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Measuring The Urban Growth in Khoms, Libya, by Using Geographic Information Systems and Remote Sensing

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دراسة النمو الحضري بمنطقة الخمس باستخدام نظم المعلومات الجغرافية والاستشعار عن بُعد

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Abstract

Rabid urbanization has become an important land use issue in Libya. This study, applies geographic information systems and remote sensing to measure urban change, focusing on the coastal district of Khoms. The results show that urban development increased by more than 658 percent for the 40-year period between 1976 and 2016. Agriculture is one of the sectors hardest hit by this exponential growth in urbanization, leading to the loss of productive fruit and vegetable farmland. In addition to the loss of major food sources, the environmental impacts of urbanization in this coastal district have been substantial. The study demonstrates how crucial geospatial technologies can be in assessing and monitoring regional environmental change.

Keywords: *GIS, Remote sensing, Urban change, Environmental change.*

الملخص

التوسع العمراني الضار أصبح مشكلة خطيرة على استعمالات الاراضي في ليبيا. في هذه الدراسة قمنا باستعمال تقنية نظم المعلومات الجغرافية والاستشعار عن بعد لقياس التغير العمراني بمنطقة الخمس الساحلية. أظهرت النتائج المتحصل عليها من هذه الدراسة زيادة التطور العمراني بنسبة تزيد عن 658% خلال الاربعين سنة الماضية (1976-2016). كما أن قطاع الزراعة هو أحد القطاعات التي تضررت بقوة بسبب هذا النمو الاسي العمراني مؤدياً الى فقدان الاراضي المنتجة للفواكه والخضراوات. بالإضافة إلى فقدان المصادر الرئيسية للغذاء فإن التطور العمراني أحدث أثاراً بيئية مهمة في هذه المنطقة الساحلية. هذه الدراسة توضح أيضاً أهمية وحساسية التقنيات المكانية في تقييم ومراقبة التغيرات البيئية الإقليمية.

الكلمات الدالة: نظم المعلومات الجغرافية، الاستشعار عن بعد، التطور العمراني، استعمال الاراضي، التأثير البيئي.

1. Introduction

Urbanization is a domain feature in most attractive cities and suburbs around the world. These places with their advantages such as industrialization, modernization, or land fertilization pull people from different destinations to settle and find stability and life. During 1930s and 1940s a wide and rapid urbanization occurred in the developed countries such as UK and U.S. which

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resulted in a huge conversion of the farmlands to urban areas (Firman, 1997). Urbanization and metropolitan areas are growing rapidly in developing countries such as Egypt in the recent years because of the rapid population growth (Kumar *et al.*, 2008). This rapid growth has resulted in decaying of the infrastructure, uncontrollable growth of informal settlements, negative socioeconomic, and environmental effects (Angotti, 1993; López *et al.*, 2001; Sudhira *et al.*, 2004; Youssef *et al*., and 2011; Lambin *et al.*, 2001). Climate and ecosystem changes as well as consumption of agricultural land are other negative effects (Irwin and Geoghegan, 2001; and Huang *et al.*, 2009). The study of urbanization process and land use change is different from other disciplines because it is difficult to allow experimentation on the ground (Irwin and Geoghegan 2001; and Verburg *et al.*, 2006). Urban development produces some of the greatest local extinction rates of living organisms and frequently eliminates the large majority of native species (McKinney, 2002). Research interest is being directed to mapping and monitoring of urban growth using GIS and remote sensing techniques (Epstein *et al.*, 2002). Remote sensing is cost effective and technologically sound, so is increasingly used for the analysis of urban sprawl and to generate Land-Use/Land-Cover (LULC) maps with improved classification accuracy and with a relatively low production cost (Sudhira *et al.*, 2004; Yang and Liu, 2005; and Haack and Rafter, 2006). The United States' NASA Landsat satellite data series (e.g., MSS, TM, ETM+, and OLI) have been widely used for mapping urban areas and monitoring urban growth, due to the sensors' capacity for overall view, repeat coverage over large areas and the availability of historical archive imagery data. Landsat sensors provide some advantages for the purposes of urban land mapping and change detection in terms of efficiency, as a single image can provide a synoptic view of an area of interest. In comparison to expensive higher-resolution sensors, the comparatively low-resolution nature of the Landsat TM/ETM+ sensor (30 *m*×30 *m*) avoids complications from sparse coverage, limited scene availability and lack of data prior to 2,000 when monitoring change for multiple periods. However, mapping urban areas using Landsat TM/ETM+ data remains a complex challenge (Zhang *et al.*, 2014), as there are few thematically pure urban pixels due to the mixture of manmade and vegetative land cover components that comprise urban areas. Complicating matters further, urban areas often display heterogeneous spectral characteristics and significant spectral confusion with other land cover classes: for example, barren land and asphalt concrete share similar spectral characteristics and, thus, can be readily confused (Zhang *et al.*, 2014). For nearly three decades, extensive research efforts have been made for urban change detection using remotely sensed images (Gomarasca *et al.*, 1993; Green *et al.*, 1994; Yeh and Li, 2001; Yang and Lo, 2003; Haack and Rafter, 2006; and Zhang *et al*., 2014). These studies have been supported through either an image-to-image comparison or a post-classification comparison. The impervious (built-up) area is generally considered as a parameter for quantifying the urban sprawl (Epstein *et al.*, 2002). Here, impervious area refers to the area consisting of residential, commercial, industrial complexes including paved ways, roads, markets, ..etc. Urban sprawl has been quantified by considering the impervious area as the key feature of urban sprawl, which can be obtained either from physical survey or

