Land Use and Land Cover Map of Ninevah Governorate Using Remote Sensing Data

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ABSTRACT

Changes in the nature of land use activities, in time and space, often result in land cover changes and, as such, are an indication of land management activities. This research represents an attempt to evaluate the ability of using the new version of Anderson's classification system up to the third level in the land use and land cover classifications of Ninevah Governorate using Landsat TM7 imagery.

The study area represents one of the most varied and complex geomorphic landscapes in Iraq, and characterized by irregular land use and different land cover in the geomorphic distribution of landforms. Geomorphic agent represent the main factors in the spatial distribution of soil types, lithological escarpments, and the existing land use patterns.

The land use and land cover map shows the whole of the apparent activities up to the third level according to the USGS system, and 27 classes of land use are shown in the final map.

The results show that visual analyses of satellite images, applying methods similar to those commonly used for aerial photo analysis, are sufficient for observing features shown on 1:100,000 scale Landsat images. Digital classification is appropriate for some applications, but it was found that land use and land cover mapping projects of the type described here are not among them. These data were utilized to draw a new regional land use and land cover map of Ninevah Governorate at a scale of 1:250,000 .

خارطة استخدامات الأرض والغطاء الأرضي لمحافظة نينوى باستخدام معطيات التحسس النائي

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الملخص

إن الاختلافات في طبيعة نشاطات استخدامات الأرض، في الزمان والمكان، غالباً ما تؤدي الى اختلافات في الغطاء الأرضي والتي تمثل دليلاً على فعاليات إدارة الأراضي. هذه الدراسة تمثل محاولة لتقدير إمكانية استخدام النسخة الحديثة من نظام تصنيف **اندرسن**، وصولاً الى المستوى الثالث في تصنيف

استخدامات الأرض والغطاء الأرضي لمحافظة نينوى بأستخدام مرئيات راسم الخرائط الموضوعي لاندسات ٧.

تمثل منطقة الدراسة واحدة من اكثر المناطق الجيومورفولوجية المعقدة في العراق والتي تمتاز بتباين في كل من استخدامات الأرض والغطاء الأرضي وفي التوزيع الجيومورفولوجي الحالي لأشكال سطح الأرض. إن العامل الجيومورفولوجي اصبح العامل السائد والمسيطر في التوزيع المكاني لأنواع الترب، المكاشف الصخرية والنمط السائد لاستخدامات الأرض.

تظهر الخارطة النهائية لاستخدامات الأرض والغطاء الأرضي مجمل الفعاليات وصولا الى المستوى الثالث وحسب نظام مصلحة المساحة الجيولوجية الأمريكية إذ حدد فيها (٢٧) صنفاً من استخدامات الارض.

أسفرت النتائج الى أن التفسير البصري للمرئيات الفضائية، وبتطبيق نفس الطرق المستخدمة في تفسير الصور الجوية، تكون كافية في تمييز وتحديد الأشكال الظاهرة على المرئيات الفضائية بمقياس ١:١٠٠.٠٠٠. إن التصنيف الرقمي يكون مناسباً في بعض التطبيقات، الا انه غير مناسب في مشاريع خرائط استخدامات الأرض والغطاء الأرضي وحسب ما جاء في هذه الدراسة. استخدمت هذه المعطيات في إعداد أول خارطة عامة لاستخدامات الأرض والغطاء الأرضي لمحافظة نينوى بمقياس ١:٢٥٠.٠٠٠.

INTRODUCTION

Land use and land cover are subjected to variations in space and time because of the influence of land management activities. In order to take corrective and protective measures, it is essential to have accurate information about any area in the form of maps (AL_Daghastani, 1999; Zhou and Hui, 2004).

The present landscape of the Ninevah Governorate, located in the north western part of Iraq between longitudes 41º 30' _44º 30' and latitudes 35º 00' _37º 00', is viewed as the product of a series of interactions between fluvial and denuded processes operating on the underlying geology, that has been subjected to both past and ongoing endogenic deformation by folding and faulting, arrising from the progression of continual plate collision between the Arabian and Eurasian plates since Miocene onwords (Daly, 1989; Numan, 2001; AL_Daghastani, 2007).

The results presented here illustrate the potential for using visual interpretation of Landsat TM images as a tool for establishing a land use and a land cover data base of Ninevah Governorate, leading to the construction of a full view new map at a scale of 1:250,000.

