



UNIVERSITÀ  
DEGLI STUDI  
FIRENZE

**GESAAF**  
DIPARTIMENTO DI GESTIONE  
DEI SISTEMI AGRARI,  
ALIMENTARI E FORESTALI

# LAND DEGRADATION AND COMBATING DESERTIFICATION (with focus on Tunisia)

Institut des Régions Arides



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# OUTLINE

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- Drylands & desertification
- Desertification in Africa
- Land degradation and combating desertification in Tunisia
- Roles of IRA-Medenine and some of its achievements (land and water resources)

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# DRYLANDS AND DESERTIFICATION

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# Drylands

- Aridity is defined as **lack of moisture in average climatic conditions caused by one of the four climatic situations:**
  - Atmospheric stability
  - Continentality
  - Topography
  - Cold oceanic currents
- Aridity index  $AI=P/PET$ 
  - Dry subhumid:  $0.5 < AI < 0.65$
  - Semi arid:  $0.2 < AI < 0.5$
  - Arid:  $0.05 < AI < 0.2$
  - Hyperarid:  $AI < 0.05$
- More than **6.1 billion ha**, **47.2 %** of the earth's land surface is **dryland**: Nearly **1 billion ha** are naturally **hyperarid** deserts and the remaining (**5.1 billion ha**) are **arid, semiarid and dry subhumid** areas house of **1/5th** world's population.



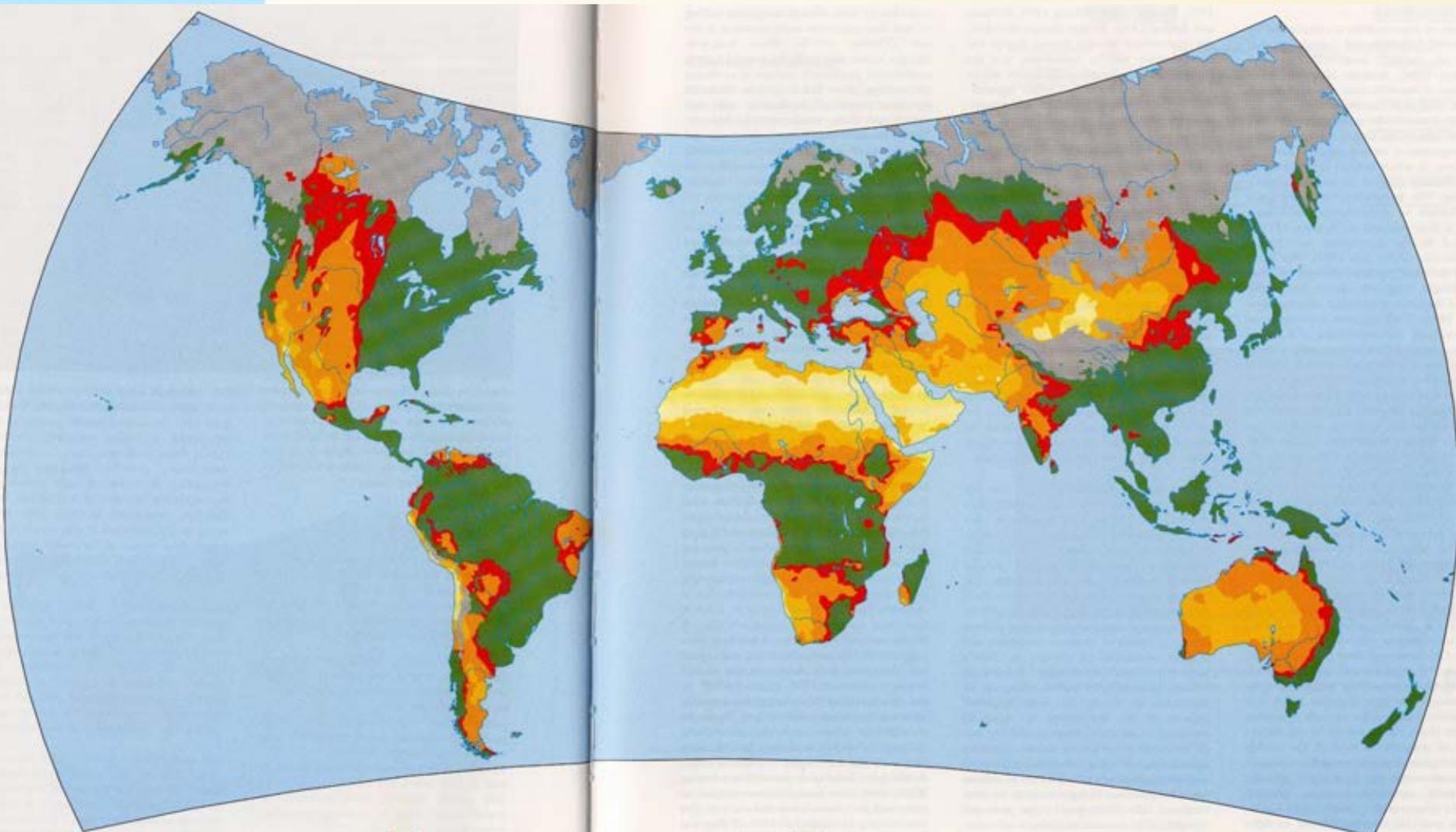
# Desertification

- The word *desertification* means an environmental crisis which produces desert-like condition in any ecosystem In ancient Egyptian hieroglyph, *tesert* means a place that was forsaken or left behind : *desere* : to abandon; *desertum*: waste place or wilderness; *desertus*: abandoned or relinquished
- The word desertification was first used in west Africa in 1949 by the French forester Aubréville to describe the way in which it was perceived that the Sahara desert was expanding to engulf the desert marginal savanna grasslands.
- The term was raised as a major environmental issue at the UN conference on human environment held in Stockholm in 1972.
- Desertification reached a wider audience in the 1970s with the plight of the drought-stricken Sahel zone. One of the outcomes was the UN conference on desertification held in Nairobi in 1977.



