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Spatial Analysis for Urban development between "1990-2010" in city of Sulaimani, Kurdistan Region-Iraq

Rebaz Nawzad
University of Sulaimani Faculty of Science and Science Educations School of Science Department of Computer

ABSTRACT: *The spatial and temporal information on land cover provides a fundamental dataset for urban ecological developments and measurement studies. The hypothesis of this study involves looking into a particular period of time to evaluate the amount of urban expansion that occurred during a twenty year period. This aim can easily be achieved using the technology available with different Landsat satellite images, as professional systems permit the integration of remotely sensed data with other sources of geo-referenced information. This will be used to gain superior classification accuracy for the urban expansion of one Iraqi city located in the Kurdistan Region. The intended city is Sulaimani city, as it has developed rapidly over recent decades and especially after Operation Freedom in 2003. Nonetheless, the change in urbanisation needs to be measured, and this is not an easy task to achieve with a lack of technology.*

A. This study focuses on providing answers to the questions surrounding Sulaimani city's urban development using the capability of spatial analysis techniques to provide the outcomes. The study has used three satellite images taken ten years apart from each other for the period of twenty years between 1990 and 2010. Then these images have been processed and analysed to discover urbanisation measures such as to what extent the city expanded during the period; where the locations of the developments are situated, and moreover, why different types of developments occurred at different times.

KEYWORDS: *ERDAS and GIS, satellite Image Processing, Remote Sensing and Satellite Images, Urban Developments and Urbanization***.**

I. INTRODUCTION

Urbanization is one of the interesting topic engaging the world community and style of living. However, it is essential to monitor and measure the expansion to detect the cause of the expansion pattern and further planning. Usually it is a constant procedure and expect to happen dynamically (Yaseen et al. 2012). Despite the fact, urban developments is a complex progress, but it can determined by the relations of biophysical factors and human factors in space and time at different scales (Chunyang He et al. 2006). This study focus or aim to monitor the developments between the devoted periods, which is 1990-2010 through use of technology and satellite images (spatial data), also to Divulge and illustrate advantage of remote sensing techniques in the course of image processing for particular area. Spatial data resolution allows reaching some level of detail to resolve individual objects in the landscape, in a similar way than the airborne data does (Gianinetto M, et al 2004). This increase of technology capability can be handled by computing power, it's also is facilitating the advance of geographic information systems (GIS), and spatial data analysis technique within a variety of disciplines which are concerned with modelling or analysis aspects of urban developments (Simon Doyle, et al 1998).

The growth of the city divided into two phased in accordance to this study, while each one has its own form of developments based on different facts that has affected the growth. The second phase were rapid mainly after the operation of freedom in Iraq 2003 (Farrah Hassen 2006), as the United State of America (USA) pumped 12billion US dollar in cash in Iraq to boost the economy (David Pallister 2007). Part of the money devoted to re-construct the study area, and to increase the standards of living. It also created more work opportunity and encouragements for people to move near or around urban areas unexpectedly (Population Reference Bureau 2010), despite the fact urbanization is a global phenomenon since 1950s (University of Michigan 2002).

Consequently, urban development's require measurements, planning and decision making, therefore to accomplish this goal the officials are require to find effective ways to get these tasks completed, and the best solution for their requirements is the use of technology, because, the technique of getting information regarding objects through the data collected by special instruments that are not in physical contact with the objects of investigation (G. L. Berlin 2010), and it is a fastest and great solution for such a fast and unintended developments.

II. STUDY AREA

The study Area is the city of Suleimani or sometimes called Sulaymaniyah, this city located in the northeastern tip of Iraq in the Kurdistan Region. The city known as a cultural capital of Kurdistan Region ever since its build in 1784 (Dargham al-Rubaie. 2010). It is located between the latitude of 35.6037°N to 35.5312°N and longitude of 45.4758°E to 45.2862°E (EarthTools 2006). However, the elevation of this city above sea level is 2895 feet (Dargham al-Rubaie. 2010). Sulaimani surrounded by the chain of mountains which are the Azmer chain, Goyija Chain and the Qaiwan chain at the north east, and Mountain chain of Baranan at the south. The city population is 725,000 people, but the entire governorates were around 1,894,000 in 2011 (CITYPOPULATION 2012). The climate known as a semi-climate weather that is rather hot, with temperature ranging from 15 C (60 F) to 40 C (104 F) and sometimes up to 45 C (113 F) in the summer (timeanddate.com 2013). The map below which is a figure 1 showing the study area, and it is surrounding locations. The figure contains three maps marked with (A, B and C) letters. Each letter on the map describes the following, the contents of map (A) is the map of Iraq with all the eighteen governorates, (B) showing the location of Sulaimani Governorate in accordance to Iraq map, and (C) Sulaimani Governorate pointing the city location (study area).

