TRENDS OF LAND USE AND LAND COVER SHIFT, KABUL CITY DURING 1999-2019, AFGHANISTAN

Project Report submitted as a requirement for the partial fulfilment of the Degree of Master of Science in Environmental Science

By

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To

CENTRE FOR ENVIRONMENTAL STUDIES

DEPT. OF ENVIRONMENTAL SCIENCE

SACRED HEART COLLEGE (AUTONOMOUS)

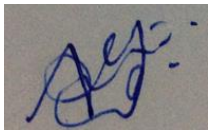
THEVARA, KOCHI – 13

KERALA, INDIA

May 2020

DECLARATION

I, AZITA SAIFI, hereby declare that the Project work entitled "**TRENDS OF LAND USE LAND COVER SHIFT, KABUL CTY DURING 1999-2019, AFGANISTHAN**", submitted to Centre for Environmental Studies, Sacred Heart College (Autonomous), Thevara, in partial fulfillment of the requirements for the award of Master of Science in Environmental Science, is an authentic record of the work done by me to the best of my ability on the basis of available literature under the guidance of **Dr. Thirivikramji, K.P Program Director and Mr. Prasood S.P** Research Associate, CED during 21/01/2020 to 21/03/2020. I further declare that no part of this work has formed the basis for the award of any other degree in any university or published anywhere.



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CERTIFICATE

This is to certify that the dissertation titled "**Trends of Land Use Land Cover Shift using Remote Sensing and GIS: A case of Kabul City during 1999-2019, Afghanistan**" is an authentic record of the work carried out from 21/01/2020 to 21/03/2020 by Azita Saifi **(18PEVS7882),** student of fourth semester M.Sc Environmental Science, at the Centre for Environmental Studies, Dept. of Environmental Science, Sacred Heart College (Autonomous), Thevara, under the guidance of **Dr.Thrivikramji K.P**, Program Director, and **Mr. Prasood S.P**., (Research Associate) Centre for Environment and Development (CED), Thiruvananthapuram in partial fulfilment of the requirements for the degree of Master of Science in Environmental Science.

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ACKNOWLEDGEMENTS

I take this opportunity to place on record my sincere gratitude to all those who have directly and indirectly helped me in completion of this study.

First and foremost, I would like to place my sincere gratitude to Centre for Environment and Development (CED), Thiruvananthapuram, and Dr. Babu Ambat, Executive Director, CED, for providing me the required facilities for successfully completing this project.

I would like to express my deepest gratitude to my project guide Dr.Thirivikramji K.P., Program Director, CED for his inspirational and valuable guidance during the entire project work.

I express my heartfelt thanks to my Project co-guide Dr. Chrips N.R, Research Associate, CED, for immense help, valuable comments, and fruitful discussions during this project work. I sincerely thank Mr. Prasood S.P, Research Fellow, for his constant encouragement. I am obliged to all my course mates for their cooperation and support during the work.

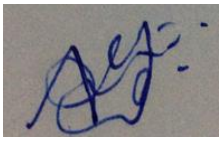
I would like to thank Dr. Prashanth Palackapilli, Principal, Sacred Heart College, Thevara, Dr. Mathew M J, Head of the Dept. of Zoology, Sacred Heart College Thevara, Dr. T. J James, program coordinator, Centre for Environmental Studies, Sacred Heart College, Thevara for giving me permission and courage to take this course and for the valuable suggestions.

I would like to express my gratitude to my internal guide Dr. Anjana N. S, Assistant professor, Dept. of Environmental Science, S H College, for her consistent encouragement and inspiring directions, I received throughout the project work. I would like to thank Dr. Remya R, and Dr. Anju S. G, Assistant professors, Dept. of Environmental Science, S H College, for the help and valuable support during the entire work.

I would like to thank my colleagues for all the support rendered throughout my study.

Not but least, I have met several people during my project period who has helped me and supported me in various ways, naming all of them is not possible within this work. However, I wish to express my sincere gratitude to all of them.

Above all, this piece of work is accomplished with the blessings and powers that work within me and also the people in my life. I bow before GOD for all with a sense of humility and gratitude.....



Azita saifi

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LIST OF ABBREVIATIONS

ArcGIS	:	A GIS software product, operating on desktop, server and mobile platforms.
DEM	:	Digital Elevation Model
Fig	:	Figures
GIS	:	Geographical Information System
Km	:	Kilometre
RS	:	Remote Sensing
SRTM	:	Shuttle Radar Topography Mission
TIN	:	Triangulated Irregular Network
USGS	:	United States Geological Survey
WGS84	:	World Geodetic System, 1984

ABSTRACT

A comparative study of land use / land change cover change of Kabul city and its 210,533km^2 hinterlands were done by using RS data and GIS software tools over the period between 1999 to 2019. The data sources for the study includes SRTM DEM data, Diva GIS data, appropriate Google Earth scenes (1999 & 2019) and archival data from CED, Thiruvananthapuram. The project uses ERDAS Imagine and Arc Map 10.2 for image classification, conversion and map generation. Microsoft excel is used for tabulation and infographic generation.

The study area revealed that there has been a considerable shift in land use characteristics of the area. Vegetation has decreased drastically by 13.71 km^2 in 2019.The built-up area increased from 20.24 km^2 in 1999 to 80.36 km^2, with a growth rate of 38%. Because of the returning refugees from neighbouring countries and other districts to capital city the urban expansion continued and built-up area increased to 80.36 km^2 in 2019.

As a response to the challenge of rapid growth of urbanization and lack of reliable data for urban planning and management, especially in the developing countries, this paper evaluates land use change and urban spatial expansion, from 1999 to 2019, in Kabul city, the capital of Afghanistan, using satellite images, and socioeconomic data. The city is highly representative of Afghanistan's rapid urbanization process.

As the city rapidly expands, there are enormous challenges to the sustainable use of land and resources. The discussion covers the increase in rural-to-urban land conversion, the delineation of urban growth boundaries, urban upgrading, and the investigation of illegal construction. This study considers the aspects of urbanization and land management systems in Afghanistan.

Efficient frames are outlined in Kabul for the following elements such as governmental self-restraint and policy modification. The results indicate the necessity of appropriate policy framework and regulations particularly for limiting linear sprawl along the main roads.

Keywords: Urban Land Expansion, Urbanization, Land Use/Land cover Change

Chapter I

INTRODUCTION

1.1. Background

The rapid growth of the world's urbanization, especially in developing countries, is one of the major challenges for governments and planning agencies. The inevitable outcomes from this process are the spatial expansion of towns and cities beyond their juridical limits and peripheries in order to accommodate the growing urban population. Therefore, effective governance and planning to achieve a more sustainable urban form are crucial for urban planners and policy makers (Mosamma et al., 2017).

The decades-long war in Afghanistan not only resulted in the tragic loss of more than a million lives, but even more tragic was the complete destruction of its built environment. Since the establishment of the new government in 2002 by the arrival of coalition forces, Afghanistan has entered a phase of high-speed urbanization. Like many other countries in the region, Afghanistan also needs to devote much attention to reconstruction and creation of townscapes with significant features. Sustainable and efficient townscape can protect living environment, facilitate residential, commercial and other business activities, thus, a city's economic performance is tied to the quality of land use policy and sustainable development (UN, 2011).

From an economic perspective, urban expansion is the result of market forces. As long as the marginal benefit of urban land-use is greater than that of agricultural land-use, urban expansion proceeds unabated. However, a single market mechanism in the allocation of urban land resources may lead to market failures, including the unfair distribution of benefits and the loss of public land resources. While representing public interests, the government may use certain policy instruments to directly or indirectly control urban spatial expansion in terms of location, speed, timing, quality, and cost.

From a global perspective, with the successive emergence of theories and ideological trends, such as the New Urbanism, Smart Growth, and the Compact City, governments have begun to promote sustainable urban development and control urban land expansion with policy instruments (Liu et al., 2017). In order to realize the revival of the central areas of cities, urban redevelopment policy was chosen as the main tool to improve the quality of cities in the developed countries. Most studies show that the policies of each country have led to remarkable achievements in improving the efficiency of urban land use, easing pressure on transportation and infrastructure, and improving environmental quality.

Since 2006, urban land expansion gradually began to be taken seriously in Afghanistan, and many scholars began to research urban growth management policies and their success in controlling urban land expansion (The World Bank, 2017). Based on the study of urban spatial expansion in Kabul, DCDA found that Kabul New City's establishment with sustainable land use can provide some effective ways to control urban expansion.

The argument that the urbanization processes, (especially the basis of land ownership system, and the driving forces of urban expansion in Afghanistan), are different from those of developed countries, it is unfair to copy the urban land management strategies of those countries without any innovation (Afghanistan Public Policy Research, 2012; Alexander et al., 2009). Thus, compared with developed countries, the characteristics of urban land expansion and the institutional environment in Afghanistan are notably special. It is difficult for such international experiences to fully adapt to Afghanistan's unique national conditions. Kabul is a city that is highly representative of Afghanistan's rapid urbanization process.

1.1.1. Kabul City: An overview

Situated in one of a number of high-altitude basins in the region, Kabul lies at an elevation of about 5,900 feet (1,800 metres) in the east-central part of Afghanistan, in a triangular valley between the Āsamāʾī and Sherdawaza mountain ranges. The Kabul River flows through the city on its way to join the Indus to the east in northern Pakistan. This natural environment (particularly, the backdrop of the Paghmān and Dāmaneh-ye Kōh mountain ranges to the west and southwest and the Ṣāfī range to the east) provides a striking setting.

Kabul Municipality is led by the mayor, a presidential appointee, and is responsible for supervision of construction and the provision of basic services and urban management. Urban planning is the responsibility of the Ministry of Urban Development Affairs. Although there have been investments in urban services since 2002, the poor state of urban infrastructure has, in the face of rapid population growth, resulted in many Kabul residents without access to adequate basic services. In response to urban growth, additional municipal districts have been created as needed. Past initiatives to address urban growth have had limited success, with much of this expansion taking place in an informal, unplanned manner, thereby presenting problems for future service delivery. In the meantime, the inhabitants of Kabul show great resourcefulness in how to manage and to provide for their families, secure access to basic services, and earn a livelihood in a very challenging urban environment.