- In 1984, a desertification hazard map was produced by the UNEP, FAO, UNESCO and WMO.
- The 1992 Rio UN conference on environment and development requested the UN general assembly to establish an intergovernmental committee to negotiate the convention to combat desertification which entered into force in 16 December 1996.
- More than a hundred of definitions have been used both in scientific and political circles.
- **Desertification means land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities;**
- Land in this context includes soil and local water resources, land surface and vegetation, including crops.
- Degradation implies reduction of resources potential by one or a combination of process acting on the land.
- Combating desertification includes activities which are part of the integrated development of land in arid, semi-arid and dry sub-humid areas for sustainable development.



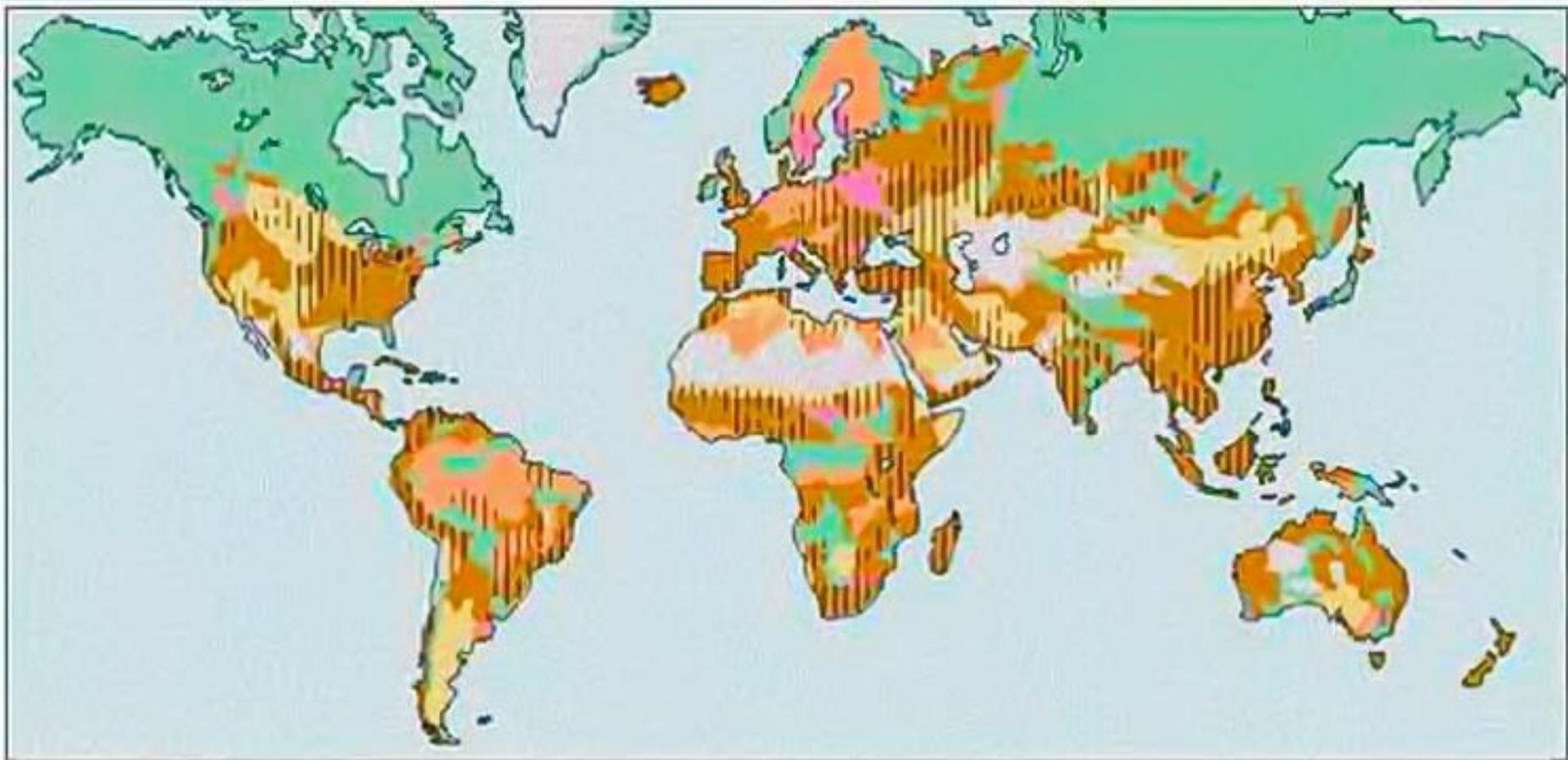


- Hyperarid
- Arid
- Semiarid
- Dry subhumid

- Humid
- Cold climates

Source: CRU/UEA, UNEP/GRID

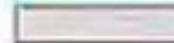
Approximate equatorial scale 1:104 million



