The implementation of Satellite images and associated digital image processing in addition to GIS modelling for urban mapping in Amman area, Jordan.

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Abstract: - Thematic maps and geo-spatial database are important tools that can be used for many purposes, such as mapping urban features, agricultural area and road network; they are also useful in urban planning and city planning. Many urban features were depicted from topographic maps and satellite digital images covering west of Amman area. GIS, remote sensing and associated digital image processing techniques have been applied on the satellite digital images in order to enhance the images. On screen digitizing techniques for both topographic and satellite images were applied to delineate Urban areas, agricultural areas, road networks. Several new maps for the western part of Amman area were produced from the topographic maps and satellite images (IKONOS 2002 and 2006). The resultant maps are: urban areas, road networks and agricultural area. The produced layers and their attributes were stored as geo-spatial database for west of Amman area using GIS technology by Arc GIS software. The produced maps and layers can be used for urban planning.

Key words-: Digital image processing techniques, Digital mapping, GIS modelling, Spatial domain filters, Geospatial database and Urban mapping.

1. Introduction

Amman is located in a hilly area of north-western Jordan. The city was originally built on seven hills, but it now spans over an area of nineteen hills (each known as a jabal or "mountain"). The study area covers an area of about 700 Km². The main objectives of this study are; to employ the digital image processing techniques on the satellite image covering west of Amman area in order to enhance the roads networks and urban features. Then apply GIS modelling & analysis for urban planning. Thereafter, produce urban features maps and attributes to be stored in GIS geospatial database.

1.1 Methodology

IKONOS satellite images and topographical maps at a scale of 1:50 000 were employed in this study to map urban areas, agricultural areas and road network. Thereafter; all the produced maps and

their attributes have been stored as geospatial database. Below a flow-chart showing the input data processing and the output of this study (figure 1).

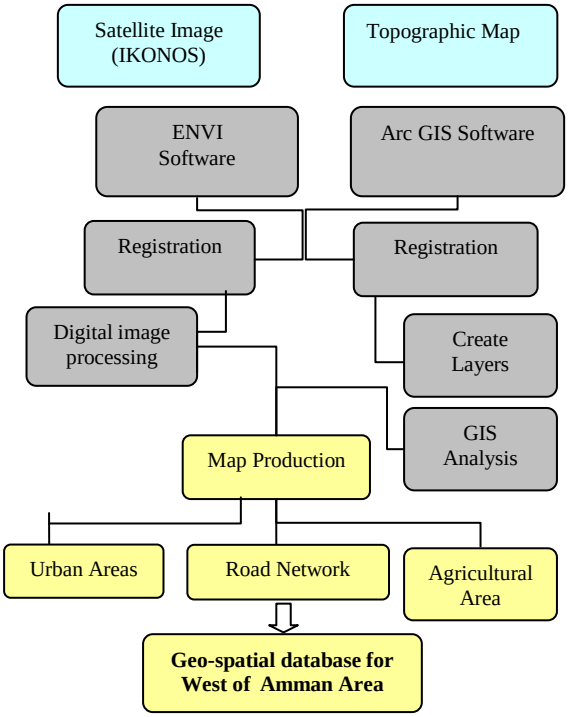


Fig. 1: Flow-chart showing the input, processing and the output in this study.

1.2 Sources of input data

Topographic map at a scale of 1:50 000 produced in (1982), IKONOS image taken in (2002) and another IKONOS image taken in (2006) were available to be used as input data in this study (figures 2, 3 and 4).

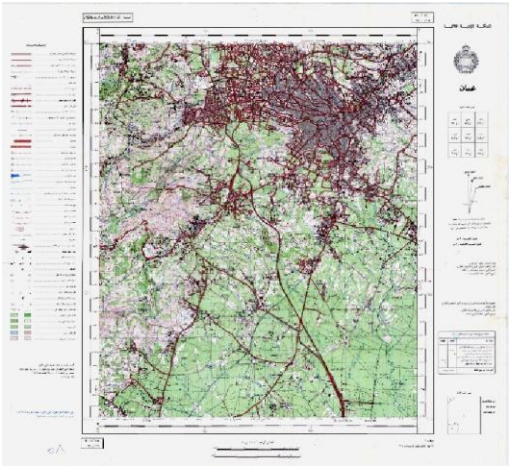


Fig. 2: Topographic map for Amman area at a scale of 1:50 000.