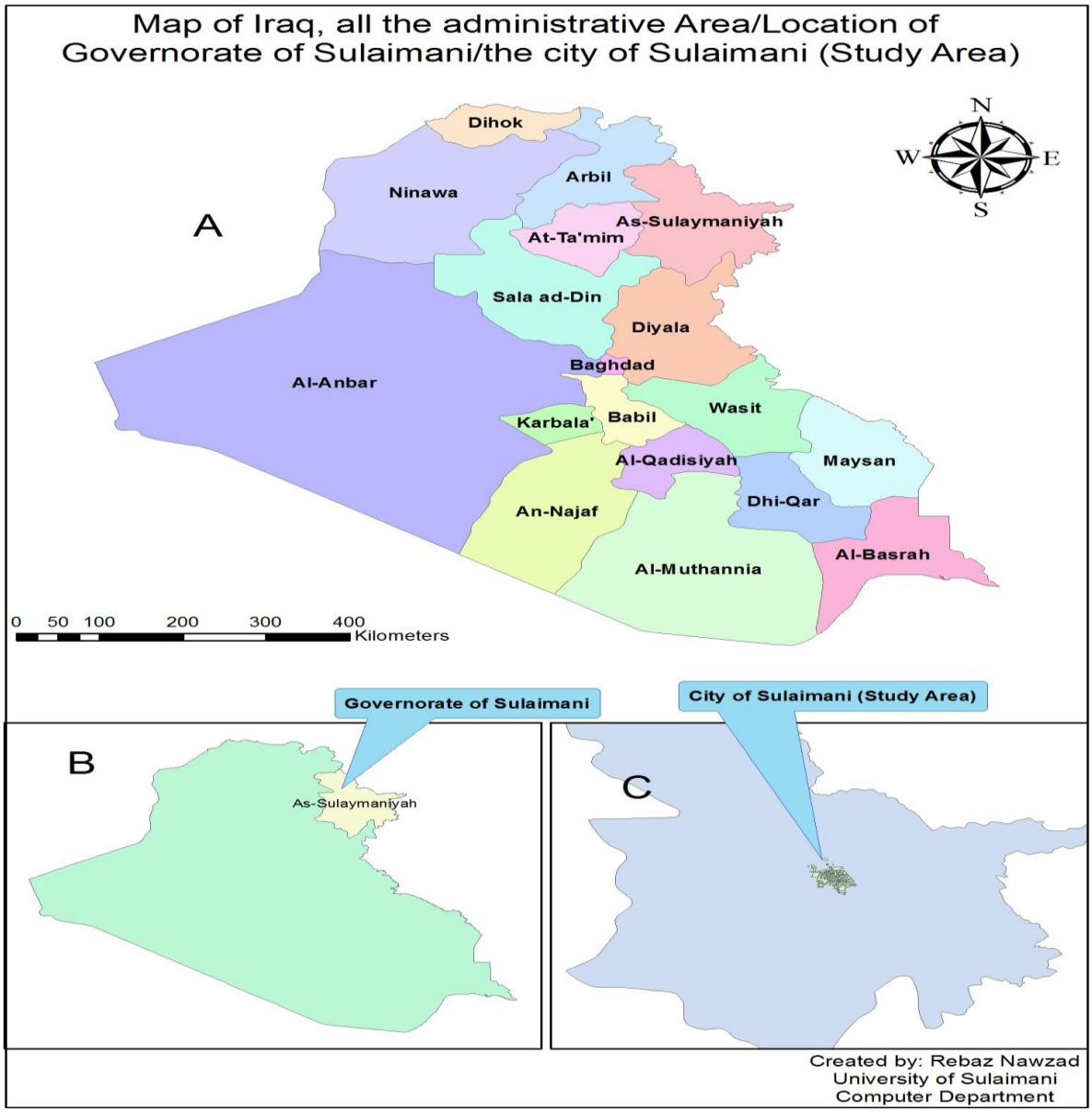


Figure No.1: Study Area: **A**: Map of Iraq, all the administrative Area, **B**: Location of Governorate of Sulaimani **C**: The city of Sulaimani (Study Area)

Figure 2: location of the city in accordance to the neighbour countries
https://maps.google.co.uk/maps?hl=en&tab=wl

III. MATERIALS AND METHODS:

In this study, the downloaded satellite image used to measure the amount of urban expansion during the 20 years of devoted period. Although since the 1950s urbanization globally developed faster than usual, and it is remain on this change, while consequently it's expected to have almost 60% of the international population live in urban with the developing world housing nearly 80% of this population by 2030 (Emma Spicer 2010).
With the purpose of distinguish the land use changes, and also to measure the amount of urbanization during the dedicated periods. Three satellite images downloaded from the United States Geological Survey (USGS) Glovis and Earth Explorer website, Landsat: L4-5 TM for the years of 1990-2000-2010 focused on the location of North East of Iraq (Study area) around the centre of Latitude 35.5500 and Longitude 45.4333. The available data supports experts to detect the urban changes in details. Nevertheless, the study area's satellite images used with a temporal distance of 20 years, and a Cloud Cover of only 20%.

