

Use of Space Technology for Disaster Management for Western Asia

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Space Techniques for Desertification Monitoring and Control in Al-Ahsa Oasis, Saudi Arabia

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Introduction

■ Objective: using integrated GIS and RS technologies

- ✓ Survey of the urban area during the last two decades (1987 and 2001)
- ✓ Establishment of urban evolution maps and
- ✓ Assessment of Urbanization Impact on Agricultural Areas

■ Study site (Saudi Arabia)

- ✓ Al-Ahsa Oasis including 3 cities: Hofuf, Mubarraz, Al-Youn.
- ✓ Study covers a rectangle of 40 Km by 60 Km.

■ Data used

- ✓ Multispectral Landsat-TM data (30 m resolution)
- ✓ Topographic maps
- ✓ Ground Observations

Adopted Methodology

■ Intensive Geographical Study

- Geography
- Urbanization
- Population
- Agriculture

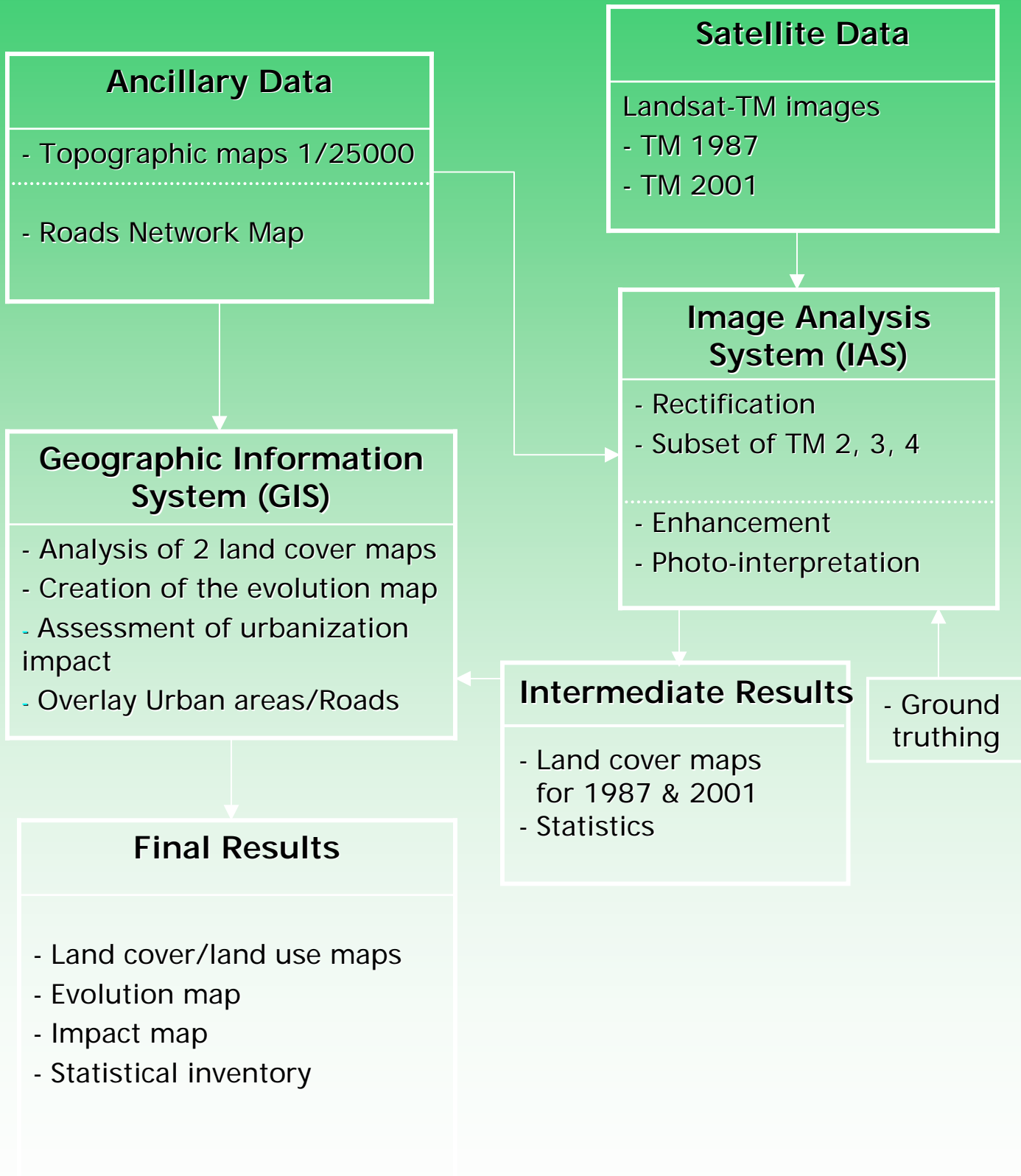
■ Land cover mapping using Satellite imagery

- Two Multispectral Landsat_TM images
- Acquisition date during 1987 and 2001
- Pre-Processing of Images (Rectification, Hardcopy)
- Computer assisted photo-interpretation
- Land cover/landuse maps for 1987 and 2001

■ Analysis and interpretation using GIS

- Land cover / land use maps for the two dates
- Evolution maps for urban areas
- Overlay of Urban areas with Road Network
- Impact assessment of urbanization on agricultural areas

Flowchart Indicating Data Input, Output and Analysis



Intensive Geographical Study

■ Geographical Conditions

- Climate: desert and drought
 - Mean Temperature increase from 25.7 to 26.8°C
 - Precipitation increase also from 75.3 to 110.4 mm
- Sand Movement from the NW/N 4.7 m³/m width

■ Urbanization

- The design of the 3 cities of Al-Ahsa has changed during the last 30 years, especially with the development of oil industry during 1970's.
- Consequence: development of good utilities and services