Fig. 3: IKONOS Image for Amman area, taken in (2002).

Fig. 4: IKONOS Image for Amman area, taken in (2006).

2. URBAN PLANNING

Urban planning is a mixture of science and art. It encompasses many different disciplines and brings them all under a single umbrella. The simplest definition of urban planning is that it is the organization of all elements of a town or other urban environment.

However, when one thinks about all the elements that make up a town, urban planning suddenly seems complicated and it is. Urban planning also became popular because of the growing need to get factory workers into healthier housing, rather than stuffing them into fire-trap tenements. With the advent of unions, workers had advocates to help lobby for better housing. Hence, "mill villages" and "steel villages" sprang up in larger cities integration [8].

Nowadays, urban planning takes all aspects of a city into consideration. It includes plans for safety, aesthetics and common sense placement of everything from houses to factories. Parents wouldn't want their children's playground next to the water treatment plant, for instance, and urban planning helps eliminate such problems. Goals for attractive architecture for city buildings are put into place and pleasing green spaces are planned.

Good urban planning gets schools into the neighbourhoods where they are needed most, places hospitals in centralized locations, allows for growth and plans highways accordingly. Because so many disciplines make up the larger concept of urban planning, a group of urban planners may have widely divergent degrees: civil engineering, architecture, botany, landscape design, electrical engineering, business administration, and so on.

Urban planners who are good at what they do are highly sought after by municipal governments. When efficient urban planning is used, cities are more attractive and serve their citizens to the best of their potential. In this study satellite images and associated digital image processing techniques in addition the GIS were implied in order to produce Geo-spatial database that can be used for a better urban planning in west Amman area.

An "Urbanized Area" is the fully developed area of a central city and its suburbs. The Census Bureau introduced the Urbanized Area concept in the 1950 Census as part of its efforts to differentiate the urban and rural portions of the nation's population. After the 1990 Census, it recognized 405 Urbanized Areas in the United States. A rather complicated but consistent formula measures for contiguous urban development. Unlike the more commonly known Metropolitan Statistical Area, an Urbanized Area includes no rural land. Nearly every organization that addresses sprawl relies on these Urbanized Area data as the foundation of any quantification of total sprawl.

3. REMOTE SENSING AS A SOURCE FOR URBAN MAPPING

Remote Sensing is the science of acquiring, processing, and interpreting images that record interaction between electromagnetic energy and matter obtained from aircraft and satellites that record the interaction between matter and electromagnetic radiation. Acquiring images refers to the technology employed, such as an electro-optical scanning system. Processing refers to the procedures that convert the raw data into images.

In remote sensing, information transfer is accomplished by use of electromagnetic radiation (EMR). EMR is a form of energy that reveals its presence by the observable effects it produces when it strikes the matter. EMR is considered to span the spectrum of wavelengths from 10- 10 microns to cosmic rays up to 10* 10 microns, the broadcast wavelengths, which extend from 0.30-15 microns.

When we look at an image on the computer screen it appears to be 2-dimensional but in addition to the rows and columns of pixels, images also have layers. These layers are commonly referred to as cervical engineers to describe a range of wavelengths (colours).

Since these image layers are created using specific. Such as a satellite image or an image from a represent the different colours or light that are used to display an image on a computer screen.

Now we know that images have three-dimensions (rows, columns, and bands), but how do these pixels and layers work together to produce a nice looking image on a computer screen? Computer monitors use the three primary colours of light; red, green, and blue, to create the images we see. We call these red, green, and blue channels.

By selecting three bands from a multi-band image and illuminating each of them with red, green, or blue light we can create a colour image. A very high proportion of the data used in remote sensing exists and is used in the form of image containing a very great deal of information. Image processing involves the manipulation of images:

- To extract information;
- To emphasize or de-emphasize certain aspects of the information contained in the image; or
- To perform statistical or other analyses to extract non- image information.

Image processing may therefore be regarded as a branch of information Technology. Some of the simple operations of image processing will be familiar from everyday live; for example the idea

of contrast enhancement will be familiar from ones experience of photography or of television viewing.