**Soil degradation types**

- |  |                               |   |                               |
|--|-------------------------------|---|-------------------------------|
|  | <b>Water erosion</b>          |  | <b>Physical deterioration</b> |
|  | <b>Wind erosion</b>           |  | <b>Severe degradation</b>     |
|  | <b>Chemical deterioration</b> |   |                               |

**Other symbols**

- |   |                           |
|---|---------------------------|
|  | <b>Stable terrain</b>     |
|  | <b>Non-used wasteland</b> |
|  | <b>Water bodies</b>       |



UNEP

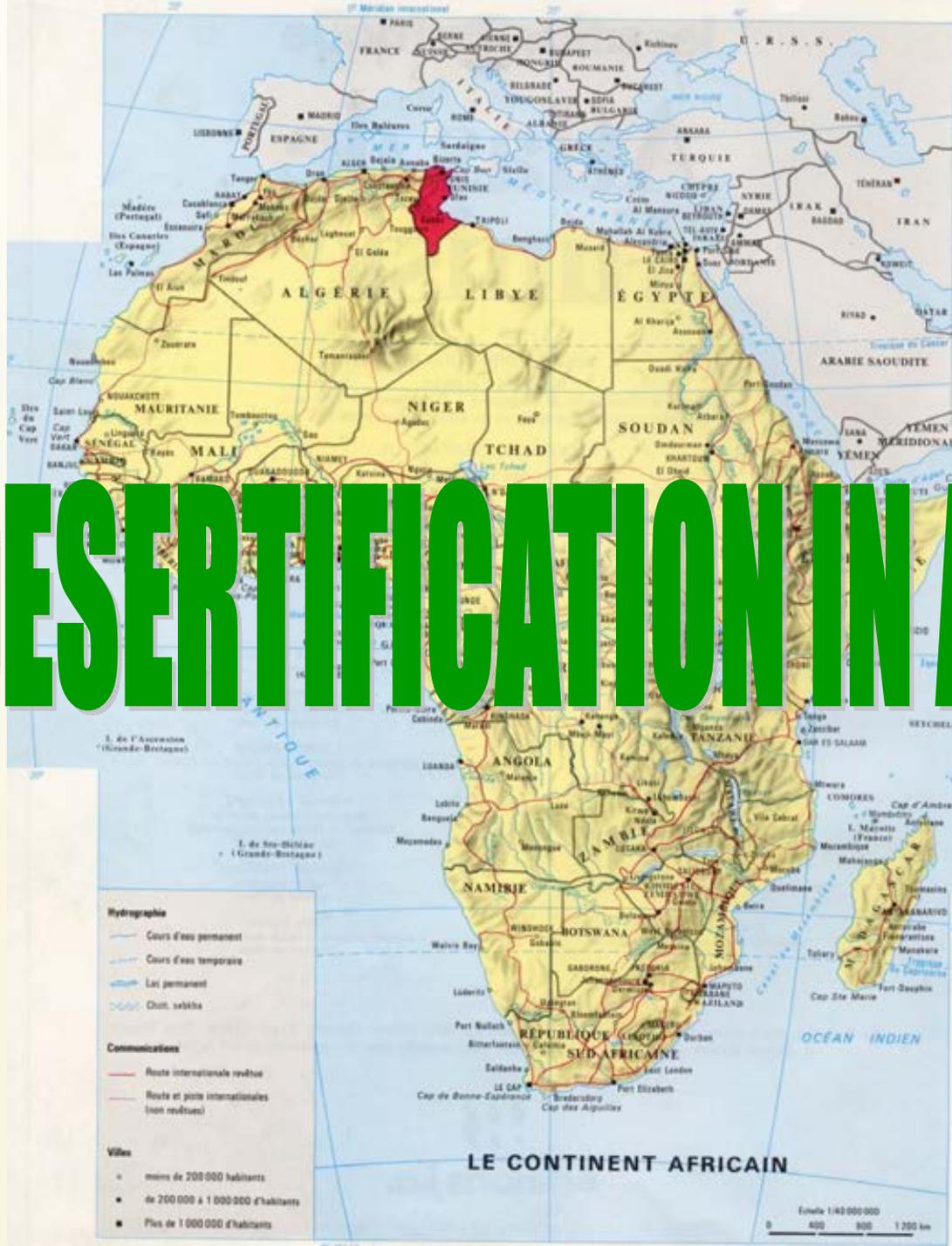


ISRIC





# DESERTIFICATION IN AFRICA



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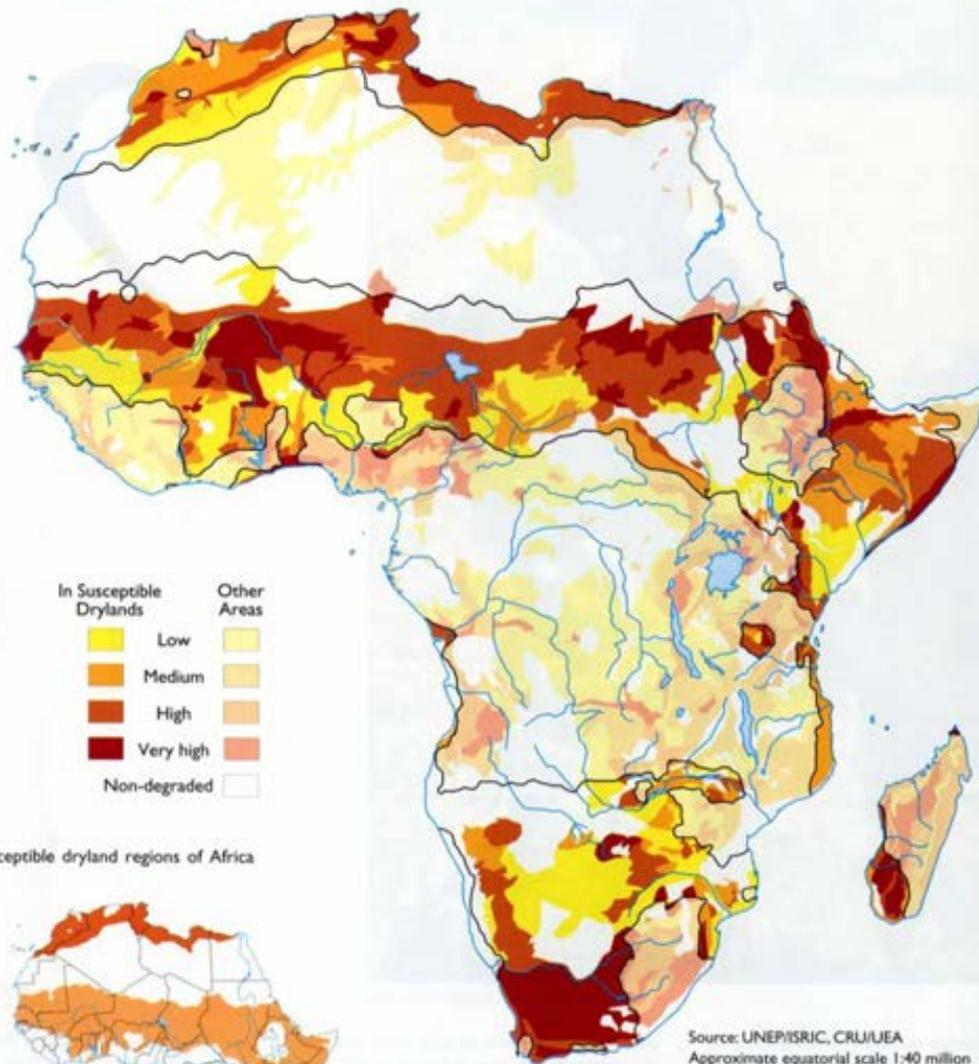
Land area in Africa by aridity zones (million ha)						
		North	Sahel	Southern	Others	Total
Hyperarid		385.4	276.4	8.2	0	670
Arid		98.1	348.6	54.1	2.7	503.5
Semiarid		37.4	303.7	159.4	13.3	513.8
Dry subhumid		15.1	150.1	81.5	22	268.7
Humid		9.3	260	127.7	612.6	1009.6
