Using GIS, Remote Sensing and Associated Digital Image Processing Techniques to produce Land Use Capability Map for Zarqa area, Jordan

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ABSTRACT

Land use capability maps are important tool; that can be used for many purposes. Many features such as lithology, topography, gradient, soil, and vegetation are essential to be identified in order to create a Land Use Capability Map. Land use capability maps are deferent from land use maps. The Land use capability map shows the potential uses (usually in relation to farming) whilst the latter shows the actual use for the land at the present time. Remote sensing, digital image processing and GIS, techniques have been implemented on Al-Zarqa area in order to enhance the required features in the image. On screen digitizing techniques were applied to delineate lithology, topography, gradient, soil, and vegetation from topographic map, geological map and satellite images. New maps for Al-Zarqa area were produced from. The resultant maps are: lithological map, faults map, a road network map, vegetation map, a contours map, slope map, aspect map, hill shade map and land use capability map. Thereafter, the produced layers and their attributes in addition to Al-Zarqa DEM were stored as GIS database using Arc GIS software to be used in producing the land use capability map for Al–Zarqa area.

Key words: GIS, Digital image processing techniques, Remote sensing, Land use mapping and geospatial database.

1. Introduction

Jordan officially the Hashemite Kingdom of Jordan is a country in the Arab World in Southwest Asia, bordered by Syria to the north, Iraq to the north-east, Palestine to the west, and Saudi Arabia to the east and south. All these borderlines add up to 1,619 km (1,006 mi). It shares with Palestine the coastlines of the Dead Sea, and the Gulf of Aqaba with Palestine, Saudi Arabia, and Egypt. Thus, Jordan has a coastline of 26 km (16 mi).

1.1 Zarqa Governorate:

Zarqa is a city in Jordan located to the northeast of Amman. At 792,665 inhabitants (2000), comprising 15.5% of Jordan's population, it is the country's second largest city. Zarqa is the capital of Zarqa Governorate (Arabic Muhāfazat az-Zarqā). Its name means "the blue one". Zarqa is Jordan's industrial centre, home to over 50% of Jordanian factories. The growth of industry in the city is the result of low real estate costs and proximity to the capital, Amman. Migration to Zarqa has steadily progressed since the 1940s. More than 50% of Zarqa's population migrated from the West Bank following the Six Day War. Zarqa's climate is desert-like, to a much greater degree than nearby Amman. Qasr Shebib is a prominent local landmark.

1.2 Area of Interest

Al-Hashimia region is the area of our interest the boundary of this area (study area) is about 35 km east of Amman its area is about 210 Km^2. We predict for this region to become industrial potential in the soon future and urban expanding because of the crudity of the city center. Therefore, we put our concerning in this area.

Projected coordinate (JTM)

X	Y
408201	551852
429218	551965
429062	541576
408082	541838

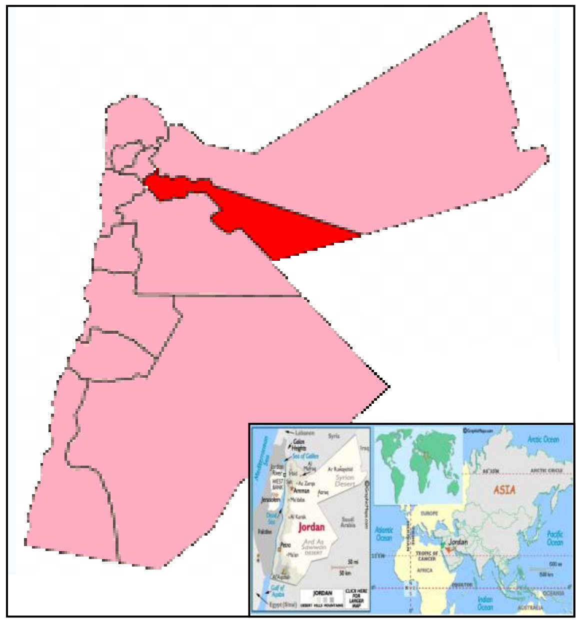

Figure 1. Study area among the Jordan governorates.

Figure 2. The area of interest (Google Earth Image).

1.3. Topography

It is different terrain models from flattening to roughness of land pattern. The average elevation in this area is 680 m from Mean Sea Level. The appearing slope is varying from place to place but it generally is from east to north east of the region. The fracturing content is very high because of the rock types that extend in that region.

1.4 Climate and Vegetation

This area belongs to the semi arid region in Jordan; the climate is cold during winter and very hot in the summer. There are changing in the temperature between the day and night. Although it is arid weather but it is very cold at night, even in summer season. The raining average is between 50 to 100 mm yearly. The area is poor in vegetation because of arid climate, the lack of rain and the shallow soil.