Digital image processing is the most important step because it converts an image into information that is meaningful and valuable for a wide range of users, the interaction between matter and electromagnetic energy. Electromagnetic Spectrum is the continuum of energy that ranges from meters to nanometres in wavelength, travels at the speed of light, and propagates through a vacuum such as outer space. All matter radiates a range of electromagnetic energy such that the peak intensity shifts toward progressively shorter wavelengths with increasing temperature of the matter integration [4].

In general usage, an image is any pictorial representation, irrespective of the wavelength or imaging device used to produce it. A photograph is a type of image that records wavelengths from 0.3 to 0.9 μm that have interacted with light-sensitive chemicals in photograph film. Images can be described in terms of certain fundamental properties regardless of the wavelength at which the image is recorded. These properties are scale, brightness, contrast, and resolution. The tone and texture of images are functions of the fundamental properties [3].

A summary of phenomena that can be observed through remote sensing includes: land cover and land use, type of soil and vegetation cover, status of crops, type of trees, roads, urbanization, rivers, lakes, watersheds, topography, geological structure of the landscape, ecosystems, suitable habitats for certain animals, flora and fauna but not directly in case of small species, colour of water leading to certain aspects of water quality and water pollution.

In this study satellite images and associated digital image processing techniques in addition to GIS modelling were implemented to produce geo-spatial database for Amman area.

3.1 Digital image processing techniques

Image Processing and Analysis can be defined as the "act of examining images for the purpose of identifying objects and judging their significance" Image analyst study the remotely sensed data and attempt through logical process in detecting, identifying, classifying, measuring and evaluating the significance of physical and cultural objects, their patterns and spatial relationship [2].

In a most generalized way, a digital image is an array of numbers depicting spatial distribution of a certain field parameters (such as reflectivity of EM radiation, emissive, temperature or some geophysical or topographical elevation. Digital image consists of discrete picture elements called pixels. Associated with each pixel is a number represented as DN (Digital Number) that depicts the average radiance of relatively small area within a scene. The range of DN values being normally 0 to 255. The size of this area effects the reproduction of details within the scene.

As the pixel size is reduced more scene detail is preserved in digital representation. Selective digital image processing techniques were applied on Amman image in order to enhance then to map the required features such as urban areas, agricultural areas, road networks.

3.1.1 Image Enhancement

The purpose of image enhancement is to render the image more interpretable, i.e. some features should become better discernible , which generally occurs at the cost of some other features which may be relatively unimportant in that specific context .

It must be emphasized that the digital image should be corrected for radiometric distortion, prior to image enhancement, otherwise the errors also become enhanced.

It is also possible to convert DN-values into absolute radiance or reflectance (physical) values before processing, enhancement and interpretation. The original satellite data, however, are generally poorly calibrated, and it is not considered worthwhile to attempt deduction of absolute physical values in most cases, as only relative DN-values are quite sufficient.

As a first preparatory step for image enhancement, it is pertinent that statistical data distribution in the images be known. A histogram describes data distribution in a single image and scatter grams provide an idea of relative data distribution in multiple image.

The underlying principle of histogram equalization is straightforward and simple, it is assumed that each level in the displayed image should contain

an approximately equal number of pixel values, so that the histogram of these displayed values is almost uniform (though not all 256 classes are necessarily occupied).

The objective of the histogram equalization is to spread the range of pixel values present in the input image over the full range of the display device. The method of contrast enhancement is based upon the histogram of the pixel values is called a Gaussian stretch because it involves the fitting of the observed histogram to a normal or Gaussian histogram.

3.1.2 Spatial Processing

Filtering methods exists is based upon the transformation of the image into its scale or spatial frequency components using the Fourier transform. The spatial domain filters or the convolution filters are generally classed as either high-pass (sharpening) or as low-pass (smoothing) filters.