<b>Total</b>		<b>545.3</b>	<b>1338.8</b>	<b>430.9</b>	<b>650.6</b>	<b>2965.6</b>
Source: CRU/UEA						

Soil degradation degree in Africa by region in susceptible dryland areas (million ha)						
		North	Sahel	Southern	Others	Total
Light		25.6	109.8	6.4	2.4	144.2
Moderate		13.4	80.3	15.9	2.6	112.2
Strong		1.7	30.8	36.4	3.9	72.8
Extreme		0	3.1	0	0	3.1
<b>Total degraded</b>		<b>40.7</b>	<b>224</b>	<b>58.7</b>	<b>8.9</b>	<b>332.3</b>
<b>Total non degraded</b>		<b>109.9</b>	<b>578.4</b>	<b>236.3</b>	<b>29.1</b>	<b>953.7</b>
source: CRU/UEA						

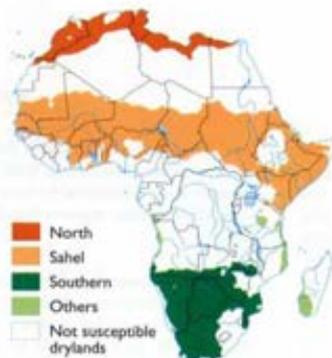
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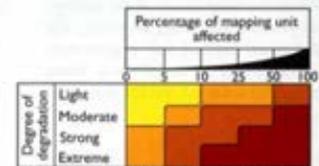
Map 2.1 Soil degradation severity



Map 2.2 Susceptible dryland regions of Africa



Source: UNEP/GRID  
Approximate equatorial scale 1:122 million



The different levels of severity were obtained by the combination of degree of degradation and the percentage of the area affected



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# Causes of land degradation

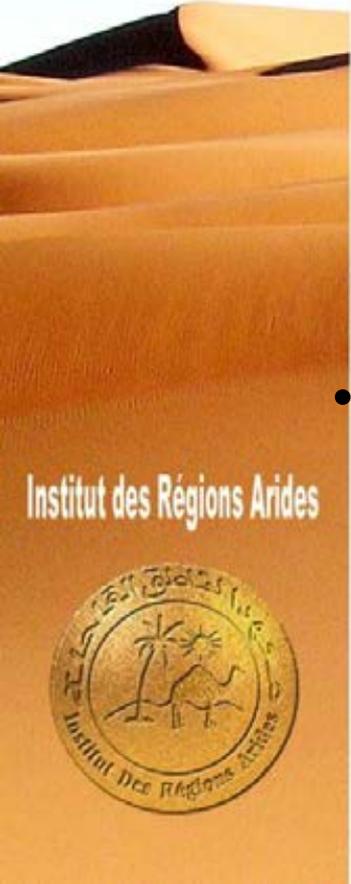


- Overgrazing:

- Affects more than 50% of the susceptible soils, especially in the arid and semi arid areas,
- Vegetation removal and soil trampling,
- Sedentarisation of nomad herders and expansion of cultivated lands,
- Long drought periods,
- Socio-economic transformations,

- Agricultural activities

- Degradation is due to poor management of drylands cropping (semi arid and subhumid ) and irrigation (arid),
- Increased cultivation of marginal soils, dry soil cereals, etc.
- Salinization and water logging,
- Declining of fallow periods to compensate for losses due to prolonged drought periods,



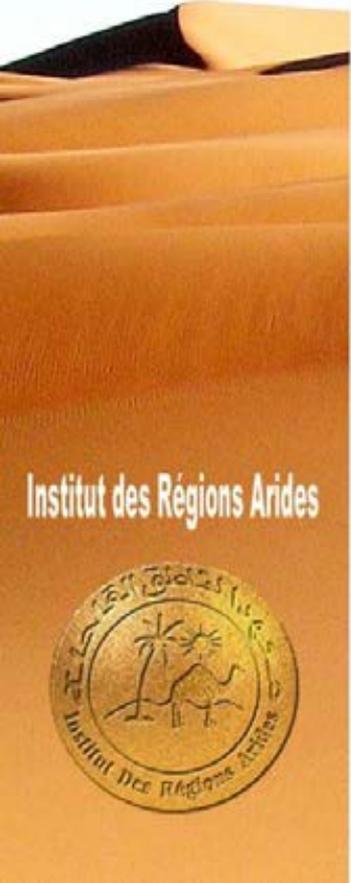
- Overexploitation of vegetation
  - Overuse of vegetation for domestic purposes (fuelwood, cooking, charcoal, fencing, etc.) and small rural industries (beer brewing, fish smoking, brick, baking, etc.),
  - Imported fossil fuels are prohibitively expensive,
  - Woody biomass is the main domestic fuel in sub-Saharan Africa,
  - Exodus to cities (Dakar, Ouagadougou, Niamey, Nouakchott, etc.).
- Deforestation
  - Complete removal of vegetation is largely confined to the Sahel region and the North of the Sahara,
  - Expansion of agriculture (irrigation, grain cultivation, predominately in the semi arid and subhumid areas,
  - Fires (natural or human induced),