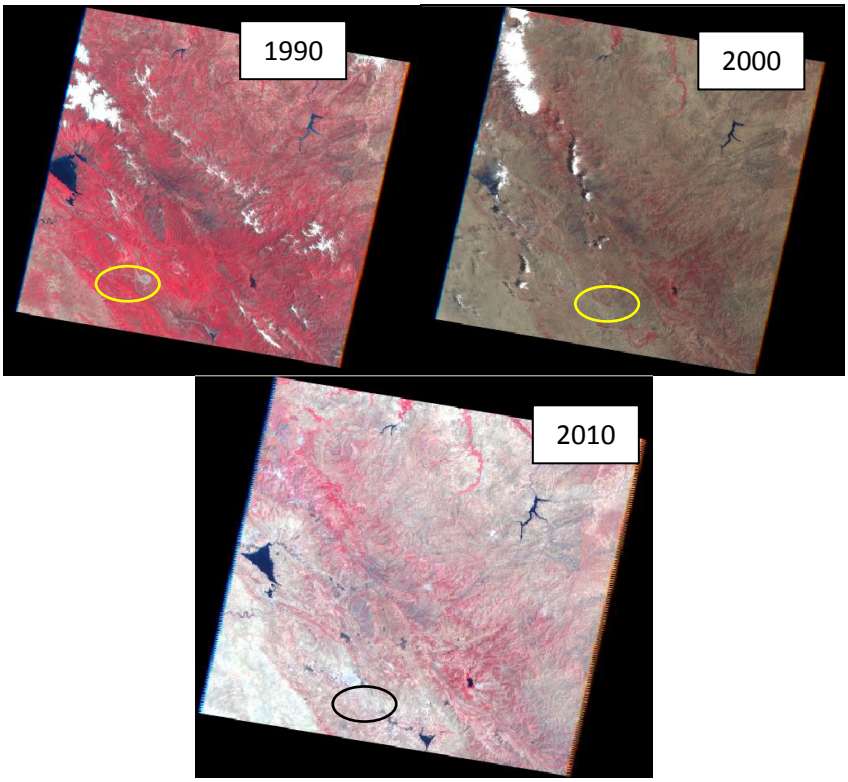


Figure No.3: three combined satellite images in the years of 1990-2000-2010.

Location: Northeast area of Iraq and the circles representing the study area, which zoomed-in in the further images. With the intention of gaining required spatial consistency with Landsat image, they need to go through image pre-processing such as: (Image Combination, Image Subset, High-Pass filter, and crisping) to become precise and clear. This is the initial steps for image analysis to attain the study aims.

3.1: Step one: Image pre-process:

The downloaded folder for each year contains seven TIFF file images, but this study uses six bands: (1st, 2nd, 3rd, 4th, 5th and 7th), however the six bands need to be combined together to produce a good quality image. Landsat: L4-5 TM Bands defined as, 1–5 and 7 each have a spatial resolution of 30m while the Band 6 (which is a Thermal infrared band) has a maximum spatial resolution of 120m (Hansen & Kathryn 2009).

3.2: Step two: image subset:

In this stage image gets subset, since the Landsat typical images covers an area of 185km by 185km, hence the study area is much smaller than this size. It is essential to subset (crop) the image to smaller size in order to obtain the closer image of the study area without loss of the image quality.

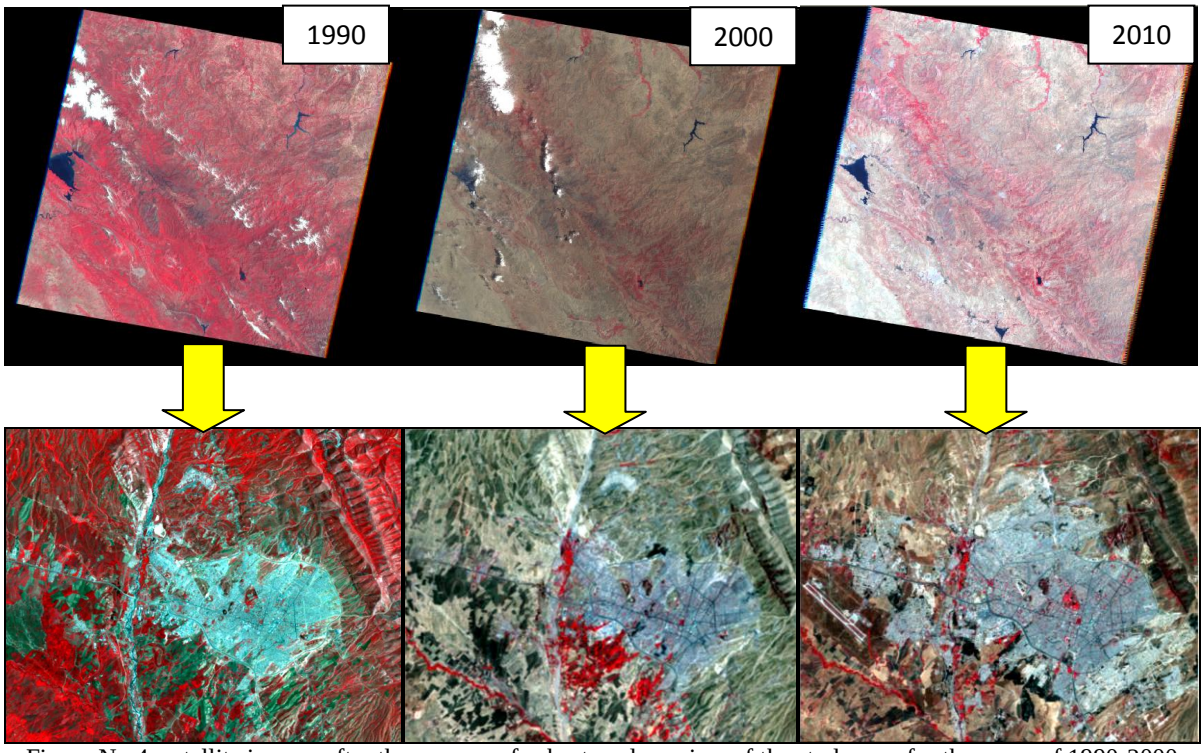
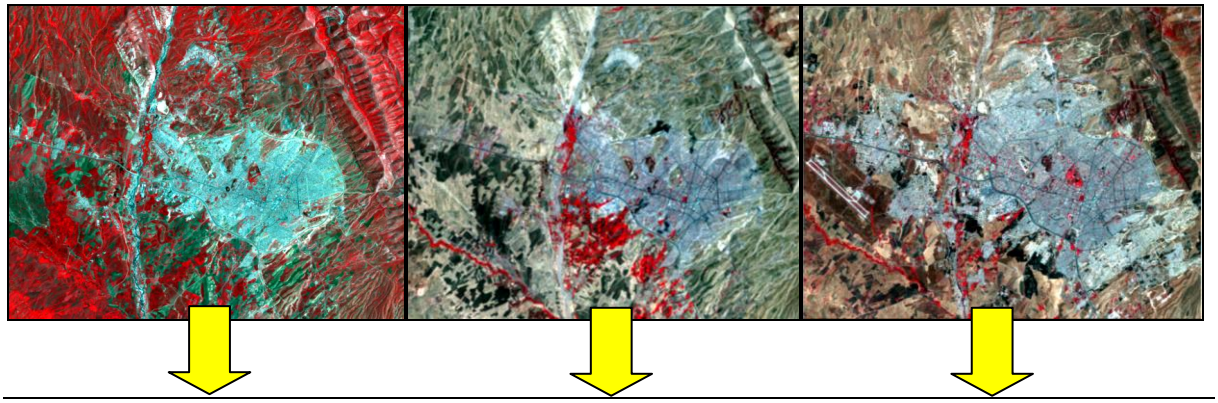