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through remotely acquired data. There are a variety of techniques have used to measure or estimate the area of impervious surfaces. The most time consuming and expensive, but the most accurate is manual extraction of impervious surface features from remote sensing images through heads up digitizing. Point sampling can be used as an alternative to digitizing, despite this being time consuming and less accurate. Remote sensing pattern recognition approaches, such as supervised, unsupervised and knowledge-based expert system approaches have been used in the near past to measure impervious area and urban sprawl (Greenberg and Bradley, 1997; Vogelmann *et al.*, 1998; Stuckens *et al.*, 2000; Stefanov *et al.*, 2001; Sugumaran *et al.*, 2003; Lu and Weng, 2005; and Mundia and Aniya, 2005). Thus, rationalizing artificial simulations to model the complexity of land use change dynamics is necessary (Verburg and Overmars 2007; and Zhao and Murayama, 2011). Implementing various studies and modeling methodologies can lead to understand the occurrence of urban growth or sprawl (Cheng *et al.*, 2003; Jat *et al.*, 2008; Tv *et al.*, 2012; and Al-shalabi *et al.*, 2013a, 2013b). However, the study of urban growth still calls for considerable attention, particularly in developing parts of the world (Jokar Arsanjani, 2011). The complexity of spatial and temporal dynamics of the urbanization process and human activities requires the inclusion of temporal and spatial dynamics as well as urban drivers in land use modeling for urban studies (Veldkamp and Lambin, 2001). The urban sprawls formed at the fringes of metropolitan areas, by spreading through commercial and industrial development with low density, and followed by large uncontrolled urban expansion with low quality of services and accessibilities. However, urban sprawl formation in developing countries may follow different growth patterns compared with other parts of the world (Gillham, 2002; and Helbich and Leitner, 2010). The quantity and the location of land use changes are main issues to be addressed by city planners and decision makers, especially in rapidly changing environments (Alsharif and Pradhan, 2014). Thus, controlling the urbanization process and creating sustainable development require accurate information about urban growth patterns (Jiang and Yao, 2010). These places spread in the coastal area and some deserted sites in Libya. With time these places are widely affected by the increasing numbers of humans to the extent of harm. Overexploiting the resources such as the soil fertility, cultivated area, water, and natural vegetation are the largest damages. Reaching the undesirable situations of these lands make them unwanted, pushed, or different grounds. Housing is one of the most appearing characters in these areas. This action has occurred to cover the best agricultural lands with their plants by concrete and luxuries and cut them from the cultivated area. There are many reasons have contributed in these actions. First, the absence of implementing laws and regulations that protect the agricultural lands and prevent damage or destroy them which are created long time ago and amended many times because of the weakness of the administration and the political instability. Second, the governments lack response to the requests of citizens to find adequate housing for living. Third, some traditions and customs that make many families eager to be collected to stay in their own lands or settle the same area that their ancestors occupied. Researchers, environmentalists, agricultural experts and engineers, and interested people in

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land use try to bring the attention of the importance of these areas and work to protect them. The country unrest in these years increases the sabotage actions and rapids the negative impacts on most cultivated and natural vegetation areas. This paper focuses on measuring the changes of the urban sprawl and housing in Khoms by using GIS and RS technologies.