1.2. Review of Literature

This section on review of literature provides relevant literature structured by mixing thematic, spatial scale and chronological approaches.

1.2.1. Pre-urban Epoch

For centuries, cities were compact with high population densities, and the physical extent of cities grew slowly and Kabul was no exception. This trend has been reversed over the last 20 years. Today, urban areas around the world are expanding on an average twice as fast than their populations. Although urban land cover is a relatively small fraction of the total Earth surface, urban areas drive global environmental change. Urban expansion and associated land cover change fuels habitat loss, threatens biodiversity, and results in the loss of terrestrial carbon stored in biomass. Land-cover change could lead to the loss of up to 40% of the species in some of the most biologically diverse areas around the world, and as of 2000, 88% of the global primary vegetation land cover had been destroyed . The results of many local-scale studies highlighted the need to understand the aggregate impact of urban expansion and land-cover change on biodiversity at the global scale.

1.2.2. Drivers of land use/land cover change

According to an official report, there were 200,000 dwellings in Kabul in the mid- 1980s. The latest available figures for 1980–88 show a total housing stock of 3,500,000 with 4.4 people per dwelling. However, years of conflict have caused severe damage to the housing stock. In 2003, UN-Habitat reported that about 26% of all housing had been destroyed or seriously damaged. About 20–25% of the population did not have access to piped water and about 84% of the population had no sanitary toilets. The UN High Commissioner for Refugees (UNHCR) has been the leader in providing homes and shelter for returning Afghan refugees, internally displaced persons, and the extremely poor.

From 2002–04, over 100,000 rural homes were built through the collaboration of UNHCR and the Afghan Ministry of Refugees and Repatriation. Others funding housing development included the UN Development Program, the International Organization for Migration, and CARE International, while the agencies implementing the programs are the Ministry for Rural Rehabilitation and Development (MRRD) in Afghanistan, the United Nations Human Settlement Program (HABITAT), the International Rescue Committee (IRC), and an assortment of international and local nongovernmental organizations (NGOs).

Houses in farming communities are built largely of mud brick and frequently grouped within a fortified enclosure, to provide protection from marauders. The roofs are flat, with a coating of mixed straw and mud rolled hard above a ceiling of horizontal poles, although in areas where

timber is scarce, separate mud brick domes crown each room. Cement and other modern building materials are widely used in cities and towns. Every town has at least one wide thoroughfare, but other streets are narrow lanes between houses of mud brick, taller than those in the villages and featuring decorative wooden balconies. The destruction of paved roads has severely constrained normal domestic trade in most rural parts of the country. Heavy fighting in Kabul completely destroyed the city's infrastructure.

1970's - 1980's

Modernization and urban development efforts continued through the two decades after 1960, including the creation of ministry buildings, public facilities such as the Kabul Poly-Technic, Kabul cinema and the Soviet cultural centre, as well as a number of initiatives aimed at providing affordable housing (Brockerhoff, 1999), including "500 Family" (in KhairKhana) and other projects for civil servants in (Kart-e-Naw) and other districts. In addition, many of the roads envisaged by the 1978 Master Plan were implemented.

1980's-2001's

After the mid-1980s, the deepening conflict between the Soviet-supported government and Mujahedeen factions also had an impact on urban development, as investments slowed. While the process of physical planning and structures of urban management remained in place, they became less and less effective. With the displacement of many rural communities to relative safety, Kabul (in which, along with other cities, services were available and many commodities subsidized) continued to grow spatially as a protected enclave (AKTC, 2011). This status ended abruptly in 1992 with the fall of the Najibullah regime, after which factional groups battled over control of Kabul, resulting in widespread destruction. Kabul's physical infrastructure, social services, educational and medical systems and governmental institutions were all devastated. Although they attempted to clarify the roles of municipalities through the issuing of a new Municipal Law in 2000, the successor Taliban administration (1996-2001) undertook only very limited urban interventions, in the absence of sufficient funding for any form of development activity.

2001-2019

Finally, the most recent period (2005-2019) is a sample of ever fastest urban land growth stage of the Kabul city which is partly due to inflow of migrants from neighbouring countries. Planning projects, most of which prioritize infrastructural needs and symbolises economic opportunity over historic preservation efforts. The Study for the Development of the Master Plan for the Kabul New City (KNC) has been implemented since March 2008 under with the technical cooperation of the Japan International Cooperation Agency (JICA). The Study is taken up by close collaboration of

the partnering agencies of the Afghan Government represented by the Independent Board for the Dehsabz City Development Authority (DCDA) and the Ministry of Urban Development (MoUD). Many other government agencies have been cooperating with the JICA Study Team and its Afghan counterpart team In Kabul, - one of the most important drivers of urban land expansion. In 2010, Kabul municipality Department of Urban planning prepared a land use policy for providing fair, orderly, economic and sustainable use and development of land resources and to protect natural resources, maintaining the ecological processes, and providing for clear open green spaces (Nazire et al., 2016).

1.2.2.1 Urban Upgrading/Redevelopment

Kabul urban reconstruction projects carried out by World Bank and UN-Habitat aims (and many more projects) to improve urban management and the efficient delivery of urban services in Kabul. The Master Plan of Two new project sites in Kabul (2011-2012). Shahrak-e Telayee residential neighborhood in eastern Kabul —the “Golden City” development—is a group of sixteen luxury houses and eight hundred luxury apartments in twelve high-rise towers built on the southern slope of Maranjan Hill, in the southeastern part of the city. The property broker explained that all the luxury houses had already been sold for three hundred to four hundred thousand dollars; but apartments were still available for $85,000, and shahraks like, shahrakAria in the north of the city- an upper middle-class region near the international airport. "In areas like Shirpur, Wazir Akbar Khan and Shahr-e Naw one square meter of land costs $1,000. To build an average house, you'd need at least 500 square meters of land. So the land alone would cost you $500,000 in the exclusive areas of Kabul," Hakim says. "Far from the city center, land prices are cheaper - 300 square meters in these areas cost around $30,000 to $40,000.

"An average three-room apartment in Aria costs about $140,000, which still is beyond the reach of ordinary Afghans," says Hakim. "That's why many people still go for mud-brick houses in remote districts or the outskirts of the city, which cost around $30,000 or $40,000 depending on their size and the area.

1.2.2.2 Rural to Urban Land Conservation

Each year, based on the private sector development, a great volume of agriculture/rural land has been converted to urban land (Mumtaz & Noshchis—Development of Kabul; Reconstruction and planning issues). As previously mentioned, local precincts play an important role in urban land expansion. Thus, Kabul municipality should issue agriculture/rural to urban land conversion quota every year, whereas such land conversion is gradually increasing (Khechen, 2012). In this process

of converting agricultural/rural land to construction land, municipality will obtain land grant fees- an important source of revenue for the Municipality and a deterrent to unplanned land expansion.

1.2.2.3 Urban Growth Boundary (UGB)

Rapid urban land expansion had led to a continued decline in the proportion of the city's ecological areas and the loss of self-maintenance capabilities. The ratio of land covered by crops, forests, and grasslands in 2012 was 35.67%, whereas the ratio in 2001 was 53.29%. Therefore, it is recommended to delineate UGB that include initial development areas, nature reserves and farmland protection areas, in addition to parks, mountains, gullies, and green spaces. The Government must implement strict building permits outside the scope of the UGB (Knaap & Hopkins, 2001; Ding et al., 1999). Except for essential road transport infrastructure, public and tourism facilities, all other construction must be banned.

1.3. Objectives of Study

General objectives

The general objective of the study is to analyse the land use land cover changes of Kabul city using remote sensing data and GIS over a span of 20 years.

The study specifically aims to

- Chart and analyse LULC patterns in Kabul city between 1999 and 2019, and
- Landscape analysis of the AOI, and familiarisation with other tools of analysis.

Chapter II
METHODOLOGY

2.1 Study Area

Kabul city: Kabul province includes 1, 053 villages, which are divided into 14 administrative and 22 municipal districts: Kabul city 210,533 km², Elevation: 1,790 m. According to estimates in 2019, the population of Kabul is 4.114 million, which includes all the major ethnic groups of Afghanistan. Kabul serves as Afghanistan's political, cultural and economic centre. Rapid urbanization had made Kabul the world's 75th largest city. Kabul is located between Latitude 34-31' North and Longitude 69-12' East at an altitude of 1,790 metres (5,873 ft) above sea level, which makes it one of the world's highest capital cities.

The climate within region of Kabul is considered to be arid to semi-aridsteppe. Because of the very low amounts of precipitation, especially from May to November, Kabul can be very dry and dusty. Extreme temperature changes occur from night to day, season to season, and from place to place. The chief characteristic of Afghanistan's climate is a blue cloudless sky with over 300 days of sunshine yearly. Even during the winter, skies usually remain clear between snowfalls, which are on average 15–30 cm (5.9–11.8 in) annually. The daily temperature for Kabul city in winter is −1 °C (30 °F) and in summer 24 °C (75 °F).The coldest month of the year is January and the hottest month is August.

Koppen Climate Classification:

Warm Summer Continental Climate The highest recorded temperature in Kabul has been recorded as 103.0°F (39.4°C), which was recorded in August. The lowest recorded temperature in Kabul is -8.0°F (-22.2°C), which was recorded in February. It is the lowest average temperature of the whole year. Kabul is influenced by the local steppe climate. During the year, there is little rainfall in Kabul. The climate here is classified as BSK in the Koppen-Geiger system. In Kabul, the average annual temperature is 11.4 °C. About 362 mm of precipitation falls annually.

