JFSSU, Vol. 1, Issue.1 (2024)

مجلة الدراسات المستقبلية جامعة سرت
Journal Of Future Studies Sirte University (JFSSU)
Source Homepage: https://journal.su.edu.ly/index.php/jfssu

ASSESSMENT OF URBAN SPATIAL EXPANSION WITH ADVANCED MULTI-CRITERIA GEOSPATIAL INFORMATION SYSTEM AND REMOTE SENSING TECHNIQUE: THE CASE OF OUJDAH AND SAIDIAH CITYIES IN MOROCCO

Mohammed Salim Mohammed

***Lecturer at Faculty of Education Geography Department Wadi Alshati University Libya*:**

mo.salik@wau.edu.ly

Abstract:

Nowadays, both GIS and RS satellite images are becoming important decision-making tools that allow the investigation and monitoring of urban growth according to a set of specified criteria and RS data. The present study is an assessment of the trend in urban growth observed in the Oujda city urban agglomeration, the Saidia coastal zone, and the South-eastern part of Morocco. A huge set of satellite images, databases, and ancillary dates have been collected, analyzed, processed, and integrated for the area under investigation. Several methodologies were exploited by using the IKONOS and SPOT images from August 2007 as well as Landsat TM and ETM acquired between the year 1984 up to 2011 covering the whole Oujda city. The obtained results present that supervised classification resulting from integrated SPOT and ETM datasets produce very great results in comparison to maximum supervised classification methods. Also, PCA was more efficient in comparison with NDVI concerning delineating urban growth without much effort. On the other side, IKONOS, SPOT detail imagery, produced higher accuracy results compared with the results of Landsat Imagery. Its increase shows that changes did take place, but most changes took place in the urban zones, bare lands, and irrigated ones. It has increased from 711.22 hectares in 1970 to 3,664.03 hectares in 2009, while the others were just a standard modification. Meanwhile, Saidia city's urban area increased from 6.5 hectares in 1988 to 28.7 hectares in 2002.

Keywords: ***Where, GIS; RS; NDVI; PCA; Monitoring urban growth; NDVI; SPOT; IKONOS; Landsat TM and ETM; Oujda and Saidia city.***

تقييم التوسع المكاني الحضري باستخدام نظام معلومات جغرافية متقدم متعدد المعايير وتقنية الاستشعار عن بعد: حالة مدينتي وجدة والسعيدية في المغرب

الملخص:

في الوقت الحاضر، أصبحت كل من نظم المعلومات الجغرافية وصور الاستشعار عن بعد، أدوات مهمة في اتخاد القرارات، مما يتيح التحقيق ومراقبة النمو الحضري وفقا لمجموعة من المعايير المحددة وبيانات الاستشعار عن بعد. تتناول هده الدراسة تقييم الاتجاه العمراني المتبع في النمو الحضري الدي تم ملاحظته في تجمع مدينة وجده، ومنطقة السعيدية، والجز الجنوب الشرقي من المغرب. تم جمع مجموعه ضخمة من صور الأقمار الصناعية، وقواعد البيانات، والبيانات المساعدة، وتحليلها، ومعالجتها، ودمجها للمنطقة المعنية. تمت الاستفادة من عدة منهجيات باستخدام صور القمر الصناعي ايكونوس والفرنسي سبوت من أغسطس 2007, بالإضافة الي صور TM لاندسات وETM التي تم الحصول عليها بين عامي 1984 و2011 والتي تغطي مدينة ودة بأكملها. تظهر النتائج التي تم الحصول عليها ان التصنيف المراقب الناتج عن دمج بيانات سبوت مع ETM نتائج متميزة مقارنة بأساليب التصنيف المراقب التقليدية. كما كانت تقنية التحليل العنصري PCA اكتر كفاءة مقارنة بمؤشر NDVI فيما يتعلق بتحديد النمو الحضري دون بدل جهد كبير. من ناحية اخري، انتجت صور ايكونوس وسبوت تفاصيل اكتر دقة مقارنة بصور لاندسات. تظهر الزيادة أن التغيرات قد حدثت، لكن معظم التغيرات كانت في المناطق الحضرية، والأراضي القاحلة، والمناطق المروية. حيت زادت من 711,22 هكتار في 1970 الي 3664.03 هكتار في عام 2009, بينما كانت التعديلات الأخرى متواضعة. في الوقت نفسه، زادت المساحة الحضرية لمدينة السعيدية من 6.5 هكتار في عام 1988 الي 28.7 هكتار في عام 2002.

الكلمات المفتاحية:

نظم المعلومات الجغرافية، الاستشعار عن بعد، مؤشر النبات الغطائي، تحليل المكونات الرئيسية، مراقبة التطور الحضري، لاندسات، ايكونوس، سبوت، مدينة وجدة ومدينة السعيدية.

1. Introduction

This has focused on a wide range of disciplines over the last two decades, from engineering applications such as (Dowod et al. 2012) to those of environmental and geographical interest, as in the case of Arnous 2013. These include groundwater quality assessment (Alqadi et al. 2013), flood hazard monitoring (Mohamed and Saleh 2012), urban planning, transportation analyses (Aljoufie et al. 2013), water resource management, desertification, tourism management, agricultural sustainability, and urban growth surveillance (Kawy, 2011).

2. Study area

Oujda is a city in Morocco and the capital of the eastern region of the Moroccan Kingdom. Its approximate geographical coordinates are situated between 34° 41' 12" and 34° 45' 13" N Latitude and 34° 41' 12" and longitude 34° 38' 09" W, respectively. Situated on an area of 82 square kilometers, Oujda is rich in natural resources and an important historical town, which connects Morocco to other Maghreb countries as a gateway and a cultural bridge (Katabi, 2006). Its strategic location makes Oujda City very important, approximately 15 km from the Algerian Moroccan border. Geographically it stands between the Ankad valley. To begin with, the climate resembles that of a desert. There is a normal rainfall of around 150mm during favorable seasons. Secondly, temperatures range between 40 and 42 degrees Celsius during summers.