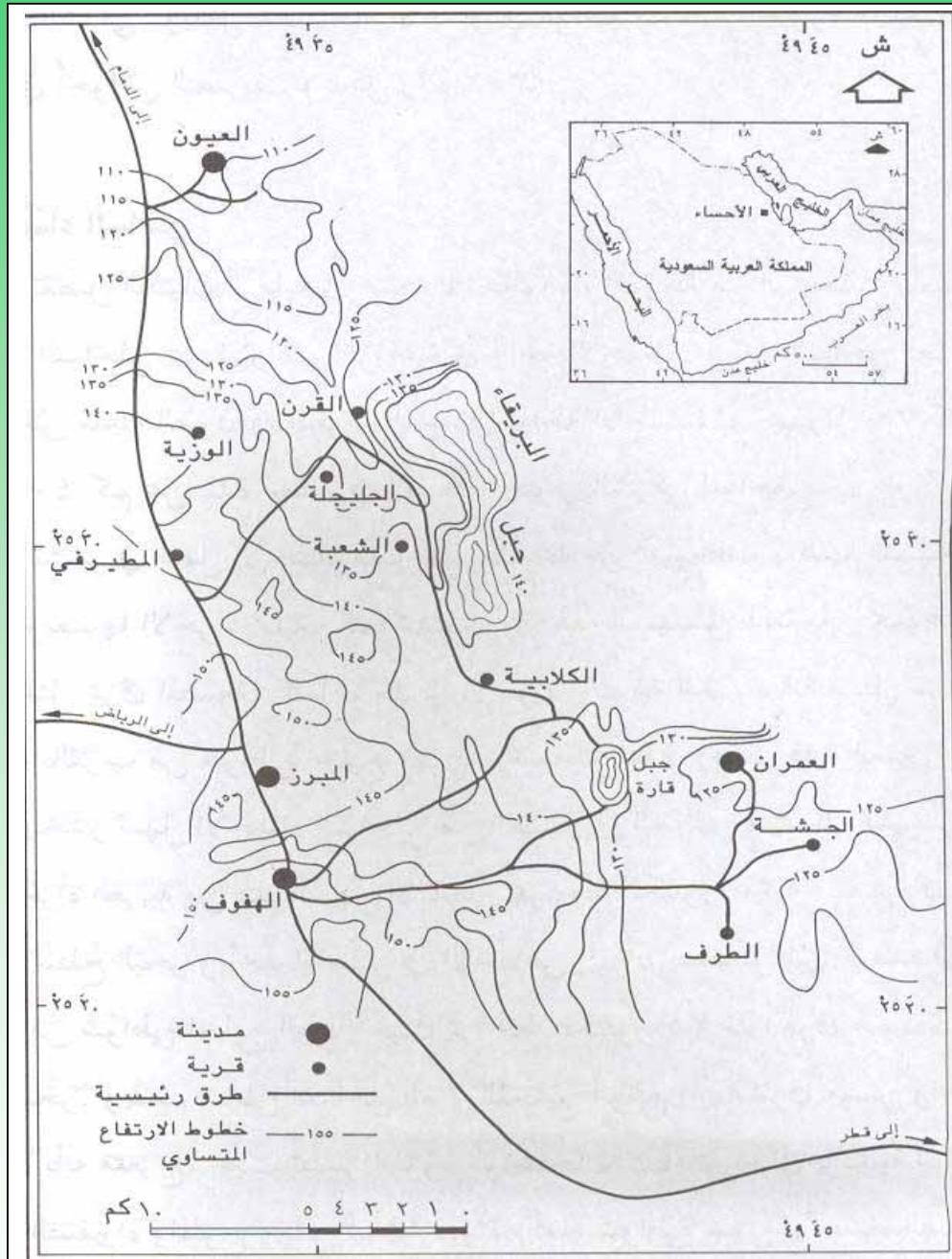
■ Population/ Demography

- Urban population 77.9 %
- Rural and Villages population 22.1 %
- Population 800 000 inhabitants due to population growth and immigration (inside SA, GCC countries)

■ Agriculture

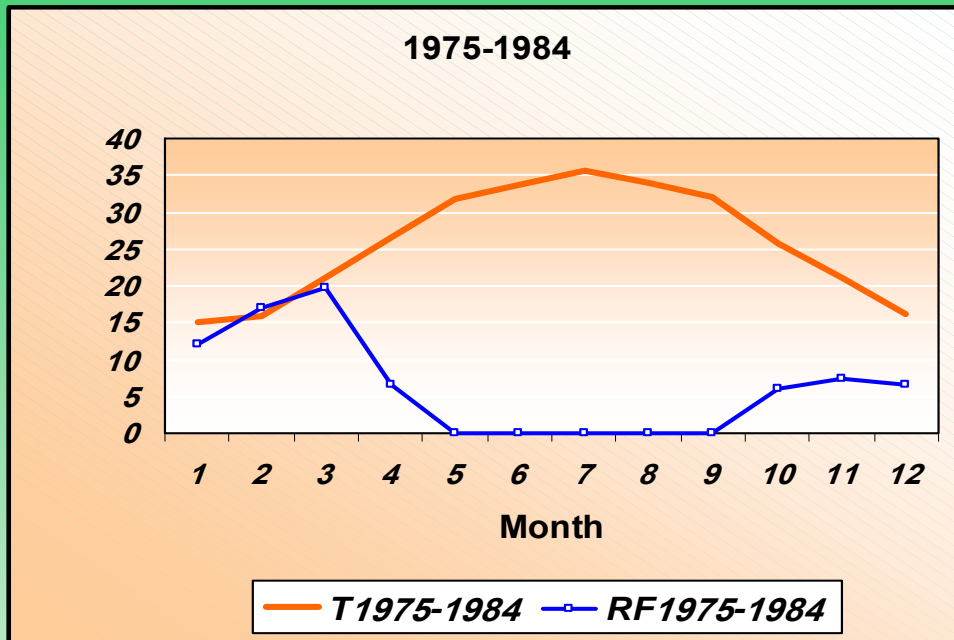
- Decrease of the Agricultural area due to, sand dunes, urbanization, ground water table, drainage (sabkha)
- Parcels with small size are not cost effective

Al-Ahsa Oasis Localization with Contour Map

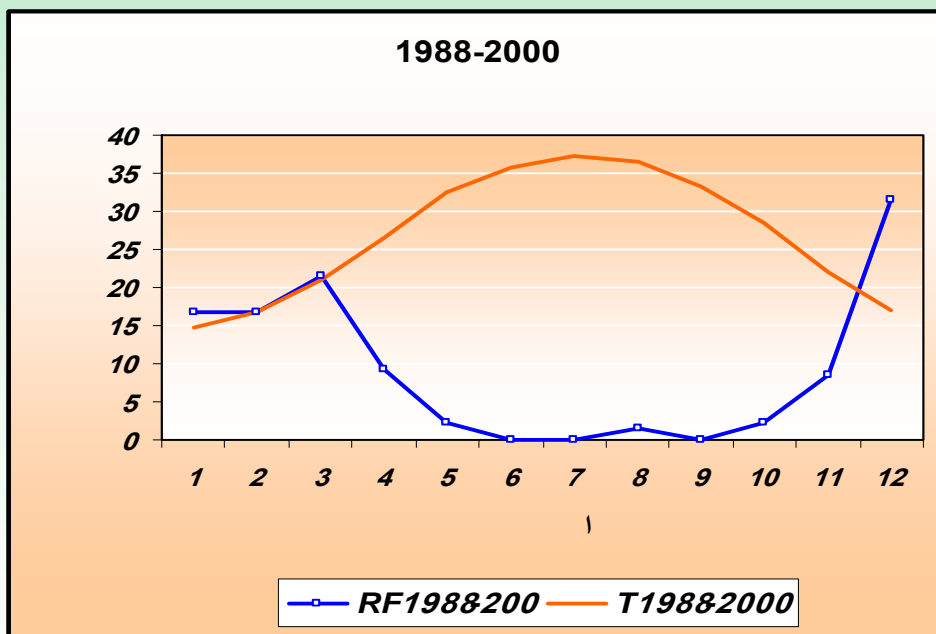


Adapted from Tahar (1999)

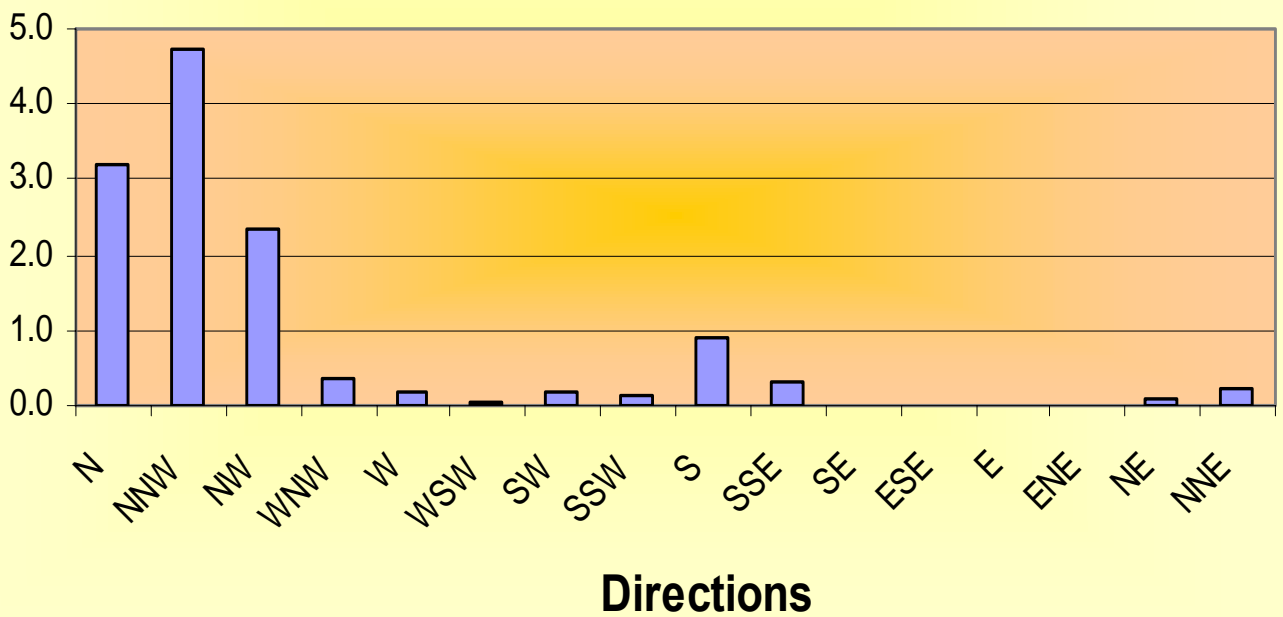
Temperature and Rainfall for two time series 1975-84 and 1988-00



T : Temperature in degree Celsius
RF : Rainfall or precipitations



Sand Movement quantity and directions (1985-94)



Land Cover Mapping Using Satellite Imagery

■ Choice of the Period of Data Acquisition and Interpretation Technique

- Two Multispectral Landsat-TM images of Autumn, taken for Al-Ahsa during 1987 and 2001.
- Computer assisted photo-interpretation of Landsat data.
- Ground truthing using GPS receiver to localize field observations (delimitation of different classes).