Figure No.4: satellite images after the process of subset, a close view of the study area for the years of 1990-2000-2010

3.3: Step three: High-pass filter

This stage the image goes through High-pass filter function, that is allow for the image enhancements by smoothing, sharpening, removing noise, and edge detection. This tool uses the basic for most sharpening methods, which makes it much clearer than the images in figure No.4.



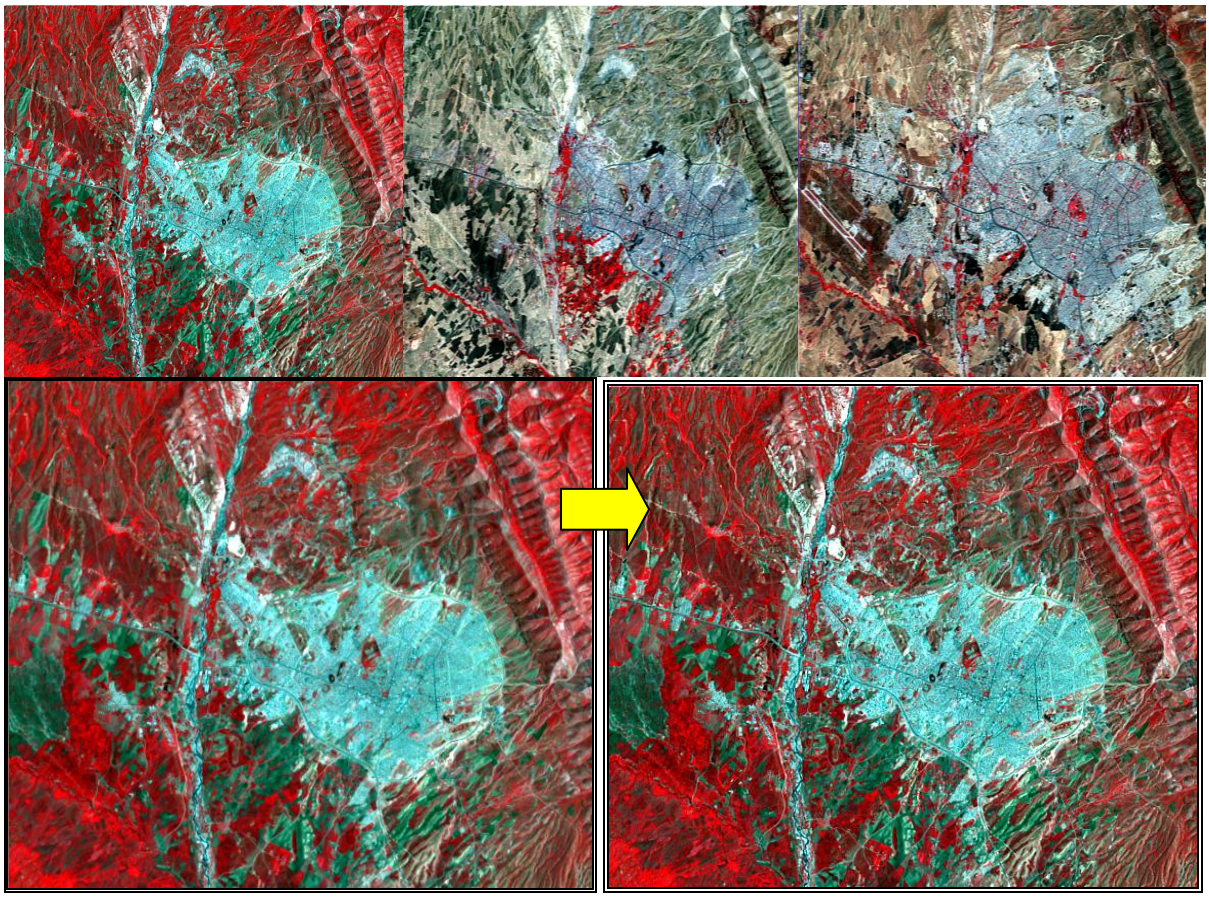
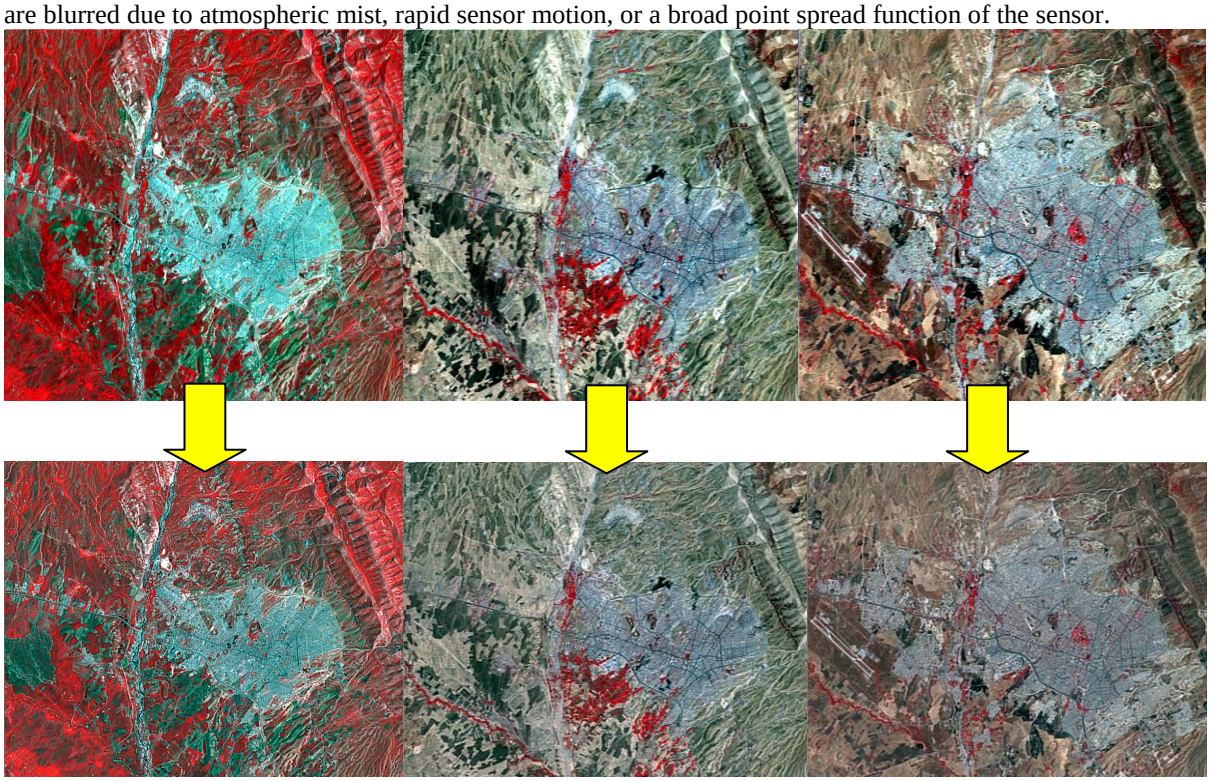