1.5 Research Objectives

Main objectives:

1. To employ the Digital Image Processing and Remote Sensing techniques on Al-Zarqa image in order to enhance the features.
2. To update & construct the land capability map of Al-Zarqa area.
3. To integrate the land capability map with the GIS layers.
4. To create GIS database (GIS layers and maps for the Al- Zarqa area).

Secondary objectives:

1. Create Lithology Layers.
2. Create DTM for the interest area.
3. Create terrain surfaces (Slope, Aspect, Hill shade, and curvature) for the interest area.

1.6 Software Modules

In this study several software were used in order to complete the production of this study, the following software were employed:

ArcGIS Desktop (version 9.2)

ARCGIS is an integrated, scalable suite of software for compiling, authoring, analyzing, mapping, and publishing geographic information and knowledge. ArcGIS Desktop starts with Arc Reader and extends to include Arc View®, Arc Editor, and Arc Info, each component exposing more GIS capabilities. Additional desktop extensions expand GIS capabilities.

ENVI (version 4.3)

ENVI program is more specific in remote sensing application, but we use Envi4.3 in order to the Land-Sat Scene.

Ski-Pro

Ski-pro is one of the famous programs in the field of the GPS processing. We used the Ski-pro program to process the raw data we obtained to make a zone for the study area from WGS84 to JTM.

1.6 Methodology

Landsat-7 image, topographic and geologic maps at scale 1:50,000 were employed in this study. Spectral enhancements and textural analysis utilizing false color composite, high-pass filter and directional edge enhancements were applied on the study area. New maps for Al-Zarqa area were produced from. The resultant maps are: lithological map, faults map, a road network map, vegetation map, a contours map, slope map, aspect map, hill shade map and land use capability map. Thereafter, the produced layers and their attributes in addition to Al-Zarqa DEM were stored as GIS database using Arc GIS software to be used in producing the land use capability map for Al–Zarqa area.

2. Land Cover / Land Use Capability

Land use: is a description of how people utilize the land and socio-economic activity. Urban and agricultural land uses are two of the most commonly recognized high-level classes of use. At any one point or place, there may be multiple and alternate land uses, the specification of which may have a political dimension.

Land use capability maps: are maps created to represent the potential uses of a "unit" of land. They are measured using various indicators, although the most common are five physical factors (rock type, soil type, slope, erosion degree and type, and vegetation). In more scientific terms, these can be classed as lithology, topography, gradient, and biotic features. Land use capability maps must not be confused with land use maps. The former shows the potential uses (usually in relation to farming) whilst the latter shows the actual use for the land now.

Land cover: is distinct from land use despite the two terms often being used interchangeably. One of the major land cover issues (as with all natural resource inventories) is that every survey defines similarly named categories in different ways. For instance, there are many definitions of ‘Forest’, sometimes within the same organization, that may or may not incorporate a number of different forest features (stand height, canopy cover, strip width, inclusion of grasses, and rates of growth for timber production). Areas without trees may be classified as forest cover if the intention is to re-plant (UK and Ireland), areas with many trees may not be labeled as forest if the trees are not growing fast enough such as Norway and Finland [1].

Terrain or relief: is an essential aspect of physical geography, and as such its portrayal presents a central problem in cartography, and more recently GIS and 3D Visualization.

2.1 Land use and the environment

Land use is the human modification of natural environment or wilderness into built environment such as fields, pastures, and settlements. Land use and land management practices have a major impact on natural resources including water, soil, nutrients, plants and animals. Land use information can be used to develop solutions for natural resource management issues such as salinity and water quality.

For instance, water bodies in a region that has been deforested or having erosion will have different water quality than those in areas that are forested. According to a report by the United Nations' Food and Agriculture Organization, land degradation has been exacerbated where there has been an absence of any land use planning, or of its orderly execution, or the existence of financial or legal incentives that have led to the wrong land use decisions, or one-sided central planning leading to over-utilization of the land resources - for instance for immediate production at all costs.

Consequently, the result has often been misery for large segments of the local population and destruction of valuable ecosystems. Such narrow approaches should be replaced by a technique for the planning and management of land resources that is integrated and holistic and where land users are central.

This will ensure the long-term quality of the land for human use, the prevention or resolution of social conflicts related to land use, and the conservation of ecosystems of high biodiversity value. The interaction between land use and climate variability is poorly understood and will require the development of models linking the geophysics of climate with the socioeconomic drivers of land use.

Providing a scientific understanding of the process of land-use change, the impacts of different land-use decisions, and the ways that decisions are affected by a changing climate and increasing climate variability are priority areas for research.

