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Case Study

Monitoring Urbanization and Comparison with City Master Plans using Remote Sensing and GIS: A Case Study of Lahore District, Pakistan

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Abstract Urbanization Growth, one of the core issue in the developing countries, has negative impacts on the cities. The rapid urbanization has become a common phenomenon for developing countries across the globe. This, according to popular notions especially among economists, is a good sign because rapid urbanization indicates economic development. According to the UN-Habitat, half of humanity now lives cities, and that the urban population will increase to 60% within next two decades. For developing countries, experiencing rapid urbanization, the inability of the existing social infrastructure to meet the growing needs emanating from urbanization, pose a major challenge for governments, with Pakistan as no exception. Lahore as the capital of Punjab Province and as the 2nd largest city of Pakistan is the largest growth pole and undergone rapid urbanization, infrastructure and social transformation. In this study detect the changes of urban sprawl and urban growth in Lahore district. Urban growth starts from a small point and after that it spreads in different directions. The growth pattern varies from one urban place to another and it is necessary to study such phenomenon for appropriate urban planning. Urban growth can be mapped, measured and modeled by using remote sensing data and GIS techniques along with several statistical measures. The outcome of this study gives a difference between the proposed land use in the master plan and existing land use. To overcome this rapid urbanization, need a detailed strategic development planning and effective master planning. For this purpose, master plan prepare and then implemented to achieve better results like economic development, utilities services and to make a better cities for living.
Keywords *GIS; urbanization; land use; urban planning; remote sensing; master plan*

1. Introduction

Urban growth defined as the process of increasing density of population within a town or city. Urban growth continues to create unhealthy and dehumanizing environments (air pollution, stress, isolation, lack of community, etc.). The growth pattern varies from one urban place to another and it is necessary to study such phenomenon for appropriate urban planning. Urbanization has undergone dramatic changes in most of the developing countries as a result of unplanned and irregular urban growth which needs to be analyzed and understood for future planning purpose. Such unplanned growth has been facilitated by rapid development in communication and new economic opportunities mostly found in the surrounding regions of an urban Center. This kind of growth later on takes different patterns in different directions and shapes. Especially, Pakistan belongs to under developed countries. So, major cities of Pakistan have been growing with high growth rate from last three decades because

mostly population migrated to cities for better living, lifestyle and employment opportunities. After migration, they were settled permanent in the cities. Lahore becomes the 2nd metropolitan city in Pakistan and 27th largest city in the world (demographia). Agriculture land very rapidly changes into urban land due to high growth of population. Spatial Patterns of Urban Development and Growth are two in which one is Lateral Growth Pattern and other Vertical Growth Pattern. In lateral growth pattern, land has available for conversion to urban land while Vertical Growth has lack of land available for conversion to urban land, City grows upward, high population density for example Hong Kong, Tokyo etc. In this study mapped and measured urbanization and urban growth by using remote sensing and GIS techniques along with several statistical techniques. In this research study, Satellite Images of Landsat TM and ETM were tacking at different time (2001, 2006, 2011 and 2016) for temporal analysis. These imageries were supervised classified to monitoring the urban extent in different directions. A measure of pattern which follow by urban growth. The results have shown that the city and it's surrounded has high degree-of-freedom, extended growth and urban growth follow the lateral growth pattern. The area of Lahore city has very high population growth rate and urban growth was increased 32% in last 16 years from 2001.

2. Area of Study

The Lahore is the second largest metropolitan city of Pakistan and capital city of the province of Punjab. It is located 31°32′59″ N, 74°20′37″ E (WGS) and Lahore district covered area 1,772 km^2. Lahore has an economic, political, transportation, entertainment, and educational center of Pakistan. Economically Lahore city with an estimated total nominal GDP of $58.14 billion (Lahore fact sheet). It is situated at a height of 208-217 m above the mean sea level, near the river Ravi. This study was consisting on Lahore District.

