Study of Change Detection in Urban Growth of Kuwait City

Fahad Almutairi and Mohamed Ait Belaid

***Abstract*—Kuwait City has witnessed rapid urban development, with a clear change in land use in Kuwait City during the last period. In the second half of the twentieth century, Kuwait witnessed an urban development due to the economic boom and the discovery of oil. This development is accompanied by a huge increase in the number of residents and Incoming; Resulting in an increase in economic and urban activities, and one of the most affected areas of Kuwait City.**

This research aims to study the urban growth of Kuwait City using aerial photographs and high-resolution satellite imagery. The study is based on the first two aerial photographs for the years 1976 with a spatial resolution of 1.5 meters and the second for 1991 with a spatial resolution of 60 cm and two satellite imagery (IKONOS) for 2000 by 1 meter and the second for the satellite (WorldView-2) for 2011 at 50 cm. spatial resolution.

The results showed that there is significant changes in the land use of Kuwait City during the period from 1976 to 2011, where the area of residential use decreased for other uses by 9.4%, while the area of commercial use increased slightly by 0.2%. Governmental use increased by 5.1%. Green areas witnessed an increase of 7.3%. While parking increased by 4.7%. The increase in roads was about 2.8%. Most of the land in the city is unused, and it is an area of space. There has been a change in the coast of the city as a result of landfill work. The area of landfill to city coast reached 0.55 km².

The study recommended the use of land space in the future urban expansion rather than re-fills the coast and reconsiders some uses and work to exploit them to suit the city center.

***Index Terms*—Kuwait, Kuwait city, urban growth, land use, air photos, space visualization, remote sensing, geographic information systems.**

I. Introduction

The urban development is going through multiple stages and depending on different variables, it may be the result of an organized planning process with specific and clear efforts within defined channels and on the other hand, in response to immediate needs according to public or private needs, So there is importance to develop strategies for urban extensions and determine their trends and dimensions, and Follow-up studies on urban development, and the changes in the use of remote sensing and geographic information systems techniques for better results.

The process of identifying and detecting change in land use (change detection) over a period of time of recent processes and trends, and the knowledge of urban growth helps to understand and analyze patterns of land use, and factors affecting them [1].

I. Determine the Study Area

The city of Kuwait is located within the cities and suburbs of the Capital Governorate. The study area is located between two latitudes (30 '21 °29 'and 30 ° 29 ٩) north of the equator and between longitude (30 '57 °47 'and 20' 0 °48) east of Greenwich, and the city has a unique location on the southern part of the coast of Kuwait bay [2], Its conditions are suitable for ship anchors because its water and its impact are more solid; it is from sand limestone rocks, as well as the southern coast line of John and the multitude of bays [3]. This is shown in Fig. 1. The city of Kuwait is currently composed of 4 administrative districts Sharq - Qibla - Al Merqab – Dasman [4].

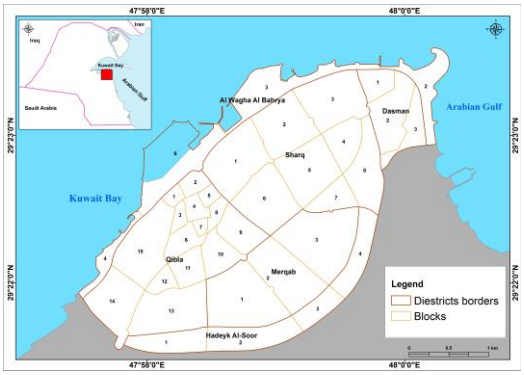

Fig. 1. Illustrates the administrative division of the city of Kuwait and the location of the study area.

II. Methodology of Work

The data processing process is divided into a set of processes using (ERDAS Imagine 2011, ArcGIS 10). To achieve the objective of the study, the ERDAS Imagine 2011 program was used for the processing of image and satellite images by correcting them and identification of the study area, processes of improvement and visual interpretation. ArcGIS 10 was also used to build a geodatabase, a set of geographical data for different types of data in a common file. Using a numbering process, a set of land use maps were produced for the study area, the changes that took place between land use were monitored during two periods. the methodology and stages of research work are divided into three phases:

1) set up a geodatabase on ArcGIS

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2) Perform analyzes and classifications of land use and urban growth over the years (1976 - 1991 - 2000 - 2011).
3) Monitoring changes in urban growth and trends in Kuwait City during the period (1976-2011).