2.2 Land Use / Land Cover Change:

Land use and land cover are linked to climate and weather in complex ways. Key links between land cover and climate include the exchange of greenhouse gases between the land surface and the atmosphere, the radiation balance (both solar and long-wave) of the land surface, the exchange of sensible heat between the land surface and the atmosphere, and the roughness of the land surface and its uptake of momentum from the atmosphere. Because of these strong links between land cover and climate, changes in land use and land cover are important contributors to climate change and variability. Reconstructions of past land-cover changes and projections of possible future land-cover changes are needed to understand past climate changes and to project possible future climate changes Land-cover characteristics are important inputs to climate models.

In addition, changes in land use and land cover affect ecosystems, biodiversity, and the many important goods and services they provide to society, including carbon sequestration. The ability to forecast land use and land cover change and, ultimately, to predict the consequences of change, will depend on our ability to document and understand the past drivers of land use and land cover change. Historical land use and cover change has occurred primarily in response to population growth, technological advances, economic opportunity, and public policy. Patterns of human settlement are shaped by both the interaction of environmental (e.g., climate, geology, topography, and vegetation) and social (e.g., cultural customs and ethnicity) forces around the world.

An improved understanding of historical land use and land cover patterns provides a means to evaluate variations in past causal factors and responses as well as a method for evaluating the trends of human activities present in the current baseline.

The systematic evaluation of these historical and contemporary factors will improve the ability to develop projections of future land use and management decisions.

2.3 Land Capability Classification

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for forestland, or for engineering purposes. In the capability system, soils are generally grouped at three levels—capability class, subclass, and unit.

2.3.1 Capability subclasses

Capability subclasses are soil groups within one class. They are designated by adding a small letter, e, w, s, or c, to the class numeral, for example, 2e. The letter e shows that the main hazard is the risk of erosion unless close-growing plant cover is maintained; w shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); s shows that the soil is limited mainly because it is shallow, droughty, or stony; and c, used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry. In class 1 there are no subclasses because the soils of this class have few limitations. Class 5 contains only the subclasses indicated by w, s, or c because the soils in class 5 are subject to little or no erosion. They have other limitations that restrict their use to pasture, rangeland, forestland, wildlife habitat, or recreation.

2.3.2 Capability units

Capability units are soil groups within a subclass. The soils in a capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, 2e-4 and 3e-6. These units are not given in all soil surveys.

2.4 Land Capability layers

The most common layers in land use capability maps are five physical factors:

1- Lithology

2- Edaphology

3- Gradient

4- Topography

5- Biotic features and vegetation

3. Remote sensing and Digital Image Processing

Is the small or large-scale acquisition of information of an object or phenomenon, by the use of either recording or real-time sensing device(s) that is not in physical or intimate contact with the object (such as by way of aircraft, spacecraft, satellite, buoy, or ship).

Remote Sensing with respect to wavelength regions is classified into three types in respect to the wavelength regions; visible and reflective infrared remote sensing, thermal infrared remote sensing and Microwave remote sensing.

Electromagnetic waves are radiated through space. When the energy encounters an object, even a very tiny one like a molecule of air, one of three reactions occurs. The radiation will either be reflected off the object, absorbed by the object, of transmitted through the object.

The total amount of radiation that strikes an object is referred to as the incident radiation, and is equal to: Reflected radiation + absorbed radiation + transmitted radiation. [5].

3.1 Digital image processing

Digital image processing is the use of computer algorithms4 to perform image processing on digital images. As a subfield digital signal processing, digital image processing has many advantages over analog image processing; it allows a much wider range of algorithms to be applied to the input data, and can avoid problems such as the build-up of noise and signal distortion during processing. Digital image processing allows the use of much more complex algorithms for image processing, and hence can offer both more sophisticated performance at simple tasks, and the implementation of methods, which would be impossible by analog means. [3].

The ENVI 4.3 software has been implemented in order to execute the various digital image processing techniques on the satellite image of the study area. Selective digital image processing techniques were applied on the image of the study area in order to enhance it, thereafter, to extract the required information for the Land use capability mapping.

4. GIS Analysis and Discussion

GIS is both a database system with specific capability for spatially referenced data, as well as a set of operations for working with the data". [6]. GIS play role in society: define GIS as "Organized activity by which people measure and represent geographic phenomena and then transform these representations into other form while interacting with social structures" [4].

General purpose of GIS analysis is to perform five processes or tasks; Input, Manipulation, Management, Query and Analysis and Visualization. In this project ArcGIS 9.2 Software was implemented that because it provides a complete set of tools for modeling geographic information to support smarter, faster decisions. Before geographic data can be used in a GIS, the data must be converted into a suitable digital format. Today many types of geographic data already exist in GIS-compatible formats.

These data can be obtained from data suppliers and loaded directly into a GIS. If the data was not in digital format there will be need for converting data into digital form. The process of converting data from paper maps into computer files is called digitizing. The digitizing process achieved by two ways Scanner and digitizer board. Scanner converts a picture into a digital image for further processing. The output of scanner can be stored in many formats e.g. TIFF, BMP, JPG [2].