2. Data and Methodology

2.1. The Study Area

This study conducted in Khoms district area, Libya, which is located about 100 *km* in the east of the capital, Tripoli. Specifically from Besis Island in northwest to Kaam spring in northeast, the Mediterranean Sea in north, and the district boundaries with Amamera, Mesalata, and Alos in south and between longitudes (13º59'00" E and 14º27'38" E) and latitudes (32º36'18" N and 32º54'17" N) with about 1,000 km^2 total area. This area contains the main city of Khoms and two small towns in the east and west of Khoms city as shown in Figure (1). The agriculture area spread in the north part and some parts of the south. This area is located in the Mediterranean weather zone with cold rainy winter and dry hot summer. Its temperature annually average is 20.4 ^oC. Its annually rainfall average is 250 *mm*. Its annually humidity average is 71%. The people of this district are 236,639.00 as 2012 census.

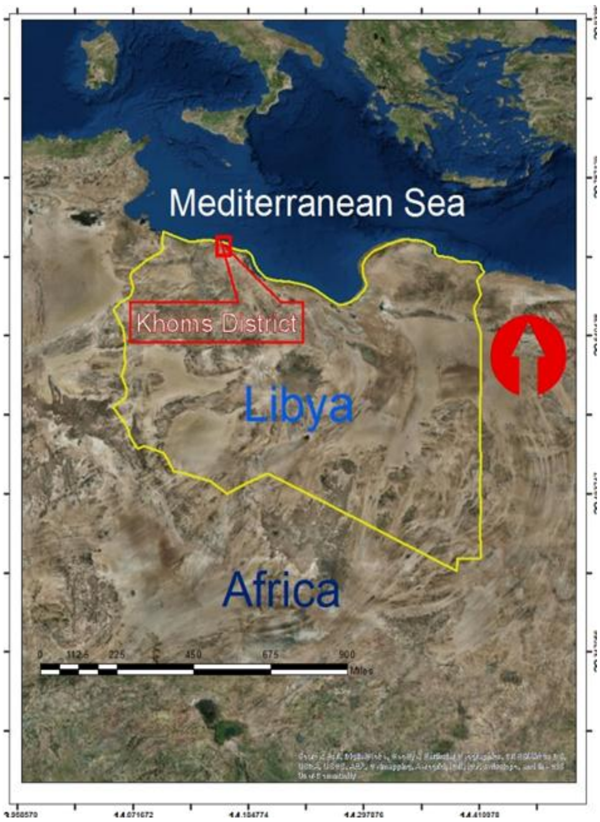

Figure 1. The Study Area

2.2. Data and Materials

Classification approaches have been used for the classification of the remotely sensed images obtained from various sensors viz. Landsat MSS (Multispectral scanner), TM (Thematic mapper), ETM+ (Enhanced Thematic Mapper Pulse), OLI (Operational Land Imager) and IRS LISS-III.

In this study, Landsat images used in different periods of time that captured by MSS, TM, ETM+, OLI to identify, quantify, and measure the changes in urbanization and housing in the study area. In addition, these images used to identify, quantify, and measure the other land uses such as agriculture lands, native vegetation, and trees.

As a reliable source of clear and spatially referenced data that can be used to get trusted and accurate results I Downloaded the Landsat images from USGS (US Geological Survey) website using 188 path and 37 raw for the north scene and using 188 path and 38 raw for the south scene (the scenes covered part of the northwestern Libya) in separated and named folders. The available data that covered the study area are for years 1976, 1984, 1990, 2000, and 2015.

