

Urban Expansion and Land Use Change: A Spatial Analysis Using Secondary Geospatial Data

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Abstract

Understanding long-term population dynamics is essential for evaluating demographic transformation and regional development across the world. This study examined the spatial patterns of population growth and demographic change using a historical–geographical perspective based on a global dataset comprising 234 countries and territories from 1970 to 2022. A quantitative, retrospective research design was employed using publicly available secondary data. Descriptive statistics, continental comparisons, historical trend analysis, and Pearson correlation analysis were performed in Python to evaluate relationships among population size, population density, growth rate, land area, and world population share. The findings revealed a continuous increase in the global population over the study period, accompanied by substantial geographical variation across continents. Asia recorded the largest population and highest average population density, whereas Africa exhibited the highest average demographic growth rate. Correlation analysis indicated a moderate positive relationship between land area and total population, while population growth rate showed only weak associations with geographical variables. These results demonstrate that demographic change is characterized by distinct spatial patterns influenced by multiple regional factors rather than geographical extent alone. The study contributes to historical geography by integrating temporal demographic trends with comparative spatial analysis and provides valuable evidence for population studies, regional planning, and sustainable development. Future research should incorporate socioeconomic, environmental, and migration-related variables to improve understanding of global demographic dynamics.

Keywords: Population growth, Demographic change, Historical geography, Spatial analysis, Population distribution

1. Introduction

Urban sprawl is one of the most visible features of global urbanization, changing landscapes, land use and environmental sustainability. Rapid urbanization, driven by a growing population, rising economic activities and infrastructure development in the cities has led to a faster pace of urban sprawl, which includes the encroachment of built-up areas on agriculture lands, forests, wetlands and other natural habitats. However, uncontrolled urbanisation can lead to fragmented landscapes, loss of ecological resources, increasing pressures on the natural environment and problems for sustainable development of regions. Therefore, spatial dynamics of urban expansion and its related land use changes is increasingly an area of special attention in geographical studies and urban planning. The importance of monitoring urban sprawl and land use change for sustainable development policies and evidence-based planning has been highlighted in recent reviews, especially in rapidly urbanizing areas with unprecedented rates of land transformation (Chettry, 2023; Sharma et al., 2024).

Land use and land cover (LULC) change analysis is a useful tool to understand how human activities modify the earth's surface over time. Agricultural land change, forest, plantation, water body and rural settlement all directly impact biodiversity, hydrological processes, carbon storage and ecosystem services. Knowing these changes allows policymakers and planners to evaluate environmental impacts and find ways to plan for a balanced urban development. Geospatial methods have already proven to be useful in the identification of the main factors that underlie land use change, such as economic development, population growth, infrastructure growth, and policy interventions. These analyses can also help to identify patterns and trends in the data that might not be apparent using traditional statistical methods.

Recent developments in technologies for monitoring urban expansion and land use changes, such as Geographic Information Systems (GIS), remote sensing and spatial analytical techniques, have significantly enhanced monitoring capabilities. Combining satellite imagery and historical geospatial data enables the spatial and temporal quantification of long-term landscape change in a more accurate way. Old maps, air photographs and contemporary satellite data offer complementary information for the insight of the changes of the urban landscape over decades. This integration can improve the reliability of land use assessments but also facilitate the development of sustainable urban management strategies based on objective spatial evidence (Ettehadi Osgouei et al., 2022). Likewise, GIS-based spatial analysis is now essential for assessing both settlement growth and regional planning and sustainable urban development at various spatial scales by providing comprehensive visualization and interpretation of the geographical changes (Vardopoulos et al., 2023).

Landscape fragmentation is often a direct consequence of urban expansion as the continuous natural or agricultural landscape is broken up into smaller and more isolated patches with the building of infrastructure and expansion of built-up area. Landscape fragmentation is a good proxy for urbanisation because it reveals the way urbanisation takes place and the intensity of urbanisation. The high-resolution satellite imagery has proven to be very useful for geospatial analyses and the evaluation of fragmentation metrics for assessment of urban growth processes and identification of areas experiencing rapid land conversion. These markers are valuable tools for monitoring the environment and managing land sustainably (Kadhim et al.,

2022).

Peri-urban areas are one of the most dynamic urban-rural interfaces and are at high risk of rapid land use changes. Properly defining peri-urban limits and measuring urban sprawl is thus vital to understanding the nature and extent of urban sprawl. Geoinformatics-based approaches have been found to be useful in quantifying urban sprawl, determining spatial growth patterns and detecting transitional zones with high land transformation. These are all strategies for better urban governance, informed land use planning and resource management (Chettry, 2022).