■ Output of Land Cover/Land Use Maps at a Scale of 1/100 000

- 7 thematic classes (Urban area, Agricultural area, Hills, Water, Sabkha, Urban planning and sand).
- Diagnosis of the two periods 1987 and 2001

■ Statistical Inventory

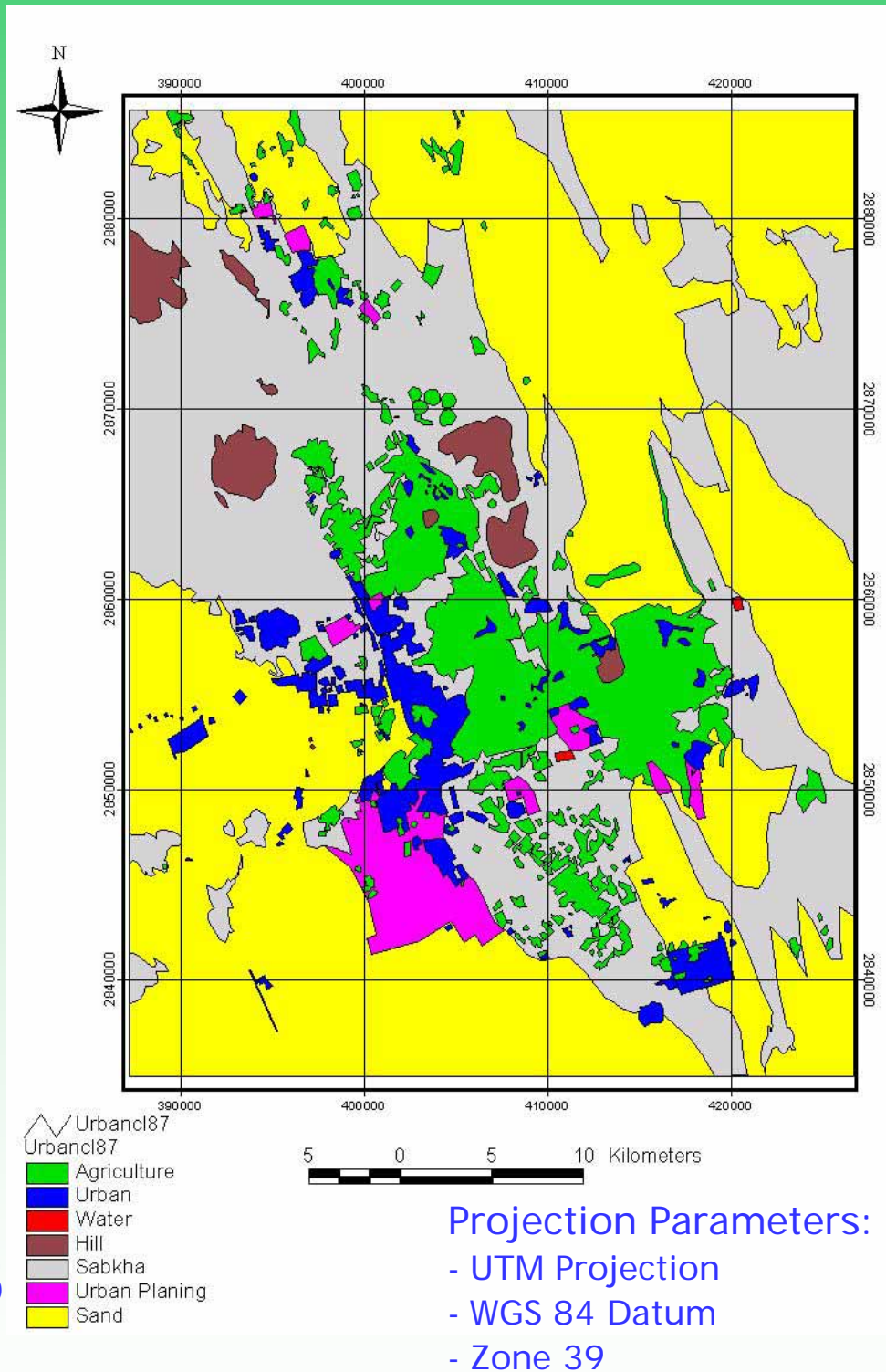
- Corresponding Area of each thematic class

Landsat-TM Image of Al-Ahsa (1987) : Bands 4 3 2 (RGB)



© EOSAT 1987 KACST/ Processed at AGU

Land Cover Map of Al-Ahsa Using TM Image of 1987

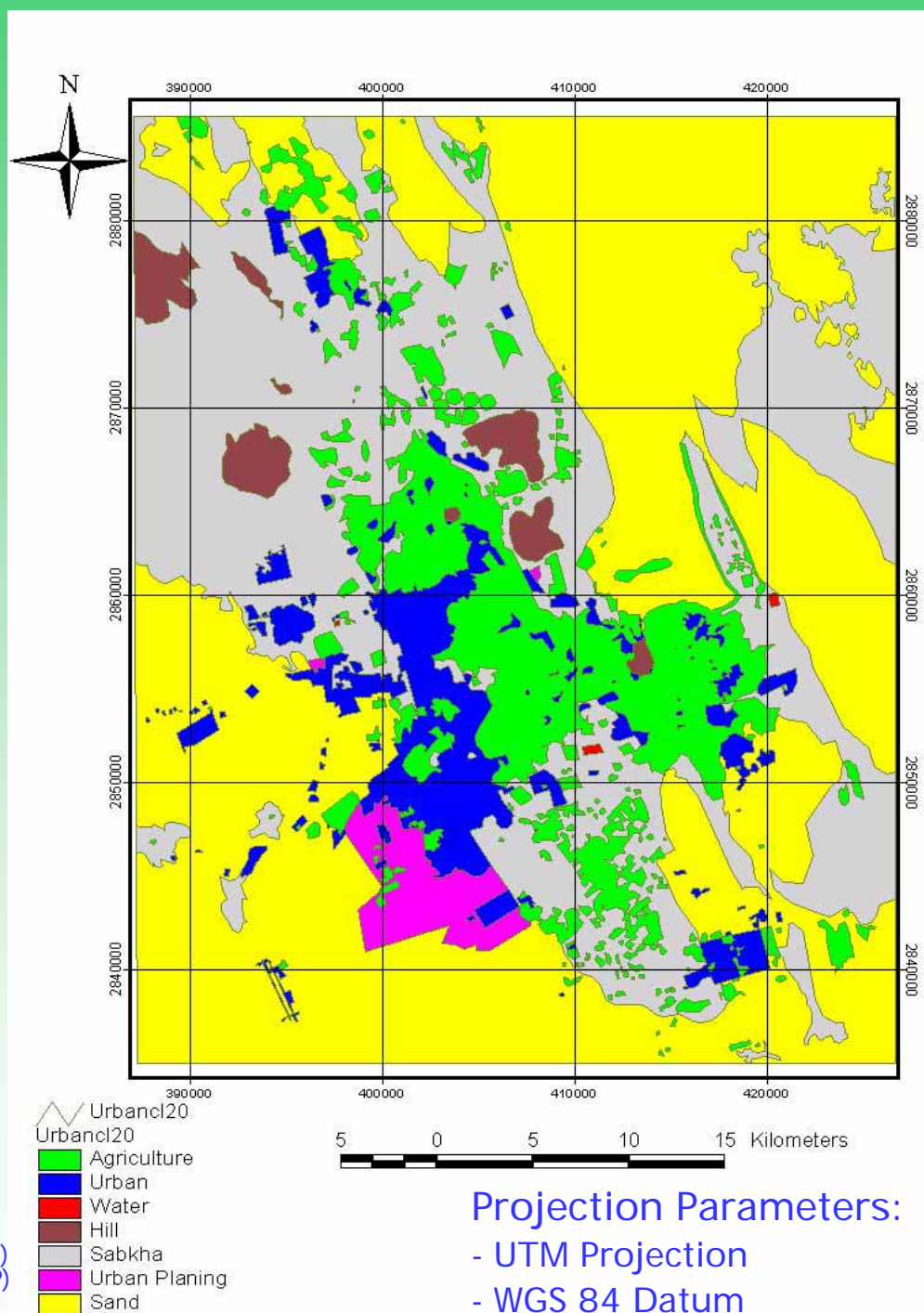


Landsat-TM Image of Al-Ahsa (2001) : Bands 4 3 2 (RGB)



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Land Cover Map of Al-Ahsa Using TM Image of 2001



Statistics of Land Cover Maps for 1987 and 2001

Area	Area of 1987	%	Area of 2001	%	Change 01-87	% of change
Classes	I	I/II	IV	IV/V	VI	VI/I
Agriculture	20392.9	9.2	24823.2	11.2	4430.3	21.7
Urban area	7152.1	3.2	12477.9	5.6	5025.8	74.5
Water	86.2	0.1	88.2	0.1	2.0	2.3
Hills	4202.4	1.9	4056.0	1.8	-146.4	-1.6
Sabkha	70053.0	31.6	61989.6	27.9	-8063.4	-11.5
Urban Plan.	4984.7	2.3	3643.0	1.6	-1341.7	-26.9
Sand	115153.4	51.7	114952.9	51.8	-206.4	-0.2
Total area	222024.6 II	100	222024.6 V	100		

Data Analysis and Interpretation Using GIS

■ Data used

- Land cover/land use maps .
- Two periods 1987 and 2001.