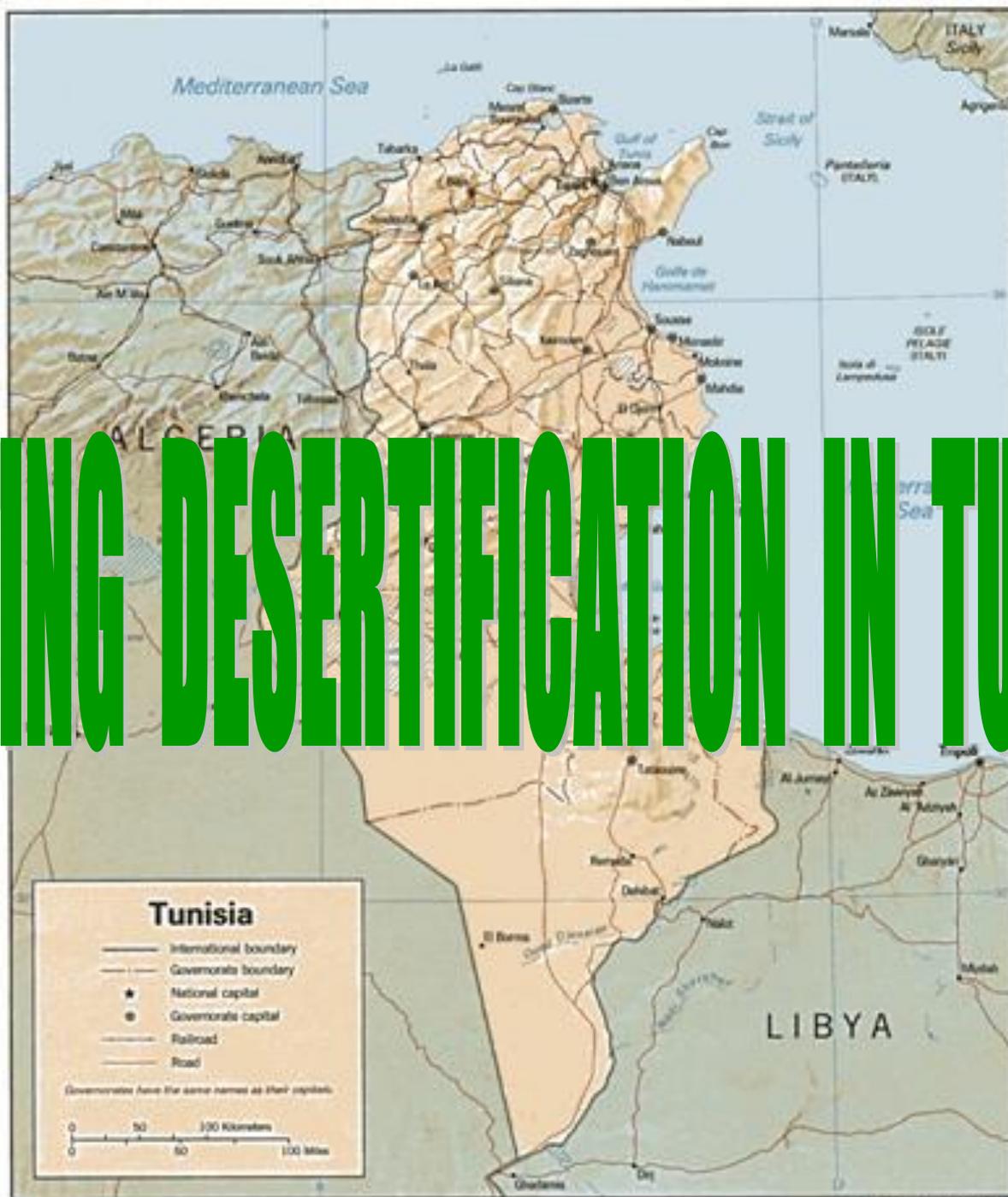
# Consequences of soil degradation



- Soil erosion
  - Water erosion
  - Wind erosion
- Soil deterioration
  - Physical (compaction/crusting, waterlogging)
  - Chemical (salinization, loss of nutrients, )
- Socio-economic effects
  - poverty, rural-urban migration (environmental refugees),
  - reduced per capita agricultural production of affected countries,
  - others.

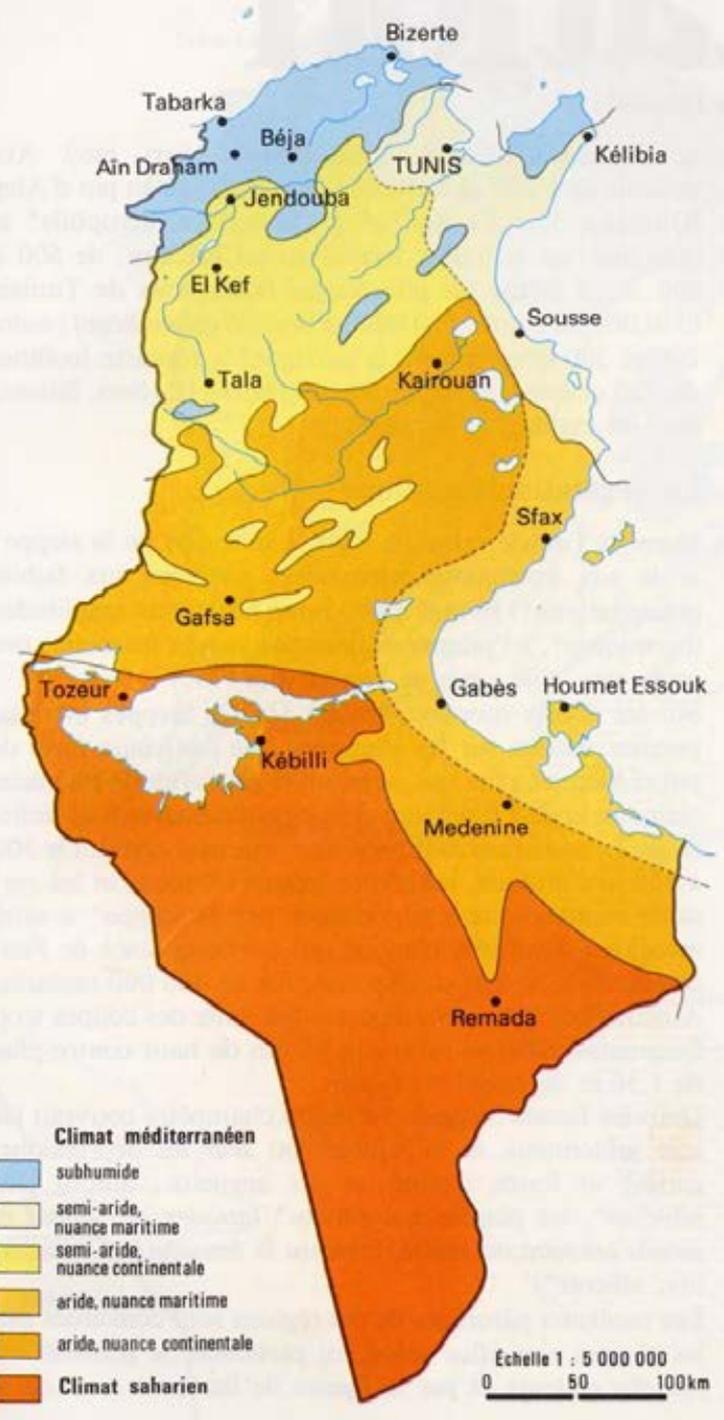
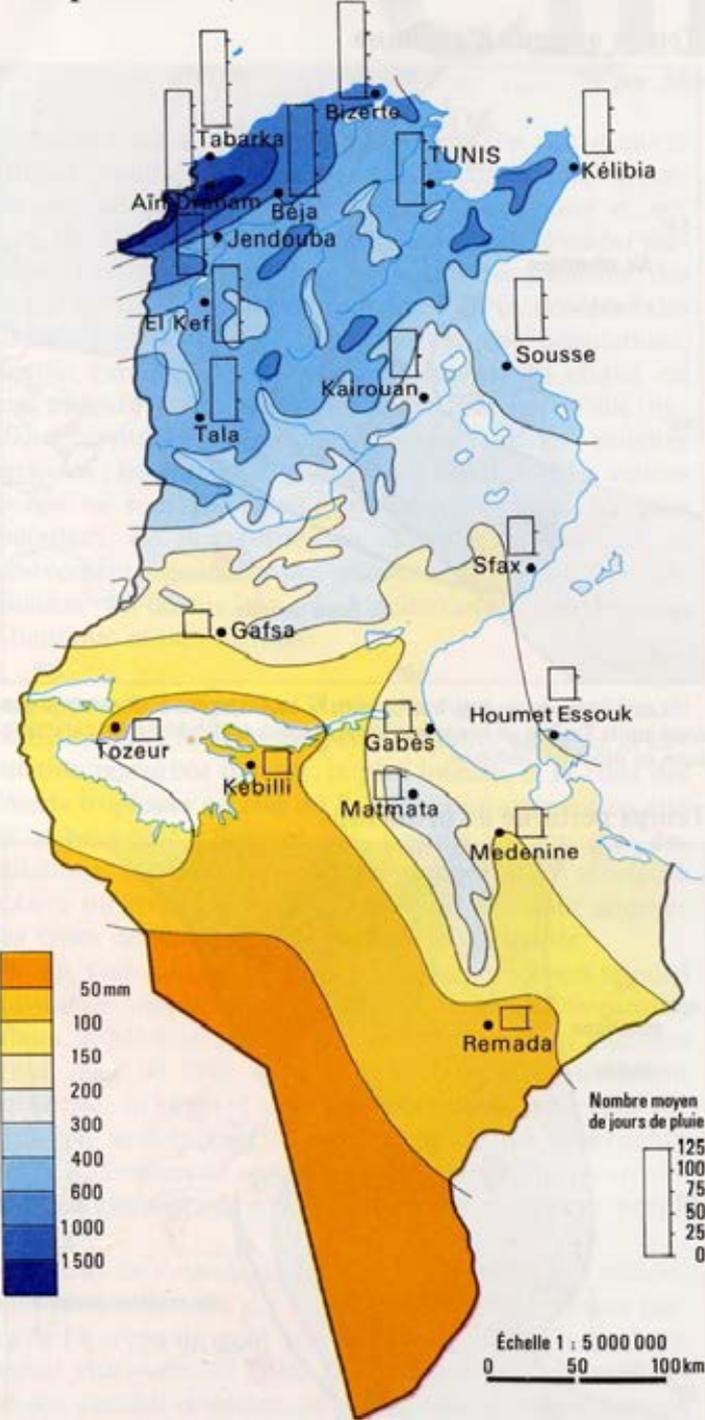