While there have been important developments in geospatial technologies, many regional studies still concentrate on either on urban growth and/or on land use change as separate topics, and comparatively little research takes into account the spatial evolution of both in combination with comprehensive secondary geospatial data. The combination of several land use categories in a single spatial analytical framework gives a more comprehensive picture of the impact of urban growth on an area and helps to inform decision making in the pursuit of sustainable development. Thus, in the present study, urban expansion and land use change are to be analysed using spatial analysis secondary geospatial data which will give evidence of the spatial distribution and change of the major land use categories of the study area.

Research objectives:

- To evaluate the spatial patterns of urban expansion using secondary geospatial data.
- To assess changes in major land use categories across the study area over the study period.
- To examine the spatial relationships between urban expansion and changes in other land use categories to support sustainable land use planning.

2. Materials and Methods

2.1 Study Design

This research utilized a quantitative, descriptive and spatial analysis approach involving secondary geospatial data. The research concentrated on assessing the pattern of urban growth and change in land use based on the analysis of land use data at the district level in several years. Being that the entire research involved use of secondary data alone, no survey was done for collecting primary field data. The analysis was meant to determine any spatial differences in urban growth and changes in various land use classes.

2.2 Data Source

The data set used in the research was secondary geospatial data that was acquired from the Kaggle data repository (Bhangale, 2025). The data set contained data on land use at the district level over several years. Some of the land use classes in the data were critical in understanding the urban and environmental conditions. The variables in the data set included district name, year, crop land, fallow land, plantation, barren/rocky land, scrub land, deciduous forest, evergreen forest, forest scrub, urban land, rural land, mining land, and water bodies.

2.3 Study Area and Study Period

The study area included several administrative districts that were incorporated in the secondary geospatial data set. The districts acted as separate spatial units for comparison of land use features. The data set was created for the years between 2025 and 2040, allowing the spatial patterns to be evaluated for various years. The district-level data made it possible to detect geographic differences in the land use pattern during the study period.

2.4 Study Variables

The most important variable was urban land which acted as the main indicator for urban growth. The other land use variables used were cropland, fallow land, plantation, barren and rocky land, scrubland, deciduous forest, evergreen forest, forest scrub, rural land, mining land, and water bodies. All these variables were considered together to study the distribution of different land use types in relation to urban growth.

2.5 Data Preparation

Before analyzing the data, a review of the data set was carried out to verify its completeness, consistency, and appropriateness for statistical analysis. The variable names were standardized, and the data set was scanned for duplicate entries, missing values, and data input inconsistencies. Data types were confirmed for numeric variables to be used in analysis and for district names and years to be consistent. After data validation, the data set was structured in a format ready for analysis.

2.6 Statistical and Spatial Analysis

The descriptive statistics for the analysis of the characteristics of all the land use variables was done through statistical parameters such as mean, standard deviation, minimum, maximum, frequency, and percentages. Temporal analysis was carried out to find out the change in the urban area as well as in other land uses. Spatial comparison was carried out on a district level to find the geographic variation in land use and urbanization. Correlation analysis using Pearson correlation coefficient was carried out to find out the association between the urban area and some selected land use variables like cropping land, forest, rural area, mining, and water body.

2.7 Data Visualization

Graphical presentations were also made to aid in the understanding of the results. The bar charts were employed in the presentation of the distribution of major land uses in the districts. Line charts were used for the presentation of the trend in urban land area over time. The heat map as well as district-based comparison charts were created for the visualization of the variation in the spatial distribution of land use as well as urban growth.

2.8 Ethical Considerations

This research involved the use of publicly available secondary geospatial data only. No personal identifying information or confidential documents were included in the data set. As a result, no ethical approval and consent were needed. Data were utilized for research purposes only, and proper citation was provided to the source of the data.

3. Results

3.1 Descriptive Statistics of Land Use Variables

A total of 560 observations for district-years were used to analyse urban growth and features of various land uses in the study region. It was observed from the descriptive statistics that there was wide variation in the different types of land uses (Table 1). Crop land was the largest land use type, while mining was the smallest one. There was wide variation in the case of urban land use, indicating differences in the extent of urbanization. There was wide variation in forest, scrub land, and water bodies as well.