2.3. Methods and Tools

In this study, ARC GIS software used to identify, quantify, and measure the urban growth and the other land uses. There are some steps followed to accomplish the study:

- Created the study area boundary shapefile by ARC GIS 10.3 editor.
- Mosaicked the two scenes by using ARC GIS 10.3. to merge the two parts of the study area that included in the two scenes in one image for clipping and classification processes.
- Made some required corrections that help in classification processes such as color corrections and noise removing.
- Clipped the study area from the mosaicked images by using the boundary shape file and ARC GIS 10.3.
- Classified the images by using ARC GIS 10.3 and spectral classification tool into three classes for 1976 image and four classes for images 1984–2015 that show the different land uses of the study area.
- Post classified the images that generated from the spectral classification processes to finalize them and prepare them for the layout.
- Created JPG images for the classified images to display the results of the study.

3. Results and Discussion

The spectral classification processes of the Landsat images of the district 1976-2015 have derived the results that are shown in Table (1).

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Table 1. The land use classes of Khoms District 1976-2015 in *Hectares*.

Class (*hecs*) \ Year	1976	1984	1990	2000	2015
Developed area	800	2,447	2,937	3639	6,067
Native plants, trees, bare land	87,367	72,457	75,784	72,849	78,831
Agriculture	18,409	31,618	27,822	30,087	21,536
Water	0	74	53	21	162
Total area	**106,576**	**106,596**	**106,596**	**106,596**	**106,596**

The results that display on the classified images which are representing in Figures (2-6), are indicate that the total area of the district is 106,576 in 1976. This area increased about 20 hectares after 1976 due to the construction of the port which takes a part in the sea at the end of 1979 as shown in the middle of the coastal area and near to Khoms city on the images to be 106,596 *hectares*. In addition, in 1976 the developed area which includes all types of constructions that have been built on territory such as the urban areas, the houses, the commercials, the governmental buildings, the schools, the roads, and the industrial facilities was about 800 hectares. The native plants, trees, and bare land was about 87,367 hectares. Also, the agriculture area was about 18,904 *hectares*. These areas are not specifically represented specially the developed area because of the low resolution of the Landsat (1) images and the temporary types of constructions such as shelters and tents that have widespread in the study area and have low radiation reflection rates.

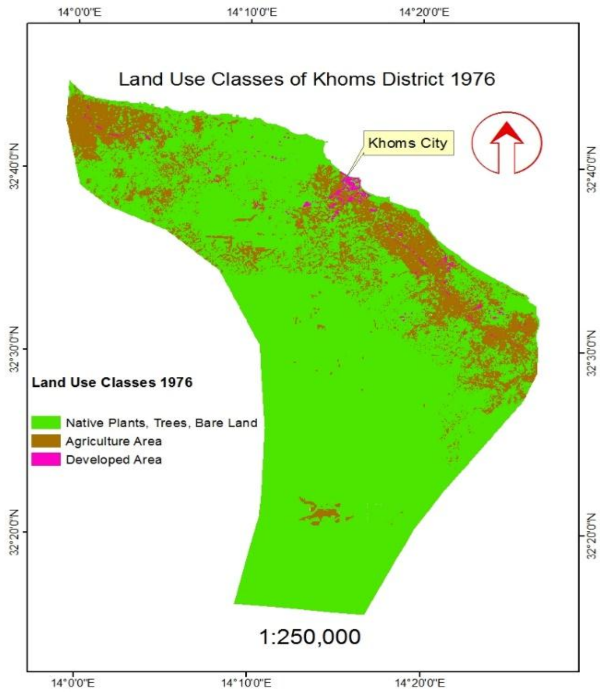

Figure 2. The land use classes of Khoms District 1976 in *Hectares*.

The developed area has increased gradually to be 2,447 *hectares* in 1984 because of the development plans that implemented by the government in 1970s, and early 1980s due to the increasing of Landsat images resolution which starts give more accurate data. The native plants, trees, and bare land decreased to 72,457 *hectares* because of the expansion of the developed area and the agriculture lands. On the other hand, the agriculture area increased to 31,618 *hectares* because of the development plans, drilling groundwater wells, and using different types of machinery that helped in land reclamation, water pumping, and cultivating more lands. The other noticeable issue this year is the appearance of the water body in the southeast part of the study area which is Kaam Valley Dam for rain water harvesting and storing with a total area of 74 *hectares*. This water body depends on the annual rains amount.