# COMBATING DESERTIFICATION IN TUNISIA



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# Desertification hazard

- Due to its geographical location between the Mediterranean and the Sahara, Tunisia is characterized by bioclimate variation in addition to landscape diversity.
- Of the 16.4 million ha, nearly 9.4 million ha are suitable to agriculture and pasture. The cultivated area is 5.4 million ha.
- It is estimated that 94% of the total lands are threatened by desertification

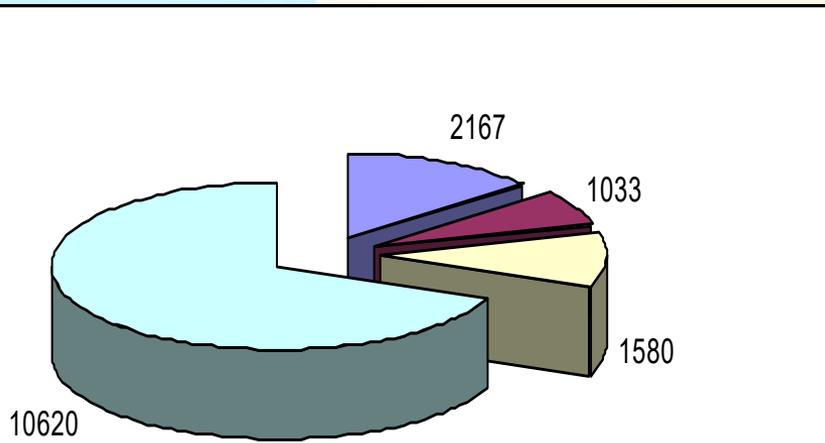
Desertification hazard of natural regions (1000 ha)

Desertification	Dorsale & tell	High steppe	Low steppe	Meridional tunisia	Total	%
Lowly affected zones	667	603	700	1820	3790	24.6
Moderately affected zones	500	143	400	4220	5263	34.2
Highly affected zones	1000	287	280	1250	2817	18.3
Desertified zones	0	0	200	3320	3530	22.9
<b>Total</b>	<b>2167</b>	<b>1033</b>	<b>1580</b>	<b>10620</b>	<b>15400</b>	<b>100</b>

