

Evaluating Urban Land Expansion Using Geographic Information System and Remote Sensing in Kabul City, Afghanistan

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Abstract—With massive population expansion and fast economic development in last decade, urban land has increasingly expanded and formed high informal development territory in Kabul city. This paper investigates integrated urbanization trends in Kabul city since the formation of the basic structure of the present city using GIS and remote sensing. This study explores the spatial and temporal difference of urban land expansion and land use categories among different time intervals, 1964-1978 and 1978-2008 from 1964 to 2008 in Kabul city. Furthermore, the goal of this paper is to understand the extent of urban land expansion and the factors driving urban land expansion in Kabul city. Many factors like population expansion, the return of refugees from neighboring countries and significant economic growth of the city affected urban land expansion. Across all the study area urban land expansion rate, population expansion rate and economic growth rate have been compared to analyze the relationship of driving forces with urban land expansion. Based on urban land change data detected by interpreting land use maps, it was found that in the entire study area the urban territory has been expanded by 14 times between 1964 and 2008.

Keywords—GIS, Kabul city, land use, urban land expansion, urbanization.

I. INTRODUCTION

LAND use systems are dynamic. Uses expand and contract, persist and change, in response to population and economic growth, public and private decisions, and market and government action [1]. Land use change is a complex, dynamic process that links together natural and human systems. It has direct impact on soil, water and atmosphere, and is thus directly related to many environmental issues of global importance [2].

Kabul, the capital and largest city in Afghanistan located in the eastern section of the country. Kabul city is estimated to be the fifth fastest growing city in the world with a population, which has increased from approximately 380,000 people in 1964 to around 4 million people by 2008 [3]. Rapid urbanization is taking a heavy toll on a city, which was originally designed for around 800,000 people during 1962-1964 [4]. The gross domestic product (GDP) of Afghanistan started to grow rapidly after 2001, and the average annual growth attained 10.7% during 2002-2006, which significantly

influenced urban land expansion in Kabul city. Currently, agriculture is the largest production sector in Afghanistan with almost the three-quarters of the population depending on agriculture for livelihood. It contributes about 53% to GDP and employs 67% of the workforce of the nation [5].

The basic structure of the present Kabul city was established in the 1940's and 50's, during which urban development actively took place, and the main street of Jadayi-Maywand was constructed together with the Kabul University, hospitals and bazaars (Commercial areas). The expansion of the street system and the residential development continued after the 1950's, and Kabul became the largest city with 68.4 km² urban land in Afghanistan in 1962 [6]. During 1962 to 2008 Kabul city has always fluctuated from various aspects of urban development indicators. This instability and unbalance can be due to the political situation of the city, economic development, population expansion, migrations, and internally displaced people (IDPs). These indicators had a vital impact on spatial and temporal changes of urban land expansion and spatial distribution of land use pattern. Finally, over this period the urban area has expanded 14 times to 1,022.7 km² in 2008.

Although some reports and papers illustrated urbanization, settlement and spatial structure of Kabul city, relatively less attention has been paid on urbanization trend, spatial and temporal difference of urban land expansion and land use change over the study period of time. The spatial distribution of land use in Kabul city has been changing at different stages of growth, and identifies various spatial land use pattern in the history of urbanization in Kabul city.

The objectives of the present study are:

- 1) To explore and evaluate the temporal characteristics of urban land expansion over 46 years of study period.
- 2) To detect and analyze the spatial difference of land use pattern, and evaluate the spatial difference of urban territories.
- 3) To analyze the main driving forces governing urbanization and urban land expansion in the city.

II. DESCRIPTION OF THE STUDY AREA

Afghanistan is a semi-arid landlocked country situated in the south central part of the Asian mainland generally, between latitudes 29-30' and 38-31' north and longitudes 60-30' and 72-00' east. The narrow Wakhan corridor in the east extends to 74-51' East longitude. The country has a surface area of about 655,000 km², in which Kabul city has 1,022.7

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km² total area. Of all the national land area about 75% of which is mountainous [7].