Figure No.5: applied High-pass Filter function on satellite images

3.4: Step Four: Crisping

The final preparation for the analysis is the pre-process of Crisping function, which is a tool for image luminance without distorting the inter-band variance content of the image. It is also enhancing those images that are blurred due to atmospheric mist, rapid sensor motion, or a broad point spread function of the sensor.



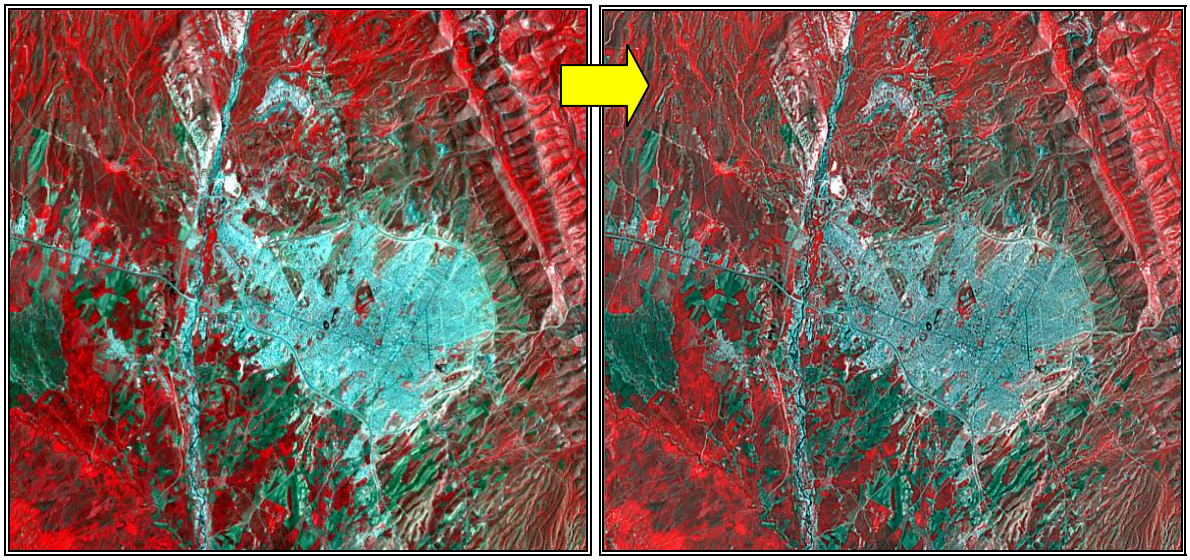


Figure No.6: applied Crisping function on satellite images for the years of 1990-2000-2010, after the high pass filter

There are also other functionalities available to improve image quality in satellite image processing software, such as Haze Reduction, but this is not useful for this study and digitization, because this function pixels behave strangely, and for digitization at this stage it's better to kept the crisp enhancements to analyze the work to achieve the aims.