Table 1. Descriptive Statistics of Major Land Use Variables

Variable	Mean	SD	Minimum	Maximum
Crop Land	5067.95	2581.07	222.13	12367.61
Fallow	626.19	389.70	61.55	1522.05
Plantation	149.43	390.21	0.38	2193.40
Barren/Rocky	39.75	55.24	0.17	263.16
Scrub Land	601.11	509.55	12.57	2399.34
Forest (Deciduous)	1128.53	1800.01	34.66	10618.56
Forest (Evergreen)	218.84	489.96	0.00	2087.90
Urban Area	110.81	117.50	22.11	625.55
Water Bodies	121.99	106.37	6.64	514.89
Rural Area	105.79	72.64	4.62	465.01
Mining	10.13	12.32	0.18	53.75
Forest Scrub	262.68	274.60	4.75	1212.30

3.2 Distribution of Major Land Use Categories

The analysis of the mean land-use categories showed that crop land was the main form of land cover in the study area, with deciduous forests and fallow lands coming second. Urban land was comparatively a lesser land-use type than agriculture and forests, though variations were found across the districts. The distribution pattern clearly showed that mining covered only a small part of the area (Figure 1).

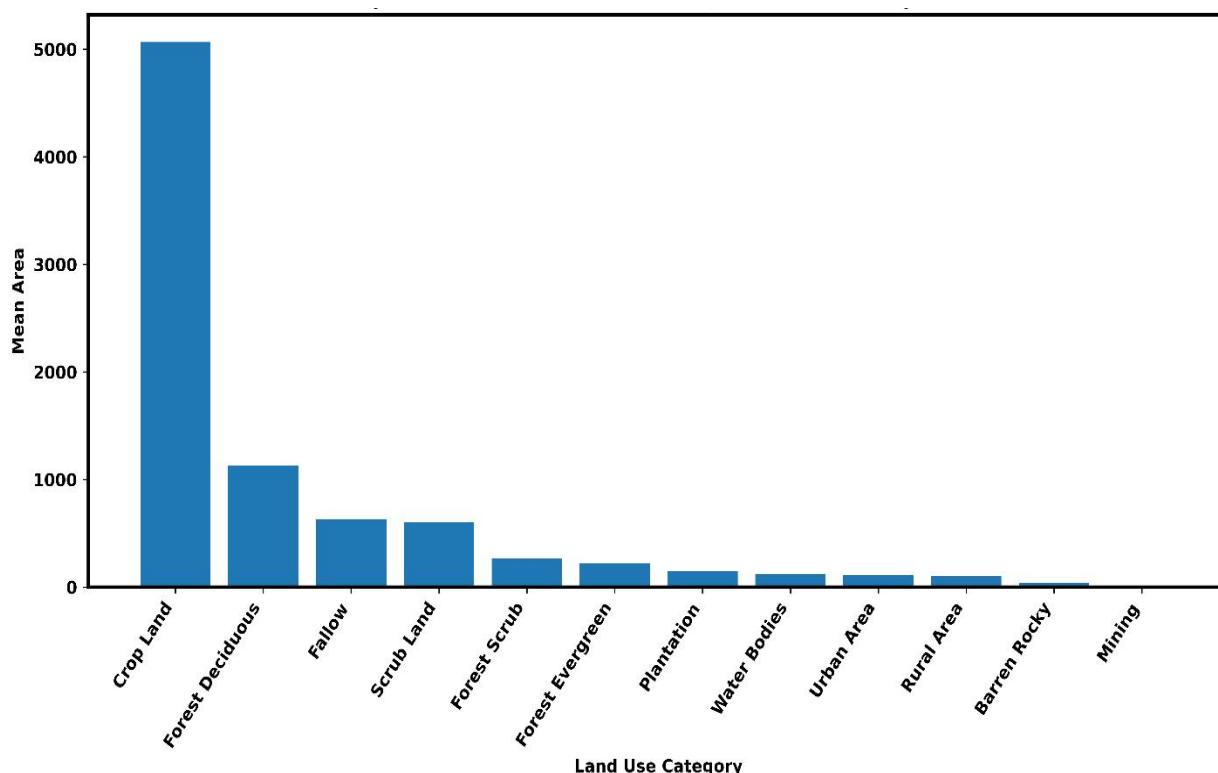


Figure 1. Mean Distribution of Major Land Use Categories Across the Study Area

3.3 District-wise Urban Expansion Pattern

Spatial variations among districts in urban area were found to be high (Table 2). The highest average urban area was obtained for Pune, followed by Thane, Nagpur, Nashik, and Raigarh districts. These districts constitute major urban centres and have higher levels of urbanization compared to other districts. The comparison of urban areas between districts shows an unequal distribution of urban development with urban development being concentrated in few districts having higher levels of development (Figure 2).