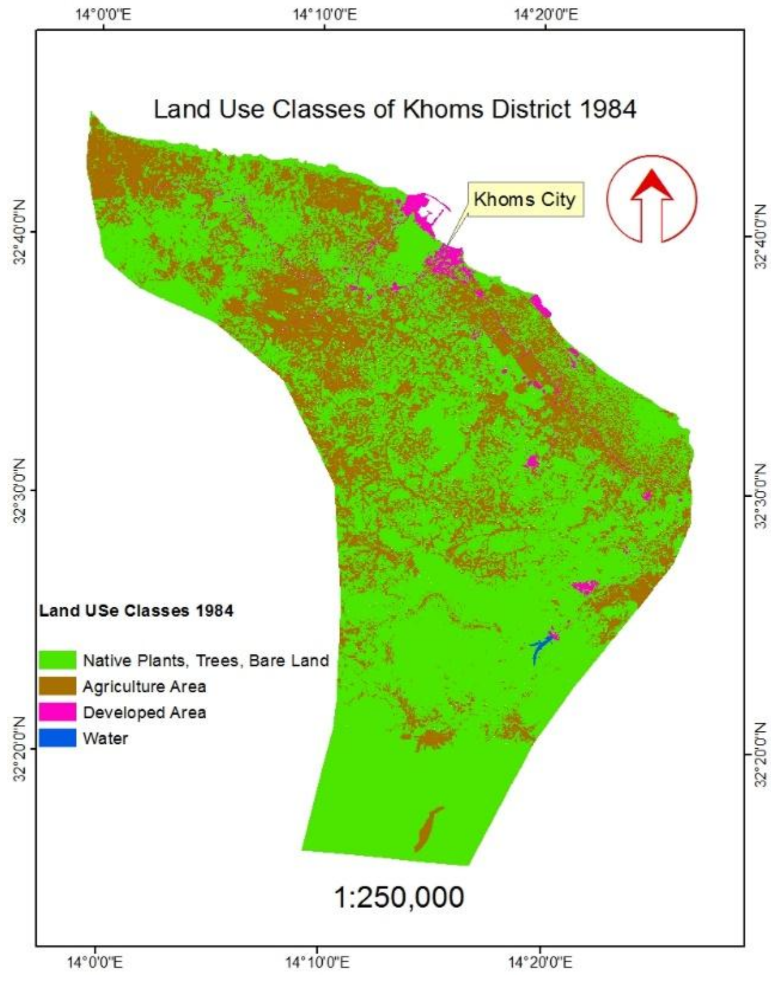

Figure 3. The land use classes of Khoms District 1984 in *Hectares*.

The developed area continued growing to reach 2,937 *hectares* in 1990 due to the continuous development and the increasing of the population. Moreover, the native plants, trees, and bare land increased to 75,784 *hectares* due to the decreasing of the agricultural lands. On the other hand, the agriculture area decreased to 27,822 *hectares* because of the development, drilling groundwater wells, and using machinery which caused the increasing of the salinity of the irrigation water on which depends the most agriculture produce. Kaam Valley Dam area decreased to be 53 *hectares* because of the decreasing of the annual rains amount.