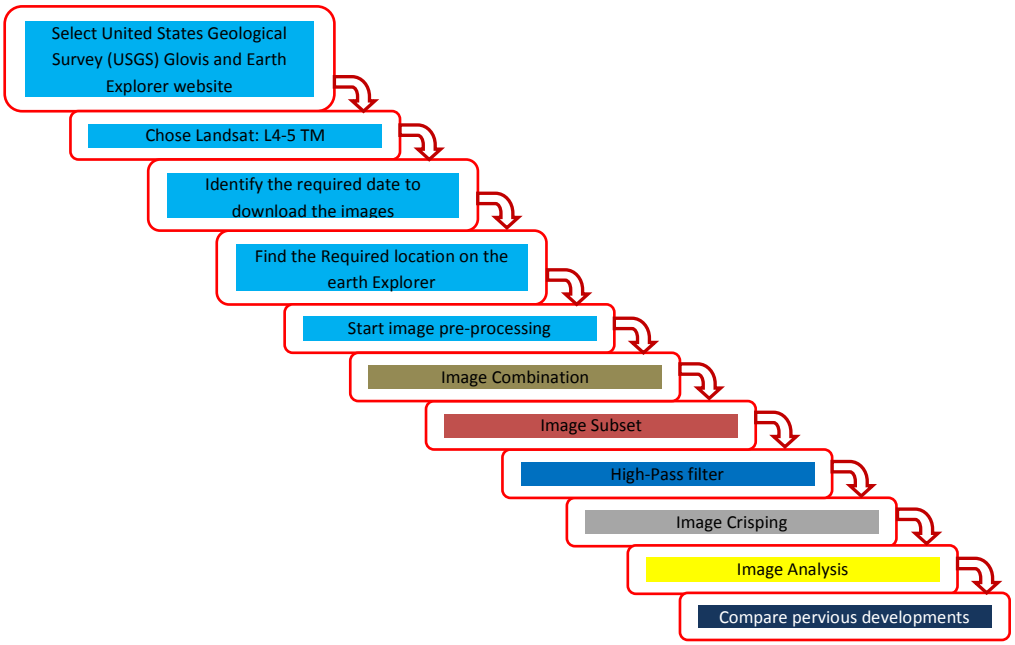


Figure No.7: waterfall model for progress of satellite image analysis and urban development's.

IV. RESULTS AND DISCUSSION

This section provides the analysis of the study aims, the satellite images results indicating the urban developments in the city of Sulaimani during 20 years since 1990. These accomplishments went through number of methods applied to the satellite images, to provide as much as accurate and reliable answers to the study aims and to provide the readers and the officials with the knowledge of planning and decision-makings. The adopted tool for image processing called Earth Resources Data Analysis System (ERDAS), which is the world's most important geospatial data authoring system, incorporates geospatial image processing and analysis, remote sensing and GIS capabilities into a powerful, convenient package. It enables you to easily create value-added products such as 2D images, orthophoto mosaics, landcover classification, 3D flythrough movies, vectors derived from imagery, and cartographic-quality map compositions from geospatial data (Intergraph Corporation 2013). However the applied methods were (Geo linking, Digitizing Process, footprints development Technique,

Overlaying, Phenomena Classification and Transformation of changes detection), and each one will be discussed individually to take part in the answers for the study aims.

4.1 Geo Linking Method:

This function links two images together at the same time, also focusing on the same location and coordinates under the condition of the same projection map system. The images below are the two satellite image of 1990 & 2010 been Geo linked. This tool allows controlling both images at the same time, and they can be compared against each other to see the changes. The two images below presenting enormous differences during 20 years, and urbanization can be seen deployed around the city from everywhere, especially towards west and south of the city (deployment footprints).

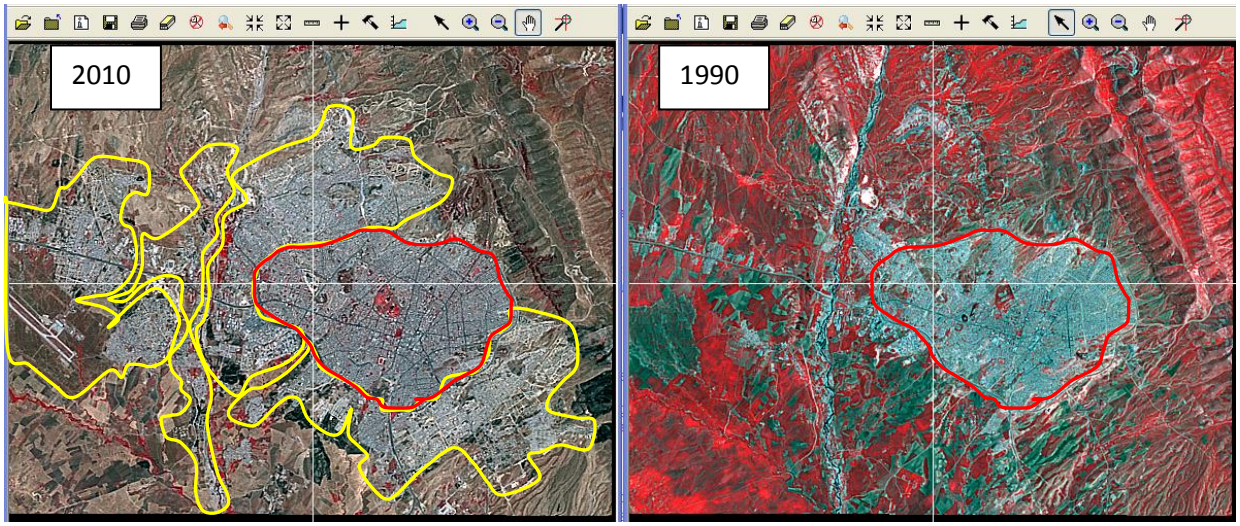


Figure No.8: showing the screen shot of the satellite images while they are Geo-Linked
Yellow lines indicate the new developed areas, but the red lines is the city border in 1990

4.2 Digitizing Process Method:

This is an important function of the study, it allow for presenting numerical (Statical) data to confirm the total and amount of urbanization, and also to authenticate the aim of the study. The satellite image of 1990 considered as a primary to indicate the amount, direction and location of urban developments.
The following steps are the digitizing and measuring process:

4.2.1: The satellite image below showing the city of Suleimani urbanization status in 1990. This image digitized on the ArcGIS software and a new layer created for the study area in digital version, which is in shape file (Map) GIS format. The first map on the left is the urbanization edge in 1990, while the second map on the right marked with purple spots, it indicating the empty areas within the urbanization boundary of 1990.