A. Data Collection

Data means information, research, statistics, maps and everything related to the study of urban growth of Kuwait City, which was referenced in the preparation of this study. A set of spatial and descriptive data required for the study were obtained from several sources, such as metadata, aerial photographs, satellite images and structural plans.

This study was based on a set of data, namely aerial photographs of Kuwait City for the years 1976-1991 [5], [6] with a spatial resolution of 1.5 meters, and two space images the first satellite (IKONOS) for the year 2000 by 1 meter [7], and the second of the WorldView-2 satellite for the year 2011 at 50 cm spatial resolution [8]. Three maps of the city's master plans Kuwait were obtained (1970-1983-2005), with 1: 30,000 [9]. and after scanner work by (Scanner), it was converted to digital maps by Digitizing, using (KTM).

The use of modern technologies helps in the renewal of geographical data by comparing a set of maps and satellite images over different time periods to determine the extent of the changes that have taken place [10]. Therefore, the need to employ these technologies is an urgent necessity in achieving the desired objectives in terms of changes in urban development and properties of uses Land for study area.

The most important applied fields that benefit from the techniques of remote sensing and geographic information systems are the urban studies, Because of its dependence on a variety of different information such as classification of land use, where satellite images can be obtained by satellite for geographical region, and Analyzed it and interpretation and the production of maps to serve the research, and Giving sufficient details on the nature of use, as well as monitoring changes affecting land use [11].

III. Results and Analysis

The results of the study of changes in land use in Kuwait City can be reviewed over time intervals. Land use maps have been produced and designed. The shapes, color selection, a set of tables for the calculation of land use areas for the years of study was also presented as shown in Fig. 2 ، 3, 4, 5.

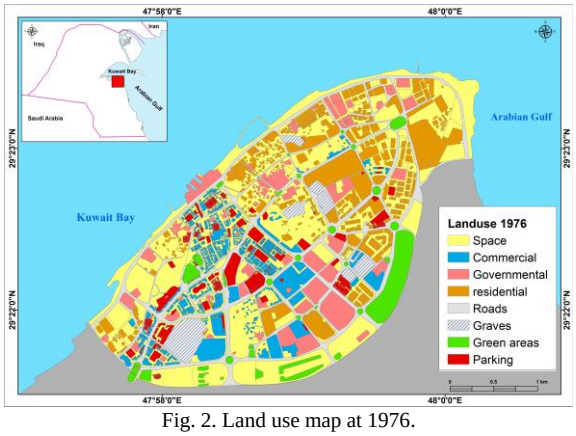

Fig. 2. Land use map at 1976.

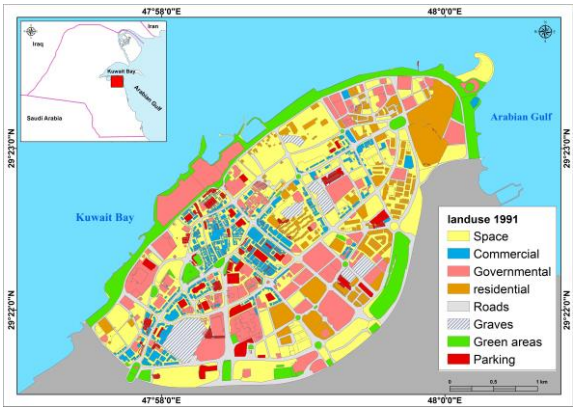

Fig. 3. Land use map at 1991.

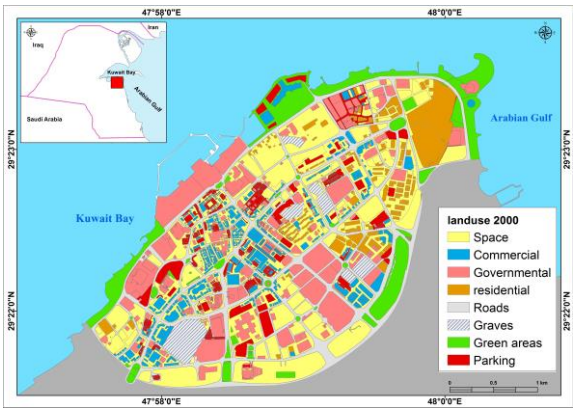

Fig. 4. Land use map at 2000.