Although the land remains scorching, many ancient accounts and prior research described Oujda as a rich land of fruits and vegetables because of its underground water potential. These are still available today to form natural wells such as Tayrat, Sidi Yahya, and Bo Shatat in the Isly Valley.

Wengler and Vernet (1992) identified the variation in climate conditions in the zone of Oujda from humid to semi-arid, with intense storms and precipitation in rainy seasons followed by dry periods. This fluctuation causes subsequent flow systems within dry valleys that transfer both liquid and solid loads towards urban areas, often causing a high amount of damage in these areas (Alhafid, 2006).

Oujda City is located near the Algerian Moroccan border at a position of 15 km while it is about 60 km from both the northern and southern Mediterranean Seas. In addition, it is surrounded by a semi-desert region to the south, the Moulouya plateau from the west and finally Algeria from the east as in figure1.

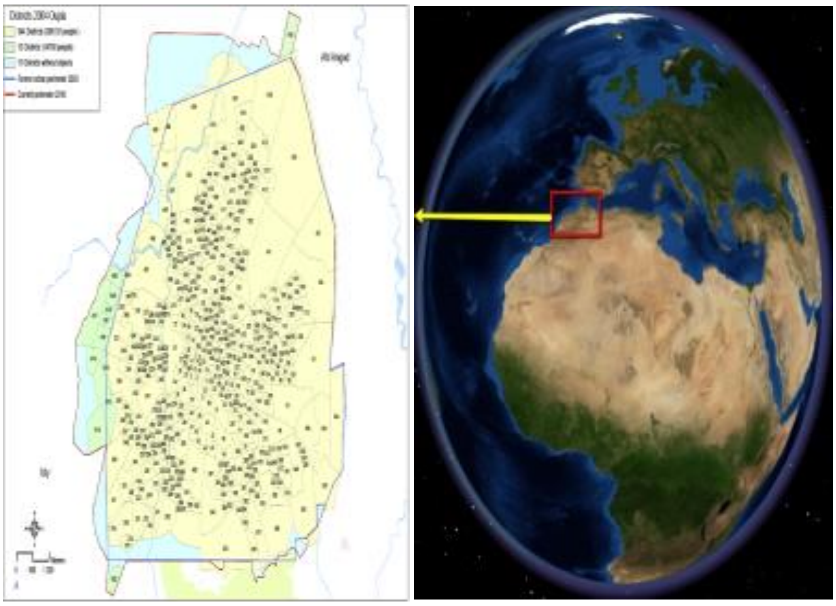

Fig1. Location of study are

The second study area, Saidia city, is located at the eastern extremity of the Mediterranean coast of Morocco (Fig.2). With a coastline spanning approximately 21 kilometres in a straight line, it is interrupted solely by the mouth of the Moulouya estuary. This marsh complex covers an area of nearly 3,000 hectares and serves as a site of significant biological and ecological importance. Many birds of international and national importance take refuge in this wetland, which also encompasses a variety of habitats for many fauna and flora species (Dakki, 2003). The Moulouya wetland comes under the main scope of the Med West Coast project, which aims at the protection of these vital coastal ecosystems (http://www.medwetcoast.com). Studies indicate that the dominant shore type is sandy beaches with coastal dunes and marshes (Kattabi et al., 2007). In the area, there are two cities, Ras El Ma and Saidia, including several highly populated villages. Presently, approximately 42,700 individuals inhabit the area permanently (RGPH, 2004), while the influx of tourists into Saidia alone can reach up to 15,000 per day during peak summer months. The region's primary industries include agriculture, fisheries, and tourism; however, a decline in fisheries has resulted in a considerable shift towards agriculture. This sector has also rapidly become vulnerable due to land abandonment or conversion to other uses.

With the periodical drought and salinization, tourism still is the only available industry. experiencing growth over the past few decades. Land-use map of the study area, Saidia coastal zone.

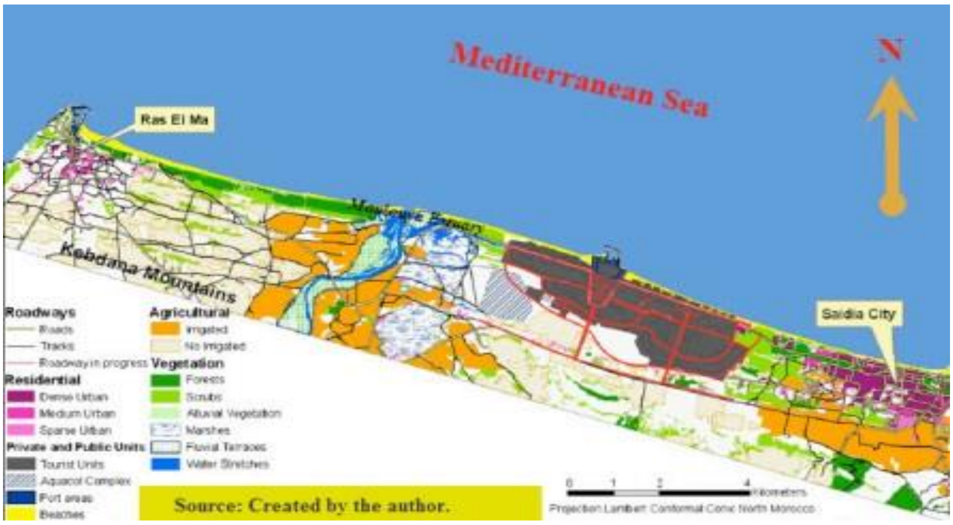

Fig2.Land-use map of the study area Saidia coastal zone.

Like other coastal areas, it suffers from damaging impacts from various human functions. Although the general human population has been meager, quite a decent disrupting action happens along the coastline.