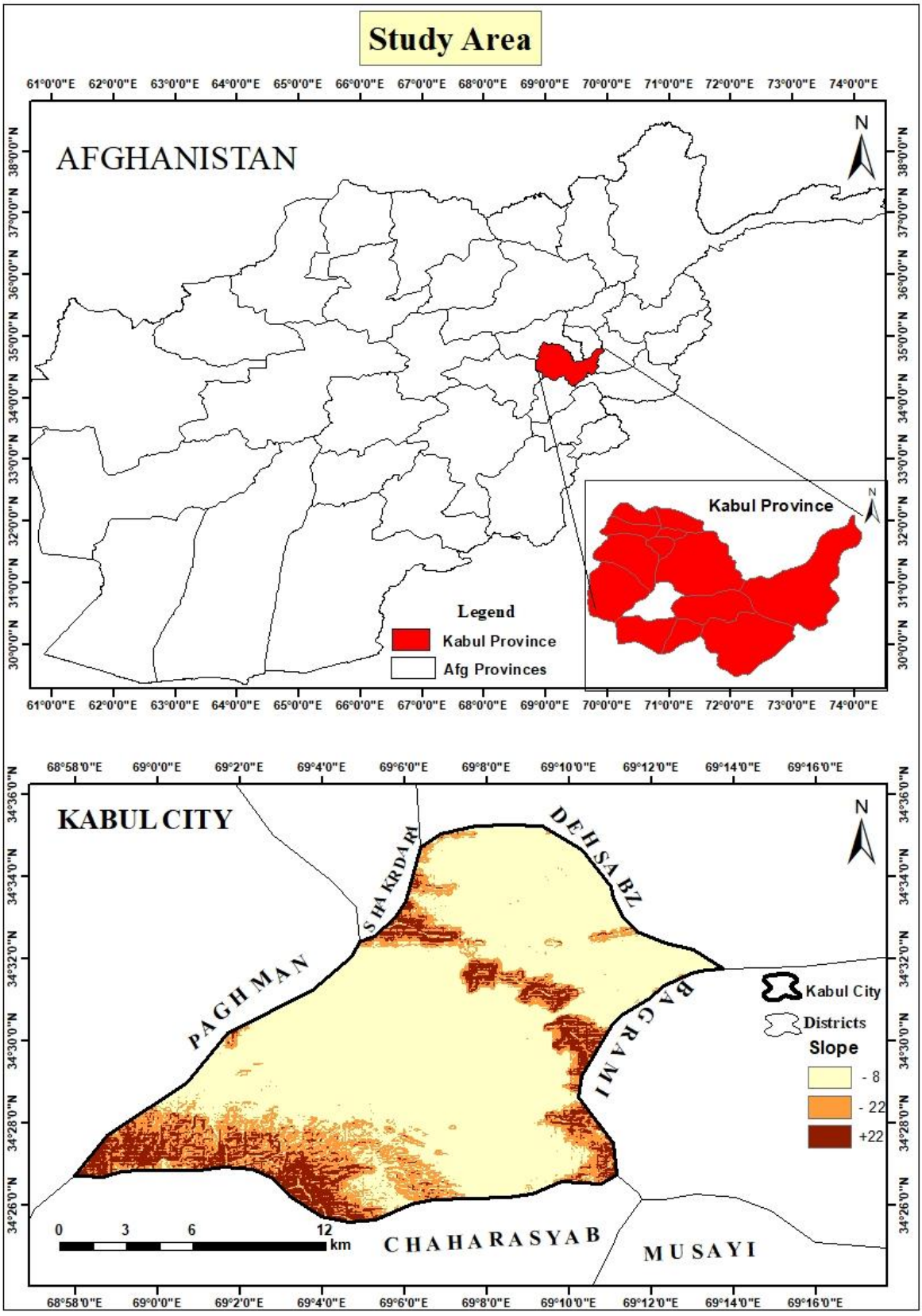

Fig.2.1. a) Location of study area; b)Kabul City Capital of Afghanistan,

The average amount of precipitation for the year in Kabul is 10.7" (271.8 mm). The month with the most precipitation on average is March with 2.8" (71.1 mm) of precipitation. The month with the least precipitation on average is June with an average of 0.0" (0 mm).

2.2 Data sources

LANDSAT 5 and 8 images downloaded from USGS Earth Explorer site are used for the supervised classification with ERDAS Imagine (2013), creating an FCC scene of appropriate bands. Currently LANDSAT images come with spatial references. (for e.g., Kabul City: WGS_1984_UTM_Zone_42N). The data sources are summarised in the table 2.1

Table 2.1 Data- types and sources

Data Types	Data Sources
Shape file	DIVA GIS
Elevation data	SRTM-DEM/USGS
SATELLITE	LANDSAT

Analytical Steps

Kabul city boundary was selected from DIVAGIS. Then overlaid the mosaicked DEM in the ArcMap. In the Kabul boundary extracted, following maps were created using the tool in the Spatial Analyst Tool and Hydrology tool, and generated the area.

Colorised DEM, Contour, Slope, Hill shade, Aspect and TIN (using Spatial Analyst tools) and Stream Network (Hydrology tool) maps were created in order to better describe the study site and relate to main topic, the LULC and changes.

Two types of image classification were practiced, viz., supervised and unsupervised classifications. Supervised Image Classification was carried out to derive a gross idea about the computer generated landuse categories for the selected timelines, i.e., 1999 and 2019.

2.3 Preparation of Biophysical Data

The LULC data (pixels of 30 × 30 m) derived from the online source of USGS Earth Explorer. The overall classification accuracy of this data and the descriptions of LULC are presented in Table.**3.1**. The topographical aspect data, i.e., slope and of LULC are presented in fig (3.2). The topographical aspect data, i.e., slope and elevation were derived elevation were derived from the

Shuttle Radar Topography Mission-Digital Elevation Model (SRTM-DEM) which is available online http://srtm

2.4 Data sources and Methodology

2.4.1 Data types and sources

For the attainment of the objectives of this study, used the Shapefiles of the study area obtained from DIVA GIS. Google Earth scenes of 1999 and 2019 SRTMDEM acquired from USGS Earth Explorer Website.

2.4.2 Tools used

The study was entirely dependent on ArcGIS 10.2 software tools and Erdas 2013 for analysis of two different periods. (1999-2019)

2.4.3 Work Flow Diagram

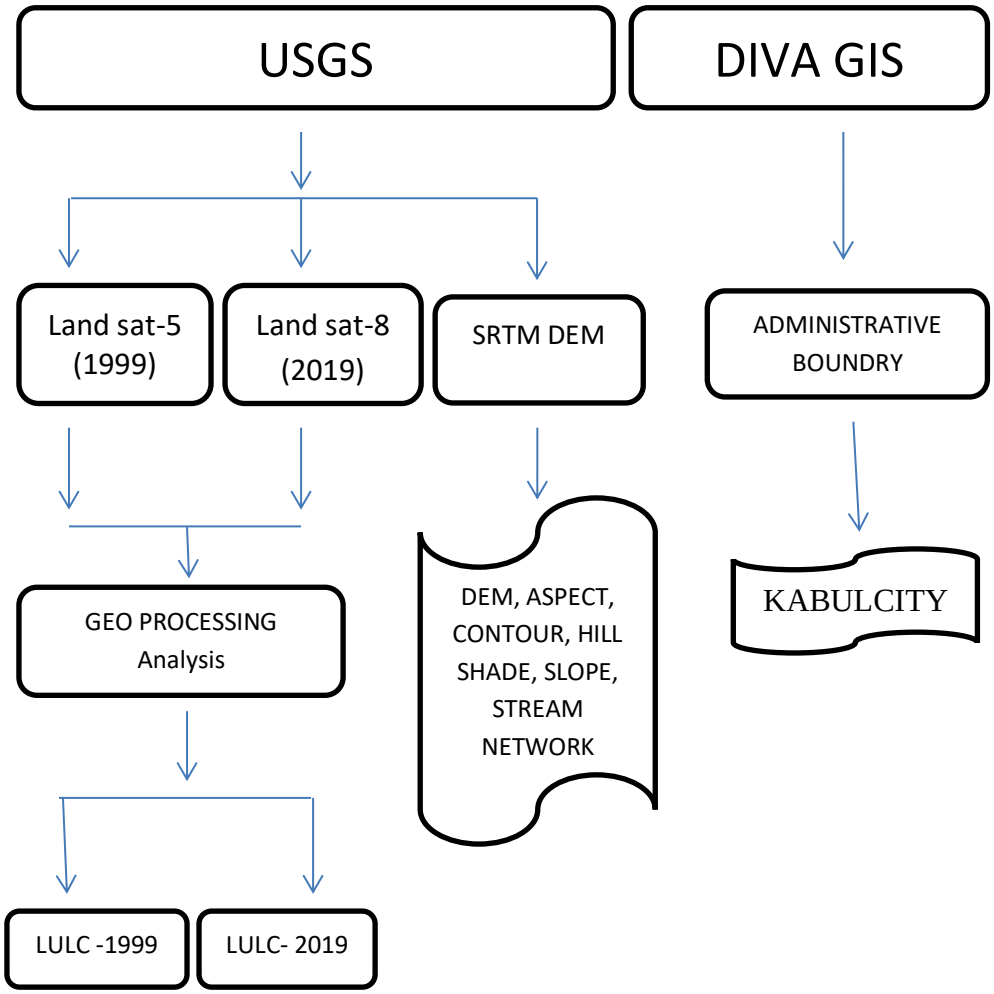

Fig.2.2.Work Flow Diagram

Chapter III

RESULTS AND DISCUSSION

3.1. Land use /land cover change comparison between 1999 and 2019

There are various types of land use/Land cover classification used by different organization and scholars based on different parameters. For the purpose of this study, five broad land use/land cover classes described briefly have been used in Kabul city map.