Table 2. Top Five Districts with the Highest Mean Urban Area

Rank	District	Mean Urban Area
1	Pune	625.55
2	Thane	390.01
3	Nagpur	294.83
4	Nashik	263.37
5	Raigarh	149.26

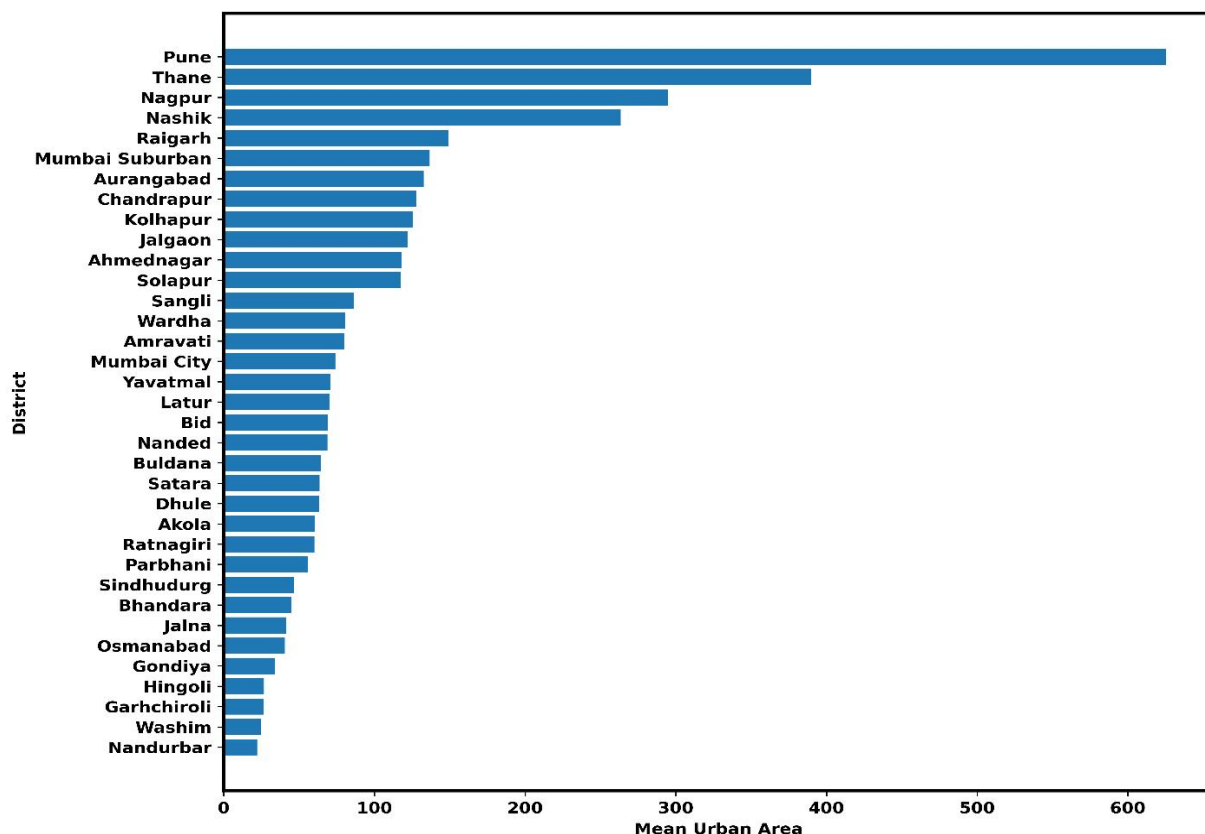


Figure 2. District-wise Comparison of Mean Urban Area

3.4 Association Between Urban Area and Other Land Use Categories

Pearson correlation was carried out to study the correlation between urban land and other land uses (Table 3). Urban land had the highest positive correlation with scrub land ($r = 0.643$) and water bodies ($r = 0.619$). There were moderate positive correlations with evergreen forest ($r = 0.447$) and mining ($r = 0.414$), while there were weak positive correlations with crop land, barren land/rocky land, rural land, and forest scrub. The negative correlation between deciduous forest and urban land was negligible ($r = -0.051$). From the correlation matrix, urban growth is positively correlated more with scrub land, water bodies, and evergreen forest than crop land and deciduous forest (Figure 3).