The main threats are: enhanced degradation due to coastal dune and beach erosion, reclamation, saline intrusion of groundwater and soils caused by over extraction, resources depletion by hunting, overgrazing, deforestation, and port establishment. Nowadays the highest human impact in the region is caused by tourism, which developed because Saidia coast has become a well-known tourist resort in Morocco.

It measures about 700 hectares, as shown in the figure above, and it contains a residential house, apartments, more than eight hotels, a number of green parks, three golf courses, and a recreational port.

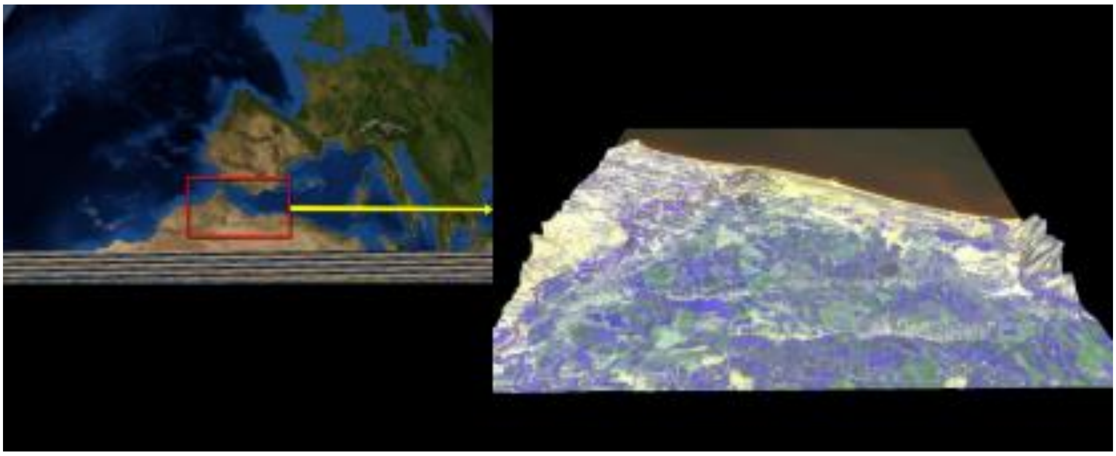

Fig3. General form of Saidia coastline and Moulouya River and Ras El Ma. ASTER 2002 image. Source: Created by the author.

3. Methodology

These spatially compiled datasets fall into three categories: the topographic map of Oujda city dated 2007 with resolution 1m x 1m including the full vector data for the whole city, and about 50 aerial photographs after mosaicking and registration to the master map of Oujda city.

The second class consists of 30 cadastral maps in AutoCAD file format dated within the year 2007. Lastly, the third class involves a land-use map, which was created by the author himself in 2011.

The remote sensing data used in this study are as follows: (1) SPOT Earth Observation Satellite with 2.5m panchromatic resolution and IKONOS with 0.6M resolution, covering Oujda city dated in August 2007; (2) Cloud-Free Satellite Data from Landsat satellites, for four different dates from the last four decades, acquired from USGS Earth Explorer website. Land cover analysis using remote sensing techniques.

Consistency, within the study period, was maintained by utilizing Landsat TM data and ETM images at 15 m x 15 m resolution, commonly employed for environmental assessment and monitoring. Landsat TM images of resolution 30 m × 30 m taken in spring and summer were used to get accurate land-cover classific ation. Four images taken on November 1984, August 2002, January 2007 and July and November 2011 were chosen which resulted in the study period of around 27 years. The socio-economic information is inherently linked with biophysical environmental data (Lo and Faber, 1997); therefore, statistical data on population, economy as well as human the activities within the counties of Oujda-following the demographic data of Census 2004-were merged with the remote sensing data.

To register the Landsat TM images with socio-economic data, topographic maps at a scale of 1:50,000 (2011) were used as ground control points. Land use and demographic data from the Census 2004 were also utilized.

ArcGIS10, ENVI 5 and ERDAS Imagine version 11 were used to process the data. The bands selected in generating false color composite images are 4, 3 and 2. For the study of urbanization, specially the TM images of 1984, 2002 and 2007 and 2011 respectively, were processed to extract city data from the whole Landsat TM scenes into four subscenes of corresponding years covering the whole city and the adjacent areas.

Ground control points distinctive on the images were identified and matched with the coordinates from 1:50 000 topographic map sheets. In view of the availability of adequate number of ground control points selected, the landsat TM data were rectified using a polynomial based on the selected GCPs. To avoid the image being twisted too much and increasing inaccuracy and unpredictability are polynomial rectification with nearest neighbor resampling method adopted.

This gave acceptable average RMS errors of generally less than 0.5 pixels, which corresponds to an error less than 15 m for TM imagery.

About 50 aerial photos in total, all registered in ERDAS and ArcGIS according to the Moroccan Projection (Lambert conformal Maroc), were used.