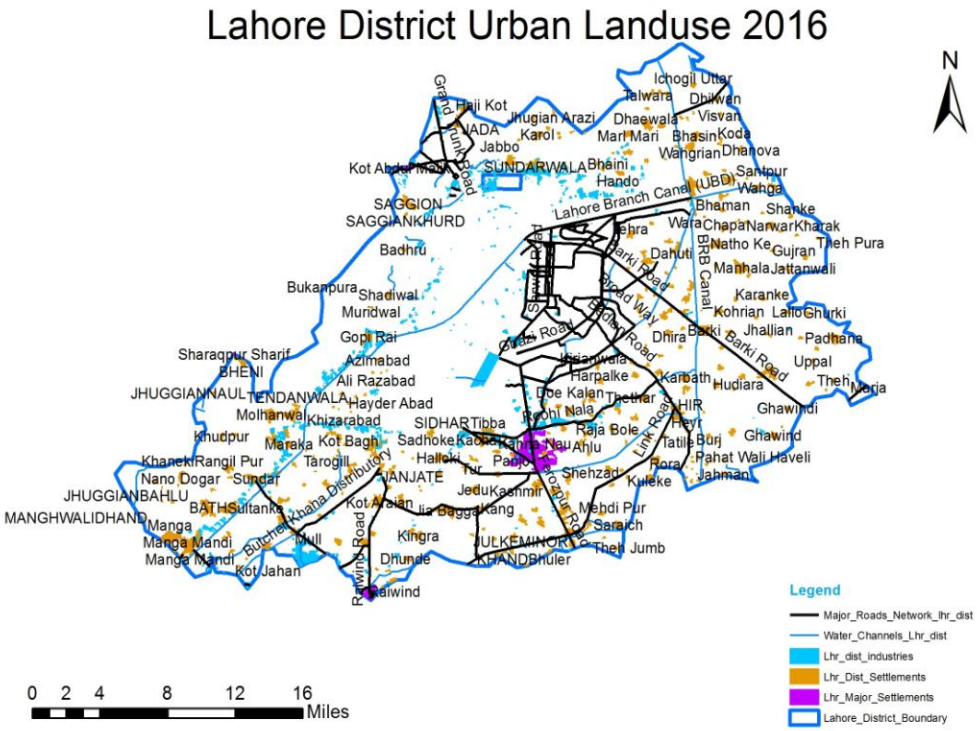


Figure 1: *Area of Study*

3. Process and Methods of Remote Sensing Data

First of all, there is so many techniques for land use detection in GIS like some of the major techniques include unsupervised classification, supervised classification, combination of classified images, and radar images comparison etc. When detecting a land use about an area then clearly know the technique which is used. In this research, the supervised classification technique was used. Remote sensing data source was satellite images. Which were tacking at four different time for spatial temporal Analysis of urbanization. Satellite images were download from USGS Glovis as following time as given in the Table 1. Different layers of Satellite Image bands (1, 2, 3, 4, 5, and 7) were stacking using ERDAS IMAGINE software. Boundary of Lahore District was clipped by using clip tool on stacked images. After clipping the stacked images then have to make the classification. Classification techniques can be broadly divided into two types: supervised classification and other is unsupervised classification. In supervised classification, Spatial Analyst has already known about the class ground reality While in Unsupervised classification, Spatial Analyst has not known about any class ground reality. Used the supervised classification in this study. The Maximum Likelihood Classification tool is the main classification method. A signature file, which identifies the classes and their statistics, is a required input to this tool. For supervised classification, the signature file is created using training samples through the Image Classification toolbar.

After the supervised classification, apply NDVI (Normalized difference vegetation index) which is a simple graphical indicator that can be used to analyze remote sensing measurements, typically observed contains live green vegetation or not in the image. The NDVI is calculated from these measurements. NDVI = (NIR-VIS) / (NIR+VIS), Where VIS and NIR stand for the spectral reflectance measurements acquired in the visible (red) and near-infrared regions.

Table 1: *Data Time Period*

Sr. No.	Data Type	Date	Scale
1	Landsat Image	2001-09-30	30 m TM
2	Landsat Image	2006-09-05	30 m TM
3	Landsat Image	2011-06-09	30 m TM
4	Landsat Image	2016-11-05	30 m TM

4. Spatial Urban Growth Pattern of the City

Table 2: *Spatial Growth Change in Landuse of Lahore City*

Year	Urban Area (hectare)	Agriculture Area(hectare)	Other Land use(hectare)	Change in Urban Area	Variation
2001	54490	83674	92506	23.23%	-
2006	70780	78145	81745	30.69%	07.46%
2011	89107	54490	87073	38.63%	15.04%
2016	108006	33619	89045	46.82%	23.60%

Urban Growth of Lahore city commenced from 2001, total area of urban city being just 54490 hectare which is 23.23% of the total area (230670 hectare). Due to rapidly increase in urban growth, urban area covered 70780 hector and 30.69% of the total area in 2006. Similarly in 2011, the urban area covered 89107 hectare which is 38.63%. While now in 2016, the urban area covered 108006 hector and 46.82%. In 16 years, total change in the urban land was increased up to 23.6%. It is a very large change in the urban built up land. These spatial urban growth measured by using satellite images and GIS techniques and tools which is describing in Table 2.