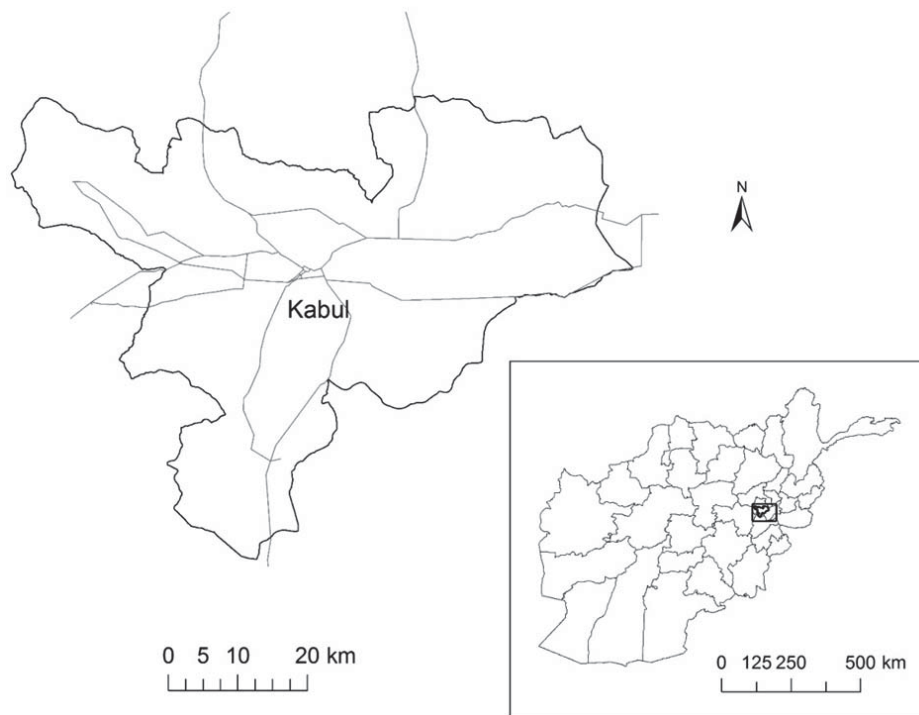


Fig. 1 The current territory and location of Kabul city in Afghanistan

Kabul city is situated in the north-eastern part of the country (Fig. 1). The elevation of the flat land areas in the Kabul metropolitan area is 1,780-2,000 m in the upper and lower Kabul basins. The Kabul city at present is divided into the northeastern and the southwestern parts, separated by the ridges of the Asmai mountains and the Kabul river. The city was originally established as an oasis along the east-west trade route and developed also to link the Central Asia in the north with the coastal areas in the south. With the establishment of national territories in the modern world therefore, Kabul is naturally linked through the national road network with the seven neighboring countries: Tajikistan, Uzbekistan, Kyrgyz, Turkmenistan, Pakistan, Iran and China [8].

The development of the Kabul city over the millennia has been supported, among others, by two most important factors. One is the geographic position along the east-west and the north-south trade routes. The other is the water resources of the upper Kabul basin [5].

III. DATABASE AND METHODOLOGY

A. Data Collection

In this study, multi-annual economic statistical data, multi-temporal *demographic* statistical data, multi-temporal master land use plan maps, and a geometrically corrected scenes of satellite imagery are collected for evaluating the temporal and spatial difference of urban land expansion and land use categories from 1964 to 2008.

The dominated land use map obtained for this study were in diverse types. The land use map of 1964 were digitally non special-referenced map with land use by broad categories of: residential, public use and commercial, industrial, and undeveloped/bare land (including river, hills and mountains) areas. The original land use map of 1978 was same as 1964 land use map, digitally non special-referenced map, but with 23 subclasses land use. Lastly, the existing land use map in 2008 was prepared by AutoCAD, which consist of 5 broad land use categories. The materials used in this study are listed in (Table I).

B. Map Processing

The land use maps of 1964 and 1978 were originally paper base maps and then were scanned and converted into digital maps. The land use maps were then digitized and put into GIS software using (ArcMap10.3). So that the digital maps have been converted to Universal Transverse Mercator (UTM) map projection, and georeferenced in GIS (geographic information system) software. The urban land territory was determined for different study time periods for calculating expansion rate of the city. The use of these historical maps to determine the extent of urban expansion is relatively operative and simple. In order to minimize the errors in accuracy of the maps during the geo-referencing process of GIS, plenty of indicator points were assigned to gain maximum accuracy.

TABLE I
DESCRIPTION OF THE DATABASE USED IN THIS STUDY

Data type	Year	Feature	Process
Maps			
Kabul city master land use plan map	1964	Digital non spatial-referenced map	Geo-referencing, digitization and coordinates integration
Kabul city master land use plan map	1978	Digital non spatial-referenced map	Geo-referencing, digitization and coordinates integration
Kabul city existing land use map	2008	AutoCAD file	Conversion to GIS file
Satellite images			
Ortho mosaic image	2011	-	Geometric correction and enhancement
Socio-economic records			
Kabul city population census	2008	-	-
Economic development report	2008	-	-
Natural environment and social development report	2008	-	-

C. Annual Urban Growth Rate

One of the indicators used in this study is the defining and evaluation of urban growth rate. This indicator was used in order to explore the extent, trend, and magnitude of urban land expansion and analyze the spatial and temporal difference of urban land expansion. Urban growth rate is defined as:

$$AGR = \frac{UA_{i+n} - UA_i}{nUA_i} \times 100 \quad (1)$$

In this equation AGR indicate Annual Growth Rate, UA_{i+n} is the total urban land area or built-up area of the considered unit to be calculated at the time point of $i + n$, UA_i is the urban area or built-up area of the considered unit at time i , and n is the interval of the calculating period (in years).