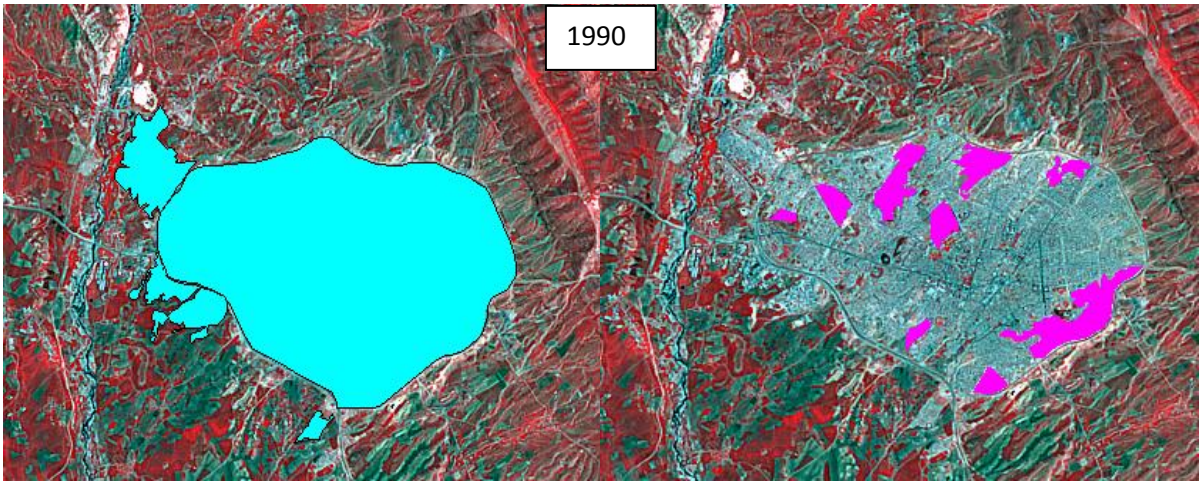


Figure No.9: Two satellite images of Sulaimani City, Left Image is the city urban boundary map layer, and the right image is the empty areas within the urban boundary. Both images are representing year 1990.

4.2.2: The digital layer (shape file) of 1990 has been added on the satellite image taken in 2000, this is allow to detect the amount and direction of developments during the first 10 years (1990-2000). However this is illustrating that blue area remain same as 1990's urban area, while both red and yellow colour represents the empty areas with in the boundary of 1990, but in 2000 only the red areas remained empty and the yellow areas which were empty in 1990 became built-up areas.

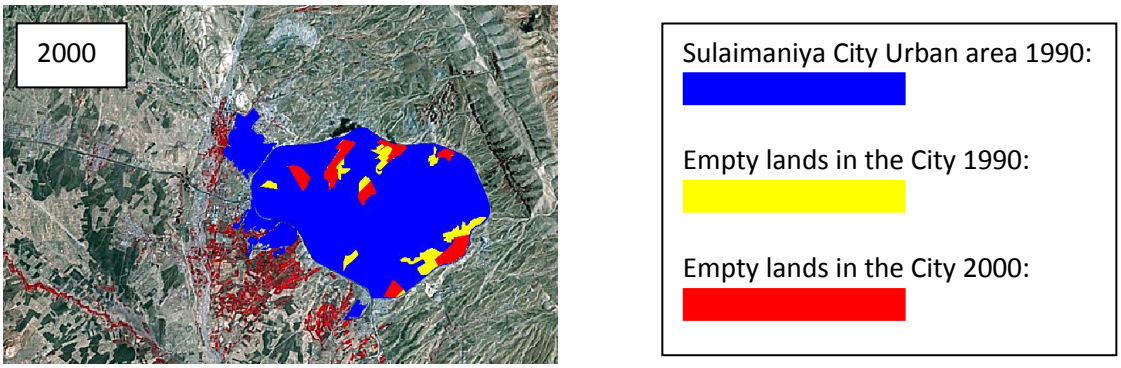


Figure No.10: Sulaimani City satellite image with a digitized layer of sulaimani urban boundary of 1990 map.

4.2.3: Figure numbers ten illustrating the urban growth within the first period of developments (1990-2000). This is within the boundary of 1990 urban areas of the city, while this period people has used the available empty lands in the districts of the city to build their shelters, also at this period the governments and local official had a spontaneous plan for urban development's, beside the economic blockade and the civil war (BBC News 2011), were engaging almost everyone, therefore people could only struggle for survivals and had a limited resources for living. Alongside the financial difficulty of the nation were the realities to stop people from developments (P. M. Kenneth 2002). This has left the city urban developments limited at the first period and remained with-in the city boundary definitely the little build-up did not solve the issue of the Population growth and residential deficiency. The city was over crowded inside a small boundary, and officials didn't have a potential suitable forecast for better and easier developments as all the financial plan were squander on the civil war.

4.2.4: The population of the city were around 548747 in the year 1999 according to an estimated survey from the directorate of statistic in Sulaimani (Sulaimani Governorate 2012), while comparing this figure to the 1990 estimated survey figure which were 325199 (Ministry of planning 2007), this is an increase of population by 68.7% increase within the first period (1990-2000), and this is not a small number of increase, hence this rapid increase has created the city overcrowd.