■ Evolution maps for urban and sub-urban areas

- Evolution map from 1987 to 2001.

■ Impact assessment of urbanization on agricultural areas

- Mapping of impact of urbanization on other land use types.
- Evolution matrix, giving all possible changes involved and the area concerned in term of extension, regression and neat evolution for all classes.

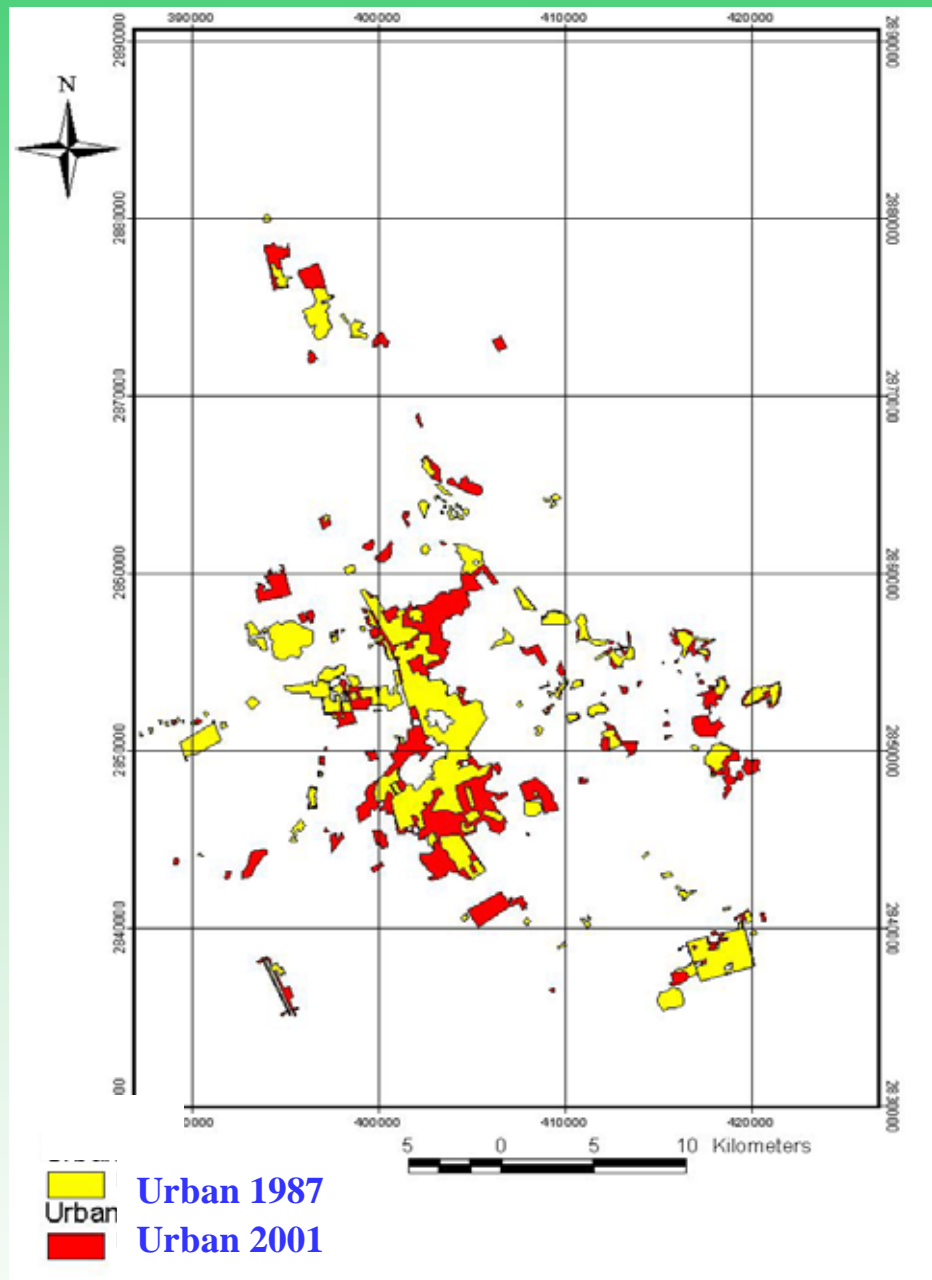
Changes (Evolution Matrix) of Al-Ahsa Between 1987-01

1987 2001	A	U	W	H	Sb	UP	S	Exten- sion	Chan- ge
A	---	119.3	---	82.4	4480.4	184.3	1654.1	6520.7	4430.3
U	513.1	---	1.5	21.5	2745.9	1499.8	972.3	5754.1	5325.8
W	---	6.4	---	---	---	---	1.9	8.3	2.0
H	1.4	15.7	---	---	197.9	---	---	215.0	-146.4
Sb	1396.0	221.2	---	257.5	---	533.3	4368.5	6776.5	-8063.4
UP	22.1	14.1	---	---	193.1	---	827.0	1056.3	-1341.7
S	157.8	51.6	4.8	---	7222.6	180.6	---	7617.4	-206.4
Regression	2090.4	428.3	6.3	361.4	14839.9	2398.0	7823.8		

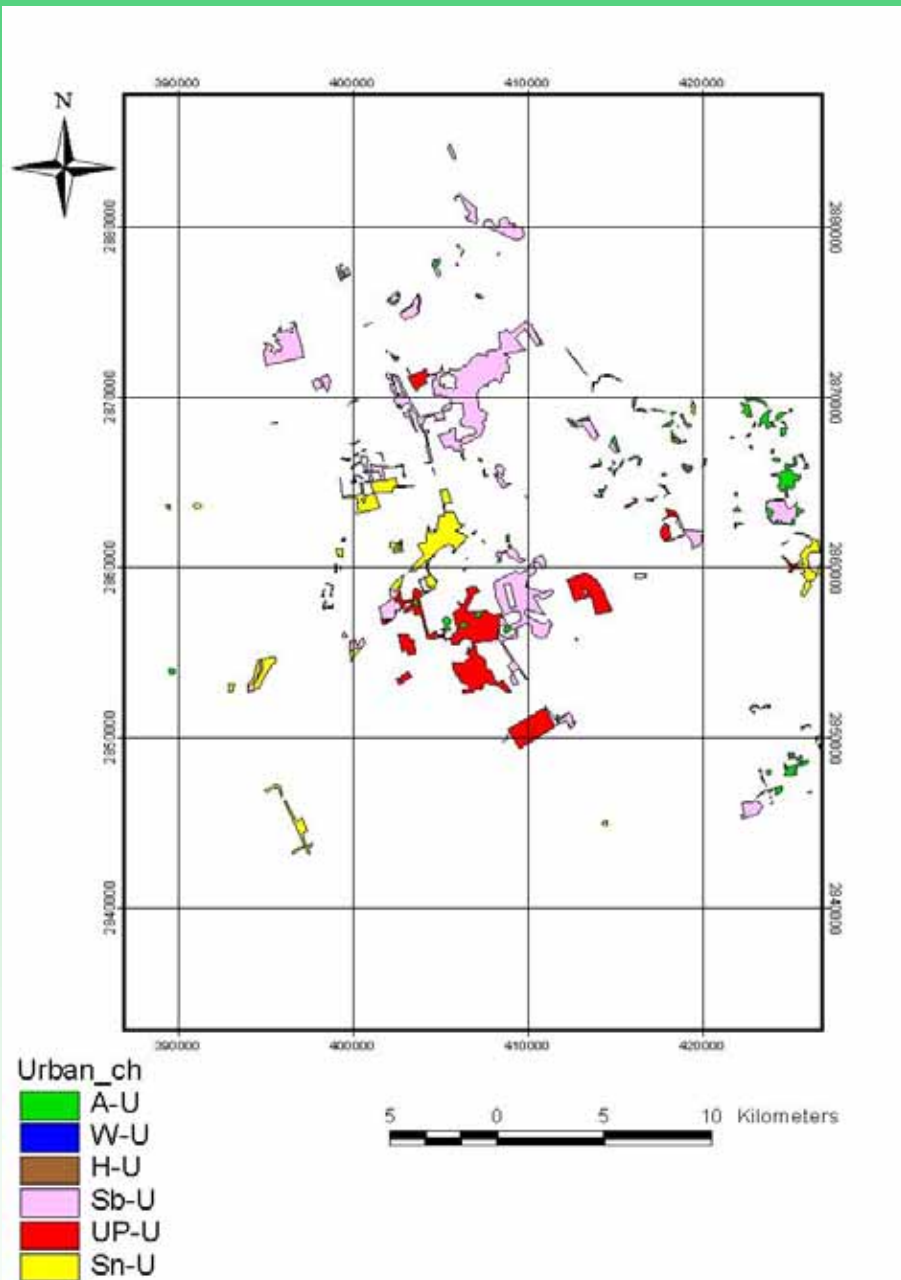
(A) Agricultural land
(U) Urban area
(W) Water bodies
(H) Hills