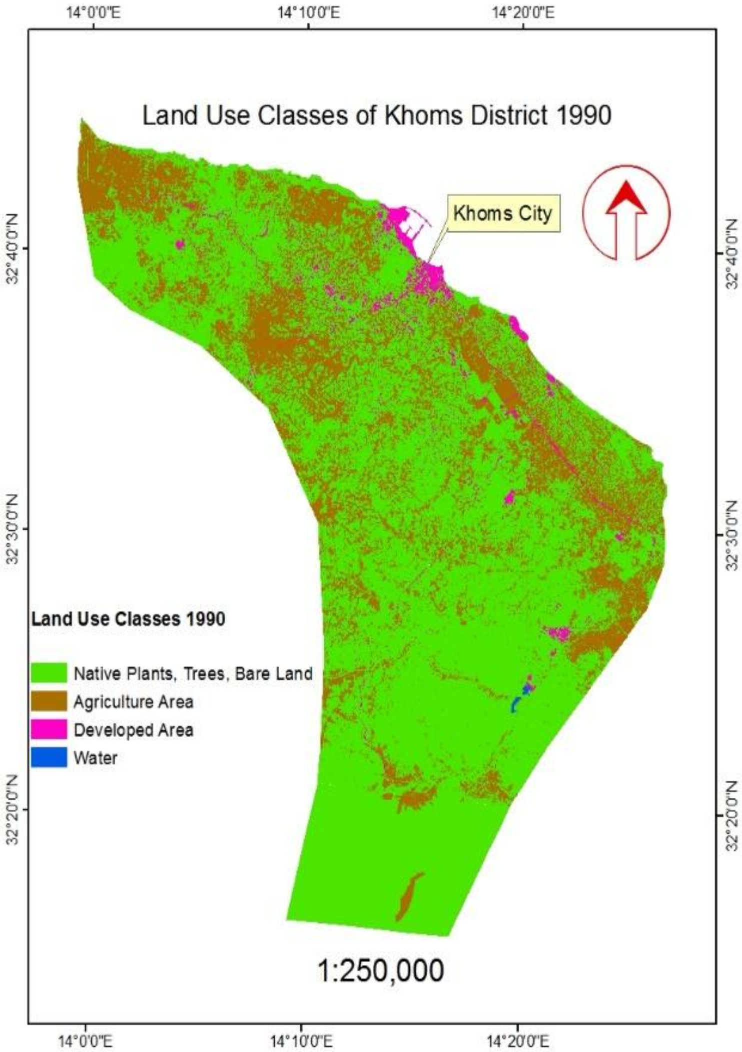

Figure 4. The land use classes of Khoms District 1990 in *Hectares*.

The developed area increased to 3,639 *hectares* in 2000 because of the increasing of the population in the district, the absence of the development plans in housing constructions in the city, and the weakness of executing agriculture lands protection laws. Furthermore, the native plants, trees, and bare land decreased to 72,849 *hectares*. Also, the agriculture area increased to 30,087 *hectares* because of the expansion of agriculture lands in the south part of the study area, drilling groundwater wells, and using machinery. Kaam Valley Dam area decreased to be 21 *hectares* because of the decreasing of the annual rains amount.