Any data types required for a particular GIS project will need to be transformed or manipulated in some way to make them compatible with your system. For example, geographic information is available at different scales. Before this information can be integrated, it must be transformed to the same scale. This could be a temporary transformation for display purposes or a permanent one required for analysis. GIS technology offers many tools for manipulating spatial data and for weeding out unnecessary data.

For small GIS projects it may be sufficient to store geographic information as simple files. However, when data volumes become large and the number of data users becomes more than a few, it is often best to use a database management system (DBMS) to help store, organize, and manage data. A DBMS is nothing more than computer software for managing a database. In this study all shape files converted into data base.

4.1 Visualization

For many types of geographic operation the end result is best visualized as a map or graph. Maps are very efficient at storing and communicating geographic information. While cartographers have created maps for millennia, GIS provides new and exciting tools to extend the art and science of cartography. Map displays can be integrated with reports, three-dimensional views, photographic images, and other output such as multimedia. Producing the contour line map for the Zarqa area in this study is adequate and sufficient to create the TIN and the Digital Elevation Model (DEM).

5. Results

Data entry could be very time consuming, but it is the most important task of the GIS process. All the required GIS process for Zarqa area were completed that including; data entering, scanning, layers designing, digitizing, geo-referencing, projection, creating layouts and (3D) Applications using "ArcGIS" program. As a result of data entering, scanning, layers designing, digitizing, geo-referencing and projection, many layers were produced for Zarqa area; such as topographical map, geological map, drainage pattern map, contour lines map, road network map, residential area map, vegetation map, faults map, lithology map, slope map and aspect map.

All produced layers and their attributes have been stored as relational GIS and RS database for Zarqa area. Any layer can be produced as a single map for a thematic purpose. The following figures are two examples of produced maps and for illustrating purposes (figures 3and 4).

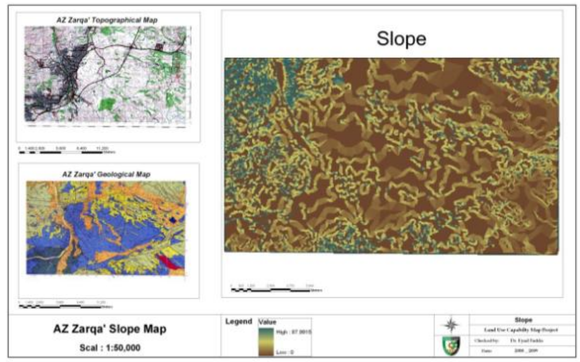

Figure 3. Slope map, example of produced layers that have been stored as Geo–database for Zarqa area.

Figure 4. Lithological section, example of produced layers that have been stored as Geo–database for Zarqa area.

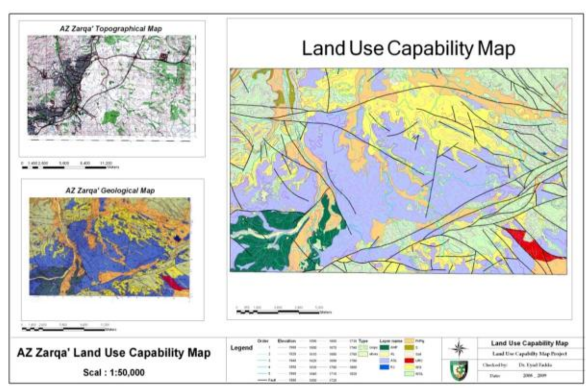

Figure 5. Land use capability map for the Zarqa area; that included many features such as lithology, topography, gradient, soil, and vegetation.

The Land use capability map for the Zarqa area that included many features such as lithology, topography, gradient, soil, and vegetation was created figure 5. The other produced layers and their attributes in addition to Al-Zarqa DEM were stored as GIS database for Zarqa area.

6. Conclusions

Many features such as lithology, topography, gradient, soil, and vegetation are essential to be identified in order to create a Land Use Capability Map. Geographic Information Systems (GIS) and Remote sensing techniques were used to delineate the required features (lithology, *topography, gradient, soil, and vegetation)* in order to create Land Use Capability Map for Al–Zarqa area.

Remote sensing, digital image processing and GIS, techniques have been implemented in order to enhance the required features in the image. Landsat-7 (ETM+) images have the advantage of low cost and large area coverage; therefore mapping can be easy and quick. Moreover, GIS is important technique that can be used to digitize spatial features and for querying, displaying and creating maps.

The produced layers and their attributes in addition to Al-Zarqa DEM were stored as GIS database using Arc GIS software to be used in producing the land use capability map for Al–Zarqa area.

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