CHANGE DETECTION OF IRRIGATED CROP LAND USING SATELLITE IMAGERY

M. ROUCHDI[a], S. CHAHBOUN[b], A. RAMDANE[b], M. HAMMOUDO[b], A. RAHOU[b]

[a] Institut Agronomique et Vétérinaire Hassan II, Madinate Al Irfane, Rabat Instituts B.P. 6263, Morocco, - mhrouchdi@yahoo.com
[b] CBTHA project, Ouarzazate Villa N° 32, Hay El Wahda, Ouarzazate, Morocco -bio@menara.ma

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ABSTRACT:

Natural resources management and environment follow up (mapping of cropland, delimitation of areas which are sensitive to desertification, fight of poverty, etc.) need appropriate decisions to be made. Or, those decisions can not be made without knowledge of the spatial extent and its environment. In the work frame of the Conservation of Biodiversity by Transhumance in the High Atlas project (CBTHA) which is taking place in Ouarzazate South of Morocco and covers about 1.6 millions of hectares, a study on the evaluation of agriculture settlements and deforestation is to be undertaken. To satisfy the purpose of this study, mapping tasks should be realized as a first step for gathering the best knowledge of actual irrigated crop land extent as well as the general evolution tendency. Nowadays, remote sensing and GIS are known as powerful tools for mapping, analysis and decision making. Hence, using these fields, the present study focuses on mapping the change in irrigated crop land from 1970 to 2006. To achieve this goal, three dates were selected: 1970, 1996 and 2006. Spot XS satellite images of 20 m resolution for 1996 and 2006 dates were acquired. Image processing which was undertaken include, image enhancement using histogram match, rectification, image mosaic as well as extraction of the area of interest. Pixel classification using maximum of likelihood algorithm followed by fuzzy classification was realized using the two sets of images acquired on 1996 and 2006. Moreover, for the 1970 data, irrigated crop land was digitized directly from georeferenced topographic maps at scale of 1/100000. Results from change detection show that there exists a high increase in irrigated crop land extent from 1970 to 2006. Furthermore, statistical as well cartographic results for the three dates will be used as a base to help in decision making during the evaluation of agriculture settlements and deforestation.

RÉSUMÉ:

La gestion des ressources naturelles, le suivi de l'environnement (cartographie des mises en culture, des zones sensibles à la désertification, sécheresse, contrôle et suivi de ces phénomènes, la lutte contre la pauvreté, etc.) supposent des prises de décisions les mieux appropriées. Or, ces décisions ne peuvent aboutir aux résultats attendus sans connaissance de l'espace géographique concerné et son environnement et par conséquent le recueil d'une information spatiale et thématique exhaustive et de qualité. C'est ainsi, dans le cadre des activités du projet de Conservation de la Biodiversité par Transhumance dans le Haut Atlas (CBTHA) à Ouarzazate situé au Sud du Maroc et couvre une superficie de 1.6 millions d'hectares, il est prévu la réalisation d'une étude portant sur l'évaluation de situation des installations agricoles et des défrichements dans la zone du projet. Pour satisfaire l'objectif de cette étude, la cartographie est le premier pas pour collecter une information de qualité sur la situation actuelle et la tendance d'évolution de la mise en culture au niveau de la zone du projet. Actuellement, l'utilisation du GPS, de la télédétection et du SIG pour l'inventaire, la cartographie, la gestion des ressources naturelles et le suivi de l'environnement est devenue pratique courante. En utilisant ces technologies, l'étude présente consiste à cartographier le changement des terres de mise en culture de 1970 à 2006. Pour répondre à cet objectif, trois dates ont été choisies : 1970, 1996 et 2006. En plus, les images SPOT XS de résolution 20 m ont été acquises pour les périodes 1996 et 2006. Le traitement qui a été effectué consiste à l'amélioration de l'image en utilisant « histogram match », la rectification, le mosaïque des images et l'extraction des zones d'intérêt. La classification supervisée par l'algorithme de maximum de vraisemblance, suivi de la classification flou, a été réalisée en utilisant les images de 1996 et de 2006. En plus, les données des mises en culture pour 1970 ont été numérisées directement des cartes topographiques d'échelle 1/100000 sous forme digitale et géoréférencées. Les résultats montrent qu'il existe une augmentation des terres de mise en culture de 1970 à 2006. De même, les statistiques et les documents cartographiques pour les trois dates seront utilisés comme base qui assistera les décideurs à évaluer les installations agricoles et le défrichement.