3.1.1. Built up area

This land use/land cover includes residential houses/settlements, industrial and commercial complexes and all other cultural footprints (man-made features) except road which is presented separately as black top and dirt road.

3.1.2. Mountain

A mountain is a landform that raises high above its surroundings. Taller than a hill, it usually has steep slopes and a rounded or sharp peak. Mountains are rarely found alone and group of mountains are called ranges.

3.1.3. Open Space

These areas are free from any sort of agricultural activity. It includes scrub lands barren land, play grounds (stadium) etc.

3.1.4. Vegetation

It includes all sorts of forested land both natural and man-made, whether it is dense or scattered. It includes shades and fences around crop land and settlement areas. The detail land use/ land cover change detection result is presented below in table (Table 3.1), and pie charts (Fig. 3.3 and Fig.3.4)

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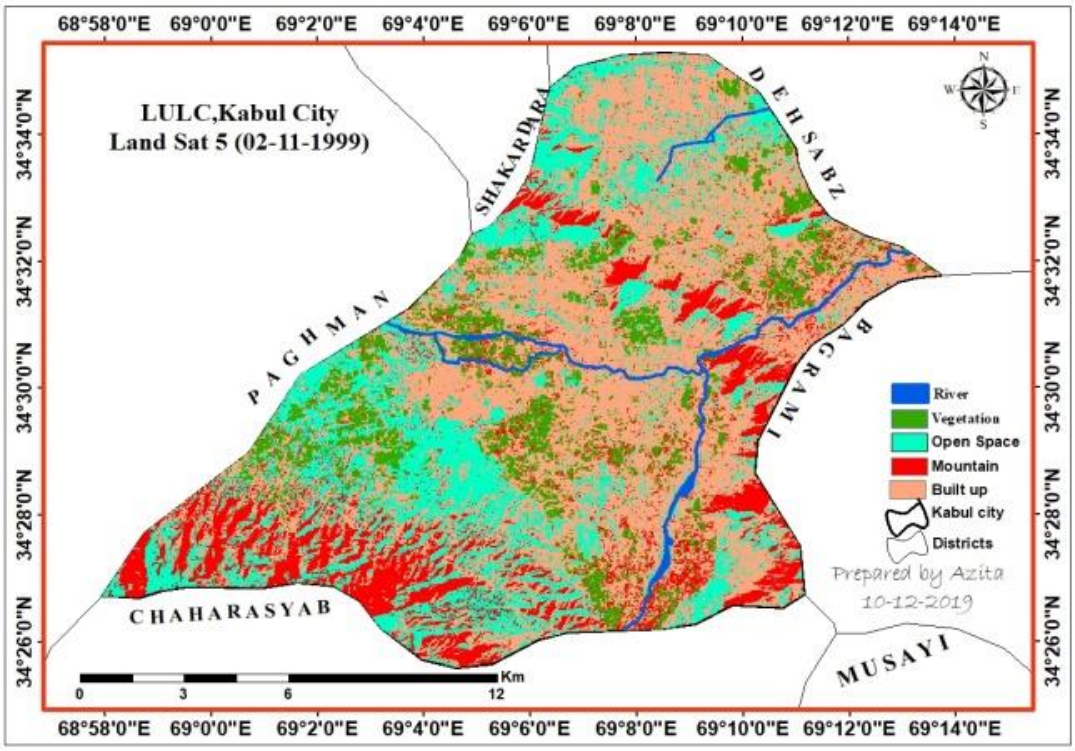

Fig.3.1 LULC Map of Kabul City, 1999

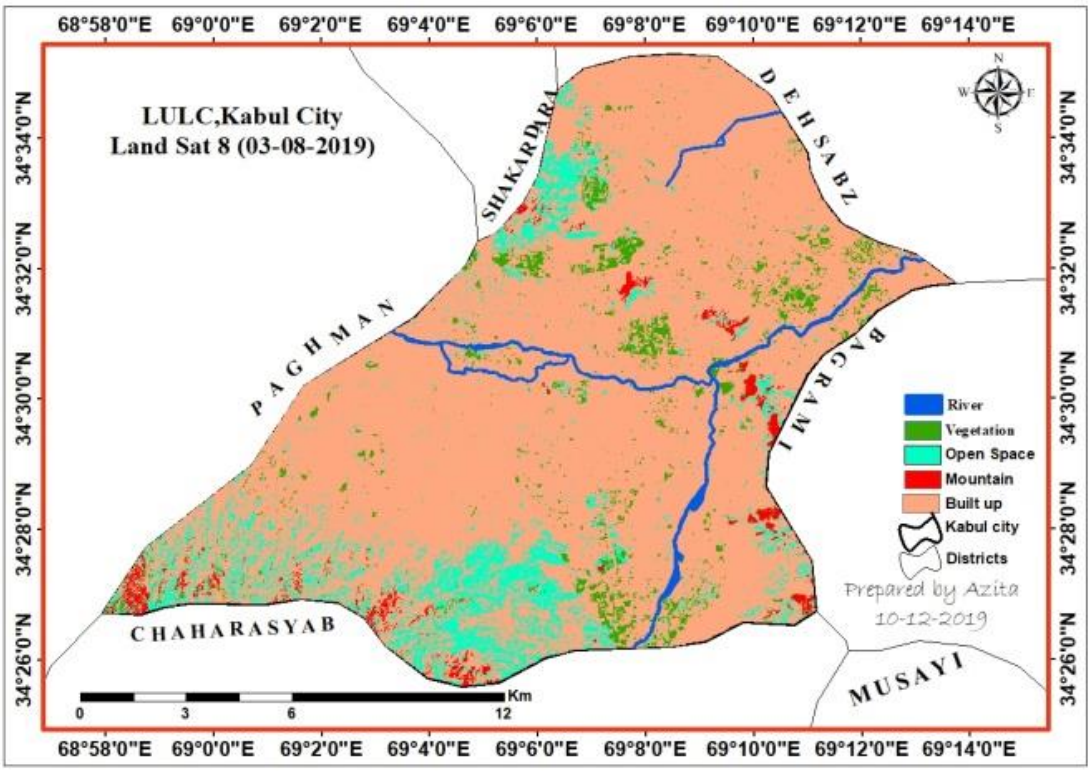

Fig.3.2. LULC Map of Kabul City, 2019

Table 3.1. LULC variabilities during the study period

NO	LULC TYPE	Landsat 5 (02-11-1999) (Area, km^2)	Area, %	Landsat 8 (03-08-2019) (Area, km^2)	Area, %	Change, km^2	Change, %
1	**Vegetation**	23.67	11.24	9.95	4.72	-13.71	6
2	**Open space**	130.75	62.10	68.80	32.67	-61.95	32
3	**Mountain**	34.68	16.47	30.00	14.24	-4.68	2
4	**Built Up**	20.24	9.61	100.6	47.78	80.36	38
5	**River**	1.17	0.55	1.17	0.55	0	0
	Total	**210.53**	**100**	**210.53**	**100**		

