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Analyzing Temporal Landscape Dynamics and Their Determinants in Multan, South Punjab, Pakistan

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ABSTRACT

This study systematically evaluates the temporal dynamics of landscape changes and their driving mechanisms in Multan, a key urban center in South Punjab, Pakistan. Utilizing advanced remote sensing methodologies and Geographic Information System (GIS) technologies, the research conducts a comprehensive analysis of satellite imagery spanning a 34-year period to quantify alterations in land cover. The analysis focuses on urban expansion, agricultural land conversion, deforestation, and modifications to water bodies. To elucidate the primary drivers of these changes, the study integrates socioeconomic data, encompassing population growth metrics, economic activity indicators, and the impacts of policy interventions. The results reveal substantial urban sprawl, predominantly at the expense of agricultural lands and natural ecosystems, with population growth and economic development identified as the primary drivers. The findings underscore the critical need for implementing sustainable urban planning and natural resource management strategies to mitigate the adverse environmental impacts observed. The study provides essential insights for policymakers and urban planners, guiding efforts to harmonize developmental goals with the environmental conservation in Multan and other rapidly urbanizing regions

Keywords: *Temporal Landscape Changes, Land Use And Land Cover (LULC), Remote Sensing, Urbanization, Driving Factors, Multan, South Punjab, Pakistan, Sustainable Land Management, GIS Analysis.*

Introduction

Landscape change has important implications for the dynamics of environmental and socio-economic transformation in urban as well as peri-urban areas. The landscape of Multan, an important city in South Punjab, Pakistan has undergone paramount changes because of the advancement and escalation that it encounters through urbanization process as well agricultural expansion and infrastructural development which is behind those rapid developments. This study hopes to measure and make sense of these changes, adding to the ever-growing narrative on sustainable land management. Human development is interconnected with socio-economic considerations and urbanization has been rapidly progressing in many cities worldwide. Surveying and mapping of growth patterns was historically expensive, time consuming particularly in developing nations. While the

development of remote sensing and Geographic Information System (GIS) technology has made it significantly easier and more accurate to track urban change.

Recent estimates indicate that approximately 2.4 million hectares of cropland, accounting for a mere 2% of total agricultural land, have been converted into built-up areas. This conversion has critical implications for the food supply, currently supporting around 249.5 million people (Population Census Organization, 2023). The rate of agricultural land loss is notably higher in developing nations, with an estimated 476,000 hectares of land annually being transformed into urban areas in low- and middle-income countries.

Estimates also predict that the population in developing nations will double from roughly 2 billion to nearly 4 billion by 2030, with urban density set for a significant spike of approximately up to around built-up areas carrying some 8,000 persons per square kilometer. It is even estimated that the built-up areas within these regions will increase by over 600,000 square kilometers, possibly trebling their current extent (Afify H. A., 2011).

the phenomenon of urban growth has significantly impacted arable land use patterns on a global scale, raising critical concerns. Pakistan, particularly the Punjab province, is experiencing rapid urbanization, necessitating a comprehensive assessment of urban expansion rates and their effects on agricultural land. Specifically, the urban transformation in Multan district warrants detailed examination. So this study focus on analyzing the urban land use and temporal shift in Land Use Pattern of Multan over the period from 1990 to 2024.This also focus the changes in open spaces and green areas, with a focus on their conversion dynamics over this period.

Material & Methods

Urban land use change is escalating rapidly in developing countries, leading to numerous urban issues such as transportation problems, slum development, urban pollution, and declining quality of life for residents. In Multan, the expansion of new colonies and towns is significantly reducing agricultural land use. This research has employed both primary and secondary data sources.

Primary data has been gathered through satellite imagery across different time periods and supplemented with ground surveys. Secondary data on historical and current urban land use changes and urban growth has sourced from various organizations, including the Population Bureau of Pakistan and the Statistics Bureau of Pakistan. Upon data collection, spatial and statistical analyses have been conducted. Satellite images of Multan have been analyzed to assess variations in urban expansion and the reduction of agricultural land. Comparative analysis of historical and current data has been performed using SPSS to identify trends and changes in urban land use. The methodological framework integrates multi-temporal satellite imagery with spatial analysis techniques to assess LULC changes from 1990 to 2024. High-resolution satellite images from Landsat, Sentinel, and other relevant sources were processed and classified using supervised classification algorithms. The study employs the Normalized Difference Vegetation Index (NDVI) and other spectral indices to detect vegetative cover changes. Additionally, a change detection matrix was developed to quantify the magnitude and direction of landscape transformations.

Results and Discussion

The findings reveal significant land use changes in Multan, with a marked decrease in agricultural land and vegetative cover, concomitant with an increase in built-up areas. The

results highlight the role of urban sprawl as a primary driver, exacerbated by population growth and infrastructure development. Additionally, climatic factors such as temperature rise and altered precipitation patterns were found to influence the observed changes, particularly in the reduction of green cover.