From Figure 2(a) and 2(b), Lahore district in 2016 shows different land use (urban land, water channels, open land and vegetation/ agriculture land). Land use classification planning has different phases

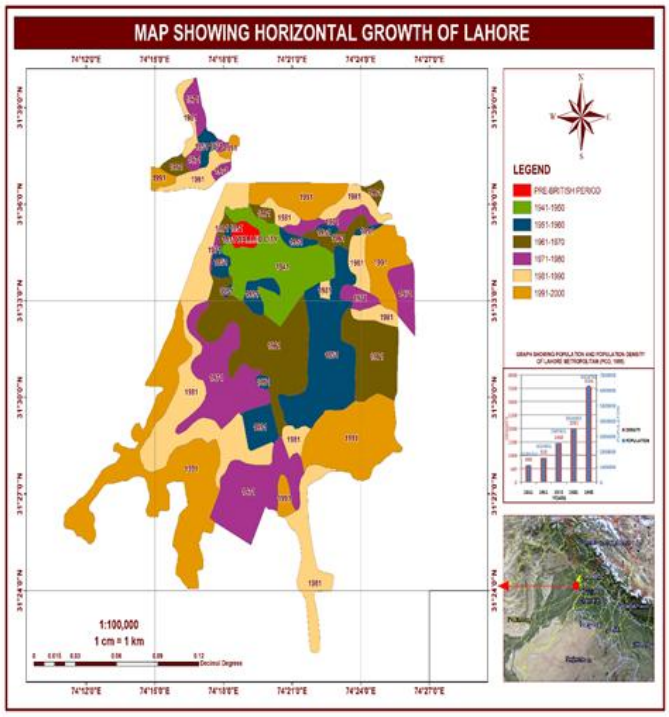


Figure 2(a): *Lateral urban growth map of Lahore from Pre-British to 2000*

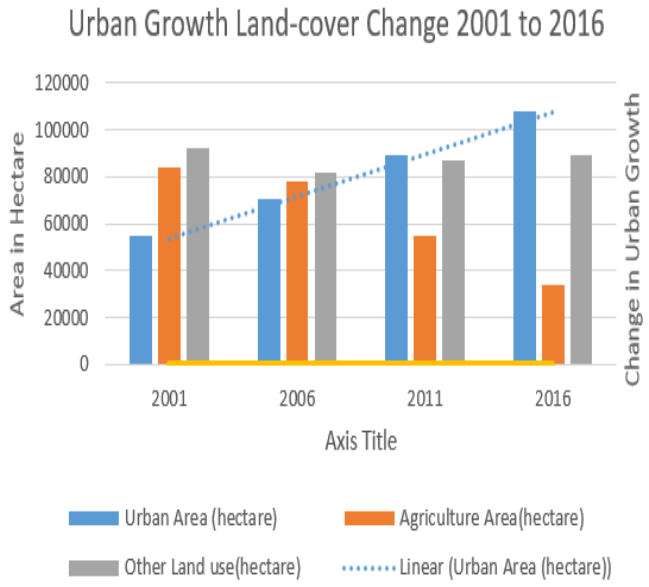


Figure 2(b): *Land cover change 2001 to 2016*

5. Urban Growth and Land Cover Maps of the City Comparison with the Master Plan

Urban Growth and land cover change can be detection with the help of different Classified raster Land use maps given below. Master Plan provides the guidelines for the future expansion of the city with recommendations in all sectors of Urban Planning i.e. land Development, housing, transportation, community facilities, public utilities, infrastructure, environment and institutional framework. Lahore Development Authority (LDA) is responsible for preparation and approval of Master plan of Lahore.