The negative (-) sign shows reduction

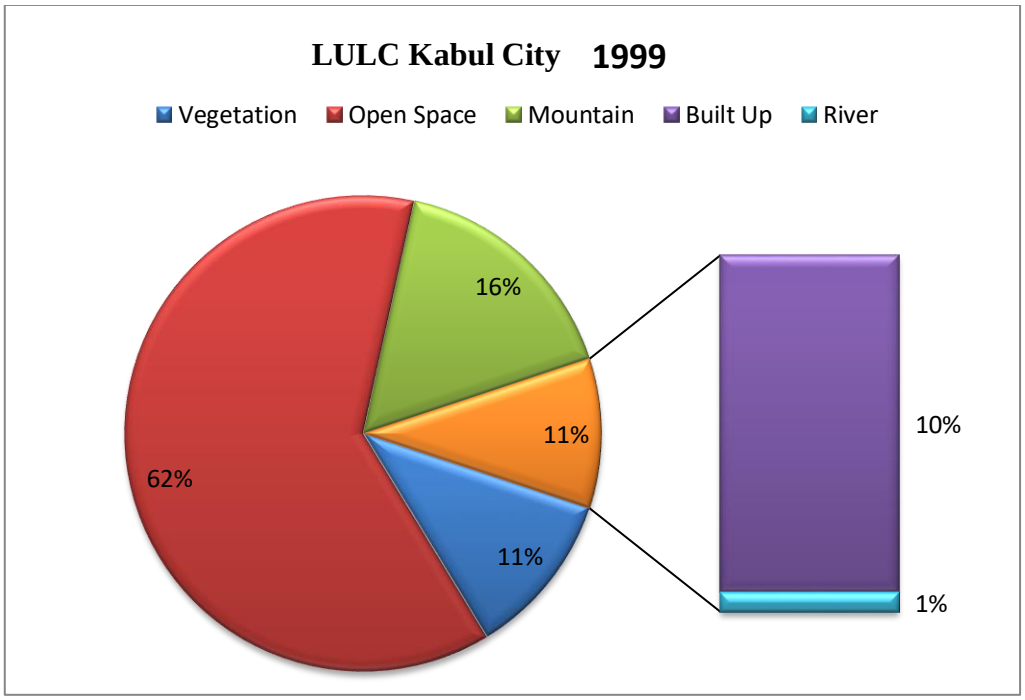

Fig.3 .3. LULCC 1999, KABUL CITY

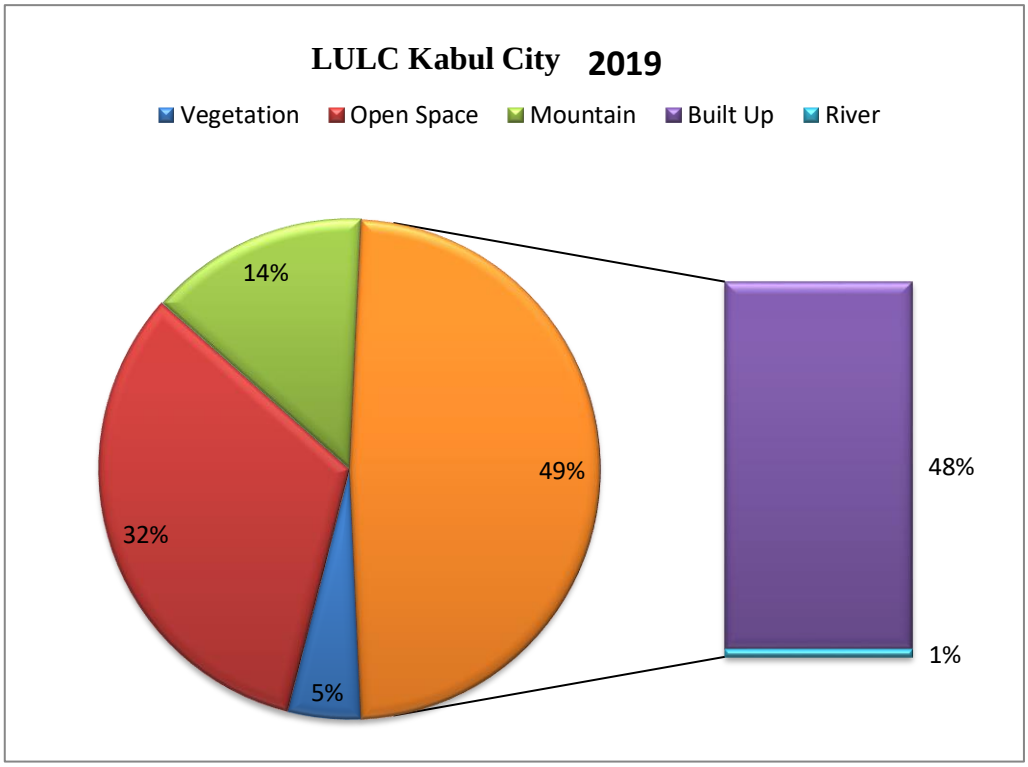

Fig. 3.4. LULCC 2019, KABUL CITY

3.2 Progression of Land Use/Land Cover Change

The result of the present study depicts that there is a massive land use/land cover conversion in the study area between 1999 and 2019.investment in urban development had slowed. Since the establishment of new government in the country has a major influence of development the built-up area increased from 20.24km^2 in 1999 to80.36km^2, with a growth rate of 38%. Because of the returning refugees from neighbouring countries, the urban expansion continued and built-up area has increased to 80.36km^{2}in 2019.

Following horizontal urban expansion towards the peri-urban area built up land use showed remarkable increment of 210.5307 km^2. On the other hand, crop land or vegetation which was the dominant land use in 1999 reduced drastically by -13.7192 km^2 2019. Likewise, open space reduced by -61.9553 km^2 in the same period.

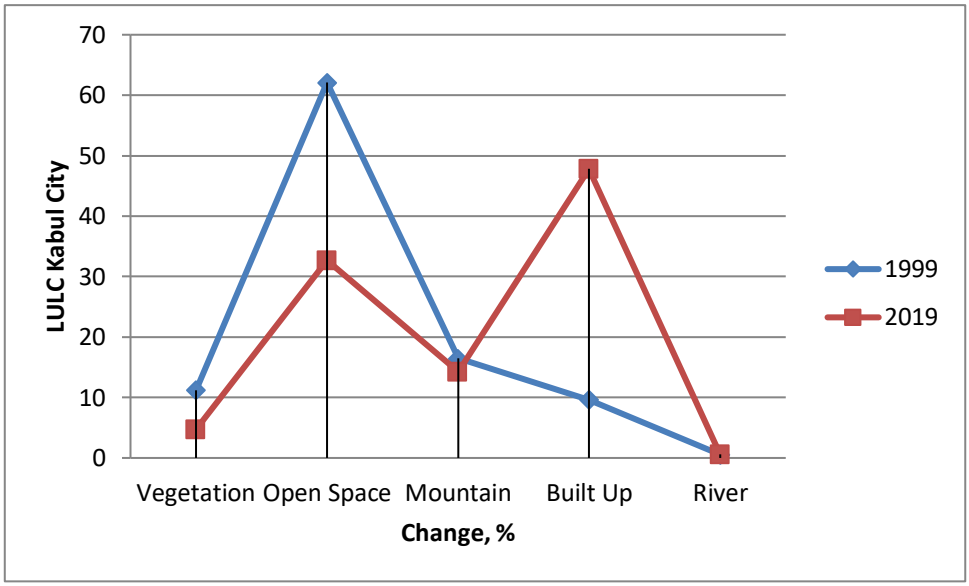

Fig.3.5. Trends of LULC change, Kabul city, 1999 and 2019

Achieved by supporting the integration of selected neighbourhoods into the urban fabric of the capital city through carrying out reconstruction and rehabilitation of urban infrastructure and enhancing the managerial capacity of the ministry of urban development and Land (MoUDL) and Kabul Municipality (KM) (Policy on Upgrading & Redevelopment of Unplanned Settlements in Afghanistan). Social surveys and interview have revealed that many redevelopment projects haven't been effective for the communities in achieving sustainable development goals (Kabul Urban Reconstruction Project, 2018). Redevelopment is considered as a useful strategy for improving informal settlements, and social equity in communities. Under the Kabul Municipal Development Program (KMDP), over one million people across Kabul city are expected to benefit from new and rehabilitated roads, new drainage, and better access to municipal services (World Bank). The city has the potential to redevelop. Thus, to encourage efficient urban redevelopment, necessary modifications in policy are required to establish a mechanism for coordinating the interests of the government, developers and land/house owners. The developers led demolition talks, resettlement compensation, and other interest negotiation work; the government only formulated rules and served as an intermediate supervisor by enforcing related matters according to the contract after all parties had reached an agreement (Qian et al., 2015; Beall & Esser, 2005). In this process, the original owner land is converted into state-owned land (which cannot exceed a certain ratio of illegal land); the developers obtain land development rights and compensate the owners monetarily or with housing; and, meanwhile, the developers have to return to the government a certain ratio of supporting facilities, such as roads, primary schools, and

kindergartens. Fig. 3.6 and 3.7 are sample views of the Kabul city and the urban periphery encroaching the foot-slope of mountainous tract.

3.3. Landscape Analysis

Fig.3.6 Alamy photography Kabul City Afghanistan (google image)

Fig.3.7.Alamy photography Kabul City Afghanistan (google image)

3.3.1. Stream network

There are a variety of ways by which a relief or natural landscape of a region can be represented through different types of maps. These maps include Digital Elevation Model (DEM) map, stream network map (Fig.3.8), Contour map, aspect map, slope map and Triangulated Irregular Network (TIN) map.

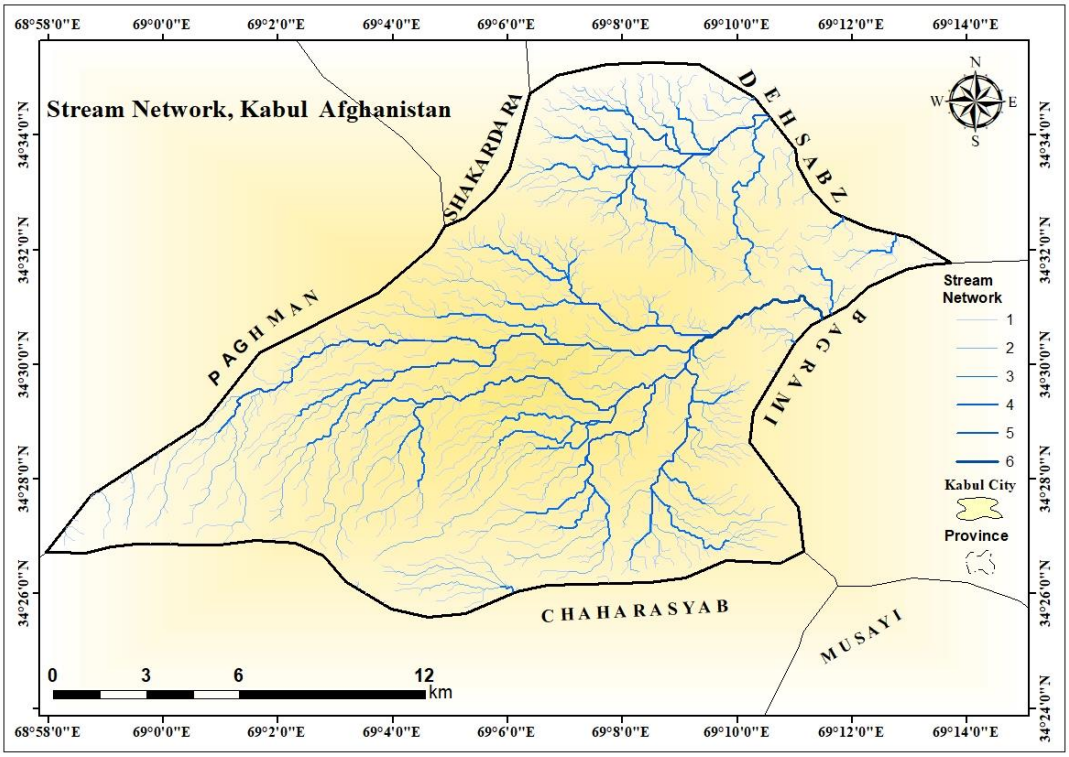

Fig.3.8. Stream Network of the Kabul city

Fig.3.9. River valley between Jalalabad and Kabul (Courtsey: Google image)

3.3.2. Digital elevation model (DEM)

Digital Elevation Model (DEM) is a specialized database that represents the relief of a surface between points of known elevation. The term digital elevation model or DEM is frequently used to refer to any digital representation of a topographic surface. It is generally restricted to the use of a raster grid of elevation values. The DEM is the simplest form of digital representation of topography and the most common one. For the purpose of this study DEM was downloaded from United State Geological Survey -USGS Explorer- website. DEM is dominant input or base to create other topographic maps such as contour map, aspect map, and slope map.