(Sb) Sabkha
(UP) Urban planning
(S) Sand
(Unit) Hectares

Urban Evolution Map of Al-Ahsa between 1987 and 2001



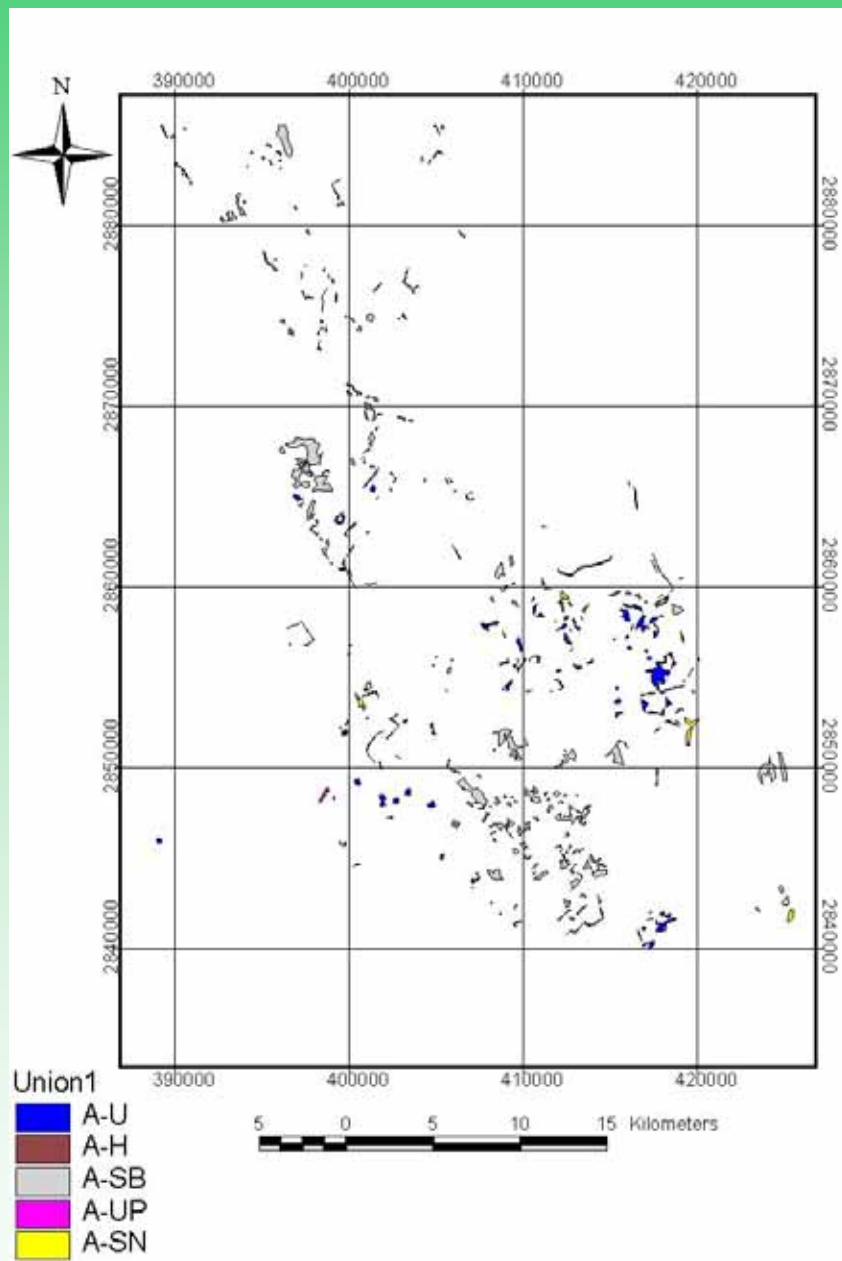
Impact of Urbanization on other land uses