The map enables users to obtain an inventory of natural resources of Ninevah Governorate. Consequently, this map is a suitable tool to assist personnel's of the departments of agriculture, natural resources, forestry, and land use planning in present and future activities.

MATERIALS AND METHODS OF INVESTIGATION

The selection of images, image products and spectral channels to be used should be based on field experience, taking into consideration the consequences these choices will have on the results of the project (Jensen, 2007). Complete cloud-free coverage of the Ninevah Governorate by the Landsat TM7 imagery (Fig. 1), taken in January 2004, has been analyzed to determine major and minor land use and land cover units, and their relationships with geomorphologic landscapes.

The Anderson's classification system presented in this map (Anderson *et al*.,1976 and 2001), provides flexibility in developing categorization at the more detailed levels. Therefore, it is appropriate to illustrate the additive properties of the system and to provide examples for users require to develop more detailed categorization. A comparison classification was carried out by visual and digital interpretation methods as follows:

1- Visual interpretation:

The principle of visual interpretation of Landsat images is as follows. Each image characteristics are translated into land management activities. The translation process is guided by local knowledge (e.g. geomorphic landforms, soil types, report of agricultural statistics, etc.), which can be collected during field work or background studies. Polygons are drawn around features (e.g. Fields, land units, homogeneous areas with natural vegetation, small cropping units, grazing land, irrigation canals, rivers, lakes, settlements, roads, etc.), and a label referenced to tables is assigned to each polygon, characterizing it by activities following the scheme devised by the USGS system (Anderson *et al*., 2001). Image characteristics could be a pattern, texture, height differences, colors or tones on the image, or the changing colors during a growing season (Lillesand and Kiefer, 2000).

The scale to be used for construction of the final map was determined by the scale of the best available base map (e.g. 1:100,000 topographic maps), the scale of enlarged Landsat images, and the need for a practical size for provincial land use planning. The transparent overlays with the interpretation results were reduced on scale 1:250,000. From the data base, the final map (scale 1:250,000) were produced, and land cover statistics were computed, class by class, for the entire study area. Based on a comparison between collected field data and the corresponding visual interpreted areas in the Landsat images, the USGS system was them finalized.

2- Digital classification:

As satellite images are stored digitally, digital processing is the logical step to obtain thematic information. To obtain this information from images, a classification procedure should be used. Numerous algorithms using single and multiple satellite images have been described (Mather, 1987, Al-Shumam, 2001, Rafael *et al*., 2002). The author's experience in the use of digital classification for complicated thematic mapping is consistently negative compared with manual methods. This experience is based on a number of earlier mapping projects in which digital classification was used and on comparative tests -for example the geomorphic map of Ninevah Governorate- between visual interpretation and digital classification (AL-Daghastani, 2007). On the basis of experience, digital and visual interpretation, a confusion information was produced showing pairs of classes which could be misclassified (Fig. 2), as follows:

- Basin of Mosul dam lake / playa lake
- River terraces / structurally controlled denudational hills.
- Mixed erosional glacis on sloping foothill surfaces / structurally controlled low folded topography.

However, as other information sources were taken into account during the interpretation process, the risk of misclassification was not considered to be high. In this study visual interpretation was found to perform better than digital processing in classifying land use and cover types.

GEOMORPHOLOGY OF NINEVAH GOVERNORATE

Interest in the geomorphic classification of the study area was based on the assumption that patterns of topography, soil type and vegetation covers are so related that one can be used to predict the others. Using indicators such as drainage density, pattern and appearance, dominant land use and land cover erosion scars (as identified by bright tones from the exposed subsoil), and topography (as identified from shadow effects), it was possible to distinguish all major physiographic regions of the study area in the images. The shadow effects also provided clues to the level of incision of the drainage network, particularly in the structurally controlled high and low folded topography which deeply cuts drainages.

The study area consists of three main genetic groups of landforms (AL-Daghastani, 2007), and based on units of tectonic, fluvial and denudation landforms types, the groups are sub divided in to 14 subunits as follows:

Group one: Landforms of Tectonic Origin

1- Structurally controlled high folded topography.
2- Structurally controlled low folded topography .
3- Structurally controlled denudational hills.