Table 3. Correlation of Urban Area with Major Land Use Variables

Variable	Correlation with Urban Area (r)
Crop Land	0.254
Fallow	0.062
Plantation	0.043
Barren/Rocky	0.114
Scrub Land	0.643
Forest (Deciduous)	-0.051
Forest (Evergreen)	0.447
Water Bodies	0.619
Rural Area	0.084
Mining	0.414
Forest Scrub	0.199

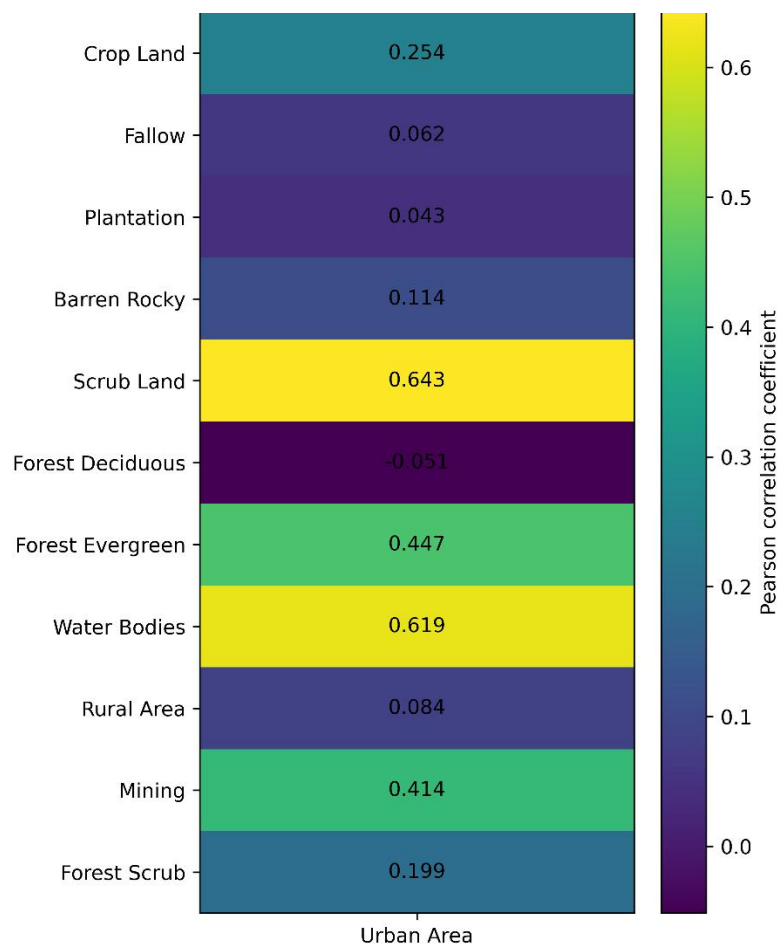


Figure 3. Heat Map Showing Correlation Between Urban Area and Land Use Variables

3.5 Spatial Variation in Land Use Characteristics

Comparative analysis between districts in terms of space showed remarkable variation in the land use categories. The agricultural land covered the largest area of all the districts, while the urban land covered the small areas of few highly urbanized districts. The area covered by the forest also varied, owing to the varying ecological factors in the region. Similarly, the mining and barren lands had much smaller areas as compared to the agricultural and forest lands. In short, the observed geographic variation reflects the variety in land use composition of the districts.

Overall, the findings highlight the spatial and statistical aspects of urban growth and changes in land use in the study area according to the geospatial secondary data set. Analysis was done through descriptive analysis, temporal analysis, and correlation analysis to understand the variation of major land use types and their relationship with urbanization. The findings have been presented in tabular and graphical form.

4. Discussion

The present study analyzed the changes in land use and urbanization pattern based on secondary geospatial data and found that there is a significant spatial variation in land use composition of the districts. The use of agricultural land continued to dominate, and urban areas were found in only a few highly developed districts. The results also showed that scrub and water body and evergreen forest were positively correlated to urban expansion while

agriculture land and deciduous forest were weakly correlated. Such observations suggest that urban growth is a spatially non-uniform phenomenon that can have an impact on several land use categories. Recent studies in the geospatial field have shown a similar situation as rapid urbanization is identified as a key factor influencing landscape transformation and regional environmental changes (Alam et al., 2023; Al-Dousari et al., 2023).