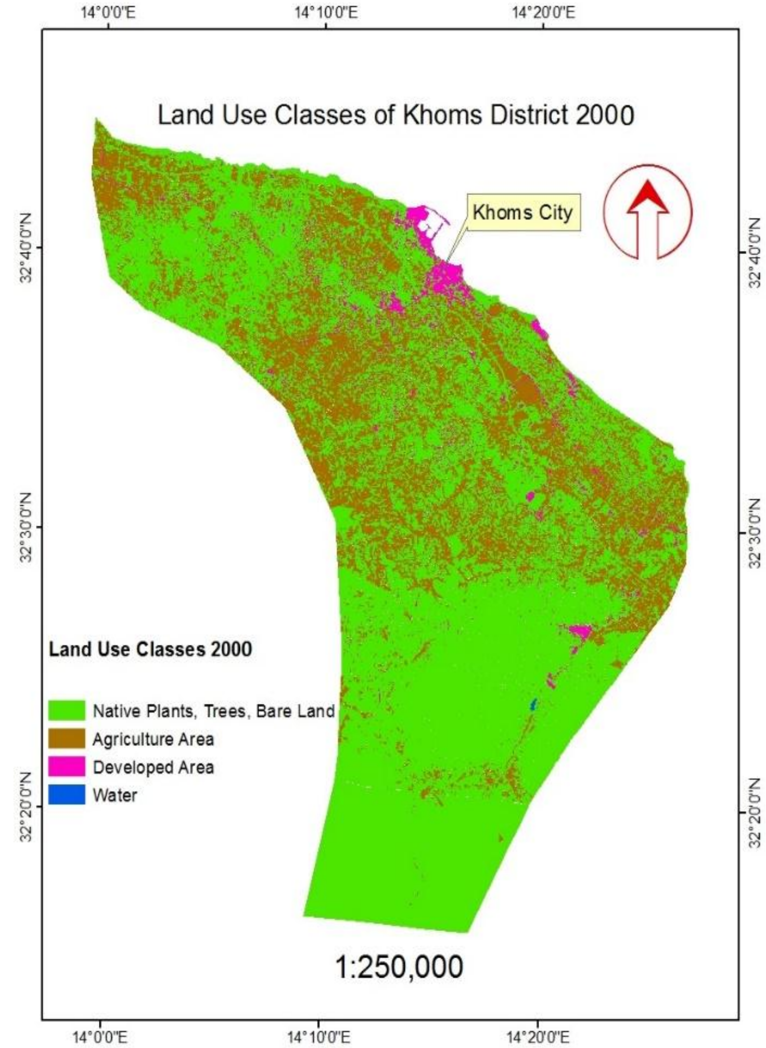

Figure 5. The land use classes of Khoms District 2000 in *Hectares*.

In 2015 the developed area expanded to reach 6,067 *hectares* by total increasing percentage of 658% due to the increasing of the population, the lack of plans, and the weakness of laws that established to regulate constructions and protect the agriculture lands. In addition, the native plants, trees, and bare land increased to 78,831 *hectares* due to the increasing of the developed areas and the decreasing of the agriculture lands. Also, the agriculture area decreased to 21,536 *hectares* because of the increasing of groundwater salinity, and unrest of the country. Kaam Valley Dam area increased to be 162 *hectares* because of the good annual rains amount.

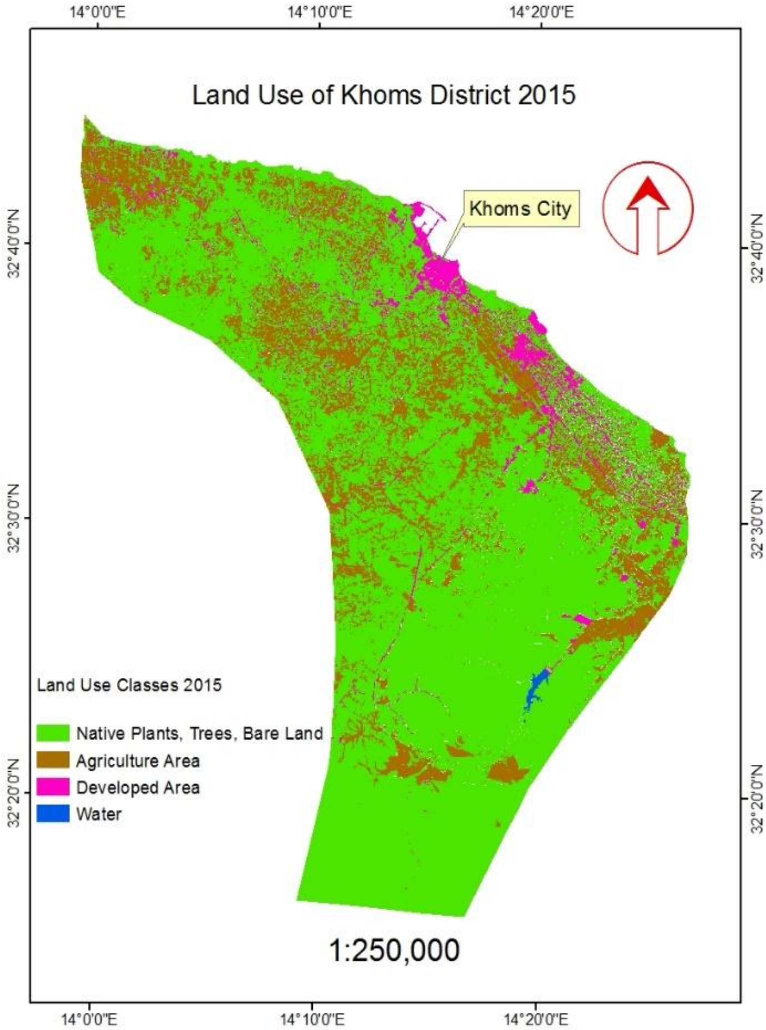

Figure (6): The land use classes of Khoms District 2015 in *Hectares*.