D. Elasticity of Urban Land Expansion to Urban Population Growth

The elasticity of urban land expansion to urban population growth, denoted as $E(urb)$, was firstly developed by the Chinese Academy of Urban Planning and Design (CAUPD) for assessing the relationship between urban land and urban population growth. It is expressed as:

$$E(urb) = \frac{A(i)}{Pop(i)} \quad (2)$$

where $A(i)$ is the annual rate of urban land growth of city i , and $Pop(i)$ is annual rate of urban population growth of city i [9].

IV. RESULTS

A. Temporal Changes of Urban Land Expansion

Kabul, the capital and largest city of Afghanistan became the capital of the country in 1775. Kabul grew from a small city with 65,000 people in its 400 hectare (4 km²) territory in 1916 to a large city with 380,000 people in its territory of about 68.4 km² in 1962 [8]. Fig. 2 illustrates the temporal

changes of urban land expansion in Kabul city from 1962 to 2008. Over the past 46 years, the urban land area of Kabul city has been expanded from 68.4 km² in 1962 to about 558 km² at an average rate of 10.64 km² /year. During the entire study period, the city has experienced different growth stages, relatively stable growth period from 1962 to 1992, followed by fast growth stage till the end of study period (2008). Based on the multi-annual urban land expansion configuration (Fig. 2), urban land expansion in Kabul city depicts four growth period.

- 1) Initial growth period from 1962 to 1978 corresponding with the establishment of the first master plan for Kabul city.
- 2) Similar growth period from 1978 to 1999 corresponding with the second revision of the Kabul city master plan.
- 3) Moderate growth period from 1992 to 1999 parallel with the completion of the communist regime in 1992.
- 4) Finally, the strictly fast urban land expansion period from 1999 to 2008 parallel with the establishment of new government in 2002 in Afghanistan.

However, the characteristics of urban land expansion was not identical among different periods. During the first growth period (1962-1978), the city has experienced slowest growth speed of 3.3 km²/year, which is corresponding to 4.87 % annual urban growth rate (Table II). As a result, through this period the city has enlarged approximately 53.3 km², and 77.9 percent as a whole in its territory.

TABLE II
TEMPORAL CHARACTERISTICS OF URBAN LAND EXPANSION

Year	Increase of urban land (km ²)	Increase of urban land (%)	Annual urban land growth rate (km ² /year)	Annual urban land expansion rate (%)
1962				
1978	53.3	77.9	3.3	4.9
1992	46.6	38.3	3.3	2.7
1999	81.7	48.5	11.7	6.9
2008	307.9	123.1	34.2	13.7

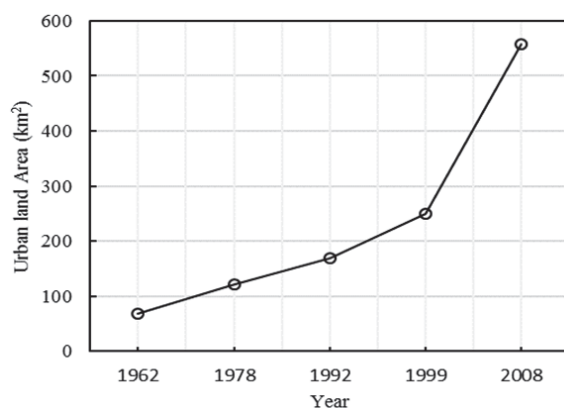


Fig. 2 Temporal changes of urban land expansion in Kabul city

Likewise, the second growth period (1978-1992) has similar temporal changes. In this 14-year period, the city area pushed out to 3.34 km²/year expansion rate, with an equivalent

percentage of 2.74% annual urban land growth rate. In this growth stage the urban land area jurisdiction extended by about 46.6 km², and 38.3% as a whole in its territory.

The growth period of (1992-1999) depicts a moderate speed stage of urban land utilization in the study period. In this stage urban area has expanded totally by 48.5% (81.7 km² in the entire stage), and the annual urban land growth rate was 11.7 km²/year, which contribute 6.9% of annual urban land expansion.

Finally, the most recent period (1999-2008) illustrates the only ever fastest urban land growth stage of the city. This stage is engaged with inflow of migrants from neighboring countries. Since 2002, more than 5.8 million Afghan refugees have returned home, 4.7 million of whom were assisted by UNHCR which strictly influenced urban land expansion in Kabul city [10].