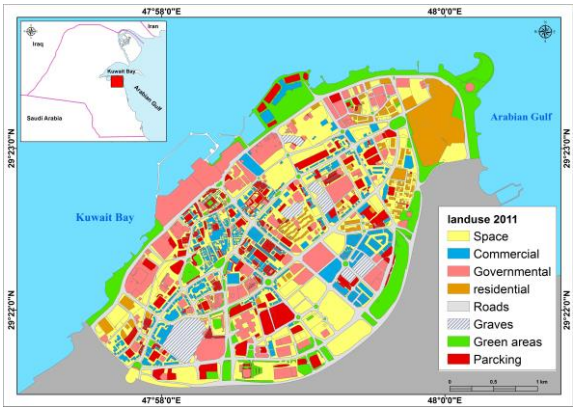

Fig. 5. Land use map at 2011.

Through the calculation of land use areas in the years of study, it is clear that there is variation whether the decrease or the increase (depending on the type of use), Table I provides information on the area of uses in Kuwait City during the study period, as shown in Fig. 6 of land use areas in columns during the same period.

TABLE I: Land Use Areas for the Years (1976-1991-2000-2011) in km ²

	Land use patterns	1976	1991	2000	2011
1	residential	1.54	1.05	0.73	0.67
2	commercial	0.83	0.62	0.71	0.85
3	Governmental	0.91	1.68	1.84	1.49
4	Space	3.81	3.25	3.25	3
5	Green areas	0.48	1.05	1.05	1.25
6	Cemetery	0.31	0.31	0.31	0.31
7	Parking	0.44	0.39	0.63	0.94
8	Roads	1.39	1.74	1.74	1.75
	Total	9.71	10.09	10.26	10.26

The results of the data indicate that there were changes in land use during the years of study. Table II shows the

difference between land uses areas estimated in square kilometers in different uses. Fig. 7 shows the difference in the form of columns.

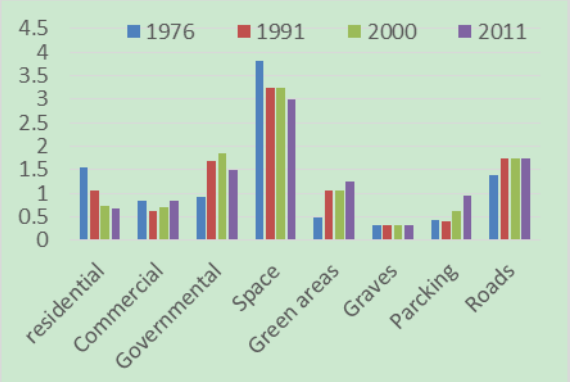

Fig. 6. Land use areas of Kuwait city during the years of study.

TABLE II: COMPARISON BETWEEN LAND USE AREAS IN THE STUDY PERIOD IN KM ²

Land use patterns	1976 1991	1991 2000	2000 2011	1976 2011
residential	0.49-	0.32-	0.06-	0.87 -
commercial	0.21-	0.09+	0.14+	0.02 +
Governmental and Services	0.77+	0.16+	0.35-	0.58 +
Space	0.56 -	0	0.25-	0.81 -
Green areas	0.57+	0	0.2 +	0.77 +
graves	0	0	0	0
Parking	0.05-	0.23+	0.26+	0.5 +
Methods	0.35+	0	0.01+	0.36 +

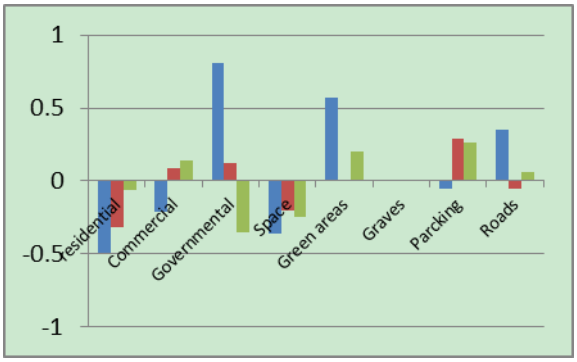

Fig. 7. Comparison between land use during the years of study.