Furthermore, from the classified images and as shown in Figure (7) it is obvious that the developed area which includes all the types of constructions is gradually increased from year to year. The native plants, trees, and the bare land decreased. The agriculture area fluctuated from year to year to end with decreasing. The water in Kaam Valley Dam fluctuated too from year to year depending on the annual rains to end with a large area of 162 *hectares* which means good amount of water. These changes have been met with decreasing in the native plants and their areas.

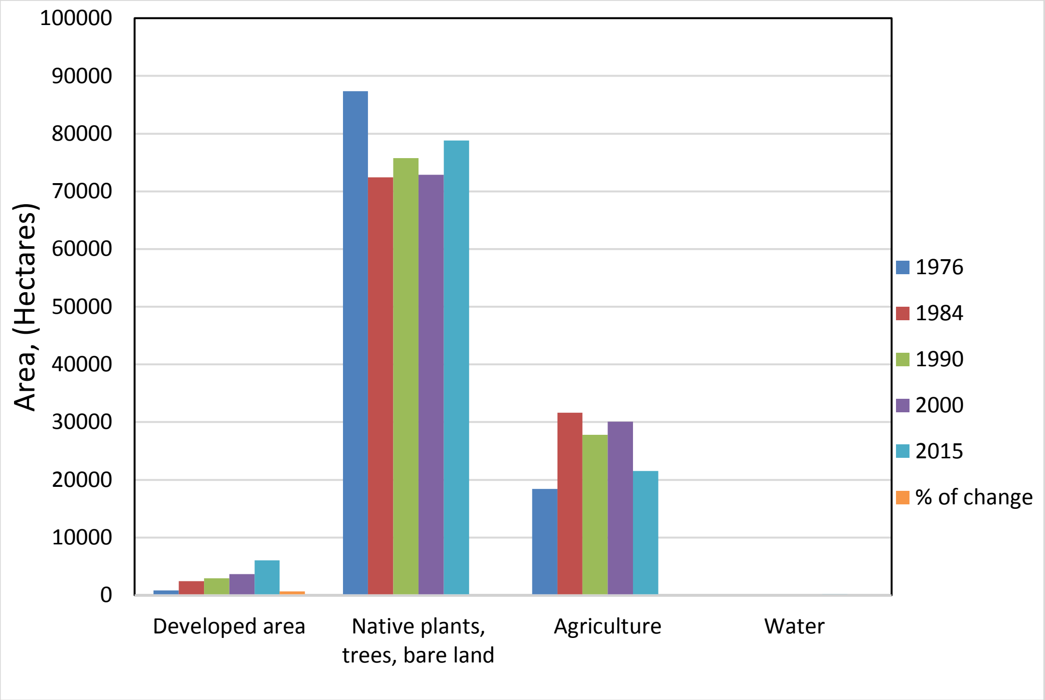

Figure 7. The land use classes of Khoms District 1976-2015 in *Hectares*.

4. Conclusion

This study has conducted in Khoms district, Libya by using geographic information systems and remotely sensed data are collected by Landsat Satellite for years 1976, 1984, 1990, 2000, and 2015 to measure the development areas and various types of constructions and their alterations. Furthermore, to measure the other land uses and their alterations. The findings from the study reveal that the urban development areas and different types of constructions increased by more than 658 percent in the last 40 years (1976–2015). On the other hand, the other land uses are negatively affected by this expansion of constructions. For example, the agriculture areas which are the major food source in the district and the surround districts increased about 42% in 1984 due to the development, drilling groundwater wells, and using the technology, but it decreased 32% at the end of the study period in 2015. Moreover, the native plants, the trees, and the bare land decreased by 10% in the last 40 years to lose thousands of various trees and shrubs which are an important part of the biodiversity of the district. These lands deducted to become urban areas, housing, and other different forms of constructions. In addition, these alterations in land uses and in the urban sprawl have caused many environmental impacts such as the release of the sewage water in many parts of the study area and the surrounded environment such as the sea. The deforestation is another huge negative issue has accompanied the urban sprawl in this coastal district. Furthermore, this study has revealed how crucial the geographic information systems and remote sensing technologies in displaying, identifying, and measuring the urban sprawl and the variation of land uses in a timely manner and less cost.

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