One of the main reason of this growth increment can be identified as the return of migrants. On the other side the rapid economic development of Afghanistan after 2001 due to the foreign and international society assistance can be considered inextricable influences on the process of urban land expansion. Factors governing urban land expansion is further described in (Driving Forces Manipulating Urban Land Expansion) part. Consequently, the entire study area spread out more by 307.9 km² with and annual speed rate of 34.2 km²/year (Table II).

This growth express 13.7% annual, and 123.1% expansion rate as a whole period.

B. Spatial and Temporal Difference of Urban Territories

After the establishment of the basic structure of the present Kabul city in the 1940's and 50's, during which residential development actively took place, and the main street of Jadayi Maywand was constructed together with the Kabul University, hospitals and bazaars. The expansion of the street system and the residential development continued after the 1950's, and Kabul became the largest city in Afghanistan with its population reaching 380,000 in 1962 [8].

Fig. 3 shows the distribution of changes in the territories throughout the city from 1964 to 2008. The first master plan of the city was prepared during 1962-1964 by Afghanistan and Russian experts for the planned population of 800,000 people (Fig. 3 (a)) [6]. Thus, the plans can be considered as the fundamental and general/master plan for the city, which indicates the initial patterns and jurisdiction of the city. The spatial land use pattern of the city was categorized as: residential, public use and commercial, industrial, bare land (including river, hills and mountains) areas. Based on the spatial land use pattern of the city in 1964 which has been georeferenced and digitized by GIS, the city had approximately 122 km² total area in its urban territory.

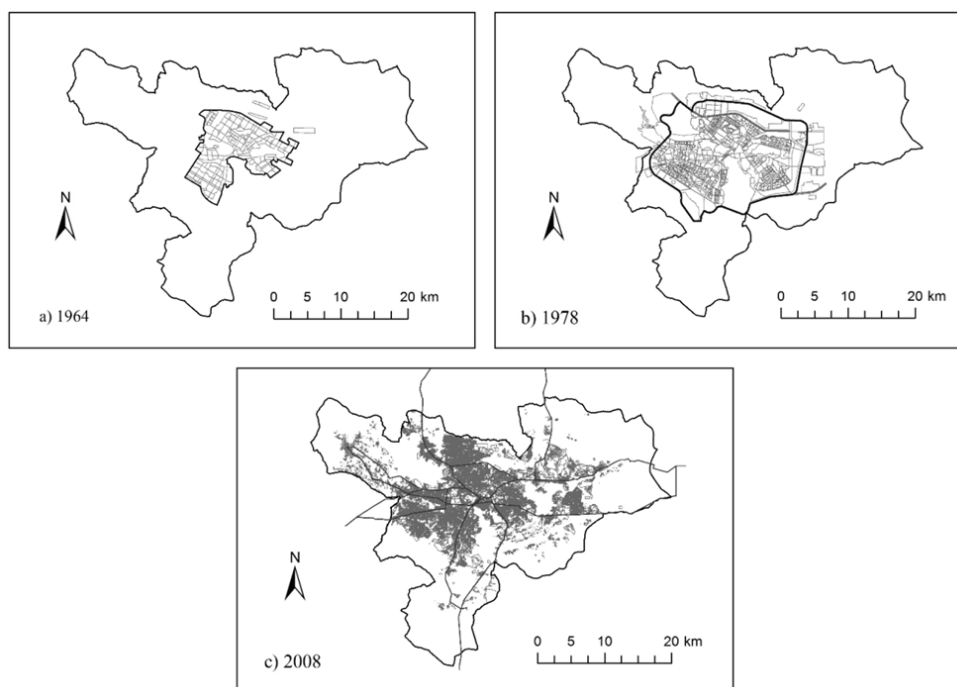


Fig. 3 Spatial and temporal difference of urban territories in Kabul city from 1964 to 2008

After 14 years, the Kabul city master plan was reviewed and revised for the planned population of 2 million in 1978 (Fig. 3 (b)) [6]. In comparison to the first general plan, the new plan was more comprehensive and inclusive. The land use plan of the city (including the road network plan) was

consist of 23 land use sub classes covered all the land use categories except agriculture area. The designated ring road at the outer skirt of the city can clearly indicate the jurisdiction of the city. In this comprehensive stage of planning, 1.2

million additional populations and 230 km² area was considered for the city with the total area of about 352. km².

During the civil war, particularly after the collapse of the communist regime in 1992, Kabul was devastated not only in its urban infrastructure but also in its social system for education, medical and other services. Human damages after 1992 include a loss of over 50,000 lives in Kabul and several hundred thousand refugees to its suburbs. It is reported that there existed close to 50,000 widows in 1997 in Kabul alone. Most refugees returned to Kabul after the establishment of the Taliban regime, and the population in Kabul was 1.78 million in 1999 according to the UN population survey in 1999-2000 (UN Regional Coordination Office, Population Survey Project, Kabul, January 2001). In 2005 the city area was consisting of 14 districts (Districts 1-16, except districts 13 and 14) [6]-[8]. Finally, due to huge return of refugees since 2002, rapid economic development since 2001 due to international society assistance and huge population expansion, the city territory has been updated.