The efficiency of land use development in Kuwait City can be calculated from Table II and Fig. 7 showing areas used in Kuwait City and Compare them to the years of study. Based on the land use map.

A. Development of Residential Use

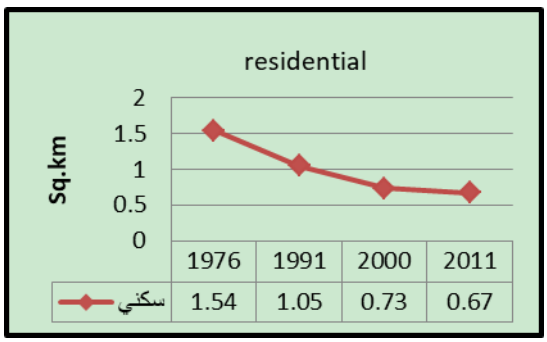

Fig. 8. Evolution of residential use of Kuwait city during the study periods.

Residential use was ranked second in 1976 with an area of 1.54 km ², representing 15.9% of the city's area. It is mainly concentrated in the Desman area and the Sharq area, especially sections 5, 7 and 8.

In 1991, there was a significant decrease in the area of residential use and by 0.49 km ²for the year 1976, especially in the Sharq area. In 2000, the area of residential use decreased by 0.32 km^2, while the decrease in residential use until 2011 was 0.67 km ²and 6.5% of the total uses, as seen in the graph Fig. 8.

B. Development of Commercial Use

Commercial use is distributed in the center of the city, especially in the areas of Qibla and Muraqab, where there is the old market (Mubarakiyah), the Kuwait Stock Exchange and the shops. The area in 1976 was about 0.83 km ²and 8.5% of the city area. Commercial use space decreased in 1991 to 0.62 km ²with a difference of 0.21 km2, there was a decrease in the Qibla area, areas 11-12-13, and Al Mirqab area, areas 2 and 3, where government departments of the State Ministries were established.

Commercial use increased in the year 2000 to reach 0.71 km ², an increase of + 0.09 km ², as a result of the establishment of Sharq Commercial Market on the coast of the city and the conversion of some residential uses in the south of Al-Merqab to commercial use, and there was increased in 2011 with an area of 0.85 km2, It was +0.14 km ², and Fig. 9 shows that.

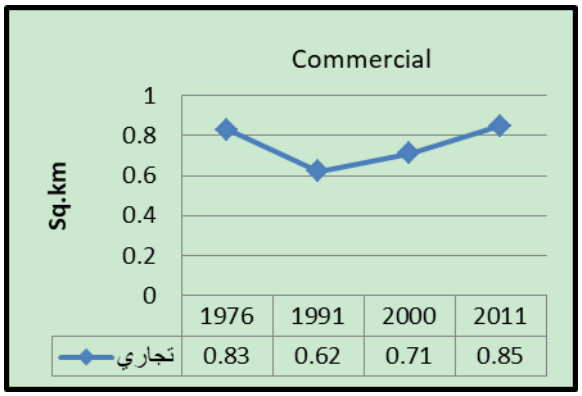

Fig. 9. The development of the commercial use of Kuwait city during the study periods.

C. Development of Government Use

The percentage of land use for governmental facilities in 1976 was about 9.4%, most of which were concentrated in Al-Mirqab area, plots 1, 2 and 3, with different areas in the areas of Sharq, Qubla and Dasman, and in 1991 it was about 1.68 km ², an increase of +0.77 km2 , as a result of the increase in the area of Kuwait City on the coast, in addition to the establishment of the ministerial complex in Al-Mirqab in 1981, which includes several government ministries.

The establishing of government buildings resulted in an increase in the area of government use for the second time, which reached 1.84 km^2, and an increase of +0.12 km ². However, in 2011 there was a significant decrease of -0.35 km2, as the government transferred some ministries and official bodies to the south of the area on the Sixth Ring Road, to ease congestion in Kuwait City because of the presence of most government ministries, and Fig. 10 shows the increase in government facilities during the years of study.