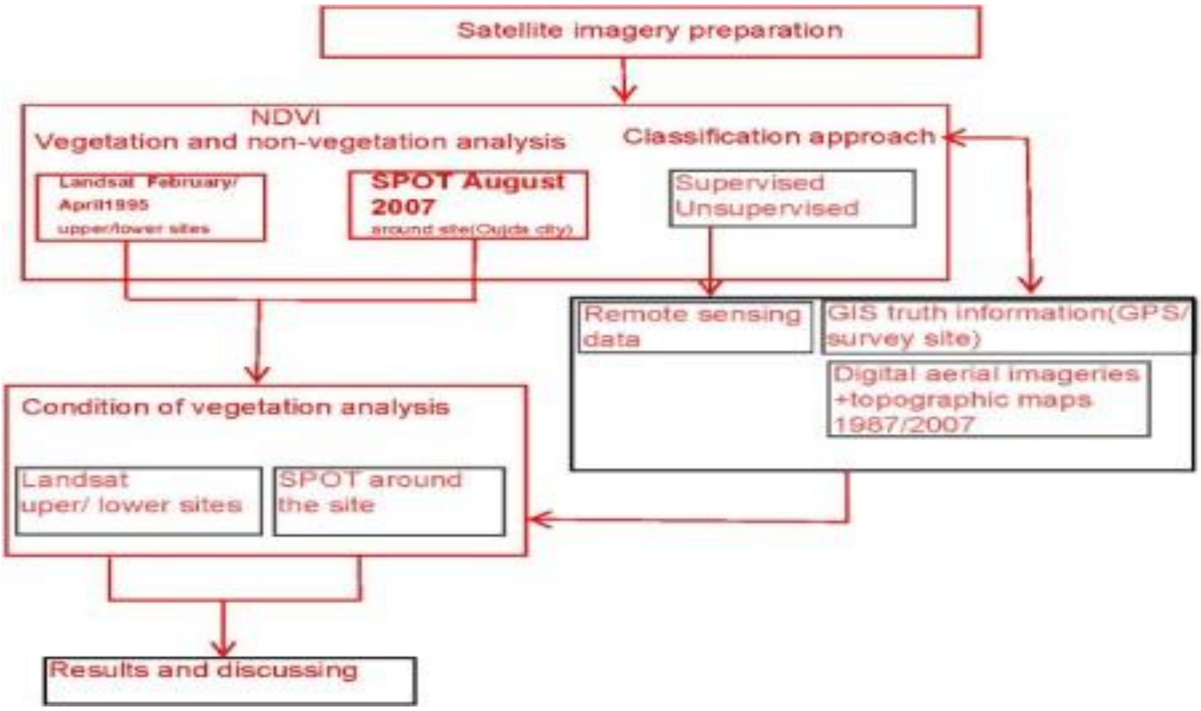

Fig4. Stages satellite imagery analysis.

4. Classifications Scheme

Supervised classification

Maximum likelihood classification was considered the most robust tool for remote sensing in the field because spectral information in each class meets the normal distribution criteria (Wang et al. 2004) and (Wentz et al. 2006). In this study supervised maximum likelihood was applied for SPOT 2.5m August 2007 and SPOT merged with Landsate ETM+ (SPOT 2.5m and ETM+ 15m) in the same date time, classes were applied to which are pastures, built up areas, forest and meadow, green areas, irrigated areas, orchards, pastures lands (arable) swamps water and mixed agriculture. Moreover, ISODATA unsupervised classification has been applied just to distinguish between unsupervised and supervised classification from both images SPOT and SPOT merged SPOT with Landsat ETM+ 2007

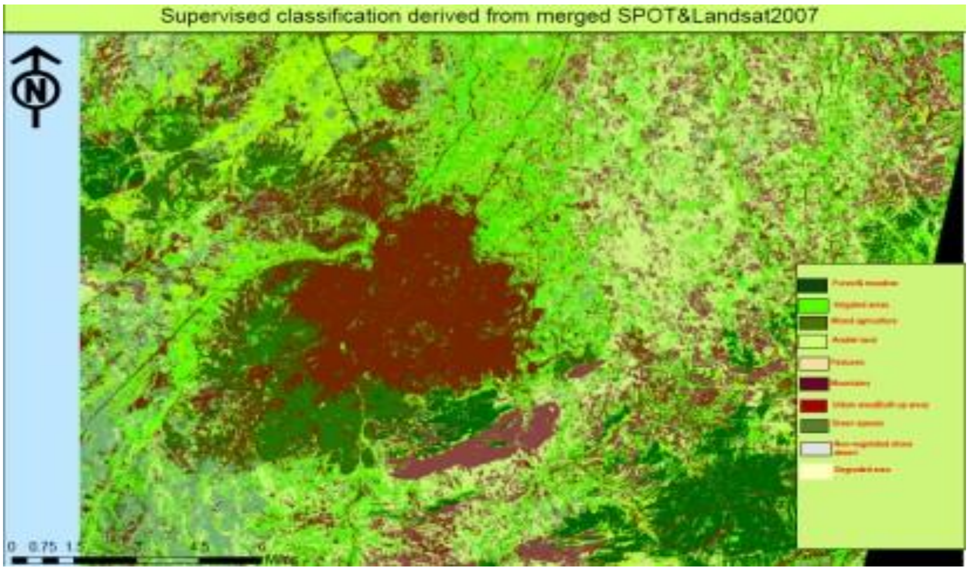

Fig5.Supervised Classification derived from Merged SPOT 2.5m and ETM+ 2007.

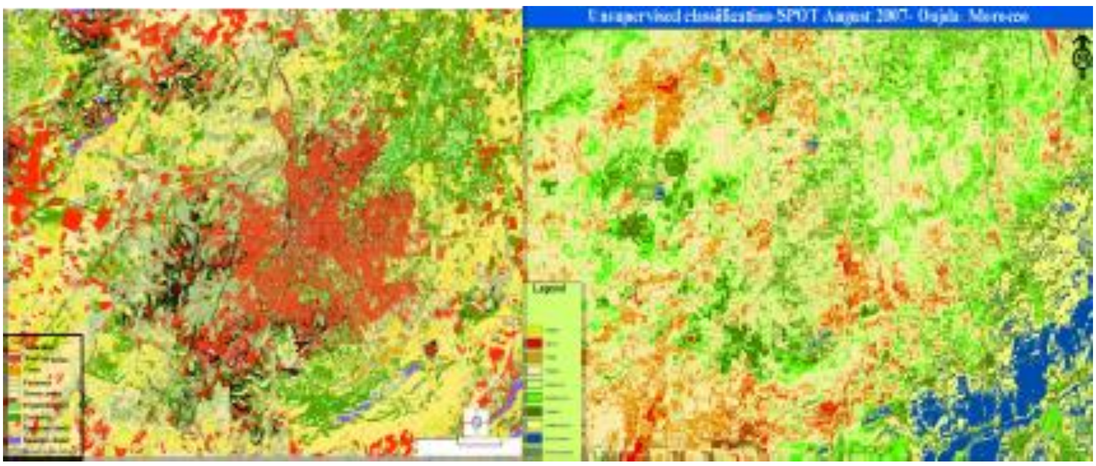

Fig6. Supervised Classification derived from Merged SPOT 2.5m 2007 in the Left, and Unsupervised classification from SPOT 2007 Right.