The jurisdiction of the Kabul city was expanded in January 2005 by the agreement between the Ministry of Interior, the Kabul provincial governor and the Kabul city mayor. The city population increased to 2,721,000 with 22 districts [6]. Fig. 3 (c) describes the territories of Kabul city in 2008 with the total area of 1022.7 km², which indicates 670.7 km² urban area

change from the 1978 plan. To sum up, in the entire study period from 1964 to 2008 the study identifies that the urban territories has enlarged 14 times.

C. Distribution and Spatial Changes of Land Use Pattern

This parts of the study expresses the distribution of land use pattern and the composition of land use categories in Kabul city over the study period (Fig. 4). The study explores the variations in land use among planed land use of 1964, planed land use of 1978 and the existing land use in 2008. The master land use plan of 1964 was consist of 4 land use categories of residential area, public area, industrial area and undeveloped/bare land. Likewise, the urban land use plan in 1978 was in 23 land use subclasses which then converted to 4 broad categories. The existing land use map of 2008 is consist of all land use types including agriculture area, which this category was not included in 1964 and 1978 maps.

The distribution of the land use pattern in different years and classes are in various proportion. The highest proportion of urban land use in 1964 was occupied by residential area which accounts 43.4 % of total 122 km² area (Fig. 4). Increasingly, the residential area was considered to be double in comparison to the previous plan in 1978. Recently, over 20 years the residential area (including its infrastructure) is doubled again to 214.7 km² in comparison to 1978 plan.

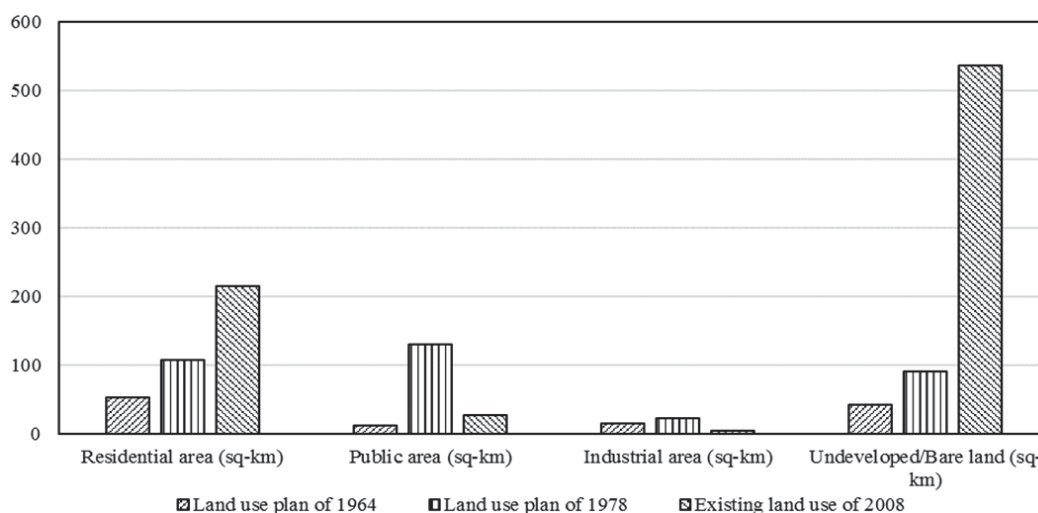


Fig. 4 Historical distribution and spatial changes of land use patterns

Public area has fluctuated during the time till 2008. However, this land use type was planned to contribute only about 10% (12.1 km²) in 1964 plan, but increasingly in 1978 it was designated to be 130.5 km² which is 11 times bigger than 1964 plan. Subsequently, this land use type dropped dramatically by 78.8% in 2008 to 27.7 km². Most of the public areas are converted to residential land and formed high informal developed area in the city.

Industrial area is the other land use type which has dramatically dropped down then the two previous plans. In three period of study (1964, 1978 and 2008) it had 14.9 km²,

22.7 km² and 4.9 km² share in the plan respectively. It can be seen in existing land use of 2008, that industrial area has been declined nearly the same as public area by 78.4 % from the 1978 plan. This is the second land use type which is strictly declined and converted to residential area in the city.

Undeveloped/bare land uniformly increased in the entire study area. In the first plan it had the second largest contribution of 42.1 km² (34.5%) in the land use. In the second plan it increased by 2 times to 91 km², and finally in existing land use of 2008 it has the highest contribution of 536 km² in the land use. This land use type high proportion in

three periods is due to geographical location of Kabul city. Despite the city has almost surrounded by mountains, it has still separated by mountains along north-west to south-east, which form big territory of 301,33 km² bare land in the city.