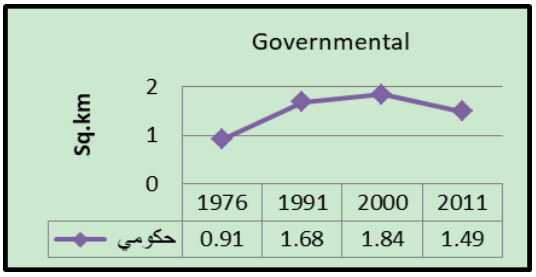

Fig. 10. Evolution of government use of Kuwait city during the study periods.

D. Evolution of Land Space

The land was classified as a use based on unexploited land, some of which are government property and others are private property, but have not yet been built. In 1976,The land space was 3.81 km, representing 39.2% of the total area of the city. Which is estimated at 9.71 km, the land is distributed more space in the eastern and western parts of Kuwait City.

In 1991, it was estimated at about 3.25 km ²and 32.2% of the area of Kuwait City, where it is clear that there was a decline of about -0.56 km2 in 1976, whereas the land space in 2000 remained constant and did not change but decreased in 2011 by -0.25 Km ²of area to 3 km ²as shown in Fig. 11, which indicates a growth in land use in Kuwait City and the conversion of part of the land space to other uses.

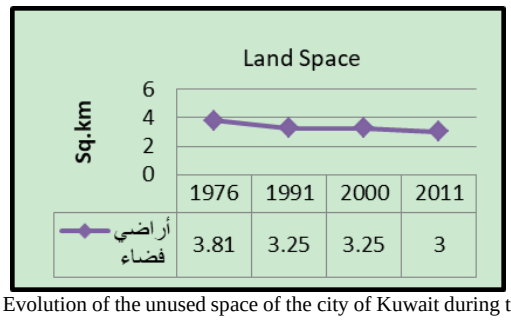

Fig. 11. Evolution of the unused space of the city of Kuwait during the study periods.

E. Evolution of Use Green Areas

The size of green areas in 1976, which includes gardens and green areas, is about 0.48 km ²and by 4.9%, most of which are concentrated in the green belt, which was previously, joined the old wall of Kuwait before it was demolished in 1957.

The increase in 1991 was approximately +0.57 km2 along the coast, which is for the waterfront project, while its area remained constant in 2000 and there was no increase. In 2011, the size of green areas increased to 1.25 km ², as in Fig. 12.

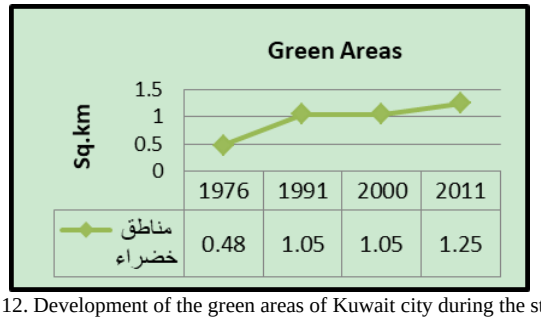

Fig. 12. Development of the green areas of Kuwait city during the study periods.

F. Evolution of Road Use

In 1976, the roads acquired a total area of 1.39 km ², in 1991, roads increased by 1.39 km ²and by 14.3%. In 1991, the road area increased significantly by 1.74 km2 and by 17.2% of the city area to the second place. The largest share of the increase was at the expense of the green belt area as a result of expansion The first ring south of the city of Kuwait, and increase the main roads within the city at the expense of land space, which decreased area, while the road area in 2000 on the same area did not increase significantly, but saw a slight increase in 2011 to 1.75 km ², and Fig. 13 illustrates The development of roads during the years of study.

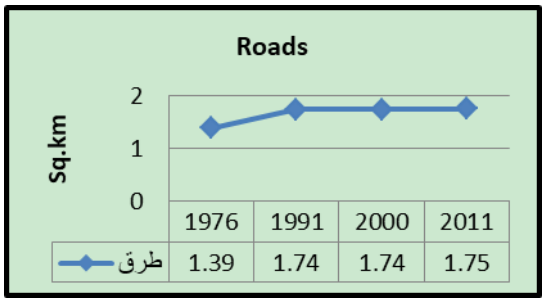

Fig. 13. Development of the roads of Kuwait city during the study periods.