1. INTRODUCTION

Rational natural resource management and the different programs related to environment and sustainable development (Poverty, desertification, drought, erosion and the follow up of these phenomena, etc.) need appropriate decision making. Those decisions can not reach the wanted results without knowledge of the geographic space and its environment. Thus, a collection of exhaustive and quality spatial information is essential. Classical methods, on the other hand, for inventory and geographic information mapping are costly and time consuming. Moreover, data are in a form of maps and reports difficult to archive and for which data quality will be lost with time.

Nowadays, the use of remote sensing, GIS, and GPS for inventory, mapping, natural resource management and the environment follow up is becoming known by most users of geographic information. Some examples of applications are realized with success in North Africa (Merzouk et al., 1990; Vogt, 1991 ; Escadafal et Girard, 1993 ; Tahri et al., 1996 ; GTZ, 1996 ; Badraoui et Vogt, 1997 ; Badraoui et al., 2000 ; Badraoui et al., 2001).
The use of GIS and remote sensing allow one to:

- Get digital data which are easily archived and updated for the several uses.
- Build a georeferenced and quality database.
- Extract information that is suitable for a specific purpose by means of thematic and/or spatial analysis.
- Do good reasoning and to study various scenarios in the aim of adequate decision making.

In its strategy, the Conservation of Biodiversity by Transhumance in the High Atlas mountain (CBTHA) project which is taking place in Ouarzazate South of Morocco and covers about 1.6 millions of hectares, is seeking a good ecologic equilibrium between intensive and extensive production systems which help in the conservation of biodiversity. Among the solutions to be adopted, spatial zoning will allow optimal use of natural resources. It is, therefore, essential to control the temporal evolution of spatial affectations of land to evaluate any transformation which are or being made and study their impact on environmental equilibrium and to develop consequently a policy for follow up and prevention.

In the work frame of the CBTHA a study on the evaluation of agriculture settlements and deforestation is undertaken. To satisfy the purpose of this study, mapping tasks should be realized as a first step for gathering the best knowledge of actual irrigated crop land extent as well as the general evolution tendency.

The present study provides information on the actual situation and the evolution tendency of irrigated crop land in the project area. Hence, this study will assist in the elaboration of land management. Moreover, this work focuses on mapping the change in irrigated crop land from 1970 to 2006. To achieve this goal three dates were selected 1970, 1996, and 2006.

A similar study, using SPOT satellite images for 1987 and 2001, and topographic maps at scale of 1/50000 was undertaken in two regions along the Atlantic Ocean coast. The first one is Souss Massa in south west part of Morocco and the second one is Doukkala in the central Western part of Morocco. This study focused on the impact of urbanization on agriculture land in the irrigated areas (CRTS, 2005). In this study the evolution of urbanization was considered from 1970 to 2001 for the Souss Massa region and from 1984 to 2001 for Doukkala region. The land cover for 1970 and 1984 was extracted by digitizing topographic maps. However, for the other dates, land cover maps were produced using photo interpretation.

2 METHODOLOGY

2.1 The study area

The methodology is based on the use of remote sensing as an important data source which will assist in the elaboration of land use map. The GIS, will be used for the purpose of integrating other data (administrative boundaries, population, etc.) and build a database which can be used for extracting new information based on specific constraints.