GIS Classifications

Table 1 and fig 6 below show the GIS classification quantities for the year 1970, 1980 and 2009 with classes are road and urban area, irrigated area, bare land, forest and public green spaces.

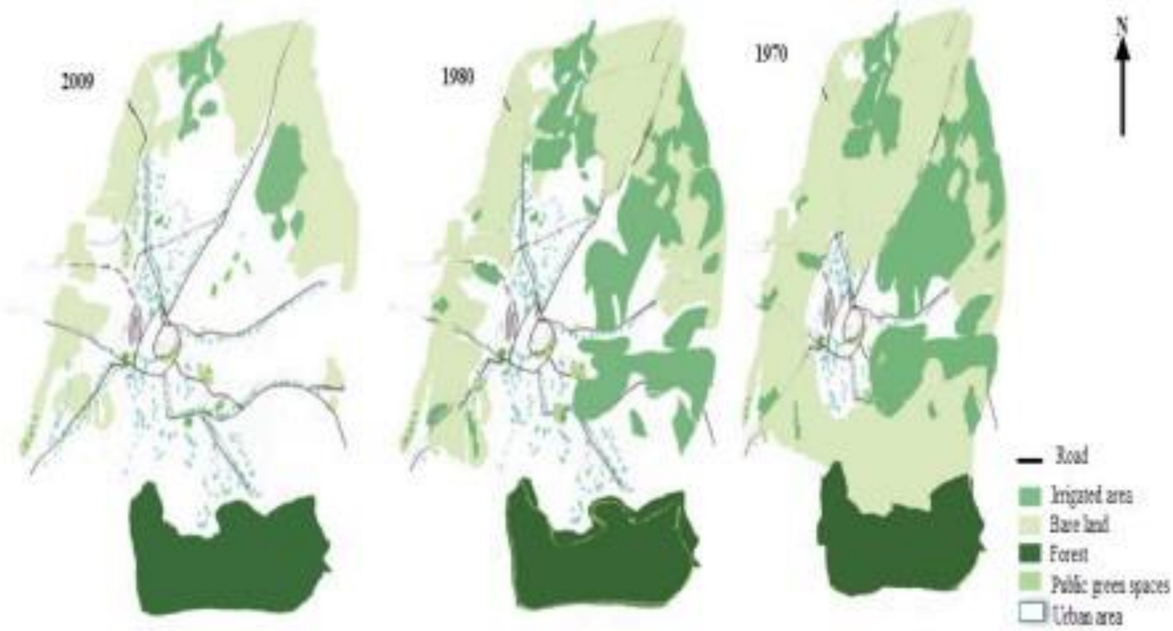

Fig.7. GIS technique-based classification for 1970, 1980 and 2009 of city Oujda, Morocco.
Classes Area 1970 hectares area 1980 hectares area 2009 hectares.

Classes	Area 1970 Hectares	Area 1980 Hectares	Area 2009 Hectares
Road & urban area	711.22	987.1	3664.03
Irrigated area	200.22	187.81	100.75
Bare land	1003.28	800.41	444.76
Forest	1000.76	1020.66	1066.04
Public green spaces	20.81	28.39	43.05

Table1. Change detecting in Oujda city between 1970, 1980 and 2009.

5. Urban dynamics modelling of Oujda City

Modelling represents one good methodology for analysis-for instance, comprehension and description of complex system structure and dynamics- and this modelling could facilitate the same to spatial phenomena conceived as complex systems, such as a city, region, and others. Objectives and goals of system modelling are hereby stated in view of the case study of Oujda city:

• Study and knowledge of observed phenomena (Urban Growth).

• Characterization and specification of system components and of their structural and dynamic interconnection.

• Refined understanding, detailed background of the system as a whole, and partially from its components in various aspects; reviewing the models as to their suitability or otherwise for the city.

• Forecasting of spatial-temporal systems' behavior upon alternative conditions and scenarios for decision support.

• Up-to-date discoveries of functioning of geospatial phenomena, enabled by the unique capabilities of computer experiments.

The available approaches for urban modeling have benefited from the recent development of information technologies, particularly Geographical Information System, and the availability of data based on these technologies like GIS and RS. Also, their integration with other technologies such as CAD has opened up ways of using them in several forms and shapes. However, urban models are not limited since big funding, time enough, and data of the real world such as already existing spatial and tangible urban models can be integrated and mapped in a modelling scenario. In fact, geographic information systems have evolved to be one of the major frameworks for handling a wide range of spatial real-world data. However, attempts to utilize GIS as a modeling approach have received various criticisms, especially because GIS is rigid, has limited modeling functionalities, and poorly handles the temporal dynamic dimension.

Figure 7 below shows 33 classes which are development area, area under development, mixed houses, Moroccan traditional houses, strategic reserve area, railway network, industrial area, new industrial area, agricultural, undeveloped area, current border of Oujda city, cemetery, church, green spaces, square, residential area with 2 floors, residential area with 3 floors, buildings area, markets, random villas, separated villas, reforestation area, developed area, mosques, public facilities, Medina (Ancient city in Oujda), hot spring, crops irrigated area, pastures and trees and crops.