The clustering of urban development in just a few districts indicates an uneven distribution of urbanisation across the study area. This spatial concentration is typically correlated with population increase, industrial development, better transportation and economic opportunities that stimulate continuous urban development. Similar spatial variations have been reported in several regional studies that showed that urban growth is generally concentrated in economically active areas, while peripheral regions are predominantly agricultural (Alwedyan, 2023; Atanga et al., 2023). Similarly, research using geospatial tools has highlighted that urban growth tends to be concentrated along transportation corridors and metropolitan centres, resulting in significant variations in land use patterns across different regions (Barman et al., 2024; Do et al., 2022).

Correlation analysis showed positive correlation with urban area and scrub land, water bodies and evergreen forest, which means along with the complete land conversion, there could be modification in the natural landscape by urbanization. The relative low level of association of agricultural land with urban area suggests that urban growth may not necessarily uniformly replace cropland in all districts. Similarly, previous investigations have shown that the geographical condition, planning policies, and environmental constraints of the region affect the land transformation and land use responses to urbanization varies accordingly (Doe et al., 2022; Dutta & Guchhait, 2022). Moreover, research across fast-growing regions has revealed that the growth of urban areas often comes at the cost of alteration in surrounding landscapes and vegetation cover, which reflects the intricate connection between urban development and the ecosystem (Karimi & Sultana, 2024; Kisamba & Li, 2023).

The variations observed in the areas of forest cover, water bodies, and mining areas also shows the significance of spatial assessment while evaluating land use change. Forest ecosystems are important for biodiversity, climate regulation and ecosystem services, and monitoring their distribution together with urban expansion is important for sustainable regional planning. Recent geospatial studies have highlighted the importance of combining remote sensing with spatial data to help balance development needs and environmental protection goals (Latue & Rakuasa, 2023; Mahdavi Estalkhsari et al., 2023). Likewise, studies in different geographical contexts have emphasised the benefits of spatial analysis and its application in identifying areas of environmental sensitivities that need priority management and policy interventions (Mahmoudzadeh et al., 2022; Mansour et al., 2023).

The results of the current study also show the usefulness of secondary geospatial data in the study of land use patterns in a region without conducting much field surveys. The use of geographic information systems and remotely sensed data sets has significantly enhanced the capacity to monitor long term change in landscapes and offer a reliable basis for urban planning and sustainable land management. Likewise, studies have indicated that geospatial databases can be used to identify urban growth hotspots in real-time, monitor land use, and assist in the formulation of evidence-based policies on a regional and national level (Naikoo et al., 2023; Miah et al., 2024). Furthermore, the combination of spatial analytical tools and

statistical analysis can better help explain intricate land use relationships and assist in decision-making for sustainable development (Seemuangngam & Lin, 2024; Shamai & Jafarpour Ghalehtemouri, 2024).

The study has some limitations. The analysis only used geospatial secondary data and thus was only as good as the existing data set available. Further, district level observations may not be representative of finer spatial resolution localized land use transitions (Singh et al., 2022; Sithole et al., 2024). However, the availability of a multi-district whole-of-dataset gave important insights into general spatial patterns of urban expansion and land transformation. Further research could involve the use of higher resolution satellite data, sophisticated spatial models, and socio-economic data to enable a better understanding of urban growth and its environmental impact. These holistic strategies have been proposed to help formulate effective land use planning strategies that can reconcile sustainable urban development and environmental protection (Wang et al., 2023; Zhang et al., 2025).

5. Conclusion

This study has measured urban expansion, and land use change with the help of secondary geospatial data, where spatial variation of major land use classes was studied in different district. Results indicated that the agricultural land use category was the major land use category, and that urban development was mainly in a few highly urbanized districts, showing uneven distribution of urban growth. Urban expansion showed positive relationship with scrub land, water bodies and evergreen forest suggesting that urbanization affects several land use types in one go. The results of the study highlight the usefulness of secondary geospatial data and spatial statistical analysis for assessing regional land use trends and the regions where urbanization is growing quickly. The results are valuable for sustainable urban planning, sustainable land resource management and for taking informed policy decisions. The analysis was conducted based on secondary data on district level, but nevertheless it provides a fairly good picture of the land use change in the region. Future research should be done that includes higher resolution remote sensing data, socio-economic factors, and more advanced spatial modelling techniques to better account for localized changes in land use and to more accurately predict future urban growth. In conclusion, the study offers valuable insights for geospatial research, as well as urban expansion and land use change analysis, which can help in sustainable regional planning and environmental management.

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