The study area is limited by the meridians 7° 9’ 47’’.31 West and 5° 18’ 19’’.31 West and the parallels 30° 44’ 19’’.35 North and 31° 47’ 7’’.82 North. The area covers about 1.6 millions hectares and is characterized by three geomorphologic entities: the Central High Atlas, the Central Anti Atlas materialized by mountain Saghro and the plain of Ouarzazate between the two entities.

The high Atlas Mountains reach more than 4000 m in elevation and constitute a natural barrier for humid air to propagate toward the south and thus results in a separation between humid Mediterranean world and southern Saharian world. The Anti Atlas Mountains, on the other hand, reach elevations between 1500 m to 2500 m. The Ouarzazate plain is characterized by altitudes less than 1500 m.

The area of study lacks a uniform distribution of meteorological stations. The mean annual rainfall is low and is about 148 to 177mm/year (Hammoudo, 1998). The mean annual temperatures, on the other hand, are very high in the low elevation land. Thus, one can distinguish three type of bio climate: semi arid with cold winter in area of more than 2000 m of elevation, a bio climate with a cool winter in medium elevations and a Saharian bio climate with a cold winter in low and medium elevations.

The human activity is concentrated along the valleys which constitute the suitable land for irrigated crops practice and economic exchange. The major population lives along the valleys where there exists about 5 to 10% of good and rich soil. The agriculture consists of crops and vegetable but dominated by arboriculture such as palm, olive, apricot trees.
Beside agriculture, ranch is a practice which continues to benefit from the large pastoral land. Transhumance is now dominating the study area and practised by 10 to 15% of the families.

2.2 Satellite image selection

4 parameters were considered to select the suitable images which will be used for mapping crops at scale of 1/100000 and to evaluate their evolution:
- The subject to be studied helped in defining the season of acquiring satellite images which is spring.
- The mapping at scale of 1/100000 results in a resolution of 20 m.
- The evolution during three periods of time results in images spaced in time with an interval of 10 years.
- The area on the study zone 1.6 millions hectares resulted in defining the number of scenes.

Thus based on the above factors and taking into consideration the budget, it is decided that the suitable satellite images for the present study are SPOT XS level 1B with a resolution of 20 m were selected.

2.3 Processing

SPOT images were acquired: 6 scenes for Mars 1996 and 6 others for Mars 2006. For the period of 1970, it was useful and easy to digitize the irrigated crop land directly from topographic maps of 1970 at scale of 1/100000.

At first a radiometric correction consisting of histogram match were applied to all scenes. The rectification of each image was based on about 12 ground control points taken from topographic maps. The root mean square error was about 15 m. A mosaic of each 6 images referring to 1996 and 2006 was realized. Then after, the area of study was clipped.

For the 1996, the irrigated crops land was easily extracted directly from the image.

For 2006, Ground truth were collected directly from the terrain and used in the supervised classification algorithm of Maximum likelihood. This classification was followed by the application of fuzzy convolution. This resulted in an actual situation of land cover map with 10 classes. The accuracy of this map is about 85%. This map provides the actual situation of land cover and it was needed by the project and it was used to extract only the irrigated crop land.

The result is three images portraying irrigated crops land for 1970, 1996 and 2006. The algorithm of change detection which computes the difference between two images was applied to these 3 images taken two at a time (1970 and 1996, 1970 and 2006, 1996 and 2006). Hence, maps showing the changes were produced and input into GIS to compute areas of changes for each tribe.

3 RESULTS AND DISCUSSION

Table 1 provides the total area of each tribe and the total area of irrigated land in hectares. From this table and from figure 1, it can be seen that there exists an increase of irrigated land practise especially in Aït Sedrate, Mgouna, and Saghro. These areas are known of intensive agriculture installations along rivers. There exists also a decrease in some tribes such as Aït Ougrour which might be due to a decrease in rainfall and to a degradation of land.

