

**REMOTE SENSING ANALYSIS FOR URBAN  
EXPANSION IN MAZAR-E-SHARIF, BALKH,  
AFGHANISTAN**

**BY**

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**INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA**

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EXPANSION IN MAZAR-E-SHARIF, BALKH,  
AFGHANISTAN

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MAZARUDDIN MERZAYEE

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## ABSTRACT

Urbanization leads to urban expansion and it is an indicators of economic and development growth in a country. Mazar-e-Sharif, as the capital city of Balkh province in Northern Afghanistan has witnessed an enormous urban expansion via development in building and road construction, industrialization, and other anthropogenic activities since 2001. Thus, this study attempt to employ geospatial technology applications to determine the extent of urban expansion in study area with the aid of LULC change detection techniques and multi-temporal satellite imageries. To be specific the objectives are: (1) to identify the patterns of urban expansion in Mazar-e-Sharif. (2) to analyze the LULC changes using (LULC) change detection techniques and (3) to recommend the use of LULC change detection as a practical method to quantify, detect and monitor the urban expansion with the aid of geospatial technologies in urban land use planning practice in Afghanistan. This study uses two satellite images for LULC change detection analysis and the images were classified and analyzed based on land categories of Built-up area, greenery and Barren land. The results shows that, greenery land cover has decreased drastically from 21 % in 2001 to 11 % in 2019, while built-up area increased form 8.5 % in 2001 to 16.3 % in 2019. The analysis has shown that urban expansion has involved of internal reorganization and outward expansion of the urban areas and greenery areas shrunk towards the remote areas. The model of built-up expansion took the form of radiation centered in the center of the city and extended outward along the major traffic routes and mostly towards the East and North-West. The causes of this changes are, population growth, socio-economic activities and rapid urbanization. Apart from the derived results, this study also shows the potential of remote sensing and GIS techniques for the analysis of urban growth patterns. It was concluded that, proper measures should be taken in accordance with scientific planning for the urban expansion of the city in the future.

## ملخص البحث

يؤدي الإعمار إلى توسع المساحة العمرانية وهو مؤشر على النمو الاقتصادي والتقدم في الدولة. مدينة مزار الشريف هي عاصمة محافظة بلخ شمال أفغانستان التي شهدت توسعاً عمرانياً هائلاً الذي ظهر في تطوير المنشآت والطرق، والتصنيع والنشاطات البشرية منذ عام 2001م. وعليه فإن هذه الدراسة تحاول الاستفادة من تطبيقات تقنيات البيانات الجغرافية لتحديد مدى توسع الإعمار في منطقة الدراسة باستخدام طرق تحديد تغير استخدام الأراضي LULC وصور الأقمار الصناعية الملتقطة في توقيات متعددة. وأهداف البحث بالتحديد هي: التعرف على أنماط التوسع العمراني في مدينة مزار الشريف. تحليل تغير LULC باستخدام طرق تحديد التغيرات و أخيراً التوصية باستخدام راصد تغيرات LULC كطريقة عملية لقياس، وتحديد، ومراقبة التوسع العمراني باستخدام تقنيات البيانات الجغرافية عند تخطيط الأراضي المطورة في أفغانستان. تستخدم هذه الدراسة نوعين من صور الأقمار الصناعية لتحليل تغير LULC التي تم رصدها، تصنيفها وتحليلها حسب فئات الأراضي التي هي المناطق المعمورة، الأراضي الخضراء، والأراضي الجذباء. وأشارت النتائج إلى تناقص الأراضي الخضراء بشكل كبير من 21% في 2001 إلى 11% في 2019، بينما ازدادت الأراضي المعمورة من 8.5% في 2001 إلى 16.3 في. ويشير التحليل إلى أن التوسع المعماري تضمن إعادة ترتيب باتجاه الداخل وتوسعاً باتجاه الخارج في المناطق المعمورة، وتقلصت المناطق الخضراء باتجاه المناطق البعيدة. وأخذ نموذج توسع الإعمار شكل الإشعاع المتمركز في قلب المدينة والمتمدد باتجاه الخارج إلى طرق المرور وغالباً باتجاه الشرق والجنوب الغربي. وترجع أسباب هذه التغيرات إلى النمو السكاني، والأنشطة الاجتماعية الاقتصادية والعمران المتسارع. وبعيداً عن النتائج التي تم التوصل إليها، تشير هذه الدراسة إلى إمكانيات الاستشعار عن بعد وطرق نظم المعلومات الجغرافية في تحليل أنماط النمو العمراني. واختتمت الدراسة بأنه يجب اتخاذ الإجراءات المناسبة مستقبلاً بناءً على التخطيط العلمي للتوسع العمراني في المدينة.

## APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Urban and Regional Planning.

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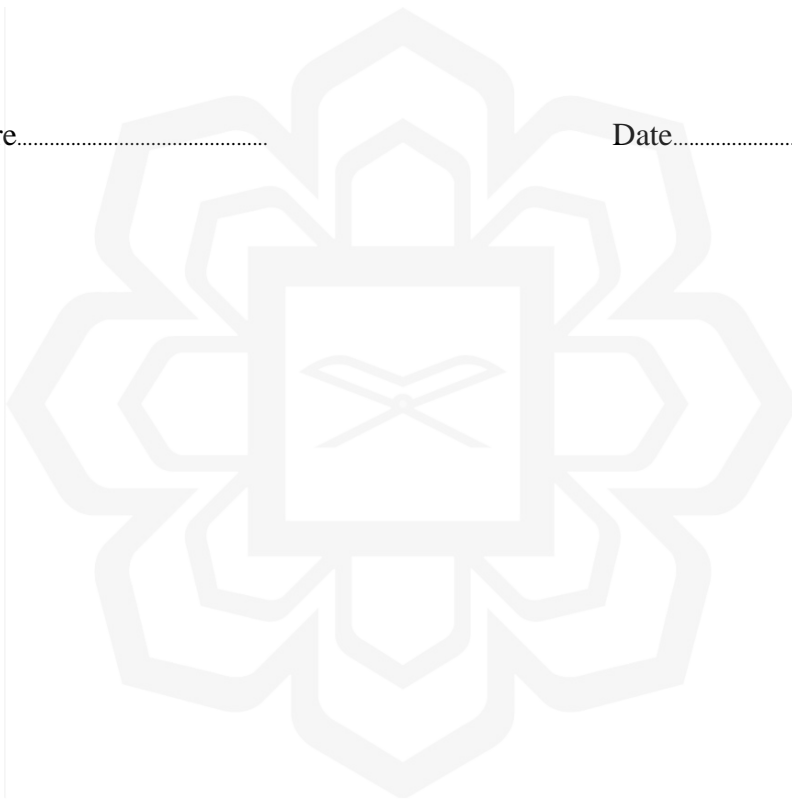
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*This thesis is dedicated to my cherished wife and parents.*

*“Our greatest weakness lies in giving up. The most certain way to succeed is always  
to try just one more time.”*

*Thomas Edison*

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## LIST OF ABBREVIATIONS

<b>CBD</b>	Central business district
<b>UTM</b>	Universal Transverse Mercator coordinate system
<b>ETM+</b>	Enhanced Thematic Mapper Plus
<b>OLI/TIRS</b>	Operational Land Imager/ Thermal Infrared Sensor
<b>LDCM</b>	Landsat Data Continuity Mission
<b>WGS</b>	World Geodetic System
<b>USGS</b>	United States Geological Survey
<b>WRS PATH</b>	World Reference System Path
<b>WRS ROW</b>	World Reference System Row
<b>NASA</b>	National Aeronautics and Space Administration
<b>EROS</b>	Earth Resources Observation satellite system
<b>ERTS-1</b>	Earth Resources Technology Satellite-1
<b>RCA</b>	Radio Corporation of America
<b>RBV</b>	Return Beam Vison
<b>MSS</b>	Multi-Spectral scanner
<b>CBERS</b>	China-Brazil Earth Resource Satellite
<b>SPOT</b>	(Satellite for observation of Earth-English) (Satellite Pour l'Observation de la Terre- French)