D. Variation of Urban Land Consumption Per Capita

The graph in Fig. 5 indicates the consumption and variation of the urban land per capita in the study area from 1962 to 2008. During the formation of the first comprehensive plan for the Kabul city 1962-1964, it seems that the urban land per capita had the highest rate of 180 m² in the urbanization history of the city. After the initial period, urban land utilization per capita has continuously declined in two upcoming stages (1978 and 1992). Since 1992 the decrement was very sharp, 30.8 % in 1978 and about 10% in 1992. The city has experienced the only rapidest increment of urban land utilization per capita between 7 years of (1992-1999) period by 25.2%. After 1999 the urban land variation per capita has remained approximately the same till 2008. However, the city population has been strictly expanded during the new government in Kabul city. Altogether, after 1999 the growth of the urban land in comparison to the city population tended to decrease slightly by 0.7% during the last period.

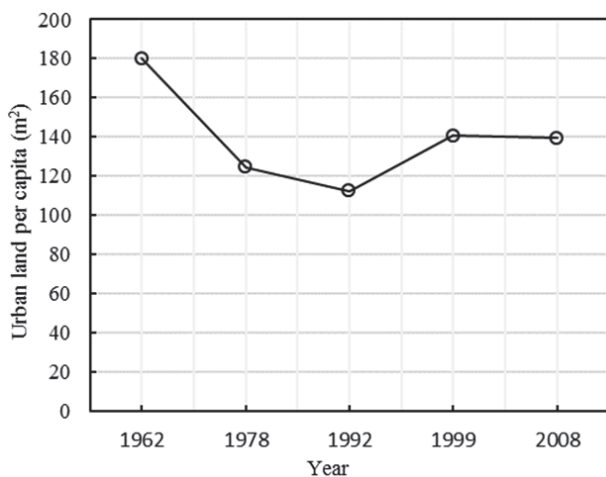


Fig. 5 Urban land per capita change

E. Variation in Elasticity of Urban Land Expansion to Urban Population Expansion

In the history of urbanization in Kabul city, the urban land growth rate and population expansion rate were in swing and tended in low growth mode of urban land since 1962. The optimum value of 1.12 for E(urb) was suggested by the Chinese Academy of Urban Planning and Design (CAUPD) [9]. The result from (Table III) indicates that the average value of E(urb) was 1.2 during the study period in Kabul city, which is virtually close to the suggested optimal value.

The ratio of annual population growth rate to annual urban land growth rate was 2, resulting in 0.5 lowest rate of E(urb) till 1978. The elasticity of urban land growth rate to urban population expansion rate was progressively speeded to 0.72 and 2.6 in 1992 and 1999 respectively. It seems from the

(Table III) that after 1999 urban population tended to increase slightly than the urban land rate till 2008. However, still the E(urb) is in optimum average value of 1.2 from 1962 to 2008.

TABLE III
VARIATION OF E(URB) IN KABUL CITY

Year	Annual urban land growth rate (%)	Annual population growth rate (%)	E(urb)
1962			
1978	4.9	9.8	0.50
1992	2.7	3.8	0.72
1999	6.9	2.7	2.60
2008	13.7	13.9	0.99
Average			1.20

V. DRIVING FORCES MANIPULATING URBAN LAND EXPANSION

Urban expansion and subsequent landscape changes are governed by geographical and socio-economic factors, such as population growth, policy, and economic development. In most cases, urban expansion and associated land use/cover changes resulted from a combination of these factors [11]. For a number of reasons, land is a special economic asset. Firstly, the supply of land is fixed, creating specific demand-supply relations. Secondly, in terms of soil quality, gradient, altitude, accessibility and etc. the marketable asset is therefore far from homogeneous, severely hampering the price-making analysis. Thirdly, the land use at a certain location influences its surrounding [2].

The economic development of the city can be considered as the biggest and the primary driving force for manipulating the urban land expansion. The high economic growth stimulated the urban land expansion in the study region from the following Three aspects. Firstly, the rapid economic development paved the way for speedy expansion of the city, especially in the last period during 1999 to 2008, in which the city has expanded 2.2 times. Secondly, the high economic growth rate had direct influence on population growth, which in the same period the population had also the similar enlargement of 2.25 times. Lastly, during the final period (1999-2008) parallel with the establishment of the new government, the economic improvements has motivated and forced the refugees from neighboring countries to reside back to the country. Simultaneously, this driving force also attracted large number of IDPs in the city.

A. Economic Growth

The economic growth seems to be the primary and biggest indicator and driving force for stimulating the urban land expansion in the city. Fig. 6 shows, that how the economic trend during the whole study period influencing urban land growth in the city.