Table- 1.1 Land use distribution of District Multan for 1990, 2007 and 2024 (Sq.Km)

LULC	1990	2007	2024
Water Bodies	45.16	14.8	11.6
Built up Area	258.8	310.9	432.7
Barren Land	852.0	679.5	455.2
Green Cover	839.7	993.7	1093.0
Total Area	1995.8	1995.8	1995.8

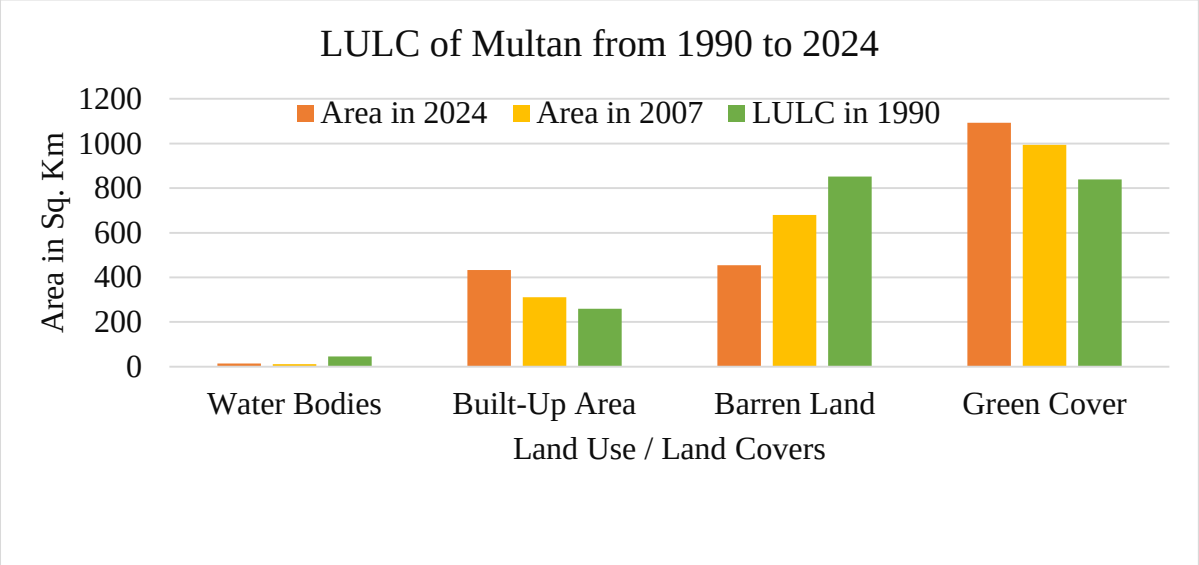

Figure 1.1: showing LULC of Multan from 1990-2024

The land use classification is shown on the figure 1.1 the Y-axis area is shown in square kilometers and the years are appeared on the X axis. The land use shows in different colors bars. From this diagram it is clear that the agricultural area is increased from 1990 to 2024. It was 839 sq. km in 1990 and 1093 sq.km in 2024. Its geographical location changed over time. The adjacent agricultural areas with city were converted into residential areas and colonies and housing societies were being constructed. Thus the valuable agricultural lands were occupied by constructed area. But increase in agricultural land was due to brought barren land under cultivation. Total increase in agricultural land during the time period from 1990 to 2024 is 12 percent. As compared to agricultural area the built up area has increased during this time period. It was 12.9 percent in 1990 and 21.6 percent in 2024. The net increase is 8.7 percent. Data shows that the decrease in areas of water bodies and barren areas has been detected during 1990 to 2024. But increase in built up area and agricultural area has been detected. In 1990 the agricultural area was 42 percent of the total area while in 2024 it was 54 percent. So 12 percent increase has been taken place in agricultural area. The area of open spaces was 42.7 percent in 1990 which were slightly greater than agricultural area. It was 22.8

percent in 2024. The net decrease in the area of open spaces was 19.9 percent. The total area of built up in 1990 was 12.9 percent while in 2024 it was 21.7 percent. The net increase in built up area was 8.8 percent. Water bodies were covered 2.2 percent area in 1990 and only 0.58 percent in 2024. The decrease in water bodies, area was 1.6 percent. Data shows that about 39.2 Sq. Km. agricultural area was covered with residential and commercial societies and markets during the period of 1990 to 2024. A negative correlation has been recorded between built up area, agricultural area and open spaces and some extent of water bodies. Two variables increased (Built up area and Agricultural area) while two variables shown decreased (Open spaces and Water bodies) during study period. (Figure 1.2)

