the amount of land available for agriculture decreases. Furthermore, rural-to-urban migration may have resulted in the abandonment of agricultural land and a reduction in agricultural activity. Finally, changes in land use practices, such as shifting from agriculture to other economic activities, may have aided in the reduction in agricultural land.

The slight decrease in agricultural fallow in Patan from 39.95 square kilometres in 2012 to 38.54 square kilometres in 2022 may indicate a reduction in the area of land left uncultivated in a given year. It is important to note, however, that agricultural fallow is a necessary practice for maintaining soil fertility, preventing soil erosion, and allowing for natural vegetation regeneration. As a result, a decrease in agricultural fallow may indicate an increase in unsustainable land use practices, such as intensive agriculture or continuous cultivation in the absence of proper soil conservation measures.

The conversion of riverbed and barren land into built-up areas, as well as the increase in vegetation cover, can be attributed to the decrease in riverbed and barren land in Patan from 1.83 sq km and 4.06 sq km in 2012 to 0.79 sq km and 1.98 sq km in 2022, respectively. As more land is developed, there is less undeveloped land and riverbed available. Furthermore, increased vegetation cover may have reduced the area of barren land.

The findings show a significant shift in land use patterns towards urbanisation and development, with an increase in built-up areas and a decrease in water bodies, agriculture, and barren land, while increasing vegetation. These findings are consistent with the expected outcomes of an area's urbanisation and development.

This research can be utilized in an array of other studies, research, and policies. Urban planners and policymakers, for example, can use this data to make informed decisions about land use planning and sustainable development. It can also help researchers who are interested in the effects of urbanization on the environment and ecosystems. Further research into the specific drivers of urbanization in the area, such as population growth, economic development, or infrastructure development, could be conducted. Furthermore, studies on the environmental and social impacts of urbanisation and development in the area, such as changes in air and water quality, biodiversity, and social equity, could be conducted. This research provides valuable insights into the area's land use patterns and changes, which can be applied to a variety of research and policy applications.

Table 1 : Comparison of LULC of both the year

Classes	2012		2022	
	Area (sq. km.)	Area (%)	Area (sq. km.)	Area (%)
Water Body	0.96	1.36	0.35	0.50
Built Up Area	6.85	9.69	10.18	14.40
Vegetation	6.40	9.05	10.31	14.58
Agriculture	10.66	15.08	8.56	12.11
Agricultural Fallow	39.95	56.51	38.54	54.51
Riverbed	1.83	2.59	0.79	1.12
Barren Land	4.06	5.74	1.98	2.80

CONCLUSION

The study aimed to compare satellite images from 2012 and 2022 to analyse urbanisation and change in the Patan city area. Water Body, Built-up Area, Vegetation, Agriculture, Agricultural Fallow Land, Riverbed, and Barren Land are all part of the study area.

The findings revealed that the total area of Patan had changed significantly over the previous decade. Water Body covered 0.96 square kilometers, or 1.36% of the total area, in 2012, but only 0.35 square kilometers in 2022, accounting for 0.50% of the total area. Similarly, the city's built-up area increased from 6.85 square kilometers (9.69% of total area) in 2012 to 10.18 square kilometers (14.40% of total area) in 2022, indicating rapid urbanisation and development. Vegetation, on the other hand, increased from 6.40 sq. km (9.05% of total area) in 2012 to 10.31 sq. km (14.58% of total area) in 2022.

Agriculture covered 10.66 square kilometers (15.08% of total area) in 2012, but this has decreased to 8.56 square kilometers (12.11% of total area) in 2022, indicating that agricultural land has been converted for other uses. In both years, the largest land class was Agricultural Fallow Land, which covered 39.95 square kilometers (56.51% of the total area) in 2012 and will cover 38.54 square kilometers (54.51% of the total area) in 2022. In 2012, the riverbed covered 1.83 square kilometers (2.59% of the total area), and in 2022, it covered 0.79 square kilometers (1.12% of the total area). Barren Land covered 4.06 square kilometers (5.74% of total area) in 2012 and 1.98 square kilometers (2.80% of total area) in 2022.

The study's findings highlight significant changes in Patan's land cover over the last decade, particularly rapid urbanisation and development. These changes, however, have resulted in the loss of riverbed, water bodies, and agricultural land, which may have long-term environmental and socioeconomic consequences.

Potential solutions to these issues include encouraging sustainable urban planning and development practices, preserving green spaces, implementing land-use regulations to protect agricultural land, and encouraging the use of alternative and eco-friendly transportation modes. These solutions have the potential to help balance the need for urban development with environmental sustainability and social equity, ensuring a brighter future for Patan and its residents.

LIMITATIONS

It is critical to recognize several limitations in this study. To begin, image classification accuracy can be influenced by a variety of factors such as cloud cover, atmospheric conditions, and image quality. Second, the analysis is limited to visible urban landscape features, which do not take into account all of the factors that contribute to urbanisation, such as demographics, employment, productivity, and economic development. It would be beneficial to combine the findings of this study with other factors, such as those mentioned above, to gain a better understanding of the effects of urbanisation. This allows for a more comprehensive and nuanced understanding of the effects of urbanisation.

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