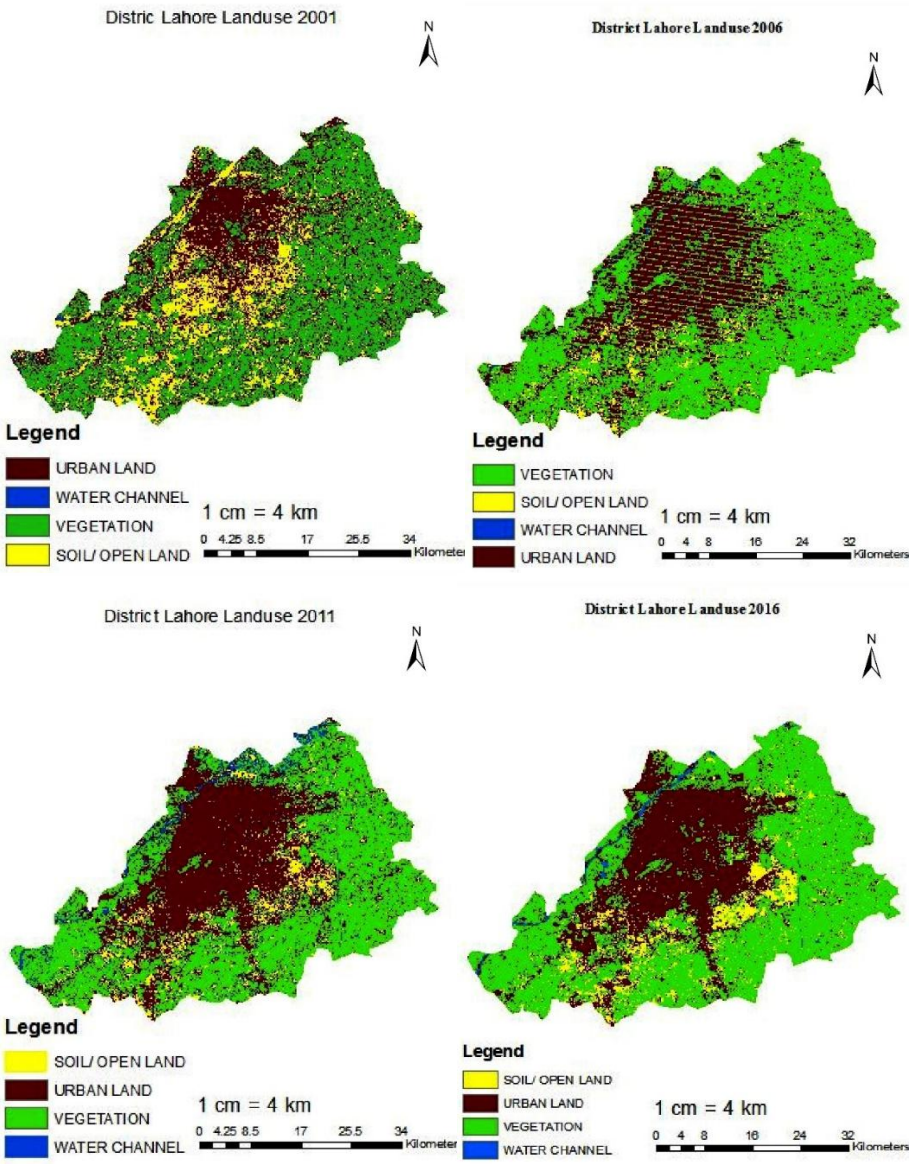


Figure 3: *Classified maps shows land use of different classes from 2001, 2006, 2011 and 2016*

5.1. First Master plan prepare with the name of "Greater Lahore-1966". It was Prepared under 2nd five year National Plan (1960-65) by Housing and Physical Planning (H&PP) Department, Govt. of Punjab. Adopted by the LMC under Municipal Administration Ordinance-1960 and notified on 13 July 1972. According to Planning Concept, 24 km Green belt was proposed around the core Urban Area, Three

Industrial Sites were proposed. Along the Green Belt, Circular Railway Line was proposed connecting all three proposed Industrial Sites. Expansion was proposed in North, South-West and South-Eastern parts of the cities.