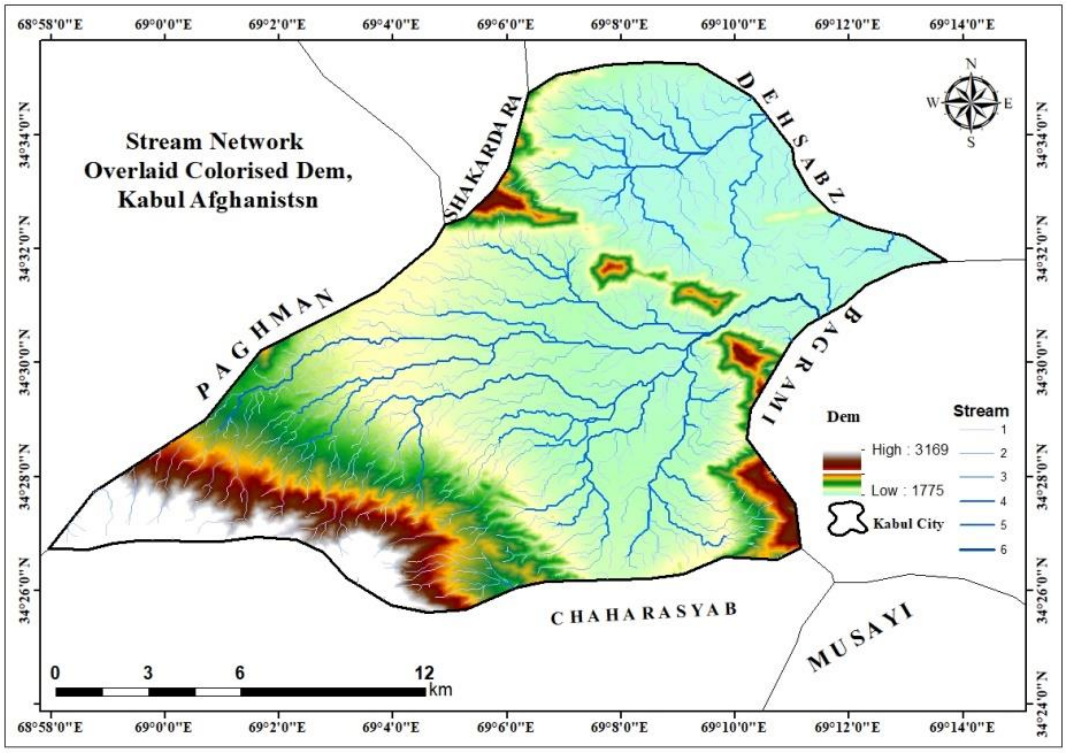

Fig.3.10. Stream net over colorised DEM of the Kabul city, AOI

3.3.3. Contour maps

Contour maps are a topographic map which shows the landscape of the earth surface using contour lines. Contour lines are lines which connect points of same elevation. The contour lines follow a certain equal interval to represent the continuous feature. The contour interval of a contour map is the difference in elevation between successive contour lines. As in many mountainous areas, passes are important. Khyber Pass at an elevation of 1,070 m (3,510 ft) is an important route between Afghanistan and Pakistan. Alexander the Great and Genghis Khan used this pass to invade areas to the east. Salang Pass at an elevation of 3,878 m (12,723 ft) conects Kabul with the north. A tunnel was built here by the Soviet Union in the 1960s

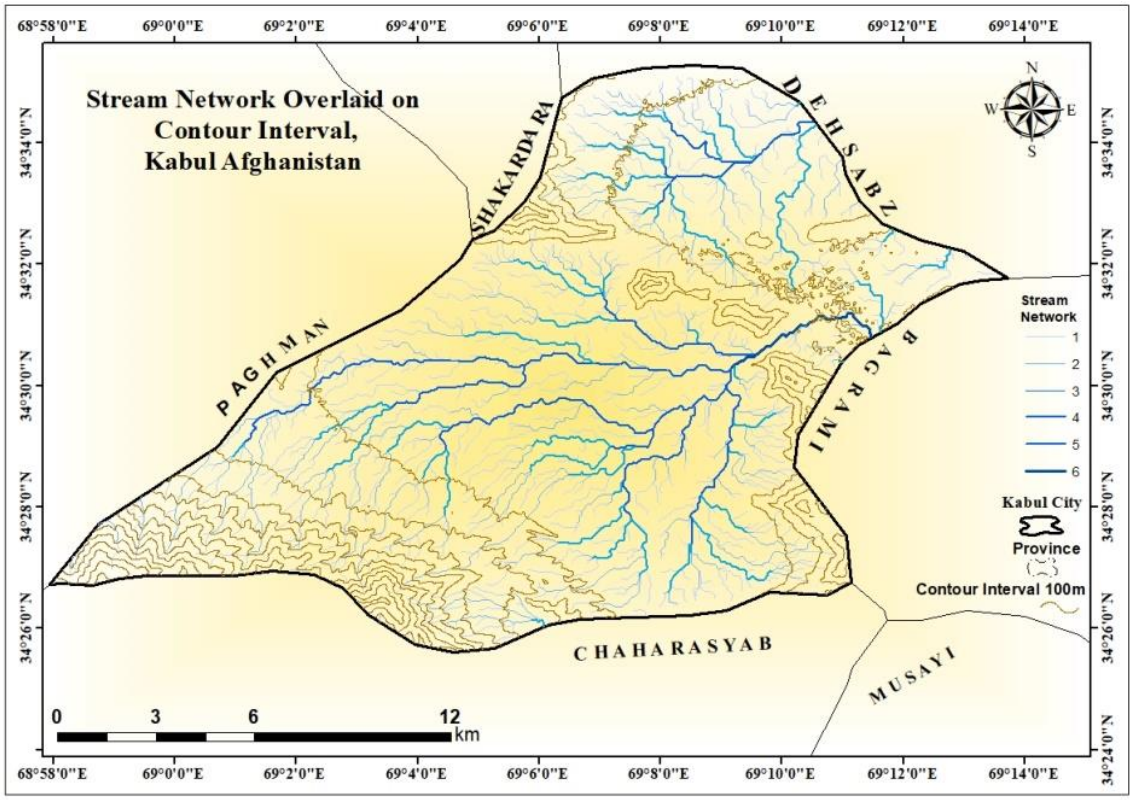

Fig.3.11. Stream net over Contour Map (100 m), Kabul City

3.3.4. Aspect map

Aspect identifies the downslope direction of the maximum rate of change in value from each cell to its neighbours. Aspect can be thought of as the slope direction. Measured clockwise in degrees from 0 to 360 degrees, where 0 is north-facing, 90 east-facing, 180 is south-facing and 270 is west-facing. The values of the output raster will be the compass direction of the aspect.

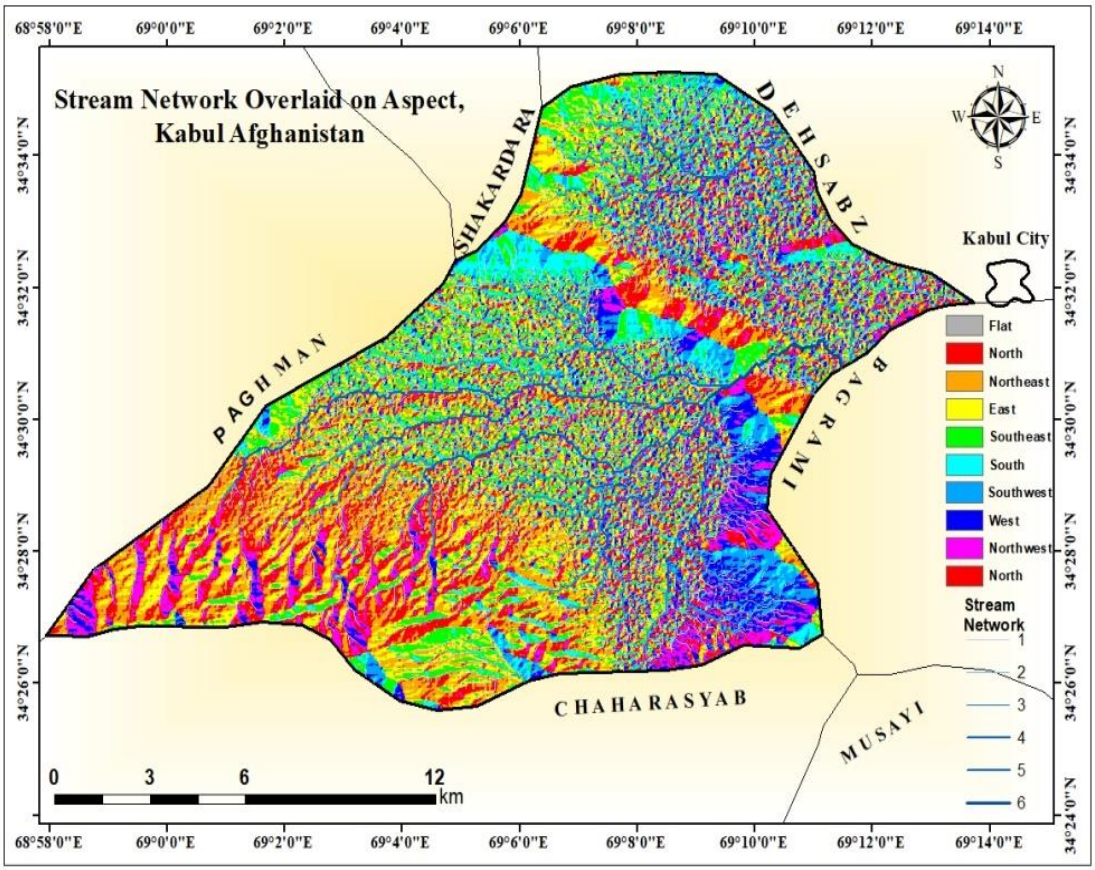

Fig.3.12. Stream net over Aspect Map, Kabul City.