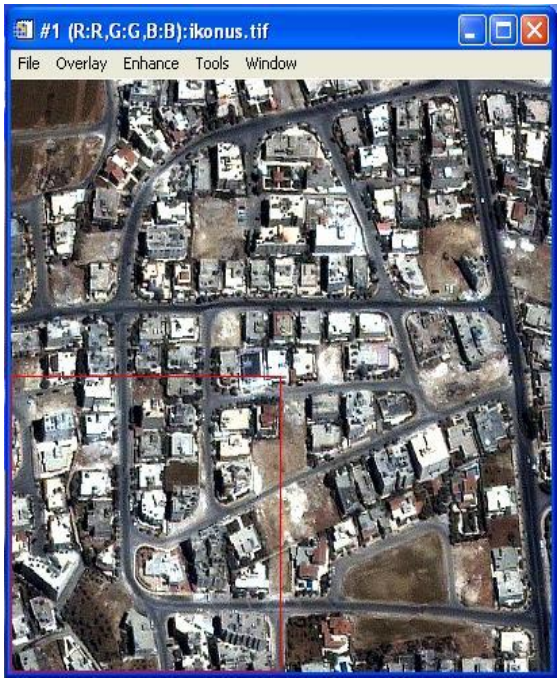
Low-Pass (Smoothing) Filters: Low-pass filters reveal underlying two-dimensional waveform with a long wavelength or low frequency image contrast at the expense of higher spatial frequencies. Low-frequency information allows the identification of the background pattern, and produces an output image in which the detail has been smoothed or removed from the original.

A 2-dimensional moving-average filter is defined in terms of its dimensions which must be odd, positive and integral but not necessarily equal, and its coefficients. The output DN is found by dividing the sum of the products of corresponding convolution kernel and image elements often divided by the number of kernel elements.

High-Pass (Sharpening) Filters: Simply subtracting the low-frequency image resulting from a low pass filter from the original image can enhance high spatial frequencies. High frequency information allows us either to isolate or to amplify the local detail. If the high-frequency detail is amplified by adding back to the image some multiple of the high frequency component extracted by the filter, then the result is a sharper, de-blurred image.

The low pass filtering did not reveal a lot of features details; therefore, high pass filtering was the more adequate and it revealed much more details on Amman image (figure 5; a comparison between low pass filter and high pass filter).

Low pass filter



High pass filter

Fig. 5: A comparison between low pass filter (up) and high pass filter (down).

4. GIS as a source of digital mapping and for geo-spatial database

A geographic information system (GIS) is a system for capturing, storing, analyzing and managing data and associated attributes which are spatially referenced to the earth. In the strictest sense, it is a computer system capable of integrating, storing, editing, analyzing, sharing, and displaying geographically-referenced information.

In a more generic sense, GIS is a tool that allows users to create interactive queries (user created searches), analyze the spatial information, edit data, maps, and present the results of all these operations. Geographic information science is the science underlying the applications and systems, taught in degree programs at many universities [1].

The power of a GIS comes from the ability to relate different information in a spatial context and to reach a conclusion about this relationship. Most of the information we have about our world contains a location reference, placing that information at some point on the globe. When rainfall information is collected, it is important to know where the rainfall is located. Using a location reference system, such as longitude and latitude, and perhaps elevation, does this.

Comparing the rainfall information with other information, such as the location of marshes across the landscape, may show that certain marshes receive little rainfall. This fact may indicate that these marshes are likely to dry up, and this inference can help us make the most appropriate decisions about how humans should inter-act important new information that leads to better decision making.

Many computer databases that can be directly entered into a GIS are being produced by federal, state, tribal, and local governments, private companies, academia, and non-profit organizations.

Different kinds of data in map form can be entered into a GIS. A GIS can also convert existing digital information, which may not yet be in map form, into forms it can recognize and use. For example, digital satellite images can be analyzed to produce a map of digital information about land use and land cover. Likewise, census or hydrologic tabular data can be converted to a map like form and serve as layers of thematic information in a GIS.

Relating information from different sources, the power of a GIS comes from the ability to relate different information in a spatial context and to reach a conclusion about this relationship. Most of the information we have about our world contains a location reference, placing that information at some point on the globe. When rainfall information is collected, it is important to know where the rainfall is located.

This is done by using a location reference system, such as longitude and latitude, and perhaps elevation. Comparing the rainfall information with other information, such as the location of marshes across the landscape, may show that certain marshes receive little rainfall. This fact may indicate that these marshes are likely to dry up, and this inference can help us make the most appropriate decisions about how humans should interact with the marsh.