5.2. Second Master plan was "LAHORE URBAN DEVELOPMENT AND TRAFFIC STUDY 1980". Integrated Urban Development & Transport Infrastructure Plan up to 2000 was prepared by Halcrow Fox UK, a World Bank Consultant. Future growth was planned in the South and Southwest axis, with adequate Transport Infrastructure. Structure Plan Roads were proposed.

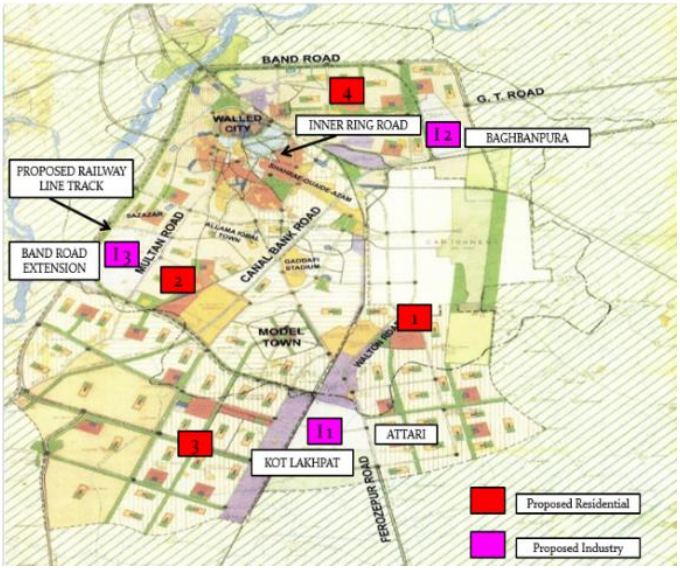


Figure 4: *Master Plan for Greater Lahore-1966*

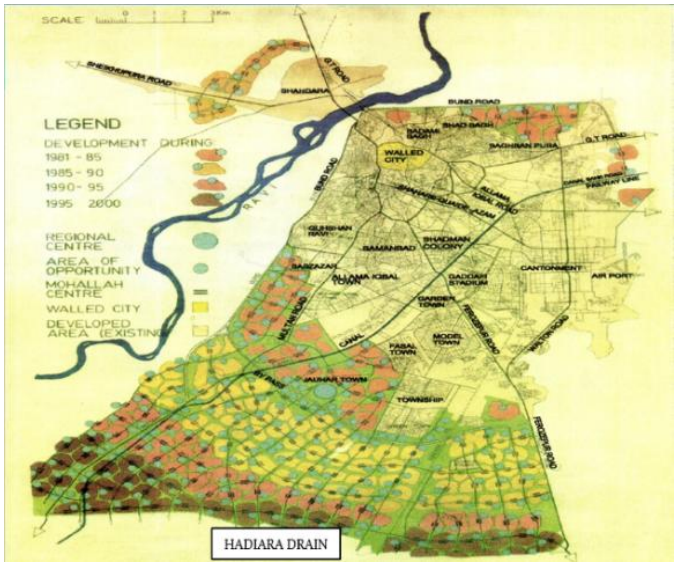
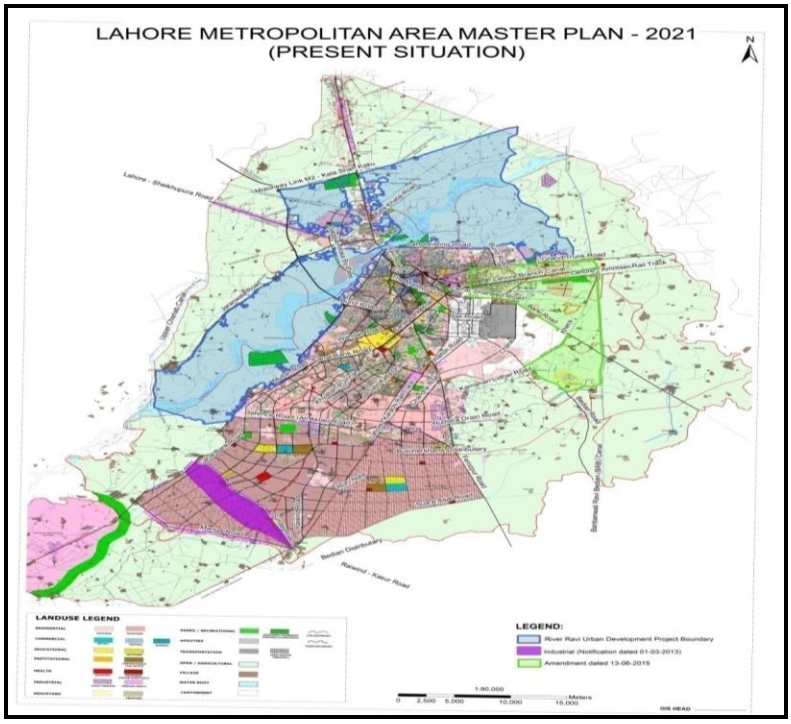
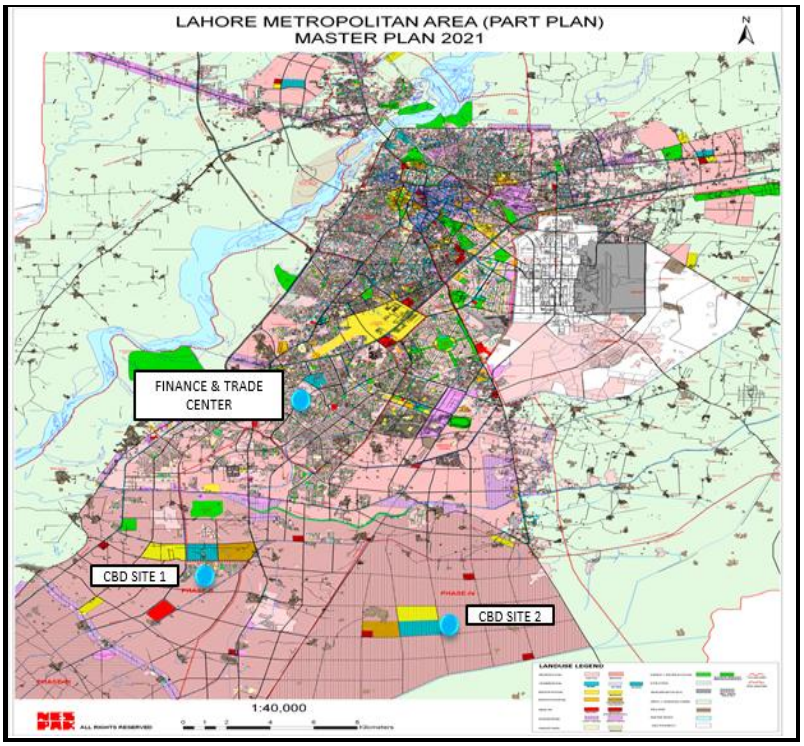