As a whole, in two periods the country has experienced high economic growth, in which the city has also had the high urban land growth except between (1992-1999). Based on the economic report from the Worth Bank [12], it has been calculated that the GDP had 31.5% annual growth in the initial stage followed by 4.9% annual growth of urban land. As the GDP was not reported in 1992, it had been estimated by liner

interpolation which during the second period it seems that the urban land growth rate of 2.7 percent is lower than the previous period. Only in the third stage the case is contrary. although the GDP growth rate is nearby zero percent, the

urban land growth rate (6.9%) is rather higher than the two previous periods. Finally, the rapidest economic growth of (44.9%) is matched with fastest urban land expansion rate of 13.7%.

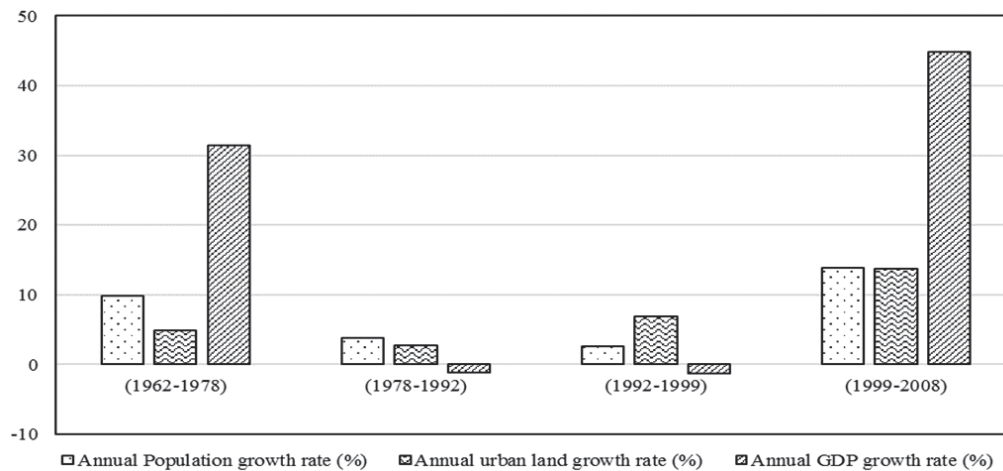


Fig. 6 The relationship among growth of driving forces affecting urban land expansion in Kabul city

B. Population Expansion

Population enlargement is the other indicator and factor similar to economic growth significantly affected urban land expansion in Kabul city. As the result shows, population expansion did not increasingly expand during the study period from 1962 to 2008. Fluctuation in population growth during the time has majorly influenced by political situation of the city. A study about urban displacement and vulnerability in Kabul illustrates the displacement of people in the city. There have been six major periods of displacement and population movement since the 1970s – all directly relating to periods of armed conflict and political instability: the Soviet invasion and subsequent conflict (1978–88); the Soviet withdrawal and subsequent internal armed conflict (1989–96); Taliban rule (1996–2001); the post-9/11 US-led invasion (2001–2002); the defeat of the Taliban and the establishment of the interim government (2002–2004); and the neo-Taliban insurgency (2004 to the present) [13].

Fig. 6 indicates that the variation in population growth is in parallel with the variation in urban land growth in all stages of the study period. During the first stage the population growth (9.8%) has been rather speedy than the two coming periods which followed by 4.9% urban land growth rate. The rapidest growth for both population and urban land is the final period, in which both had close growth rate of 23.9% and 13.7% respectively. This growth consistency and uniformity express how both are directly proportional to each other.

C. Return of Refugees and IDPs

The political situation in the capital city of Kabul has always dominant in variation of the population and migration during the study period. In various political periods in the country specially in Kabul city huge number of residence forced to leave their homes by either migrating to

neighbouring countries or move to other parts of the city. Indeed, the migration and internal displacement of city inhabitants has always changed the population trend in the city.

The Soviet invasion in 1979 triggered the forced displacement of millions of Afghans from rural areas, where the conflict between the Soviet army and the Afghan resistance was most intense, to the relative safety of the country's main cities, including Kabul, Herat and Jalalabad. At that time, some 1.5 million Afghans were internally displaced and an estimated five million, or nearly a fifth of the population, fled to neighbouring countries. The Najibullah administration was toppled in 1992, and the subsequent brief period of relative stability saw the voluntary return of 1.6 million Afghan refugees in 1992, and a further 964,000 in 1993. By 1995, there were over 1.2 million Afghan refugees in Pakistan and just over 1.4 million in Iran. By 2001, an estimated 950,000 Afghans were internally displaced and 3.6 million were registered as refugees by UNHCR. Between 2002 and 2005 more than 6 million Afghans returned to the country, increasing the population by almost 20% [13].