A GIS, therefore, can reveal important new information that leads to better decision-making. Many computer databases that can be directly entered into a GIS are being produced from different sources; different kinds of data that has been extracted from topographic map and from the IKONOS image of Amman were entered into the GIS as geospatial database. Digital satellite images can be analysed to produce a map of digital images about urban features as layers of thematic information in a GIS environment.

4.1. Data integration

A GIS makes it possible to link, or integrate, information that is difficult to associate through any other means. Thus, a GIS can use combinations of mapped variables to build and analyze new variables. In Amman case, using GIS modelling make it possible to combine urban features with all related data to determine which areas are useful for urban growth and which is not.

It is impossible to collect data over every square meter of the earth's surface. Therefore, samples must be taken at discrete locations. A GIS can be used to depict two- and three-dimensional characteristics of the earth's surface, subsurface, and atmosphere from points where samples have been collected.

4.2 Registering the paper map

Paper map must register into real-world coordinates before start digitizing. This allows digitizing features directly in geographic space. Always register the map at the start of each digitizing session, even if this means registering the same map more than once. The paper map might shift between sessions; reregistering helps ensure that digitizing is accurate. When registering the map, you have the option of saving the ground coordinates you entered for later use for example, if you want to reregister your map or register another map that uses the same control points. These ground coordinates are stored in tic text files. The topographic map of Amman has registered several times as explained above. The following figure 6 shows registration process.

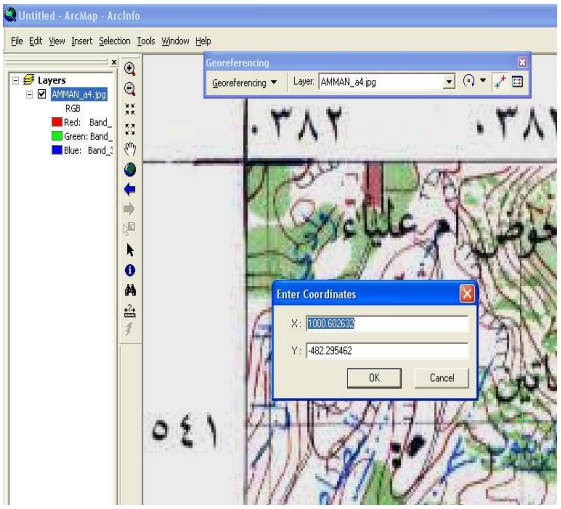


Fig. 6: Registering the paper map by ArcMap.

4.3 Digitizing and map production

Digitizing is the process of converting features on a paper map into digital format. To digitize a map, you use a digitizing tablet (also known as a digitizer) connected to your computer to trace over the features that interest you. The x,y coordinates of these features are automatically recorded and stored as spatial data. (Figure 7 an example of road network digitizing).

Digital mapping: is to get maps you can use in many application and have (temporal, thematic, and spatial) and flexibility in any correction or any application. The digital mapping is getting by used GIS software. GIS is used in a variety of agricultural applications such as managing crop yields, monitoring crop rotation techniques, and projecting soil loss for individual farms or entire agricultural regions. GIS is a tool for managing business information of any kind according to where it's located. You can keep track of where customers are, site businesses, target marketing campaigns, and optimize sales territories**.** And another application which is translation in digital mapping.

Before start digitizing, we must register our map into real-world coordinates Use the JTM projection, this allows us to digitize features directly in geographic space. Editing is the process of correcting any errors may present through the digitizing process on ENVI such as Trim, merge, unclosed polygon, and so on.

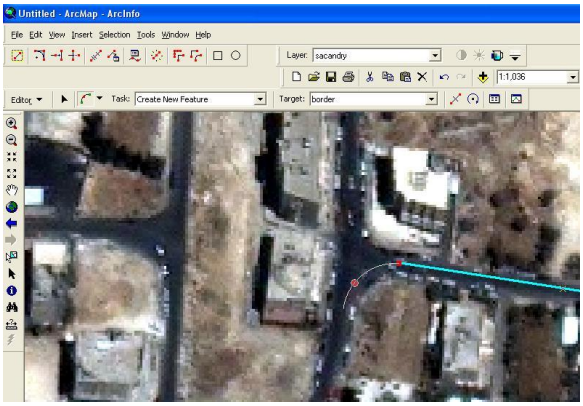


Fig. 7: Road network digitizing by ArcMap.