Figure 5: *Lahore Urban Development and Traffic Study 1980*



(a)



(b)

Figure 6(a) and (b): *IMPL-2021 shows present situation (b) IMPL-2021 shows different Land use*

5.3. Third Master Plan was "INTEGRATED MASTER PLAN OF LAHORE – 2021". The study was conducted by NESPAK and approved by District Assembly, CDGL in Oct 2004. This Master Plan designate different land uses and provide guideline for expansion of Lahore City up to year 2021.Urban Planning proposal were Expansion of Residential area in South West of Hadiara drain as Phase-II, Phase-III, Phase-IV, Establishment of Chunian Industrial Estate Near Bhai Pheru along Multan Road with 1 km Buffer zone, Establishment of Environmental Protection Zone (EPZ) and Industrial area along Sundar-Raiwind Road. For Business and Commercial Activities Trade and Finance Center in Johar Town measuring about 1400 Kanal is proposed to be developed. 200 Hectors area is proposed for development of Business District towards South of Hadiara Drain on both sides of Railway Lines. Three parks have been proposed along the river side to explode the river, recreational potential and to introduce boating, fishing and water game facilities. Besides a multi propose river site development zone, river view city comprising of commercial, recreational, and residential uses has been proposed in the areas bounded by three bridges vice versa Lahore bypass bridge, Sagain Bridge and old Ravi Bridge.

6 Urbanization Analysis result Comparison with Master Plan IMPL-2021

When Urbanization Analysis Land Use results compared with Master plan IMPL-2021 a major difference found between them. From following pie charts shows existing urbanization 2016 and expected in 2021. Urban land use in 2016 is 47% of the total land use while in IMPL-2021 proposed is 31%. There are 16% increase in urban land use before five years; it was a dramatic increased change in urbanization.