4.2.5: After the year of 2000 and in the second period of the study (2000-2010) of the urban development's the city population has increased again and this time from 548747 population in 2000 survey to 831,495 by 2010 estimated survey (Ministry of planning 2010), which is an increase of 51.5% in the second period of developments. The urban developments of the second period after 2000 were more organised and well planned. During this period the civil war finished and strong financial economy were available especially after the operation of freedom in Iraq 2003, while the U.S has pumped 12bn cash in to the Transitional Government Ministers to rebuild the country and create works (David Pallister 2007), hence the study area developments moved to the outer boundary of the 1990 residential. This growth clearly showing in figure Number eleven in cyan color, as it represent the new residential areas.

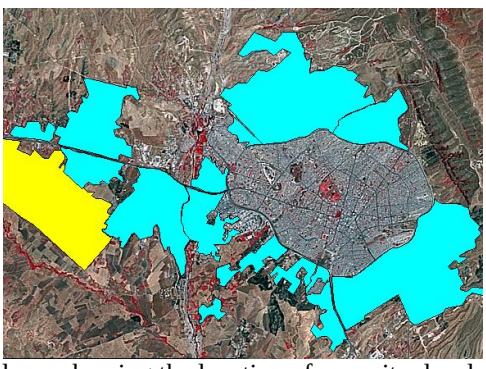


Figure No.11: the map layer showing the location of new city developments in cyan colour.

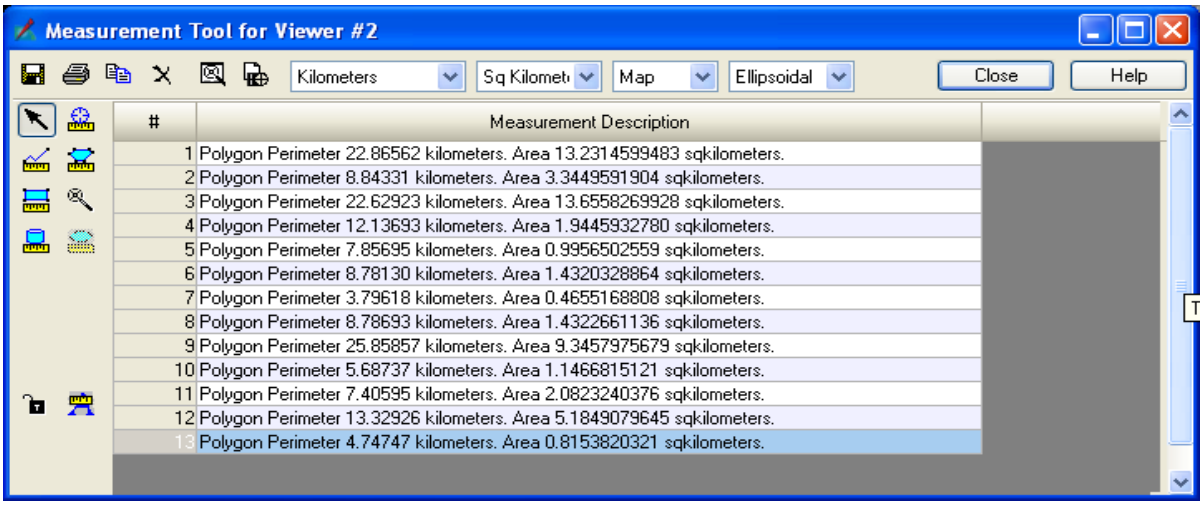


Figure No.12: total area measurements of new developed area polygons.

4.2.6: The second period of urban development's (2000-2010) were outside the city, therefore these developments made the city bigger than what it used to be. This has reduced the crowd and traffic inside the city. This success has come after the local government has made a solid plan with the financial support to make people build outside the pervious border of the city.

4.2.7: The new developed area shown in figure eleven confirming that most of the developments took place towards left and south of the city, due to land availability in the area and less mountains and hills. The figure number twelve showing the polygons measurements of new developed areas in square kilometer to calculate the total amount of developments during the second period of Urban Developments. As they are as the following figures:

- *Figure 12 includes the new airport, and the total developed area showing: 55.5 sq kilometers.*
- *The new urban area without the airport is: 41.9 sq kilometers, the city was 30.50 sq kilometer in 1990-2000, and then in 2000-2010 the city expanded another 41.9sq kilometer which made the total size of the city 72.40 sq kilometer. This figure means that the city grown larger by %137.5 between "2000-2010".*

V. CONCLUSION

This study considered being an attempt to distinguish the advantages of using technology over the traditional land survey and for urban development measurements, also using technology for obtaining the requirements through analysis. The study used a new way to evaluate urban development's in the city of Sulaimani by applying remote sensing and GIS techniques to gain the results for the transformation detection techniques, this technique showing the city has changed considerably and also transformed variously in different stages, however the periods of developments has been divided in to two periods which were the 1990-1999 and 2000-2010, while the two periods allow for a better analysis and created differentiation between the two periods of development method. It's also turn out to be clear that economic ability has a great effect on the developments. Although in the first period of developments the urban area has increased inside the city boundary which was 30.50 sq kilometer in 1990-1999 and the city became overcrowd within the small boundary, but in the second period the city development moved to the outer civilized boundary and the city grown by %137.5 which is another 41.9sq kilometre outside the 1990 boundary. This study emphasized that spatial information, i.e. GIS and remotely sensed data are particularly helpful in providing time-series information on urban landscape evaluation and this, in turn, provide interesting supports for decision-making for future planning and monitoring plans.

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