5. GIS MODELLING AND GIS ANALYSIS

6.1 GIS modelling

In this study, all the digitized layers have been modelled and then stored as geo-spatial database for west of Amman area; consequently, many maps were produced directly by using Arc GIS software, as following:

- Urban area maps showing the urban area in west of Amman area; as delineated from the Topographic Map1982, IKONOS Image 2002 and IKONOS Image 2006 (figure 8).

- Agricultural area maps showing the agricultural area in west of Amman area;

as delineated from the Topographic Map1982, IKONOS Image 2002 and IKONOS Image 2006 (figure 9).

- Road network maps showing the road networks in west of Amman area; as delineated from the Topographic Map1982, IKONOS Image 2002 and IKONOS Image 2006 (figure 10).

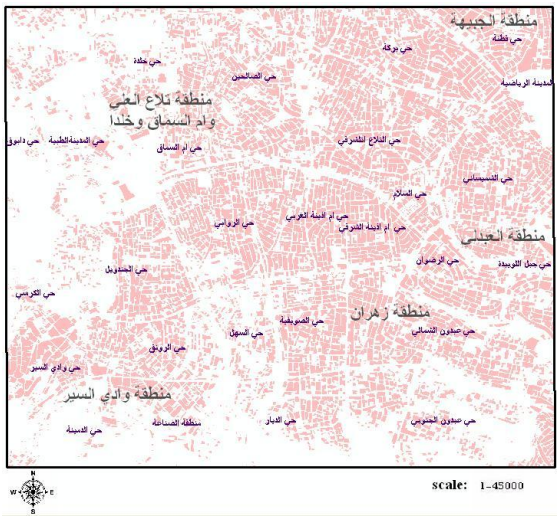


Fig. 8: Urban areas in west of Amman area as delineated from the topographic map1982, IKONOS image 2002 and IKONOS image 2006.

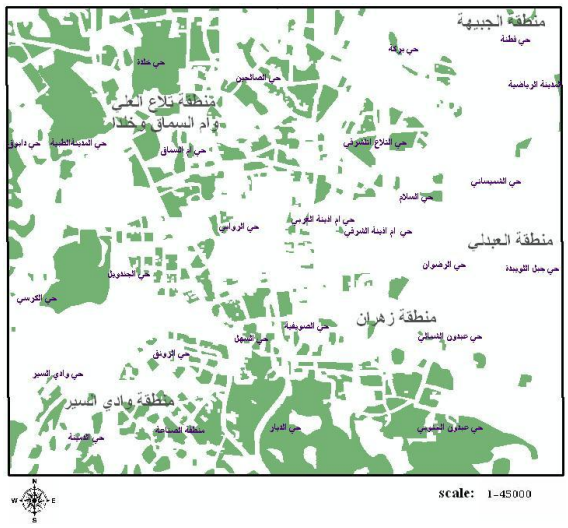


Fig. 9: Agricultural areas in west of Amman area as delineated from the topographic map1982, IKONOS image 2002 and IKONOS image 2006.

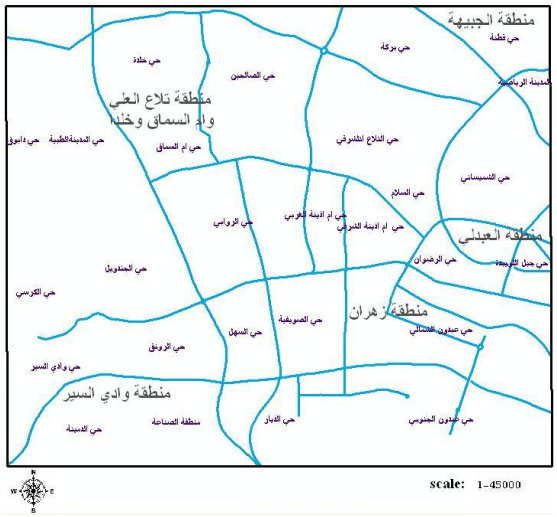


Fig. 10: Road network in west of Amman area as delineated from the topographic map1982, IKONOS image 2002 and IKONOS image 2006.