# **CHAPTER ONE**

## **INTRODUCTION**

### **1.1 INTRODUCTION**

This chapter of this study explains the urban expansion and other relevant terms related to urban studies. This chapter later describes the problem statement, research questions, objectives, scope of the study, and importance of the study as well as the organization of the report as a whole. In addition, this research attempts to use the land use and land cover (LULC) change detections techniques as a tool with the aid of Geographic Information System (GIS) and Remote sensing technologies to analyze the urban expansion in the selected study area.

Growth in the urban area or urban expansion provide the path to the change of land use/land cover in many areas around the globe, specifically in developing countries. LULC change is a widespread term used instead of human action and human modification of the surface of the earth it is driven by human actions for thousands of years. Currently it is an era in the world where the population of the globe is rapidly increasing, thus, the trend of urbanization due to human movement toward urban area is also increasing. Relatively city areas are very small in its size, incorporating just a small portion of the earth's land area, but, they provide accommodation for nearly 55% of the population in the world which is anticipated to increase to percent (68%) by 2050. Therefore, due to the rapid increase in urbanized area, and the growth of land in land use, urban LULC change studies rest at the center of modern theories and urban studies.

Furthermore, urbanization is the major cause of land use and land cover changes and the LULC detection technique is needed in the process of monitoring the urban growth with the aid of geographic information system and remote sensing applications. As well as, indeed it is needed for future land use and cover change projection in most of the developing countries particularly in Afghanistan. There exist important restrictions of Remote Sensing and GIS use in developing countries particularly in Afghanistan which is facing political and economic unpredictability as well as in the area of technical knowledge on how to use and get a good data for GIS and remote sensing analysis which will be used for taking out the meaningful information from the data. In this context, spatial technologies such as remote sensing and geographic information system are huge origin of information needed by land development policy makers, land resources managers, land development forecasters, and other users, and at the main time its more and more vital for the constructive and sustainable future urban land development and management. According to Goleman, Daniel, Boyatzis, Richard & Mckee, (2019), sophisticated new remote sensing technology has been developed to gather expansive quantities of remotely sensed data, and the mathematical techniques used to process and analyze the perceived data has increased considerably.

In addition the growth of population and the increase of socio-economic and physical development impose pressure on land use which lead to urban growth. Moreover, Butt, Shabbir, Ahmad, & Aziz, (2015) mentioned that, the land resources are the most vital sources for human beings. Exploring and using land resource reasonably is the basic principle for development of human society. Land use and land cover change evaluation assists to detect the range of human impact on natural environment.

Moreover, Mazar-e-sharif is among the largest cities in Afghanistan, as well as it is the cultural and economic hub of the Northern Afghanistan. During the past two decades Mazar-e-sharif witnessed a tremendous growth in Land use and its development where many new town ship has been introduced and new public and private infrastructure has been built. There are a lack of awareness among the local authorities on the importance of GIS and remote sensing in land use planning and other related fields. As well as, there is no digital data of land use development and patterns with the municipal authority and it is really hard to recognize the land use development pattern and urban expansion in the capital city of Mazar-e-sharif. Therefore, in this study an effort has been made to analyze the status of land use and land cover changes as well as to quantify the urban expansion between 2001 and 2019 in the capital city of Mazar-e-Sharif in Afghanistan. In this study, remotely sensed data from Landsat 7 ETM for the year 2001 and Landsat 8 OLI for the year of 2019 has been used for extracting and classification of land use and land cover changes in the study area. The thematic resultant of this process compared to between the 2001-to-2019. The outcome are introduced in the formation charts, tables, and maps.