513.1 ha
1.5 ha
21.5 ha
1745.9 ha
1499.8 ha
972.3 ha

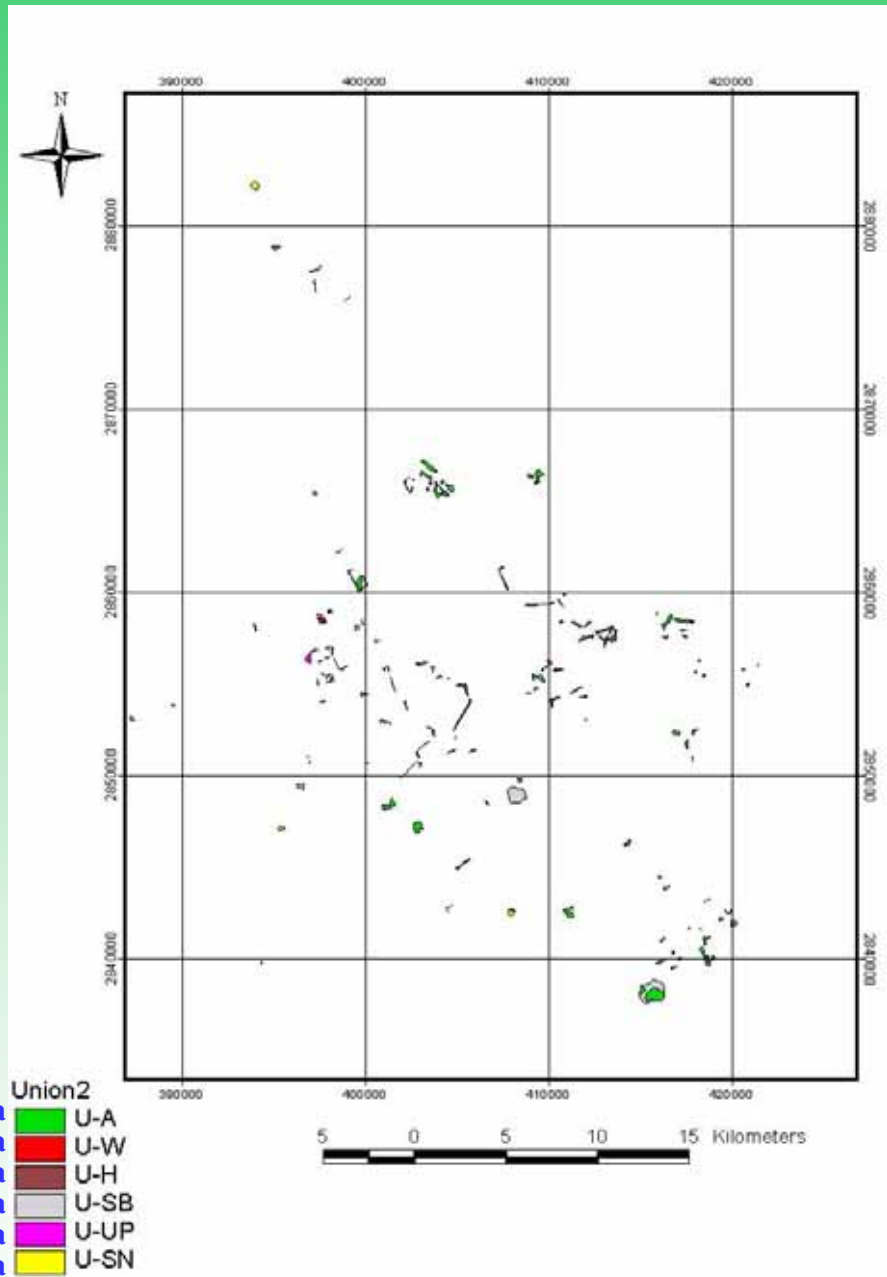
5754.1 ha

Changes from agriculture to other land uses

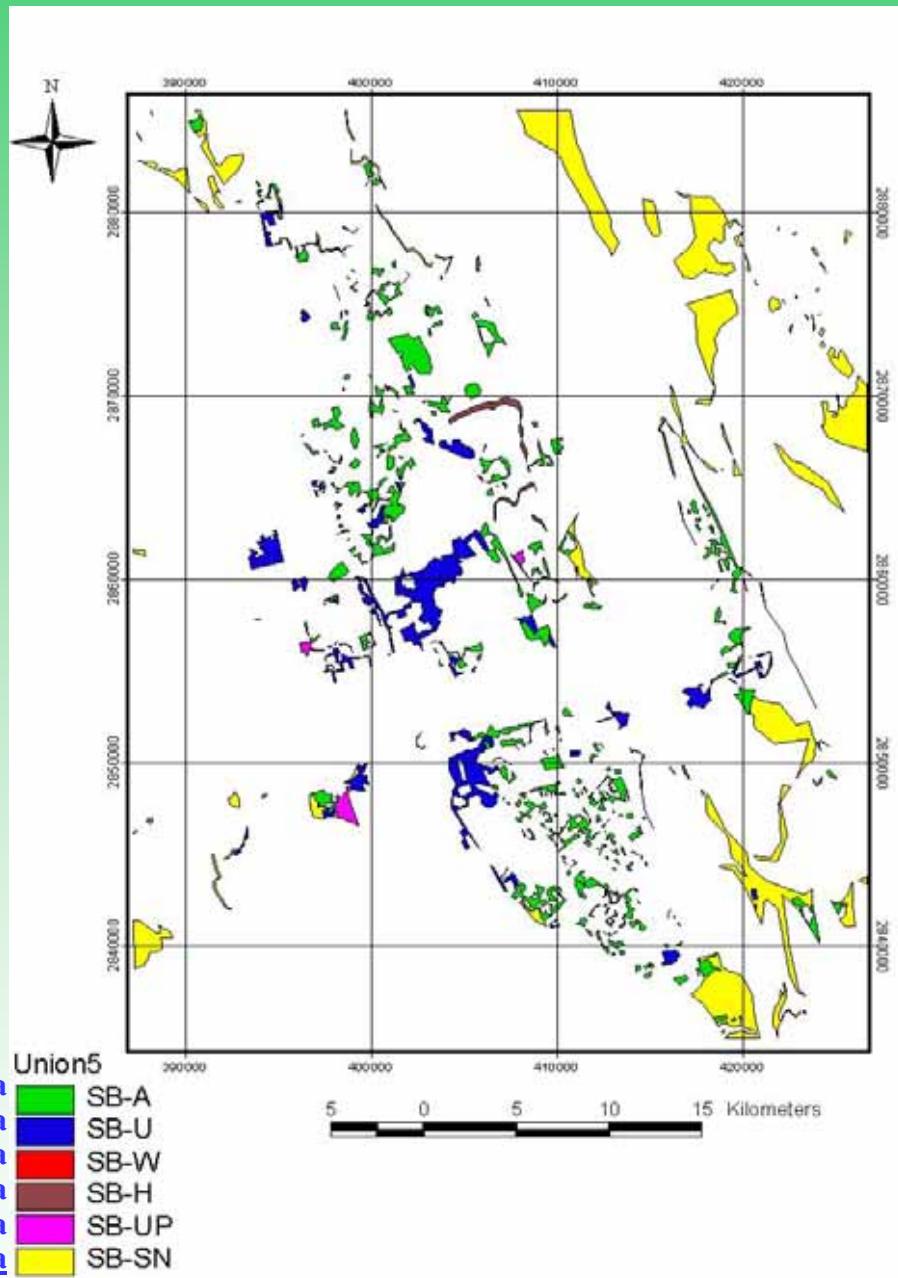


2090.4 ha

Changes from urban area to other land uses



Changes from Sabkha to other land uses



14839.9 ha

Agricultural lands (Palm trees, other crops, Irrigation)



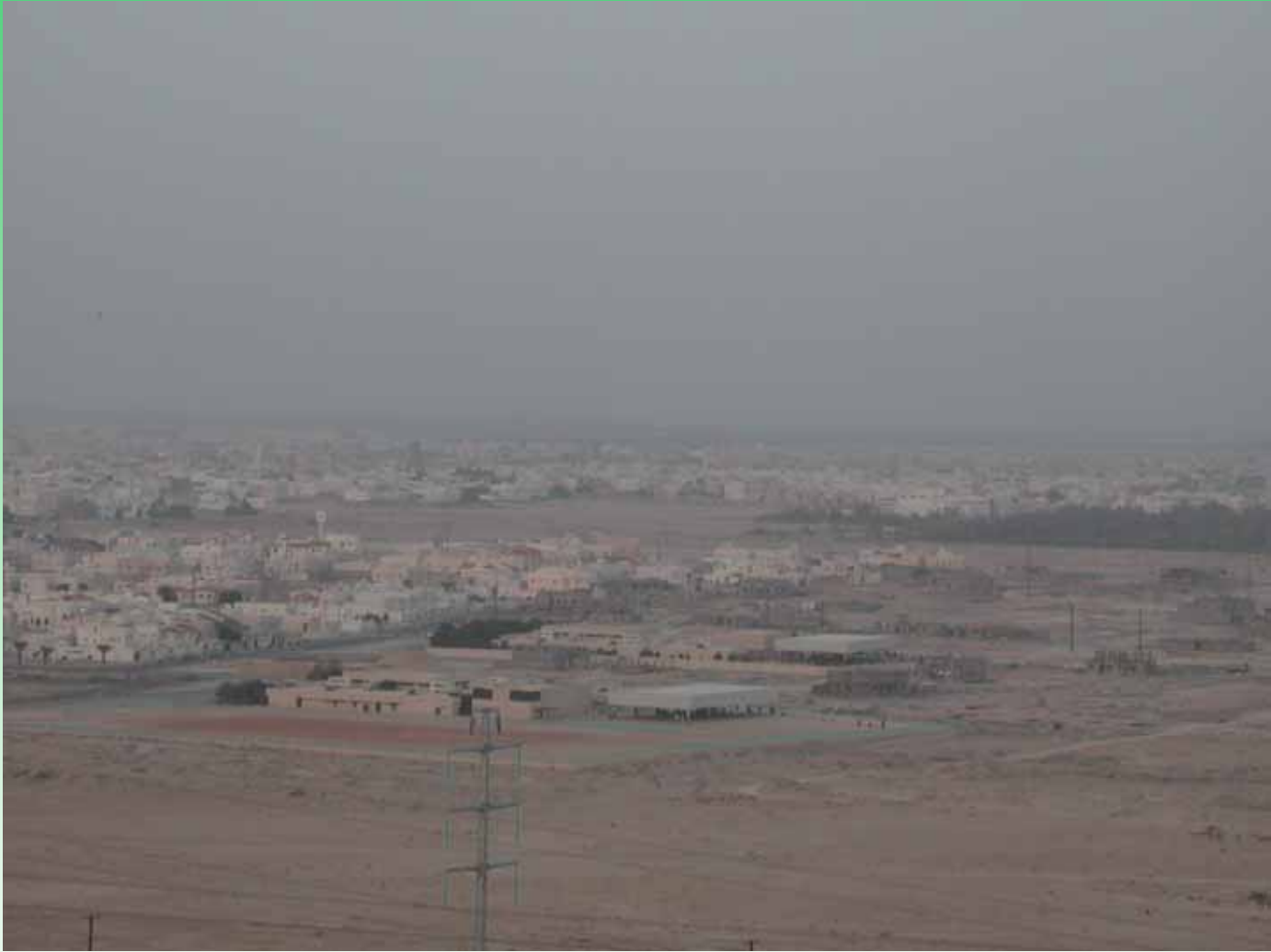
Sand dune formation



Sabkha (Salinization)



Urban Areas (Urbanization)



Conclusions

- Detailed land cover/land use maps, scale of 1/100 000, offering an exhaustive diagnosis of urban and sub-urban areas at each period (1987 and 2001).
- Evolution maps for the period 1987 to 2001 (14 years), giving a temporal evolution trends for 7 thematic classes: agriculture, urban, etc..
- Overlay of the evolution map with road network to localize the urban changes & their directions.
- Impact assessment of urbanization on agricultural areas and other classes, in term of extension, regression and neat evolution
- Cartographic and statistical results are a good tools regarding the protection of agricultural lands and the planning of urban areas .
- These results will assist decision makers to prepare future plans in order to find adequate solutions to urbanization encroachment.
- The methodology could be used in other regions to investigate impact of urbanization in other cities or oasis.