6.2 GIS Analysis

Many GIS databases consist of sets of information called layers. Each layer represents a particular type of geographic data. For example, one layer may include information on the streets in an area. Another layer may contain information on the soil in that area, while another records elevation. The GIS can combine these layers into one image, showing how the streets, soil, and elevation relate to one another. Engineers might use this image to determine whether a particular part of a street is more likely to crumble. A GIS database can include as many as 100 layers.

Data analysis is the process of interpreting data; this may range from simple exploratory data analysis, which involves simply looking at the data and describing what you see to complex analysis such as modelling. In this section, a model will be used to analysis and produce maps for west of Amman area that is appropriate for urban planning.

Spatial analysis of GIS starts with the basic operation of visualisation (exploratory data analysis). Visualization is a critically important function in GIS: the human ability to recognise spatial relationships on maps, images and other graphical displays (on screen) or hardcopy (maps) output. Geoscientists are accustomed to looking at maps, and from the map patterns they have the ability to postulate geological structure.

In GIS geo-spatial database is a powerful tool that can provide better information to support many types of difficult decision- making. With the rapid advancements taking place in computer hardware and GIS software, more complex models are being developed. These models help researchers and planners to simplify complex systems and to develop theories to better understand the processes at work.

Present analytical functions and conventional cartographic modelling techniques in GIS are based on Boolean logic, which completely assumes that objects in a spatial database and their attributes can be uniquely defined [5], [6] and [7].

The following map was produced by adding three different GIS layer (urban areas, agricultural areas and road networks) as digitized from the same sources (topographic map or IKONOS image 2002 or IKONOS image 2006).

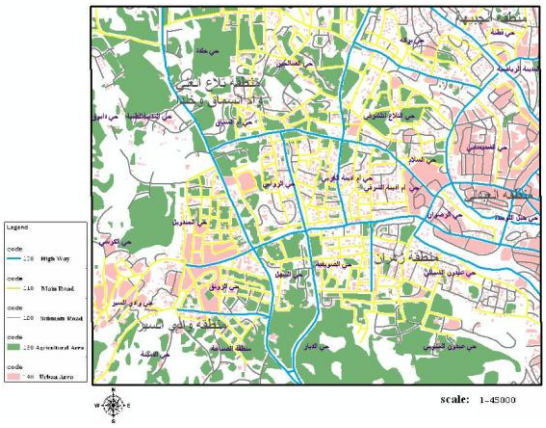


Fig. 11: Final map showing the urban areas, agricultural areas and road networks for west of Amman as delineated from the topographic map1982, IKONOS image 2002 and IKONOS image 2006.

The simplest and best-known type of GIS model is based on Boolean operations. These operations correspond to the set operation of complementation, union and intersection. This is the basis for most GIS-related integration.

"Present analytical functions and conventional cartographic modelling techniques in GIS are based on Boolean logic, which completely assumes that objects in a spatial database and their attributes can be uniquely defined". [7] The Boolean method, which applies the rules of Boolean algebra, where the results take on one of two values, e.g. yes/no, true/false, or 0/1, was used for modelling in this study. In this study, all the mapped features have been stored in the GIS database; consequently, a map was produced directly by using the Boolean OR (logical union) operator. The final map showing the urban areas, agricultural areas and road networks for west of Amman as delineated from the topographic map1982, IKONOS image 2002 and IKONOS image 2006 are shown in figure 11.

7. Conclusion

Digital image processing techniques in addition to a GIS modelling were used for mapping geospatial features in west of Amman area. The resultant of this is a number of GIS layers and their attributes.

It has been found that remote sensing techniques and GIS modelling have a direct and major role for a fast and accurate mapping.

Several new maps for the western part of Amman area were updated and produced from the topographic maps and satellite images (IKONOS 2002 and 2006). The resultant maps are: urban areas, road networks and agricultural area.

Satellite images and associated digital image processing techniques in addition the GIS were implied and they were very useful in order to produce Geo-spatial database that can be used for a better urban planning in west Amman area.

IKONOS satellite image and topographic maps at a scale of 1:50 000 were employed to produce maps for urban areas, agricultural areas and road network. Thereafter, all the produced maps and their attributes have been stored as geospatial database consequently spatial map can be produced.

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