G. Evolution of the Use of Parking Lots

The area used for car parking in 1976 was 0.44 km ², which was largely distributed near commercial use in the center of the city, while there was a slight decrease in 1991 to 0.39 km ² by -0.05 km ²for the year 1976.

As a result of the increase in commercial use, the area of parking increased in 2000 to reach +0.23 km ²and to become 0.63 km ². Parking in 2011 increased by 0.26 km ²to 0.94 km ², as shown in Fig. 14.

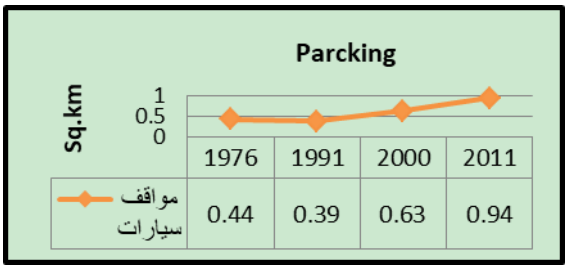

Fig. 14. The development of Kuwait city parking during periods of study

H. Development of the Use of Graves

As for the use of graves, its size in 1976 reached about 0.31 km2, where there was no change in its size during the years 1991, 2000 and 2011, which are seven graves that have remained on the same area since its allocation. The largest area is the Qibla grave in Qibla area, there are also three graves in the area of the east and they are the grave of the northern and southern Madwa and the tomb of Al-Sawaber and the tomb of Hilal al-Mutairi near the Arabian Gulf Street, and the Al-Hassawiya and Al-Jafariya villages in Al-Merqab area.

I. Changes in the Coastal Area of Kuwait City

The area of Kuwait City increased from 0.76 km ²to an area of 10.26 km ². The increase was in coastal areas along the Arabian Gulf coast to the east and south of Kuwait. The

increase was carried out east of the Kuwait Towers and included the increase in the size of the Palace of seif, which includes the Amiri Diwan , the Council of Ministers and the Ministry of Foreign Affairs, as well as the construction of the Sharq Commercial Market, which opened in 1997.

Table III provides information on the Unused areas and the increase and change in the shape of the coast of Kuwait City during the period from 1976 to 2011 due to the landfill operations, where the city area on the coast increased by approximately 0.55 + km.

TABLE III: THE INCREASE IN THE AREA OF KUWAIT CITY AS A RESULT OF THE OPERATIONS ON THE COAST

Years	Total area (km²)	Unused space (km²)
1976	9.71	-
1991	10.09	0.38 +
2000	10.26	0.17 +
2011	10.26	-

IV. CONCLUSION

Through the use of remote sensing techniques and Geographic Information Systems, the following was reached:

1) It turns out that the predominant use of the city is land unused space.
2) The structural plans in the land use classifications of the State of Kuwait have not been complied with, leading to poor planning of the city in its current form.
3) The appearance of Kuwait City in general is characterized by the existence of open spaces and empty vouchers currently used as parking places.
4) There are seven old cemeteries in the city of Kuwait that are not used, and classified in the structural plans as parks and green spaces.
5) Some plans covered a long period of time but they needed to be redeveloped after years, as inaccurate expectations and non-compliance with the scheme itself.

The study reached a set of conclusions and recommendations that can be mentioned in the following points:

1) The study recommends that residential uses should not be changed to commercial use unless parking is provided for staff and visitors.
2) Also recommends the need to stop the establishment of institutions and ministries in the city center between shops and residential communities and put them in surrounding the city to relieve the pressure on the center.
3) The need to preserve all historical buildings located in surrounding and center of the city.
4) Conduct a detailed study of parking spaces in Kuwait City to identify and distribute the most appropriate parking spaces. With the establishment of an advanced parking system using smart technology.
5) The development of legislation and standards for planning to determine the height of buildings, because of the high buildings and low buildings, because of the absence of functional division of buildings in the organization of the city, resulting in an overlap in uses.
6) Reviewing some of the land uses within the city which are not suitable for the present time with the physical and aesthetic situation, and work to exploit them to suit the status of Kuwait City as the capital of the country.
7) To review land use planning, especially residential use as the most important uses, in coordination with the relevant authorities.
8) To make use of the findings of this study, especially in the field of land use review periodically every three or five years.
9) Utilization of land space in the future urban expansion instead of landfill.

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