TRIBE	AREA	1970	1996	2006
AIT AFFANE	25815	77	94	272
AIT ZAGHAR	40870	451	543	763
AIT ZEKRI	126012	403	587	719
AIT SEDRATE	162169	3269	4116	4177
AIT OUGROUR	63494	1043	1024	919
AIT OUITFAO	50401	1293	1604	1504
DAM	17094	14	170	555
IGUERNANE	41877	49	173	333
KANTOLA	34536	159	159	225
MGOUNA	154110	1129	1690	1888
SAGHRO	201452	422	774	1518
SKOURA	37212	2785	3204	2392
TOUNDOUTE	241	183	166	200

Table 1: Area in hectares of tribes and irrigated crops

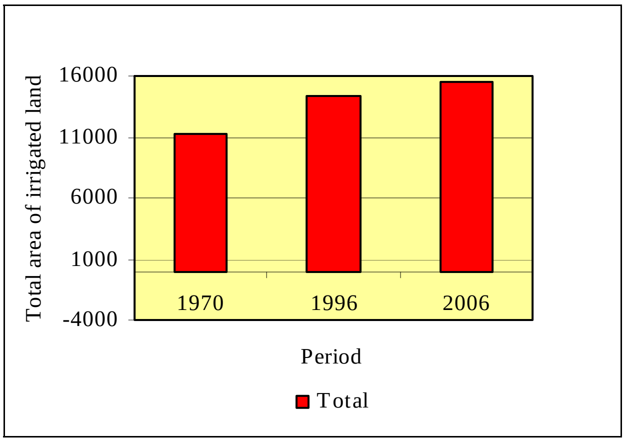

Figure 1: Total area of irrigated land in the study zone

By application of the change detection algorithm, the total areas through the three periods in the whole study zone were computed (Figure 2). From this figure, it can be seen easily that there exists a small decrease from 1970 to 1996, a large decrease from 1996 to 2006 in irrigated land and small increase from 1970 to 2006. Moreover, there is almost no change between 1996 and 2006.

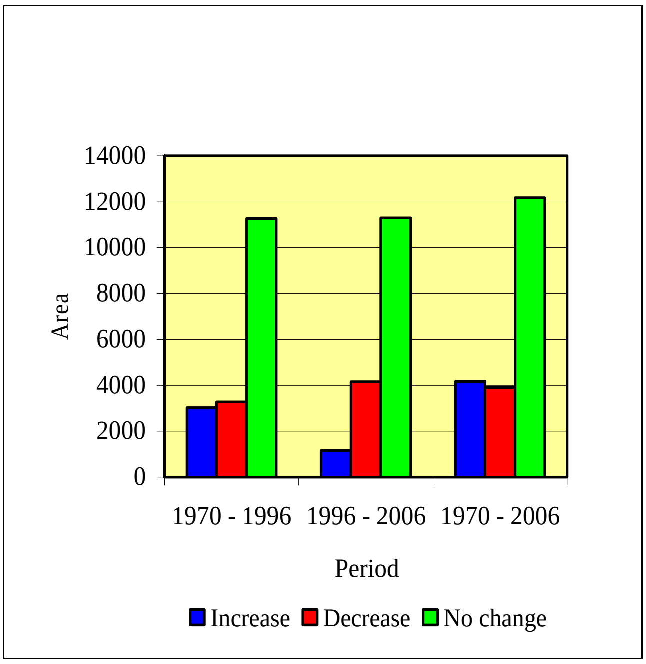

Figure 2: Evolution of total irrigated land

Table 2 presents the rate of biodiversity lost. This one is computed as the sum of increase and the decrease in land. From this table it can be seen that mainly the largest rate exists in Aït Sedrate, Saghro and Skoura. This is due, as it was stated before, to the intensive agriculture installations in those areas.