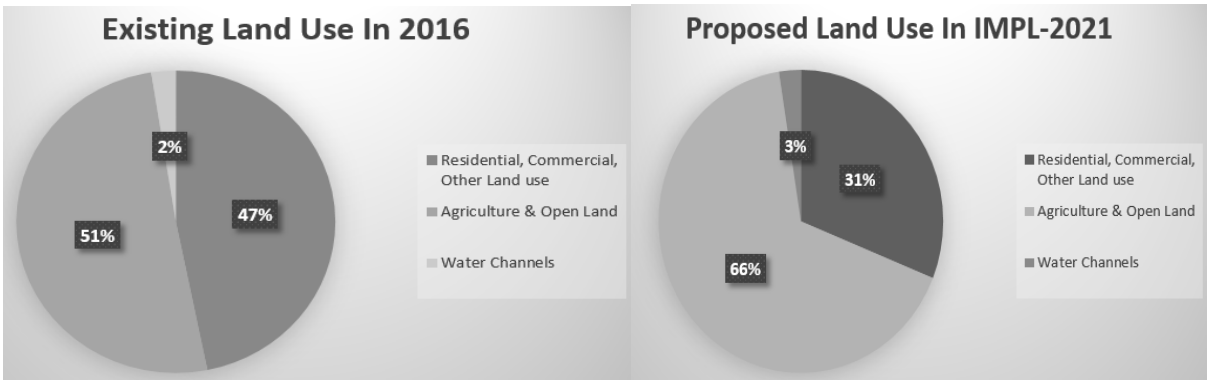


Figure 7: *Different Land Use comparison between Existing and proposed Land Use in IMPL-2021*

7. Integrated Strategic Development Plan (ISDP) - 2035, Lahore Division

Since the Integrated Master Plan 2021 for Lahore was prepared in 2004, rapid urbanization of the City of Lahore and its surrounding towns has changed its economic & socio-economic characteristics and urban form. The urban area of Lahore has expanded much beyond the limits of defunct metropolitan corporations, resulting in unregulated urban sprawl and has even expanded up to the urban areas of Sheikhupura and Kasur.

8. Planning Strategies for Lahore City

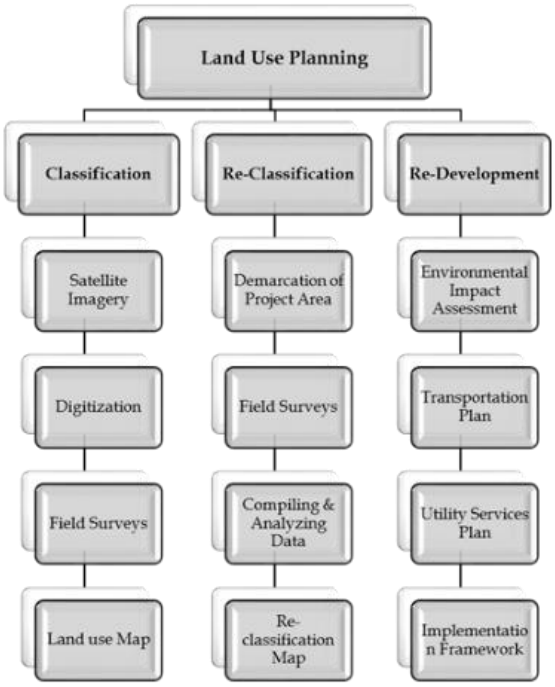


Figure 8: *Landuse Classification Planning*

The estimated population of Lahore is around nine million, whereas the population of Lahore Division is estimated to be close to 15 million, further expected to double in next twenty five years. This implies, if the current trend of unplanned and unregulated growth has to continue, another Lahore City will be required to accommodate additional population of future, with poor quality of life and services delivery. Moreover, due to reliance on outdated estimates and secondary data, the requirements of future urban Lahore cannot be worked out. Development scenario of Lahore Division has been changed since some recent years due to:

1. Rapid Urbanization Economic boom
2. Load on Infrastructure & Services
3. Environmental degradation
4. Housing Shortage
5. Inadequate public transport and Transport Management
6. Rapid Urbanization (Population growth @ 4% per annum)
7. Land Speculation
8. Illegal housing development (Katchi Abadis, Slums etc.)
9. Development in contravention of Master Plan provisions
10. Intermingle of industries with residential areas
11. Lack of utility services (Physical infrastructure, Health, Education, Water supply etc.)
12. Encroachment on roads
13. Inadequate parking facilities
14. Growing environmental degradation Un-employment
15. Lack of skilled labor
16. Inadequate vocational training centers/ institutes

17. Overlapping of functions (Authorities & Agencies)
18. Lack of coordination between government service provider departments.
19. Inadequate land-fill sites
20. High security risk
21. Governance & Implementation weakness

With all these core issues, there are need of Conventional Master Planning, Structure Planning, Outline Development Planning, Landuse Classification Planning, Strategic Development Planning and Regional Planning.

9. Recommendations

Urbanization presents one of the key challenges and, at the same time, opportunities in the new millennium. Urbanization is taking place at a rapid pace and is beyond the effective control of most government across the world. Even in jurisdictions where growth control boundaries have been implemented, such as Portland, such boundaries have been repeatedly revised to meet the demands for growth. The scale and complexity of urban problems are increasing everywhere. All cities must plan ahead to enable a sustainable future in the rapidly changing urban environment. Cities must review their strategic plans to develop better economic, social and environmental future. Those cities that fail to plan ahead and execute the pans will not be competitive in the globalized world. Urban economies are contributing significantly more too national exchequer and at the same time have become key employment markets. Cities indeed are important engines of economic growth and provide significant economies of scale in the provision of jobs, housing and services. In addition to spatial and physical expansion and lack of reliable data & studies on the existing profile of the City and Region, the Institutional set up of services delivery and Governance in Punjab and Lahore has undergone major changes during past few years, which requires carrying out of preparation of a master plan. The previous master plans and studies kept narrow focus on land use planning and lacked strategic vision and focus on economic development, environmental conditions, financial and implementation arrangements.

City boundary should be defined and control the uneven growth of urbanization. Basic facilities should be provided in surroundings of Lahore city so that migration of peoples should be minimized. While multi-stories buildings culture promote in the city. Urban sprawl has already spread to extreme lengths around the world, fortunately it can be stopped and its effects can be reversed. Doing so, however, will require cooperation from homebuyers, property developers, and government officials alike. Especially focus on the implementation of Master plan to achieve desired objectives of development and planning of the city.

10. Conclusion and Results

The study demonstrates measure and monitor urbanization in Lahore district and its environs, using remote sensing and GIS techniques. This method can be easily implemented using GIS to facilitate the measurement of urbanization for land use change detection and comparison of different Maser plans. There is a significant change (23.16%) in the last 16 years. These values indicate that there is an increase in urban sprawl and the urban growth tends to be more dispersed over a period of time. With the development of urban utility and service facilities around the city centers, urban sprawl would mainly impact on natural resources, i.e., agricultural land, water bodies, forest and fringe ecology. So the wisdom lies in how effectively the urban growth is planned and governed without hampering the natural resources and disturbing the green agro-rural setup.

The future scope of this work would look into generating the images of further sprawl under different scenarios to understand new threat to urban-agro ecosystem. This will judiciously demonstrate the application of geospatial technology in studying the dynamics of urban sprawl in Pakistani cities and elsewhere. Make Master plan for long term period and implemented for urbanization control in a better manner so that improved urban governance; Improved economic productivity & financial sustainability (through a proposed revenue collection/generation system which incorporates efficiency, transparency and accountability, and identification of buoyant sources of municipal tax revenue etc.); efficient land use planning & growth management; improved mobility & accessibility across region for work/education and recreation including focus on non-motorized transportation; improved access to basic services & public amenities including establishment of standards for municipal service delivery; improved urban environment including adaptation to the impacts of climate change and energy conservation. Similarly urban land use classes (built-up land, vegetation, water channels etc.) separately management with the help of Master plans.

The ISDP-2035 will make areas self-sustainable by enhancing their economic development and at the same time, providing solutions to upcoming issues. The Scope of ISDP will entail Formulation of vision, analysis of existing situation, identification of issues, Regional economic development plan, and comprehensive and regional land use plan, Strategies for all sectors like housing, transportation, and environment. Strategic short, medium and long term projects, Institutional framework, Public consultation and strongly Implementation Mechanism.

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