## **1.2 BACKGROUND OF THE STUDY**

Presently Urban expansion is one of the contemporary issues of cities all over the world. Urban growth was a considerable problem in terms of urban development in Western countries in 20th century, majority of the urban growth is examined to be the expansion of low density go along by a sequence of environmental and socio-economic problems. The factors impacting the development of urban expansion are multifaceted and include rapid urbanization, industrialization, and migration to urban areas, development in

economy, and growth in income, development policy, and population growth. Therefore, the notion of urban growth is becoming important nowadays. Moreover, it can be clear that urban expansion is associated with urbanization where it takes place in developed and developing countries. The studies on spatial patterns of urban growth on unlike periods of time can be methodically mapped out, observed and precisely derived from remotely sensed data. Therefore, remote sensing and geographic information system (GIS) technologies can be utilized individually or compounded for applications in studies of urban expansion. In the matter of a compounded application, the integration of geographic information system (GIS) and remote sensing are highly advanced and applicable approach nowadays.

In urban studies the LULC detection techniques are widely utilized. According to Goleman, Daniel, Boyatzis, Richard & Mckee, (2019) Land cover refers to the physical and biological cover over the surface of land, including water, vegetation, bare soil, and artificial structures. In contrast, Land use is identified by the arrangements land cover, activities on land, and putting inputs by people in a certain land cover type to construct, to change, or to preserve it. Land use and land cover change (LULC) can be defined as the human alteration of the surface of the Earth. In addition, the drivers and factors affecting the land use and land cover changes are the local, physical, socio-economic, and demographic factors.

Thomas M. Lillesand et al., (2015) mentioned that, detecting and analyzing LULC changes of a large geographic area or a regional area can be examined in two ways which are the discrete long time span and in a continuous time series with highly high resolution of multi-temporal remotely sensed satellites images via a process commonly called 'change detection'. Al-doski, Mansor and Shafri, (2013) explained

that, LULC Change detection is an effective and useful instrument in verity of applications relevant to land use and land cover (LULC) changes and other environmental studies such as landscape pattern change, quarrying, deforestation and urban sprawl. Land use and land cover change analysis techniques has become a leading component in current blueprint for management of natural resources and keeping an eye on environmental changes.

The advances in obtaining high resolution spatial satellite imageries, remotely sensed image processing and GIS technologies made it easy to consistently monitor and model the land use land cover change patterns. As Rawat and Kumar (2015) mentioned, the use of remotely sensed images made it practicable to examine the changes in land cover in less time, at low cost and with better accuracy with the aids GIS that provides suitable platform for data analysis, update and retrieval. Remote-sensing has been commonly utilized in upgrading the land use and land cover maps and it is one of the most important applications of remote sensing and geographic information system. Satellite imageries are highly efficient means of obtaining information on urban areas needed for analyzing, modeling and projecting land changes. It is significant to examine and analyze the LULC changes and its degradation day by day due to natural and anthropogenic factors. The current study is extremely important for those who make policies and take decisions in land use planning.

### **1.3 PROBLEM STATEMENT**

Urbanization process in most developing countries is a well-known agenda for the past few decades. At the present time nations in developing stages encounter speedy urbanization which is the resulted of migration to urban area or natural increase in

population in urban areas. Currently approximately fifty percent (50%) of population of the world are living in urban areas, and that number is expecting to increase in the next upcoming decades. The rapid increase of population in urban areas will produce pressure to expand land, due to a high request for residential dwellings and associated services. The analysis and study urban expansion through land use and land cover (LULC) change detection is very important for having a conventional and accepted planning and utilization of natural resources and its management. Geographic information system and remote sensing have become an important instrument applicable to development of land in urban areas.

Mazar-e-sharif, which is the capital city of Balkh province in Northern Afghanistan has experienced an astonishing urban expansion, developmental activities such as building construction, industrialization, road construction, and many other anthropogenic activities since 2001. In addition, it has witnessed a remarkable growth population via natural growth and migration from the neighboring provinces as it is an economic hub in North of Afghanistan. The outcome is an increase in the consumption land, modification and alterations of LULC over period of time without any complete and comprehensive effort to evaluate and analyze this status as it changes over time. In context of detecting the land utilization rate and making an effort to analyze the changes it is therefore significantly important to study the urban expansion and land use and land cover changes in the study area. Indeed it will be crucially helpful to the land use planners and land resource managers for an acceptable and efficient land use and land resources planning.