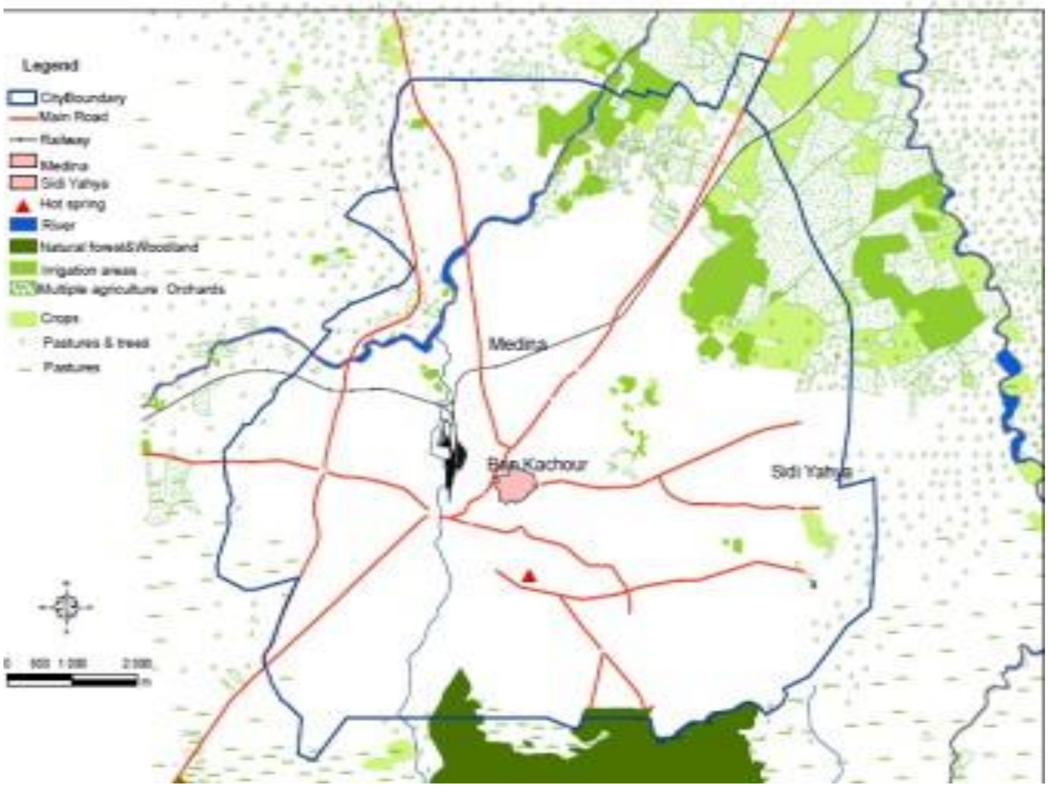

Fig8: Classes of Urban Models in Oujda city in 2011

6. Results and Analysis

Visual interpretation gave an idea of the general form taken by the land cover change over the period. More green harvests were detected than before, especially on the right side of Moulouya valley. Most of these harvests were not shown on the ETM+ 2002 (Fig.7), whereas it is by processing NDVI on the Landsat TM on 26 May 1990 on (Fig. 8) and only few of them appeared on the image of Landsat ETM+ 2002. Many new roads and irrigation channels were noticed in the image of 2002 and not in the one of 1990. A noticeable change is detected in areas of new sand dunes and grassland is noticeable in the northwestern part of the study area where part of the desert was converted to cultivated lands.

On-screen digitization for Sabkha, deep water and non-deep-water land cover classes, as well as bare lands, was done. Fig. 8 and Fig.9 below.

Fig9. Supervised classification of north-western coast of Saidia, using ASTER 2002.

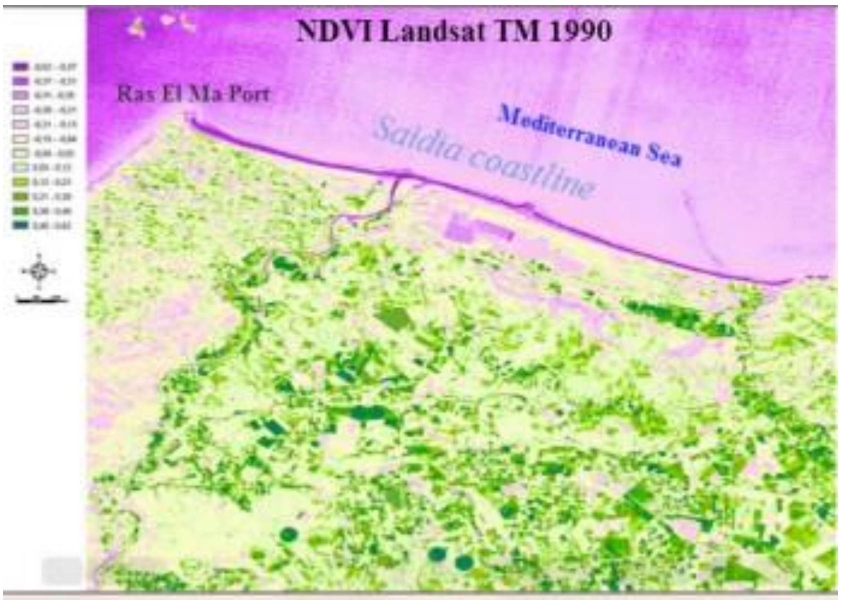

Fig10. Results of NDVI using Landsat TM 26 May1990 for the Saidia Coastal.