Group two: Landforms of Fluvial Origin

4- Tigris River Valley and its tributaries.
5- Seasonal dry valleys .
6- Fluvial river terraces at low levels.
7- Fluvial river terraces at high levels.
8- Basin of Mosul Dam lake .
9- Depression salt areas and playa lakes.

Group three: Landforms of Denudational Origin

10- Stable accumulation glacis on sloping foothill surfaces.
11- Mixed erosional glacis on sloping foothill surfaces .
12- Active erosional glacis on gently sloping surfaces .
13- Karstic landforms with sinkholes and subsurface valleys.
14- Aeolian sand deposits without distinct dune forms.

The climate of the study area has a marked dry hot season between June to September, and wet cool season between November and April. Differences in elevation between the different physiographic units create a climate range that varies from

Moderate in the high folded topography (e.g. 1470 masl) to Semi Arid in some areas in the gently sloping surfaces (e.g. 150 masl).

Fig. 1: Coverage of Ninevah Governorate by normal color Landsat TM imagery showing major and minor land use and land cover units.

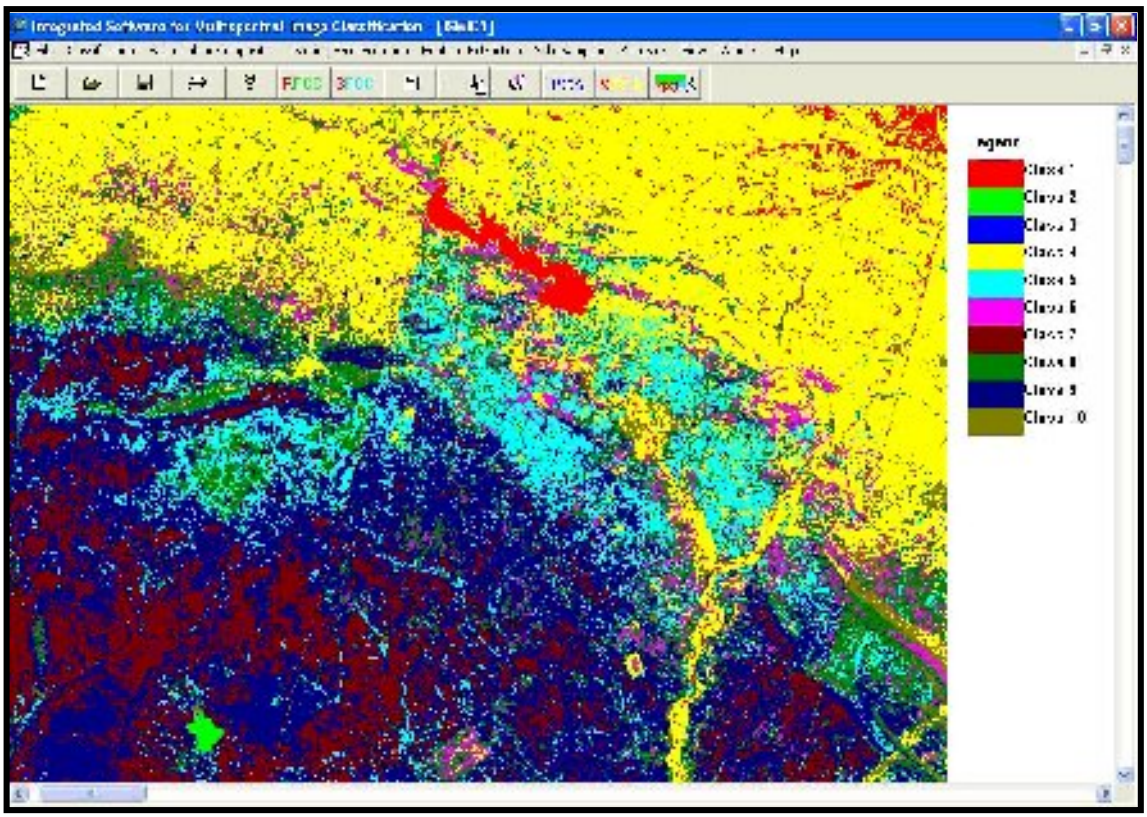

Fig. 2: Ten major classes are shown on an unsupervised classification method.

One of the prime prerequisites for better use of land in Ninevah Governorate is information on existing land use patterns and changes in land use through time. Knowledge of the present distribution and area of such agricultural, industrial, recreational and urban lands, as well as information on their changing proportions, is needed by planners and state or local governmental officials to determine better land use policy.