Apparently, the LULC change detection has a significant role in supervising, controlling, and development of land in urban area. Thus, urban land use and land cover

change detection techniques is a serviceable tool for the sustainable land development in the city. Even though GIS and remote sensing have become a popularly utilized planning tool in many western developed countries, its application in many developing nations is still limited. Afghanistan is one of those counties where the use of geospatial technology is extensively limited. Due to limited use of geospatial technology majority of authority in municipal councils are not familiar with this highly important technology. Thus, the data and its accessibility in digital format are very important in urban planning and in assessing urban land use problem. Therefore, both geographic information system (GIS) and remote sensing can be considered having a remarkable potentials in developing a new perspective on solving urban development problems.

#### **1.4 RESEARCH QUESTIONS**

As a result of the statement on the problem, and complications on the study area the below research questions have been developed:

- i. How to identify the urban expansion by finding the changes in LULC classes in Mazar-e-sharif over a time span of 19 years (from 2001-to-2019)?
- ii. How to analyze the LULC change occurred in Mazar-e-sharif using LULC change detection techniques?
- iii. How the geospatial technology can help the local authority in urban land use planning?

## **1.5 AIMS AND OBJECTIVES**

The prime objective of this research is to employ geographic information system and remote sensing applications to determine the extent of urban growth happened in Mazar-e-Sharif using the land use and land cover change detection techniques with the aid of GIS and remote sensing technology over a time span of 19 years which is approximately two decades. The specified objectives of the study are:

- i. To identify the patterns of urban expansion in Mazar-e-sharif over a period of 19 year (from 2001 to 2019) using multi-temporal satellite imageries.
- ii. To analyze the LULC changes in Mazar-e-sharif using LULC change detection techniques.
- iii. To recommend land use and land cover change detection as a practical method to quantify, detect and monitor the urban expansion with the application of geospatial technology to assist the policy and decision makers in urban land use planning practice in Afghanistan.

## **1.6 THE SCOPE AND LIMITATION OF THE STUDY**

To begin with, in general sources connected to urban studies are considerably enormous and wide, the center of attention for the current research is set to the sector of the build environment that pays attention substantially to urban expansion. However, there are which are tributary component of the research that supports the focal point of this research which analyzing the urban expansion with the assist of land use and land cover change detection techniques with the aid of remote sensing and geographic information system. For instance, social-economy, growth of population, environmental

and culture that are affecting urban growth. Urban land use can be considered as a composite system where often occurs together with spatial economic, social and environmental changes and are engagingly relevant to land assets and land uses. Considering the time span, this study is narrowed to focus only on the analysis of urban expansion using LULC change detection techniques with help of geospatial technology and ranging from the year of 2001 to 2019. Therefore, the earlier or later studies rather than the specified year on the mentioned issue is not taken into the consideration. In addition, this study will be supported by the satellite imageries for the Land use land cover changes, satellite data pre-processing, processing, accuracy assessment and change detection of LULC of the study area. The application of geographic information systems and remote sensing based instruments are the key element in this research.

The limitation of the study usually constricts the scope and the finding of the research. The design and patterns of urban spatial development are remarkably composite and needs a theoretical and methodological structure to understand it. However, this study has some limitations in data collection and time constraint. The study constraints came about when some restriction and limitation occur while doing this study. The great difficulty arose during the collection of the data where, the relevant agency do not have the required digital data. In addition, the span of time devoted to this study also acts as a constraint factor in preparation of this research.

## **1.7 THE SIGNIFICANCE OF THE STUDY**

Utilizing satellite data in analysis of expansion in urban area with the aid of LULC change detection techniques and its influence has already led to exciting achievements. The spatial technology of remote sensing is a considerably un-expensive as well as a