An object-based classification of two satellite images, acquired 7 June 1988 and 20 May 2002, was supervised by the maximum likelihood classifier using all the reflective bands. The results of this classification are shown in Figs. 8 and 9. However, in order to increase the accuracy of was integrated with the classification results using GIS software extension (Image Analysis). land cover mapping of the two images ancillary data and the result of visual interpretation

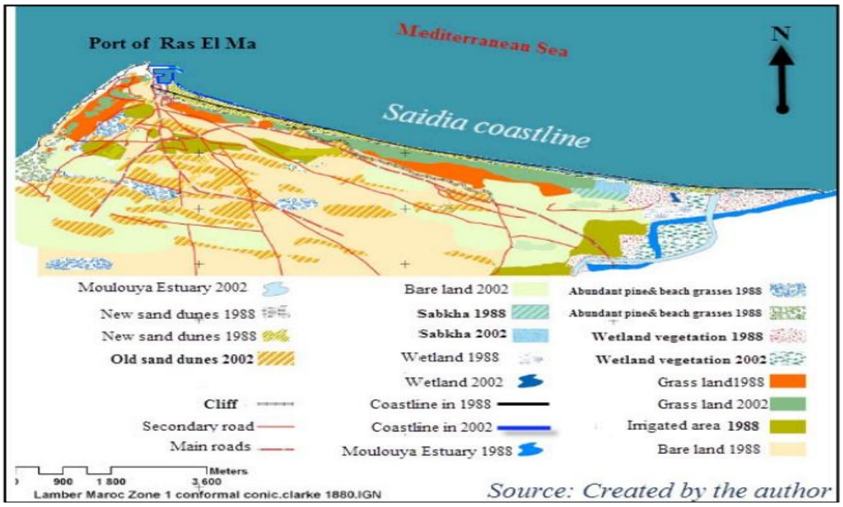

Fig.11. Land cover change detection image between 1988 and 2002.

The nature of the changes of different land cover classes could be derived from Table 1. For example, cropland land covered 22,259 ha in 1988 and 77,266 ha in 2002. Out of the 22,260 ha that was cropland in 1988, 21,189 ha still cropland in 2002 but 386 ha was converted to salt marches, 289 ha was converted to Sabkha and 202 ha was converted to urban areas.

Increase of cropland during the same time from 1988 to 2002, was 5079 ha from Sabkha, 35,759 ha from grassland and 15,220 ha converted from bare land.

Grassland covered an area of 163,064 in 1988 and 76,806 in 2002. From these figures, it may seem that 86,258 was degraded, but through cross-tabulation analysis, 35,759 out of the lost grassland was converted to cropland, which is a positive change and not land degradation. Only 66,354 hectares that were changed to classes other than cropland were actually degraded.

While at the same time, 12,857 hectares were restored from bare land back to grassland and about 2715 hectares from Sabkha. This information reveals that

The integration of remote sensing and the GIS environment in land cover change detection studies is important in terms of furnishing basic information on the nature and spatial distribution of land cover changes. It is thus recommended that account be taken of the accuracy of the different classifications, since the error in the classification will prejudice accuracy in the figures on change detection.

The land degradation procedures in the case study area are the degradation of natural vegetation due to overgrazing and remarkable inter-annual variation in the amount of rainfall. The other cause of land degradation is water logging generated from mismanagement of irrigation.

The major problems associated with irrigation schemes are their wasteful use of water, excess applications compared to possible plant uptake, and a poor drainage system, leading to water-logging and salinization problems.

This has been clearly manifested in the land cover and land use map of 2001, where the salt marshes' areas increased from 2070 ha in 1988 to 6657 ha in 2002. The third process of land degradation in the area is wind erosion and water erosion, which accelerate as a result of loss of vegetation cover. Wind and water erosion led to the removal of the relatively fertile topsoil and this could lead to desertification.

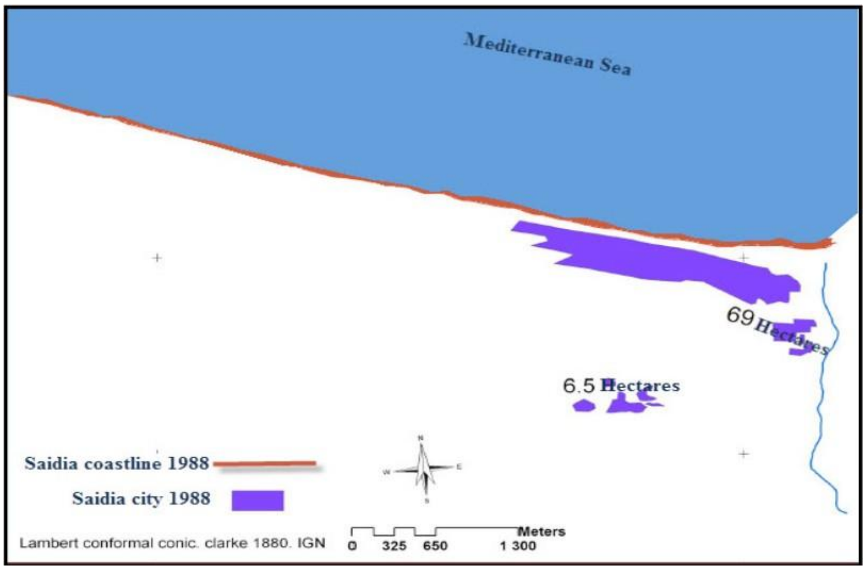

Fig 12. Urban Area in Saidia City in 1988.

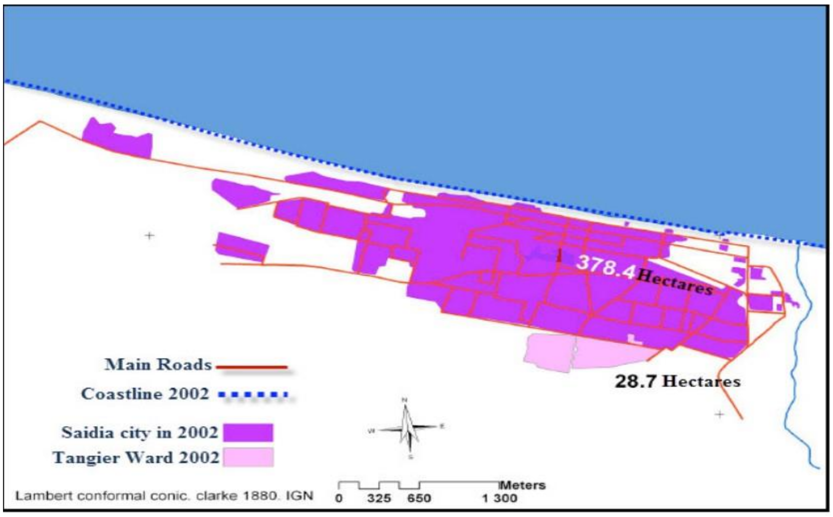

Fig13. Urban area in Saidia City in 2002.