More recently, this information is needed to identify future development pressure points and areas, and to implement effective plans for regional development.

The land use and land cover classification system presented in this map (Table 1) includes only the more generalized first, second and third levels. Figure (3) depicts typical map which has been produced using the USGS land use and land cover classification system. The extent to which land use and land cover changes can be detected depends on the extent to which these changes are detectable using the techniques described above.

Land use features mainly include different types of agricultural (vegetable and crop) lands. They were best identified by image signals such as colors, texture, pattern and location. The analyses of land use features, as well as settlement and infrastructure, were greatly facilitated by using transparent overlays of topographic map of the same scale as the images. By placing these transparencies over the images, their information could be related directly to the image content.

The clearest features in the images were primarily the extensive North Al-Jezira Irrigation project, and the winter crop (wheat and barley) plantations in the gently sloping surfaces. The seasonal vegetable plantations (with their characteristically angular pattern in the images), which were often located along the main fluvial river terraces (Tigris River and its tributaries) to ensure access to water. These three classes could be easily mapped in all the images.

All major road network, population centers such as towns and major villages were identified to a level comparable to that of 1:100,000 scale topographic maps.

In order to provide a systematic and uniform approach to the presentation of land use and land cover information in map format, a scheme of colors coding is employed, using a modified version of the USGS colors code, and a numerical system for the level two and three land users has been illustrated on the final map (Fig. 3).

Actual land use and their geomorphic expression are indicated by line symbols for which only the black color is used, so as to simplify the mapping system, in order to produce a satisfactory map that is not overcrowded. The basic problem with land use and land cover maps is the great variety of information that could be included. Restraint in this respect is an absolute necessity; otherwise the maps produced could be complex, costly in printing and difficult for the user to read. Simplicity, is achieved by emphasizing the most essential information and generalizing or omitting less important information, should be a guiding principle (Yousif, 1988).

Table 1: USGS land use and land cover classification system for Ninevah Governorate.

Level I	Level II	Level III
1/ Urban or build up land	11 Residential	111 Major cities
	12 Commerical and survice	121 Irrigation canals 122 Mosul Dam resorts
	13 Industrial	131 Heavy manufacturing 132 pipeline and oil refineries
	14 Transportation	141 Major high ways 142 Rail ways 143 Airport and Military areas
2/ Agricultural land	21 Cropland and Pasture	211 Seasonal vegetable lands 212 Winter crop lands 213 Irrigated land 214 Mixed crop and pasture lands
3/ Rangeland	31 Herbaceous rangeland	311 seasonal grass rangeland 312 Man made confined rangeland
4/ Forest land	43 Mixed forest land	431 Man made forest plantations
5/ Water	51 Streams	511 Tigris River valley 512 Upper Zab River valley 513 Khazir River valley 514 Dry valleys
	52 Lakes	521 Playa lakes 522 Sinkholes
	53 Reservoirs	531 Mosul Dam Reservoir
6/ Wetland	62 Nonforested wetland	621 River flood plains
7/ Barren land	73 Sandy areas	731 Aeolian sand sheets
	74 Bare exposed rock	741 Steep and sloping bedrock exposures 742 Flat gypseous pavement
	75 Strip mines, quarries, and gravel pits	751 Limestone and river gravel quarries