3.3.5. Slope Map

Slope is the steepness of a surface in degrees. Then the slope for a particular location is computed as the maximum rate change of elevation between that location and its surroundings. Specific to the study, the slope expressed in degrees.

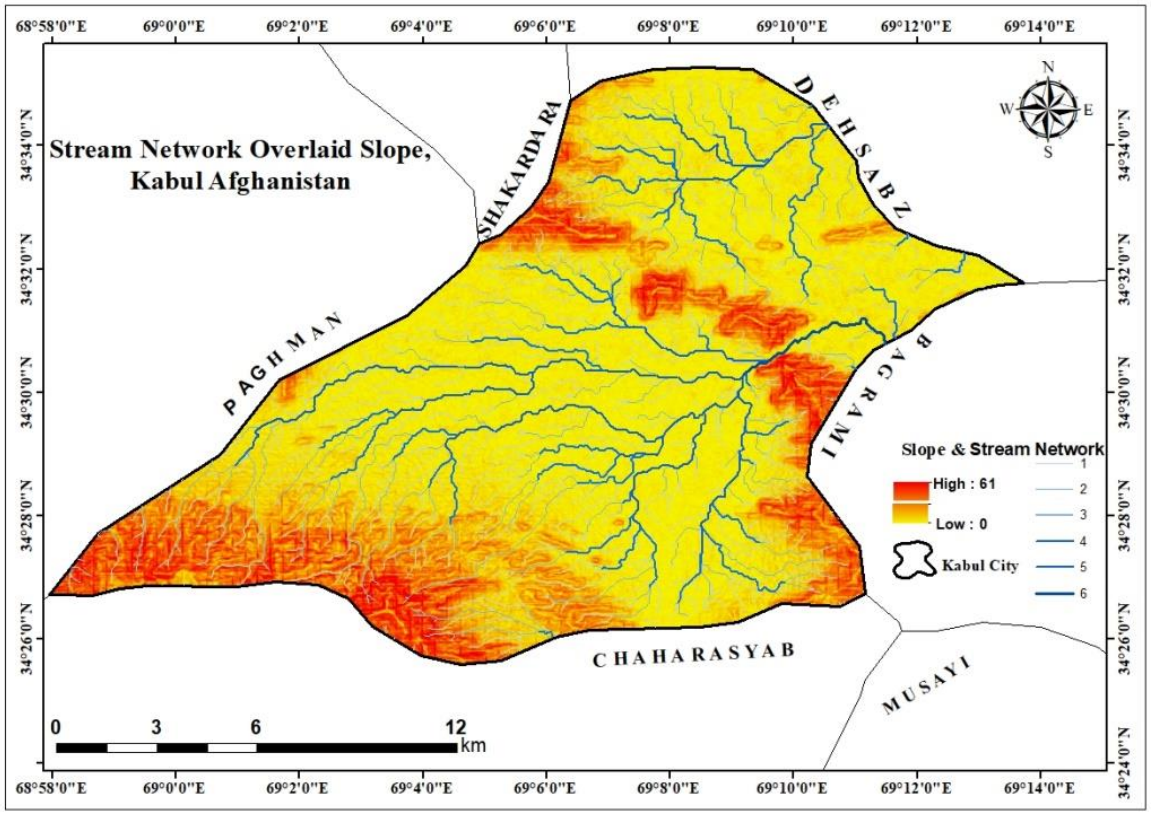

Fig.3.13. Stream net over Slope Map, Kabul City.

3.3.6. Triangular Irregular Network (TIN) Map

A triangulated Irregular Network (TIN) is a vector – based representation of a surface Although TINs are commonly used in applications that involve terrain, they can also be used for representing other variables that can be conceptualised as surface TINs are composed of a series of contiguous , non- overlapping triangles that are known as faces. They are built from a series of points using a technique called Delaunay triangulation, in which a network that connects each point to its nearest neighbours to form the triangular faces. TINs have some advantages over raster based representations of surfaces in that they are much more efficient at storing data because the resolution of the representation can be matched to the scale of variability present in the surface by including more or fewer points. Furthermore, TIN map is important for visual representation of topographical features and appearance of the physical land surface in the AOI. TIN map of the study area (Fig.3.14) is created in ArcGIS software which is presented below.

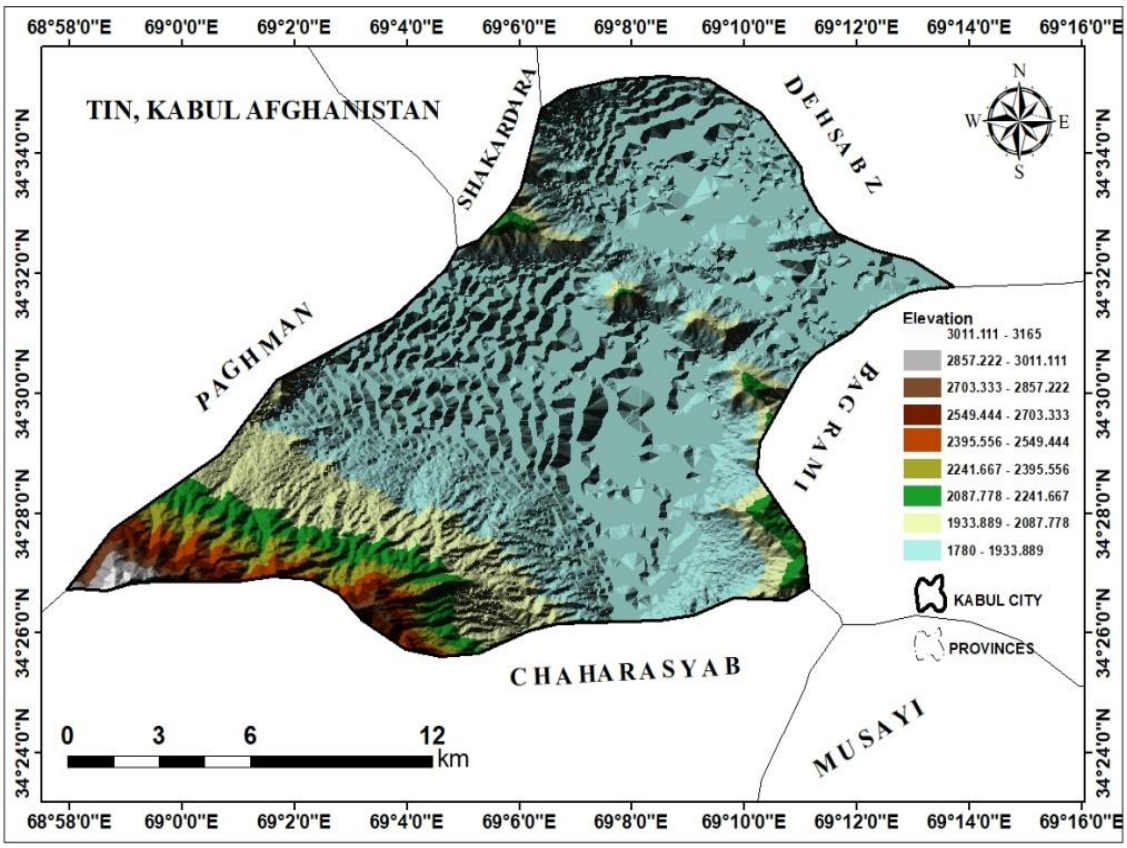

Fig.3.14.TIN model, Kabul City.

3.3.7. Land use/Land Cover, Kabul province

The focus here is the LULC classification status (during 2019) of Kabul Province (22 municipalities or precincts; area = 1030.5km^2; Population = 3,961,500 as on 2017). The city has witnessed unprecedented growth since the U.S.-led invasion of the country in 2001. Despite continuing acts of violence against the civilian population, Kabul has continued to expand. The Municipal Law, based on Article 130 of the 1990 Constitution of Afghanistan, and asserts that Kabul Municipality is part of the national government. This means that the Mayor of Kabul reports directly to the President. All other municipal governments in Afghanistan must report to provincial governors, who in turn report to the Interior Minister.