7. Recommendation and Conclusion

This work classifies remote sensing images based on supervised and unsupervised classification methods, considering GIS approaches and urban models. The most important features of the original data are spectral, texture, and shape properties of ground objects. Data fusion made by IKONOS, SPOT, and Landsat satellite images reached a 0.61 m spatial resolution, which considerably decreased the impact of mixed pixels on the accuracy of the classification.

This had been done on different time data using the GIS classification technique, which proves to be quite potential in providing land cover and land use, but it requires quality ancillary data. In Oujda city, the given potential is restricted because of partial coverage of the land-use map and mixture of data. Urban models method: It proves that the local government partially uses these models regarding major tasks of city planning, like the siting of markets, main roads, railway networks, green spaces, and some residential areas.

The classification approach in the current study can effectively improve the classification accuracy of ground objects and could consider the theoretical bases and approaches that were needed.

The autoimmunization of land cover supervised maximum likelihood has shown an understandable feature and meaningful information extracted from both data SPOT and merged SPOT with Landsat ETM+, and also it can be considered as the most sophisticated and achieves worthy separation of classes. However, this approach does need strong training set to describe precisely the mean and covariance structure of classes and enough geographical acknowledgement of the study area.

Conclusively, the result from Supervised classification maximum likelihood derived from merging SPOT 2.5m with ETM+ 15 m, were clearly viewed particularly differentiated the urban areas to land cover and arable land, while results from supervised classification derived from only SPOT 2.5m were noticeable especially presented the road networks to the residential area were noticeable but there were some confusions between irrigated land and the urban areas which can be seen in brown colour in figure 12. Besides, the forest in black colour was mapped with agricultural land.

Along with rapid advances in information technology, different development applications have, until now, been subject to computer-based decision support models. In summary, comprehensive geographic information will increasingly become a trend in the development of classified remote sensing images.

Such a study is expected to apply the GIS multi-criteria and classifications technique to high-resolution remote sensing images of various kinds from different data sources, which would have bright prospects in studying land cover in very wide situations and extracting detailed information for analysis.

Knowledge rules were developed by considering information on spectral, texture, and shape, but it can be said that if more geographic information can be utilized comprehensively, the increase in classification accuracy will be greater. Thus, it is recommended that the accomplished result considered by the local decision-makers in Oujda and Saidia city in whatever future city planning.

It is also suggested that regular city and regional planning activities within Morocco apply the GIS multi-criteria analysis in managing their resources efficiently and use up-to-date remote sensing data for monitoring city urban growth movement. For this reason, there is a need for up-to-date satellite imagery with the help of GIS and ancillary data.

References

GIS modeling to assess the agricultural sustainability in Kafr El Sheikh governorate, Nile Delta, Egypt, Arab journal geosciences, DOI 10.1007/s12517-011-0377-5.

Alqadi, K., Kumar, L.,andKhormi,H.,(2013),Mapping hotspots of underground water quality based on the variation of chemical concentration in Amman, Zarqaand

Balqaregions, Jordan, Environ earth sciences,DOI10.1007/s12665-013-2632-4

Arnous,M. (2013),Geotechnical site investigations for possible urban extensions at SuezCity,Egyptusing GIS,Arab journal of geosciences,6,pp1349–1369.

Dawod, G., Mirza, M., and Al-Ghamdi, K., (2012), GIS-based estimation of flood hazard impacts on road network in Makkah city,SaudiArabia,Environ earth sciences, 67,pp2205–2215.

Dakki, M. (2003) *Diagnostic pour l'aménagement des zones humides du nord-est du Maroc:* : Sebkha Bou Areg (lagune de Nador). projet MedWetCoast-Maroc, Rapport définitif, PNUE/ Secr.Etat Eenv./Départ. Eaux et Forêt, Maroc, 55P. Available at: http://vinc.s.free.fr/IMG/MWC_Maroc_ZH_BouAreg.pdf (Accessed on: 11/12/2013).

Kattabi, A., Ezzahiri, M., Rifai, N., Rifani, N., El Anzi, R., Naji, H., Soumaa, A. And Fernandez,

P. (2007) *Analyse de la situation actuelle de la zone côtière de Nador : Milieu biophysique.* Available at: http://www.eucc.nl/en/capnador/Analyse_Milieu_Biophysique_FR.pdf (Accessed on 10/08/2024).

RGPH, (2004). Recensement Ge´ne´ral de la Population et de l'Habitat, Royaume du Maroc, 2004, Rabat. Available at : http://www.hcp.ma/Recensement-general-de-la-population-et-de-l habitat-2004_a633.html (Accessed on: 22/01/2-2024).

USGS, (2010)' *What is NDVI'* [online]. Available at: http://ivm.cr.usgs.gov/whatndvi.php (Accessed on: 04 August 2023).

Wang, L., Sousa, W.P., Gong, P., Biging, G.S., (2004). Comparison of IKONOS and QuickBird imagery for mapping mangrove species on the Caribbean coast of Panama. *Remote Sensing of Environment*, v.91, p.432–440. [Online] Available at: http://www.sciencedirect.com/science/article/ pii/S0034425704001129 (Accessed on: 07/02/2024).

Wentz, E.A., Stefanov, W.L., Gries, C., Hope, D., (2006). Land use and land cover mapping from diverse data sources for an arid urban environments. *Computers, Environment and Urban Systems*,v. 30, p.320–346. [Online] Available at: http://www.sciencedirect.com/science/article/pii/ S0198971504000511 (Accessed on: 23/02/2023).