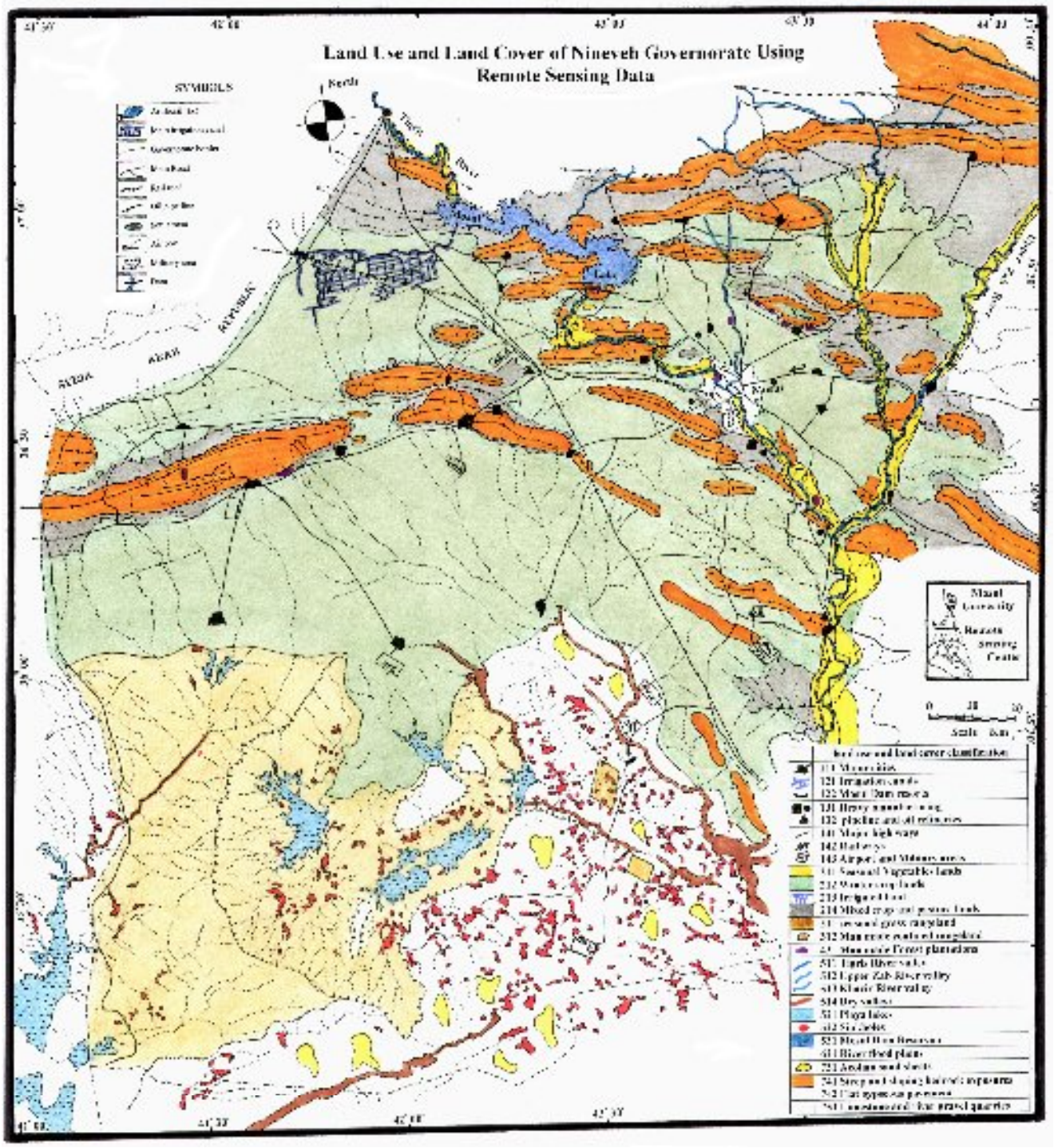

Fig. 3: Land use and land cover map of Ninevah Governorate.

CONCLUSIONS

The following conclusions can be drawn from the thematic mapping project described here.

1- The Anderson's classification system, with a logical structure and suitable for both the image interpretation and statistical analysis of the result, was developed during the lab and field work. The final land use and land cover thematic map shows the whole of the apparent activities up to the third level according to the USGS system, and 27 classes have been shown in the final map. Some of these classes were known or suspected from ground studies, but the majority was revealed for the first time during the Landsat investigations.

2- The vegetation cover in the study area, as well as the land use, is heavily influenced by varying climatic conditions, lithological escarpments, soil fertility and former land uses. Subsistence farming is found mainly along Tigris River valley and its tributaries, as well as on the stable accumulation glacis on sloping foothills surfaces.

3- Most digital classification methods do not give sufficiently accurate results and could not divide an area into more than a few, usually less than 10, classes. The land use and land cover map produced was improved using the geomorphic distribution of landforms. The significant superiority of visual classification can be explained by its capacity to integrate complex characteristics such as texture, size, pattern and associations of objects, as well as the interpreter's knowledge.

4- This map should be available for local authorities to consult when preparing their district, and later, at the National Agricultural Research Center, compiled for a nationwide use, in the National Program on Agro-Ecological Characterization leading to preparation of land suitability maps for major crops in Iraq. This map was finalized in 2007 at the Remote Sensing Center, in Mosul University.

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