Recommendations

- Development of urban databases for Al-Ahsa oasis based on the results and products of this study along with existing and historical data.
- Database updating using RS/GIS every 3 or 5 years to draw up the new changes according to the socio-economical development of the oasis.
- Appropriate urban planning with impact studies in order to protect agricultural lands.
- According to the results obtained from this study, the appropriate zoning of Al-Ahsa oasis should be as follow:
 - Residential areas concentrated in the north and south-west
 - Industrial and commercial activities concentrated in the far south
 - Development of protected areas in the north and in the north-east to protect the oasis from sand Movement.

Abstract

Urbanization is considered as an important problem because of the great loss in the agricultural areas surrounding urban areas. It is of importance especially with the loss of the green zone in the desert and arid zones such as the study site under investigation in this study. The loss of such green areas is a great fallen in that they are sources of food and amusement.

This study focuses on the use of remotely sensed (RS) data and geographic information systems (GIS) technology in investigating the effects of urbanization on the agricultural areas in Al-Ahsa oasis. The study is based on two satellite images taken of Al-Ahsa oasis in 1987 and 2001 from Thematic Mapper sensor of Landsat satellite, topographical maps and current ground observations. The adopted methodology consisted of three phases: 1) intensive geographical study; 2) visual interpretation and analysis of the satellite images; and 3) spatial analysis of the remote sensing results.

The geographical study revealed that Al-Ahsa oasis is suffering from urbanization phenomenon and population growth. The visual interpretation based on computer and remote sensing softwares (Ermapper, Erdas/Imagine) enabled us to produce two maps of land uses and to identify the areas of the uses (agriculture, urbanization, hills, water, sabkha, planned areas, and sand) of these lands. The changes occurring in the period between 1987 and 2001 were studied using geographic information system softwares (Arc/Info, Arc/View). This proved that urbanization has impacted the agricultural areas due to the less effectiveness of the economic value of these areas because of dividing the areas on the basis of inheritance. Also, urbanization has occurred due to other lands uses (planned areas, Sabkha.).

In conclusion, remote sensing and geographical information system technologies together with ground observations and topographic maps can be used to assist decision makers to prepare future plans, in order to find appropriate solutions to urbanization encroachment and recognize the environmental and socio-economical effects resulting from it.

Land Use Change Detection Methods

■ Multi-Date Composite Image Method

- Combination of images of different periods to form a new single image
- Enhancement procedure for change detection includes Image overlay, Image Differencing, Image Ratioing, and Vegetation Index.

■ Image Comparison Method

- Comparison can be made between separate images of different dates

■ Comparison of the Classified Images

- Comparison is made between classified images of different dates.
- Used to study the trend of urbanization in Morocco, Egypt, Algeria and Taiwan.

■ Combination of the Classified Images

- Combination of 2 classified images done by a mathematical model (Thailand).

■ Classification of the Radar Imagery

- Potential of SAR data for land use classification with textural analysis(Japan).
- Multi-frequency & multi-polarization SAR data proved to be useful (Malaysia).



Land Use Change Analysis and Modeling

■ Regression Model applied to land use/cover maps (China).

- produced during 1987 and 1999 at the country level.
- The monitoring of such changes was ensured by a multivariate regression modeling which links land use changes with human activities.

■ Modeling and forecasting effects of land use changes (China).

- based on socio-economical drivers and the application of time series econometrics and artificial neural networks.

■ Modeling of urban growth changes in the Atlanta Area (USA).

- Using an urban growth model coupled with land transition model.
- 3 scenarios were designed to simulate the consequences of urbanization.

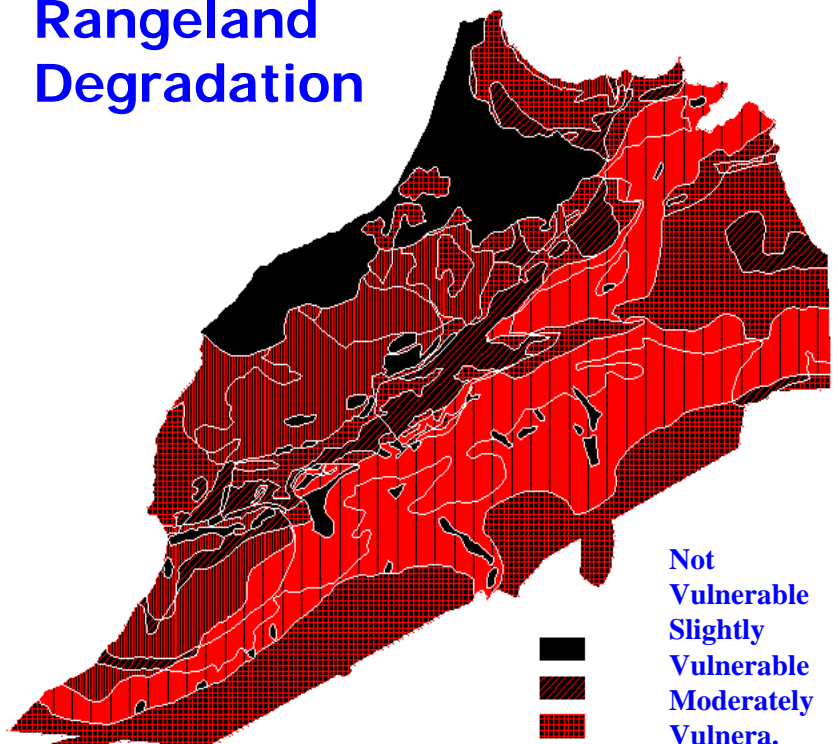
■ Maximum likelihood interpolation and genetic model (Japan).

- To Reconstruct long-term land cover changes during 1900-90 by 10 years interval.
- From fragmentary observational data and knowledge of changes.



Forestry and Rangelands

Rangeland Degradation

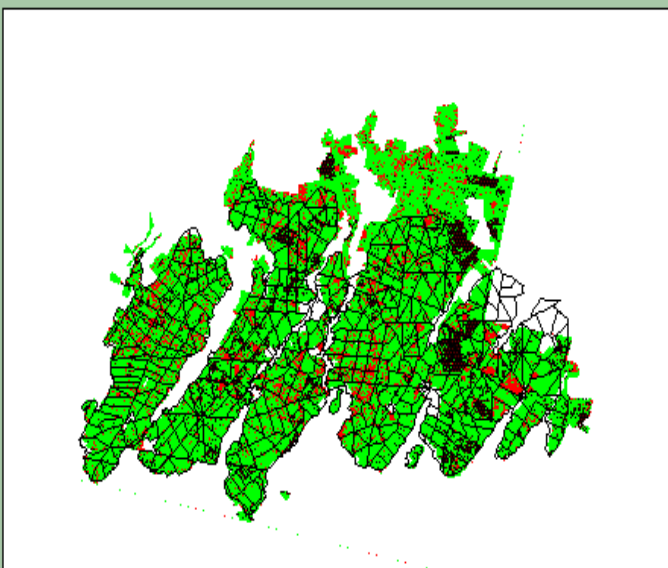


Not
Vulnerable
Slightly
Vulnerable
Moderately
Vulnerable
Vulnerable
Very
Vulnerable