	1970 - 1996	1996 - 2006	1970 - 2006
Tribe			
AIT AFFANE	119	242	257
AIT ZAGHAR	443	481	443
AIT ZEKRI	510	577	596
AIT SEDRATE	1833	1349	1951
AIT OUGROUR	1076	758	1148
AIT OUITFAO	1093	843	1081
BARRAGE	184	525	563
IGUERNANE	180	245	315
KANTOLA	170	144	196
MGOUNA	1163	944	1325
SAGHRO	996	1643	1676
SKOURA	1719	1674	1719
TOUNDOUTE	109	67	103

Table 2: Rate of biodiversity lost

4 CONCLUSIONS AND FUTURE WORK

Based on the presented results, it can be seen that the use of satellite images for 1996 and 2006 is of great importance to map the actual situation of irrigated crops land and the one of 1996.

Moreover, the topographic map of 1970 was useful in mapping the irrigated crops land for that period of time. Data for the three periods were integrated into GIS and have resulted in mapping the evolution of irrigated crops land.

The decision maker is thus in possession of quantitative spatial data which describe the area, the rate and the type of change and rate of biodiversity lost.

It is important to recommend for future work:

- The use of socio-economic data to evaluate the impact of irrigated crops land on biodiversity.
- Undertake the same study each 5 years.
- Evaluate the change not only for irrigated land but for all land cover classes and hence be able to get information on biodiversity lost and then decide on the actions to be undertaken.
- Use for classification other algorithms such as sub pixel classifiers or other new ones to better map land cover.
- Undertake the same study with high resolution satellite image in areas where there exists a large change.

REFERENCES

Badraoui M. et Vogt, 1997. Application de la télédétection à l'inventaire et à la cartographie des sols et de la végétation dans le Pré-Rif marneux au Nord Ouest du Maroc (Région de Ouezzane). ANRH-IAV Hassan II-LECT-GTZ. Rapport du Projet d'Aménagement Intégré du Bassin Versant de oued Mina, Algérie

Badraoui M., Rouchdi M, Chimi H., Soudi B., Mhamdi A. 2000. Analyse Environnementale Initiale du Projet SIGEK. Système Intégré de Gestion de l'Environnement de la ville de Khouribga au Maroc. EFESO-IAV Hassan II

Badraoui M., Rouchdi M., Pascal N., Yachou H. 2001. Elaboration d'une base de donnée sous SIG pour la gestion intégrée du PMVB de Tanant. Rapport du projet. IAV Hassan II-DAF-AGR-Ct de Tanant

Escadafal R. et Girard M.C. 1993. Observing arid land with SPOT and TM : what can be remotely sensed. Sistema Terra. Vol. 3 :31-32.

Hammoudou M., 1998. L'élevage pastoral chez les Mgoun : Etude des parcours et des Systèmes d'élevage. Office Régional de Mise en Valeur Agricole de Ouarzazate

GTZ, 1996. L'aménagement des zones marneuses dans les bassins versants des montagnes de l'Atlas Tellien semi aride. Schriftenreihe GTZ N° 256

Merzouk A., Badraoui M., Fassi D., Bonn F., Gwyn Q.H.J., Hinse M. 1990. Essai méthodologique pour le classement et la cartographie des Terres en vue de la conservation des sols et des eaux en zones arides. Apport de la télédétection. In J.M. Dubois et P. La France eds. Apport de la télédétection à la lutte contre la sécheresse : 163-171, AUPELF-UREF

Tahri M., Kabbasi M., El Kenz M., Badraoui M. 1996. Application de la télédétection et du SIG à la cartographie des sols à croûtes calcaires dans le Sahel des Doukkala, Maroc. Rapport du projet MAMVA-DPAE-MRAC

Vogt T., 1991. Télédétection et risque de désertification : inventaire par télédétection des types de surface (données Landsat TM) Oasis de Mareth, Sud Tunisien. Sym. Inter. Cartog. Thematique dérivée des images satéllitaires. Saint Mandé. Bull. Comité Français de Cartographie, 127-128 : 178-181.