Therefore, the population growth remarkably affected by migration and IDPs during the political conflicts in the city. Consequently, the migration and displacement responses directly affected urban land expansion in the city.

VI. CONCLUSION

During the urbanization history, cities have always tendency to change and expand in their spatial and temporal distribution in response to population and economic growth, government and political situation. This paper investigated integrated urbanization trends, explored the spatial and temporal difference of urban land expansion and land use categories from 1962 to 2008 in Kabul city.

The results show that during the entire study period the city has experienced different urban land expansion stages. Relatively stable and slow growth (4.9 %, 2.7 %, and 6.9 %) period from 1962 to 1992, followed by fast growth stage till 2008. The city had rapidest average annual growth rate of 13.7 percent in this stage. Beside the land expansion, the city's territory has been expanded 14 times in its spatial distribution since 1964 plan. In 2008 the jurisdiction of the city has been reached to 1,022.7 km². The extensive enlargement of urban land has been related with the land use change. After the two comprehensive plans of 1964 and 1978, the land use pattern of 2008 has been witnessing a massive reduction and conversion in public and industrial area by 78.8 % and 78.4 percent respectively. If we look at to the other characteristics of urban land like urban land per capita and Elasticity of urban land to urban population $E(urb)$, it seems the city had the highest value of 180 m² land per capita in 1964. Even though the urban land has extensively expanded, but still the land per capita totally decreased by 22.5 percent. However, the average value of $E(urb)$ is calculated to be 1.2 in the entire study period which is close to optimum value of 1.12. But, after 1999 urban population tended to increase slightly than the urban land which probably might cause further reduction of $E(urb)$ in future.

On the other side, questions may rise about the forces motivating urban land expansion in the city. The prior factor manipulating the growth of land seems to be economic improvement of the city, especially in the last period between 1999-2008. The highest average annual economic growth rate of 44.9 %, parallel with the highest average annual urban land expansion rate of 13.7 percent can prove this claim. Subsequently, population increment due to normal growth, return of migrants and (IDPs) directly drove the increase of urban land growth rate in the city. For better understanding about the relation of driving forces with the urban land, please refer to the (Fig. 6) in the (Driving Forces Stimulating Urban Land Expansion) section.

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REFERENCES

- [1] Urban Land Use Planning, Philip R. Berke, David R. Godschalk, and Edward J. Kaiser, with Daniel A. Rodriguez, (2006), pp. 198-199.
- [2] Modelling land use change, Progress and applications, the geojournal library 90, Edited by: Eric Koomen, John Stillwell, Aldrik Bakema, Henk J. Scholten, pp. 2-3.
- [3] "World fastest growing cities and urban areas from 2006 to 2020", (July 2016), city Mayors. http://www.citymayors.com/statistics/urban_growth1.html.
- [4] Ahmad Sharif Ahmadi and Yoshitaka Kajita, Land Development Pattern in Kabul city, Afghanistan. 43rd Conference Kanto-branch, Japan Society of Civil Engineers (JSCE). 2016 March.
- [5] The study for the development of the master plan for the kabul metropolitan area, Natural environment and social considerations, September 2009, RECS International Inc., Yachiyo Engineering Co., Ltd., CTI Engineering International Co., Ltd., Sanyu Consultants Inc.
- [6] The study for the development of the master plan for the Kabul metropolitan area in the Islamic republic of Afghanistan, Land use planning and GIS, September 2009, RECS International Inc., Yachiyo Engineering Co., Ltd., CTI Engineering International Co., Ltd., Sanyu Consultants Inc.
- [7] Product of Technical Cooperation Project for Promotion of Kabul Metropolitan Area Development, June 2011, RECS International Inc., Yachiyo Engineering Co., Ltd Sub Project for Revise the Kabul City Master Plan.
- [8] The Study for the Development of the Master Plan for the Kabul Metropolitan Area in the Islamic Republic of Afghanistan: Final Report, RECS International, 2009.
- [9] Minghong Tan, Xiubin Li, Hui Xie, Changhe Lu. Landscape and Urban Planning 75 (2006) 69–80, Urban land expansion and arable land loss in China—a case study of Beijing Tianjin–Hebei region.
- [10] The UN Refugee Agency (UNHCR), 2001-2016, (July 2016), <http://www.unhcr.org/pages/49e486eb6.html>.
- [11] Jieying Xiaoa, et al. Land Use Policy 22 (2005) 187–196. Evaluating urban expansion and land use change in Shijiazhuang, China, by using GIS and remote sensing.
- [12] World Bank, (July 2016), <http://data.worldbank.org/country/afghanistan>.
- [13] Victoria Metcalfe and Simone Haysom, with Ellen Martin, June 2012, Sanctuary in the city? Urban displacement and vulnerability in Kabul.