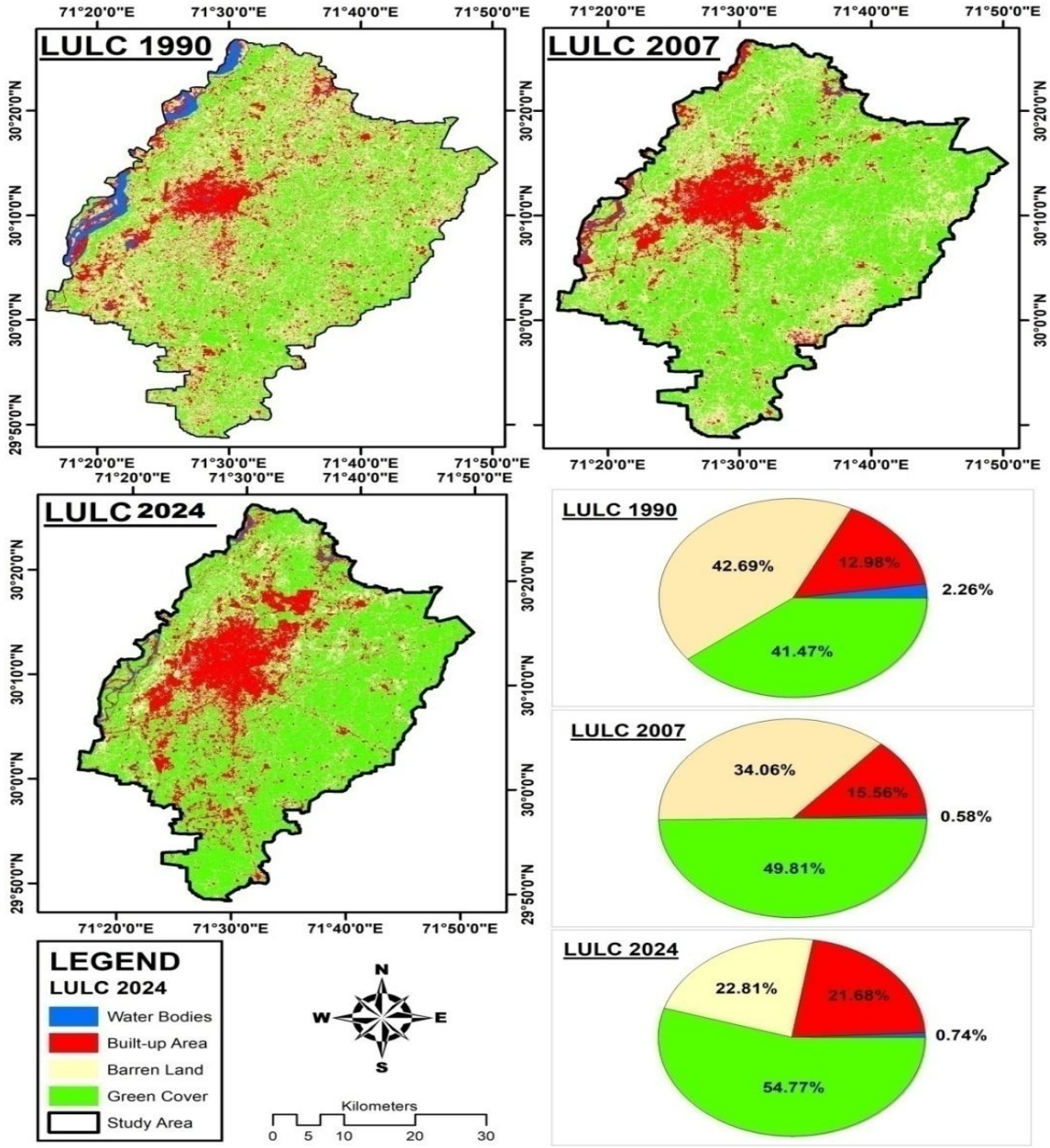

Figure 1.2: Spatial LULC change detection from 1990-2024

Conclusion

It includes four types of land in Multan, such as agriculture class, bare soil (BS), built-up area and water bodies. Damage classifications are mapped annually, for all years of studies. Since 1990, land covered by agriculture has always been the large proportion area and then follow by bare soil which cover smaller side comparing to build up areas and water body. The category "agricultural land" is all the greenery that naturally exists in the environment: agricultural fields, forests, green belts, parks and other vegetated areas. A similar assessment for cropland across time (1990–2024) indicates a righteous trend since there is more than 12.77% has an increase in the net value. The general trend was an increase in this regard and then it shows that agriculture used to do more, or there is natural vegetation forecast on the ground relating land uses change. This growth endorses reflects dynamics of use changes for how long lived signed space into category. The importance of our results for forest landscape change and sustainable land management cannot be underestimated. Results of land based category, built-up landed has an increasing trend 8.71% in year for the same period (1990-2024). The growth is mainly on account of the upsurge in industrial units and residential colonies developed within District Multan, leading to mushrooming urban sprawl. Such increasing built-up land over this period underscores the necessity of efficient urban planning and sustainable development approaches that would guide population growth in conjunction with exercise caution to conserve ecosystem services. Evidence of some aspects, like trends in open spaces bare soil generally is negative. The area of bare soil also decreased by 19.89% in 1990–2024, which may indicate a change of land use such as agricultural expansion, urbanization development or the natural vegetation re-growth. This understanding is critical for getting the best from land and needs to balance social requirements against environmental sustainability. Ensuring a comprehensive land-use plan that balance, the growth of urban areas while protecting our agricultural lands. Encouraging the development of vertical in urban areas rather than horizontal expansion will help to conserve agricultural land. Encouraging green building practices and urban landscaping can have a significant impact on the environment. Involving the local communities is a tool by which they will ensure their needs and topics of concern are addressed. The more communities are instructed about the value of agricultural land and sound urban practices, the better support we can garner for conservation.

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