IMAGE DIFFERENCE DE LA MAMORA ENTRE 1989 & 1991

Image Différence entre 1989 et 1991



Déplacer le rectangle
vers la nouvelle
location désirée



Ajouter couche

Full Extent

Zoom In

Zoom Out

Identifier

Requête

Imprimer

Page d'accueil

Reboisement

Déboisement

Forestry
Management

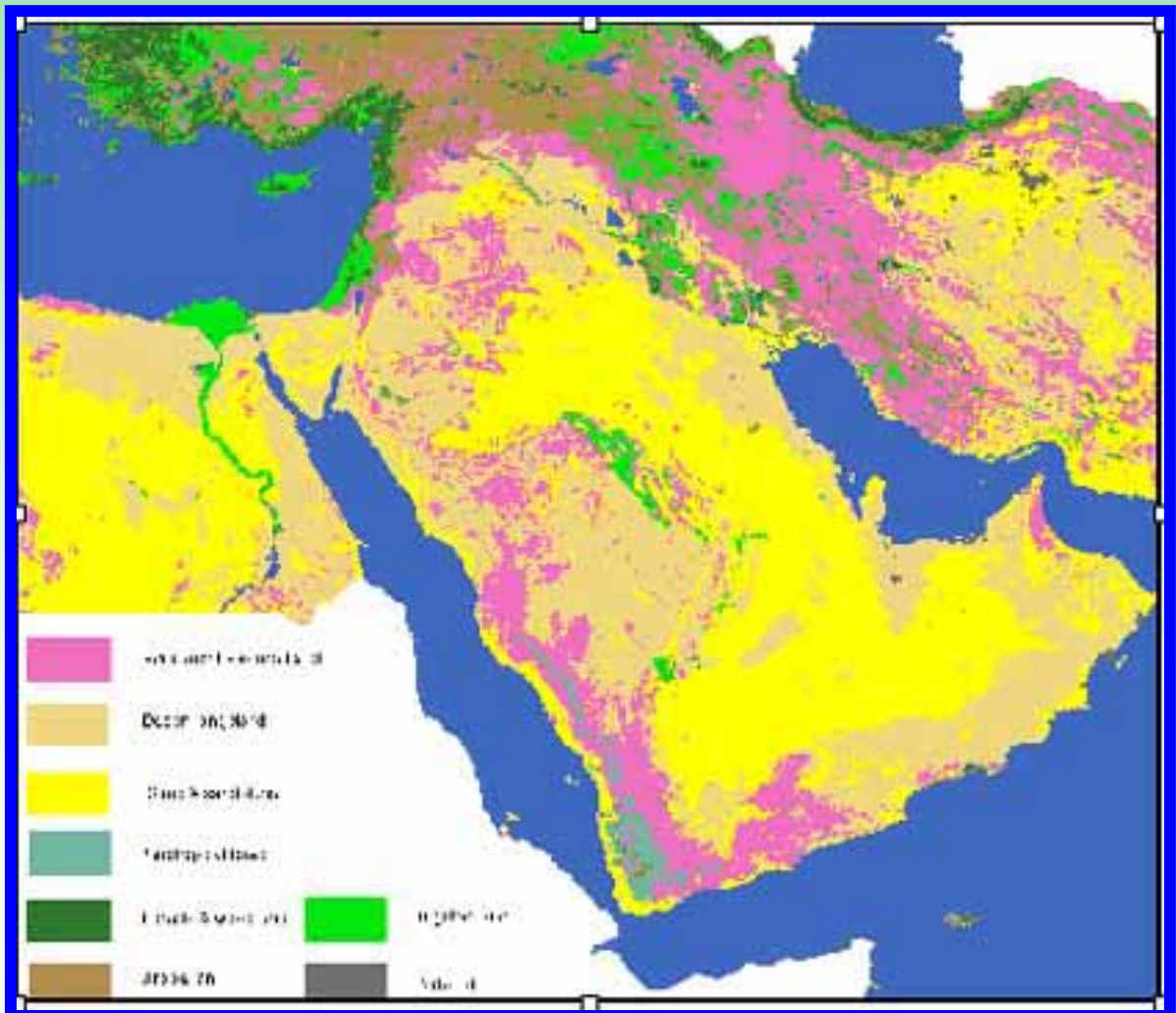
Desertification Studying

Desertification assessment was achieved

- ✓ Based on Land cover, soil, climate, topography, socio-economy.
- ✓ The causes of desertification are: wind & water erosion, vegetation degradation and salinization.

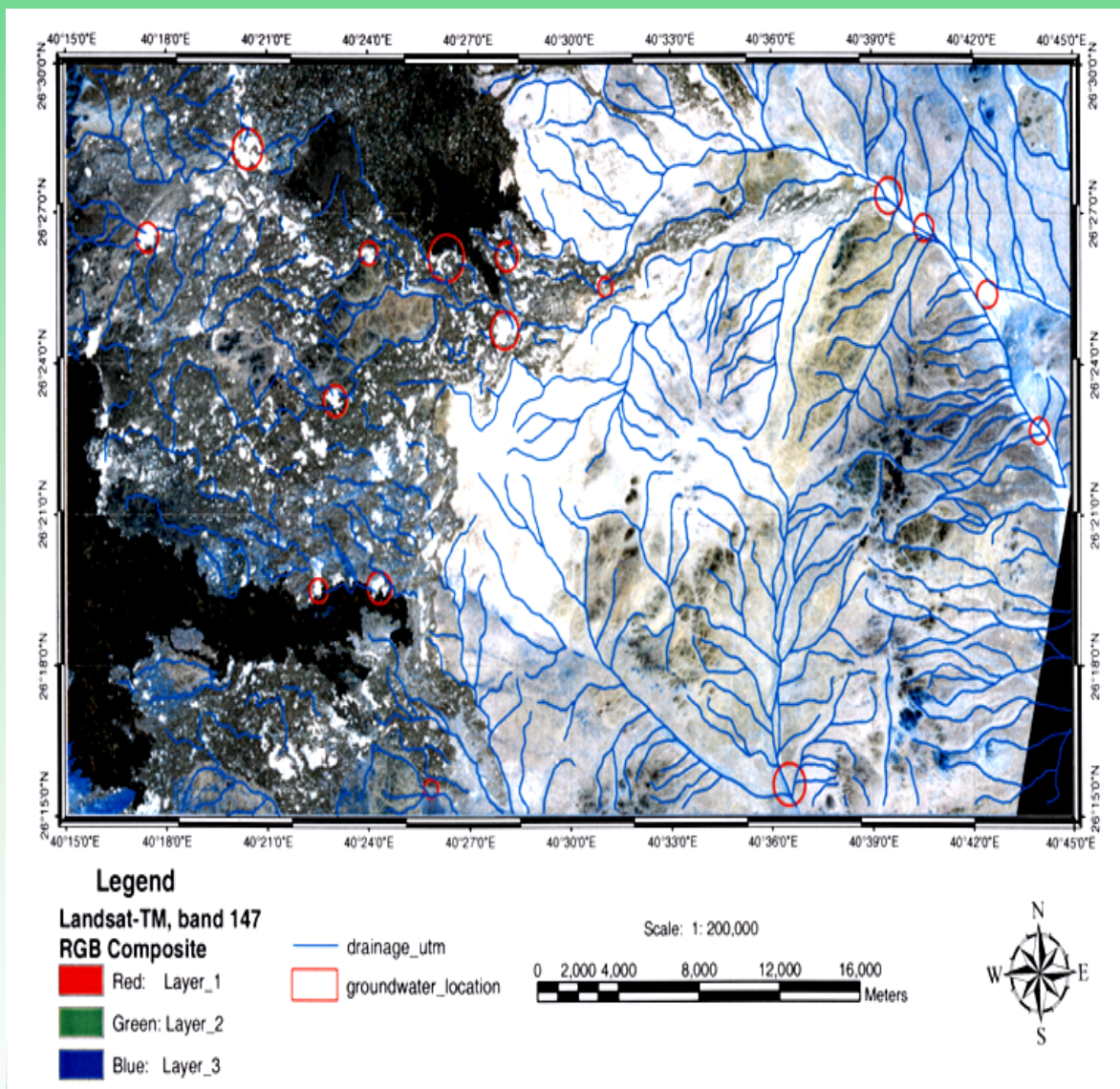
Desertification Status

- ✓ 31 % of land is desert.
- ✓ 27 % slight to moderate.
- ✓ 42 % severe to very severe.



Groundwater Exploration

Groundwater Exploration Based on Hydro-Geo-Spatial Database in Hail Region in the Kingdom of Saudi Arabia.



شكل 5-7 أ المواقع المحتملة للمياه الجوفية على صور Landsat-TM

Hotspots for groundwater Exploration