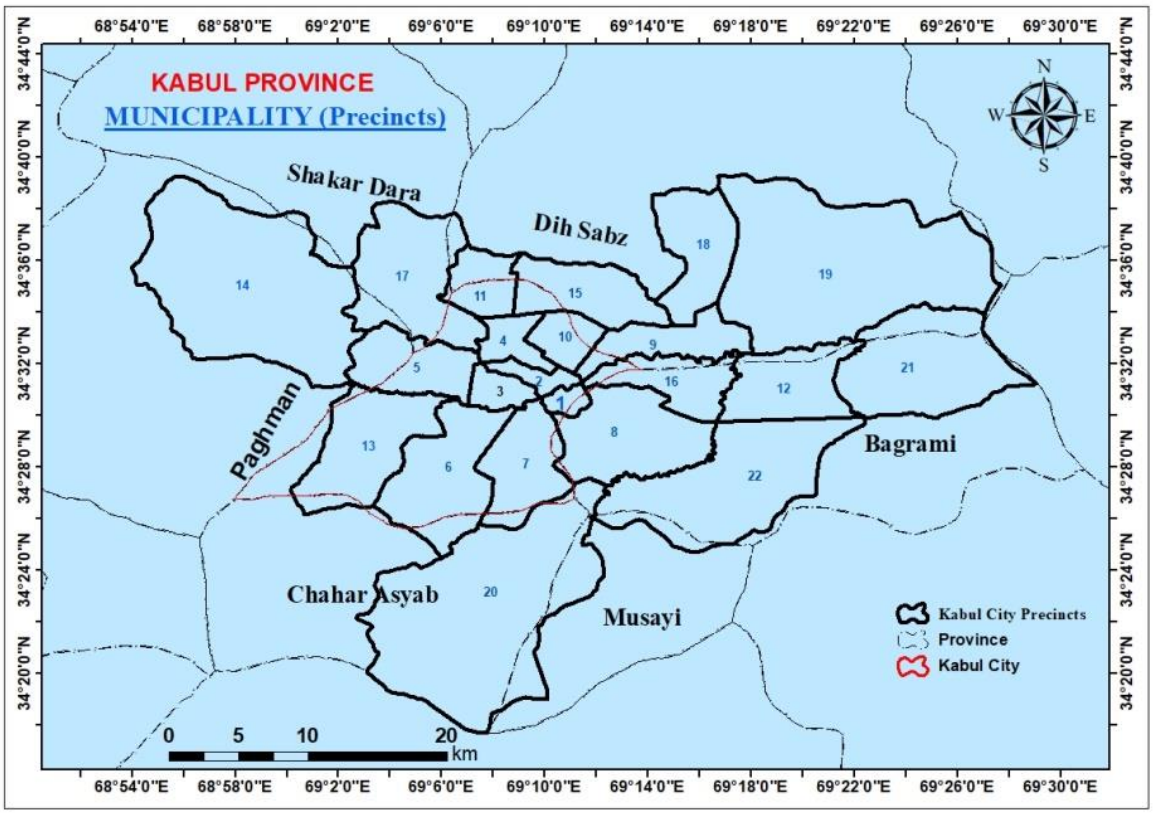

Fig. 3.15. Map of Kabul Province (22Nahya)

3.3.8. Land Use Land Cover Map, 2019

Results of LULC (2019) analysis the study area is given in Fig. 3.16 and Table 3.2. In 2019, urban area has increased to 25.9%.

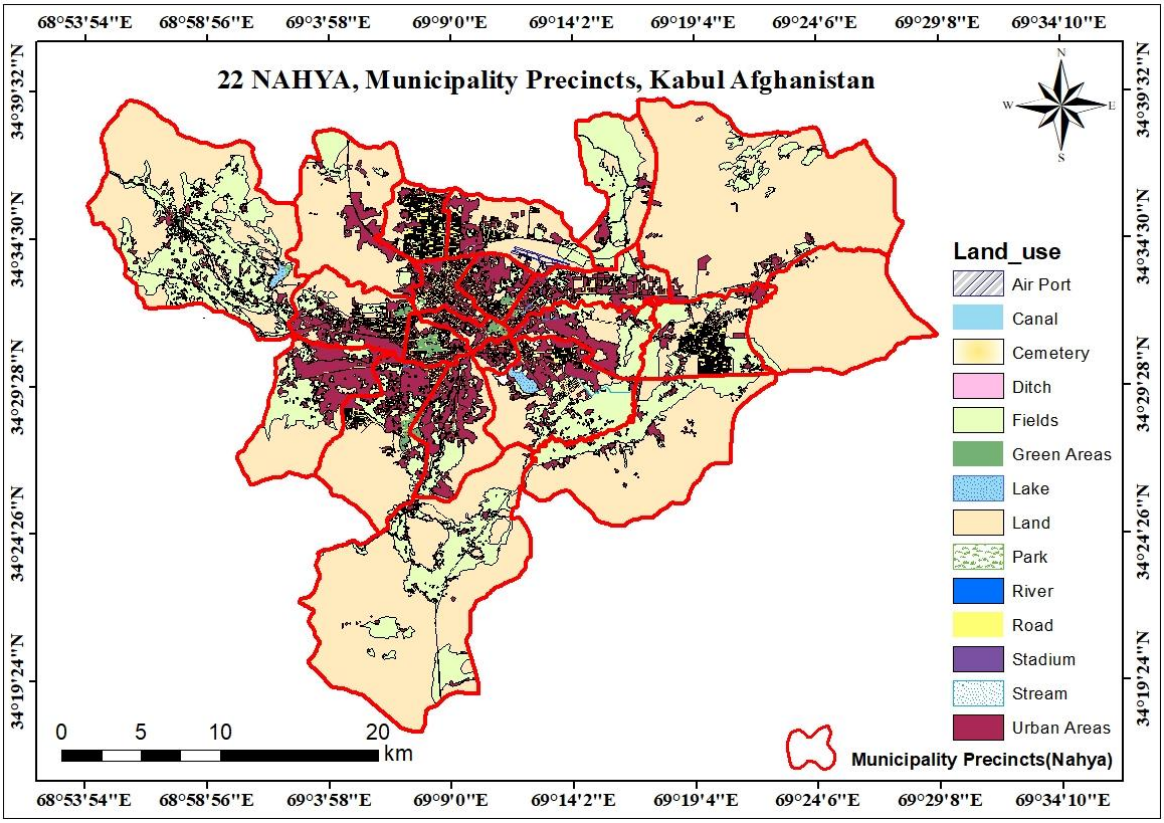

Fig.3.16. Land Use Land Cover Map, 2019

Table.3.2. LULC (Digitization)

NO	LANDUSE TYPE	Area, km^2	%
1	**Urban**	266.989	25.9
2	**Road**	23.532	2.3
3	**Land**	170.81	16.6
4	**Field**	540.44	52.4
5	**Park**	3.569	0.3
6	**Green areas**	8.279	0.8
7	**River**	10.31	1.0
8	**Canal**	0.163	0.0
9	**Stream**	1.503	0.1
10	**Airport**	1.022	0.1
11	**Ditch**	0.107	0.0
12	**Lake**	3.757	0.4
13	**Stadium**	0.03	0.0
TOTAL		**1030.511**	100

Municipality Precincts 22 (Nahya), Kabul Province

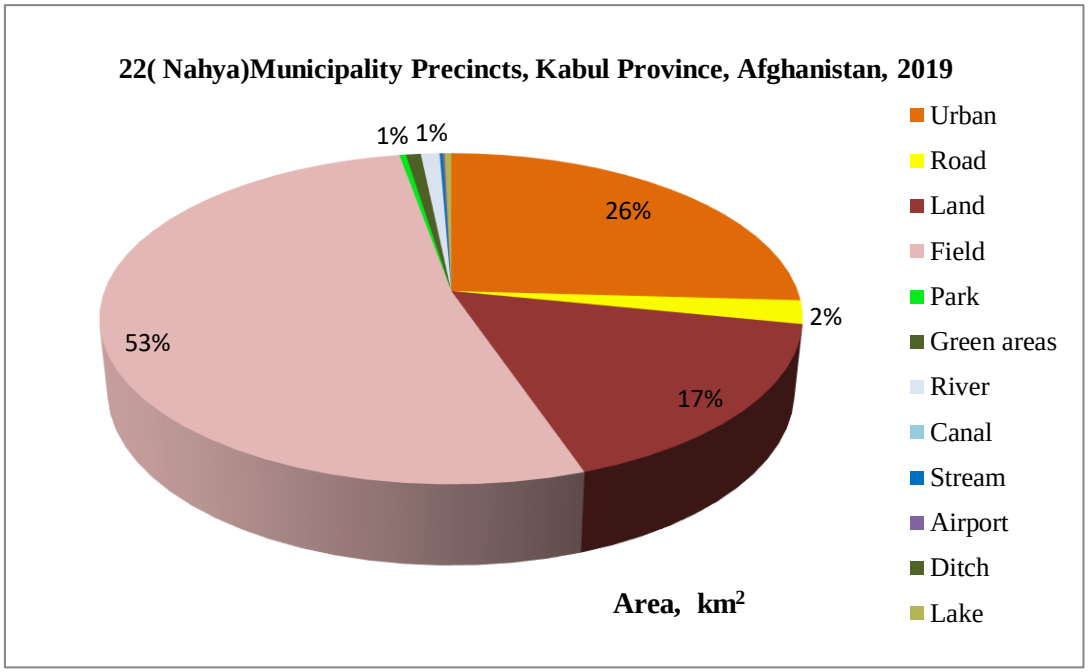

Fig.3.17. LULC, 2019

In Fig.3.17, it seems that slope due to high value of ROC, in the model had the least impact on expansion of the Kabul city Metropolis during 1999–2019. Because the ROC resulted by deleting this factor, has had the least difference from modelling using all of the implemented factors. On the other hand, the extent of urban area which took the dominant position is 25.9 %, had the least ROC values It seems that this factor has had a noticeable impact on the expansion of Kabul city during 1999–2019. Thus, probably, this factor has had the highest impact on growth of Kabul, and rapid growth of north region of this city is confirmable. During 1999–2019, the areas under built up in the north have experienced more and rapid growth than others. As observed from the existing growth trends until 2019, risk assessments factor such as distance to faults have had a small role in the development of this city. Needless to say, that this factor could be a big challenge at high dense and informal urban areas.

Chapter IV

CONCLUSIONS

The results of research on the LULC changes undergone by Kabul city (during 1999 and 2019), Afghanistan assessed, using Remote sensing data sets and GIS tools, are summarised in the following.

1. Built up area in Kabul city increased from 20.24 km2 (in 1999) to 100.6 km^2 (2019).
2. Vegetation covered area on the other hand decreased from 23.67 km2 (1999) to 49.95 km2 (2019)
3. Open space reduced from 130.75 km^2 (1999) to 68.8 km^2(2019)
4. Due to expansion of city toward foot-slopes of mountain front, area under mountain reduced from 34.68 km^2 (1999) to 30.00 km^2 (2019).
5. However the water covered area (river) did not show any change.

A series of landscape maps, such as colorised DEM, stream net, contour, slope and aspect, of Kabul city have also been created as part of the study

In addition a LULC map of Kabul province has been created as part of the study and the results are provided as map, table and Pi diagram.

From the 1999's to 2019, Kabul city's urban land use has experienced three stages of development. In the third stage of the transformation, Kabul's land use policy has played an extremely important role.

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