MEAT, 1998

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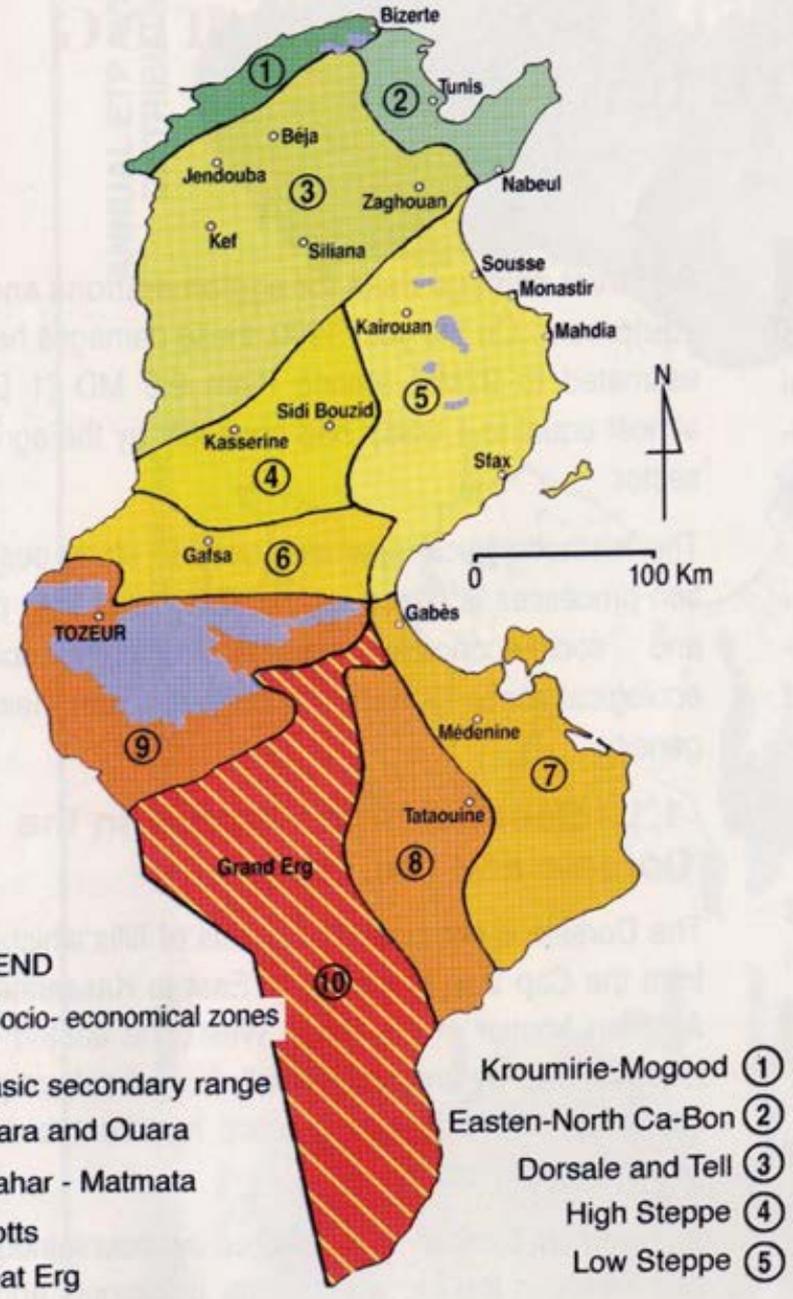


- Dorsale & tell
- High steppe
- Low steppe
- Meridional tunisia

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**MEAT, 1998**



# Combating desertification (CD)

- Before the XX century: Though the concept of desertification is relatively new but the pressure on the natural resources is an ancient practice. In fact, the Mediterranean basin was the cradle of various human civilizations: Phoenician, Greek-roman, Carthaginian, Arab-Muslim, etc.) which induced a high perturbation level of the ecosystems. However, a certain equilibrium was preserved until the beginning of the XX century through the adoption of various strategies (transhumance, water harvesting, etc.).
- After the independence: CD has been a major concern for the Tunisian Government in order to cope with increased food demand. It became more explicit after the UN conference of Nairobi in 1977.
- In the 80s there were the implementation of the PDRI ('integrated' rural development projects) based mainly on the sector approach and targeting the technical/physical feasibility.



- In 1985, there was the formulation of the first national strategy for CD. Tunisia encouraged the adoption of the UNCCD during the RIO conference in 1992 and ratified the convention, after its adoption in 1994, in 1995 which ended with the drafting of the UNCCD-NAP in 1998.
- For the period 1990-2000-present:
  - National strategy for SWC
  - National strategy for water resources
  - National strategy for combating sand encroachment
  - National forestry and pastoral strategy
  - Projects of Natural resources management and development
- In 2018: The NAP was revisited to adopt the concept of LDN



# National Action Plan (NAP)

- Preparatory steps:
  - Production of the ‘yellow hand’ program by the MEAT
  - National consultation
  - Creation of the national committee for CD
- Principles:
  - Projects and actions for socio-economic development and poverty alleviation,
  - Projects and actions for natural resources conservation,
  - Institutional and legal measures.
- Monitoring and evaluation: efficiency, sustainability and impacts.



# Technical Operations

- Water and soil conservation
  - Preventive practices: rotation, mulching, contour ploughing, strip cropping, etc..
  - Curative practices: Gully correction, terracing, earth embankments, plantations, etc.
- Water mobilization
  - Construction of hill lakes,
  - Installation of groundwater recharge units,
  - Installation of flood diversion units,
- Salinity control
  - It is mainly preventive by avoiding the use of excessive saline water (more than 3-4 g/l).
- Reuse of treated waste water and drainage water
- Combating sand encroachment
- Forest regeneration



- Pastoral and agricultural development
  - Intensify agriculture
  - Improve rangeland production
  - Diversify the agricultural and animal production
  - Develop agro-forestry
- Marginal lands reclamation
- Horizontal projects
  - Knowledge base development and Observation systems for drought and desertification,
  - Elaboration of drought emergency and early warning systems,
  - Energy consumption
  - Education and awareness
  - Implementation of the national strategy for geothermal water,
  - Creation of the national agrarian observatory.



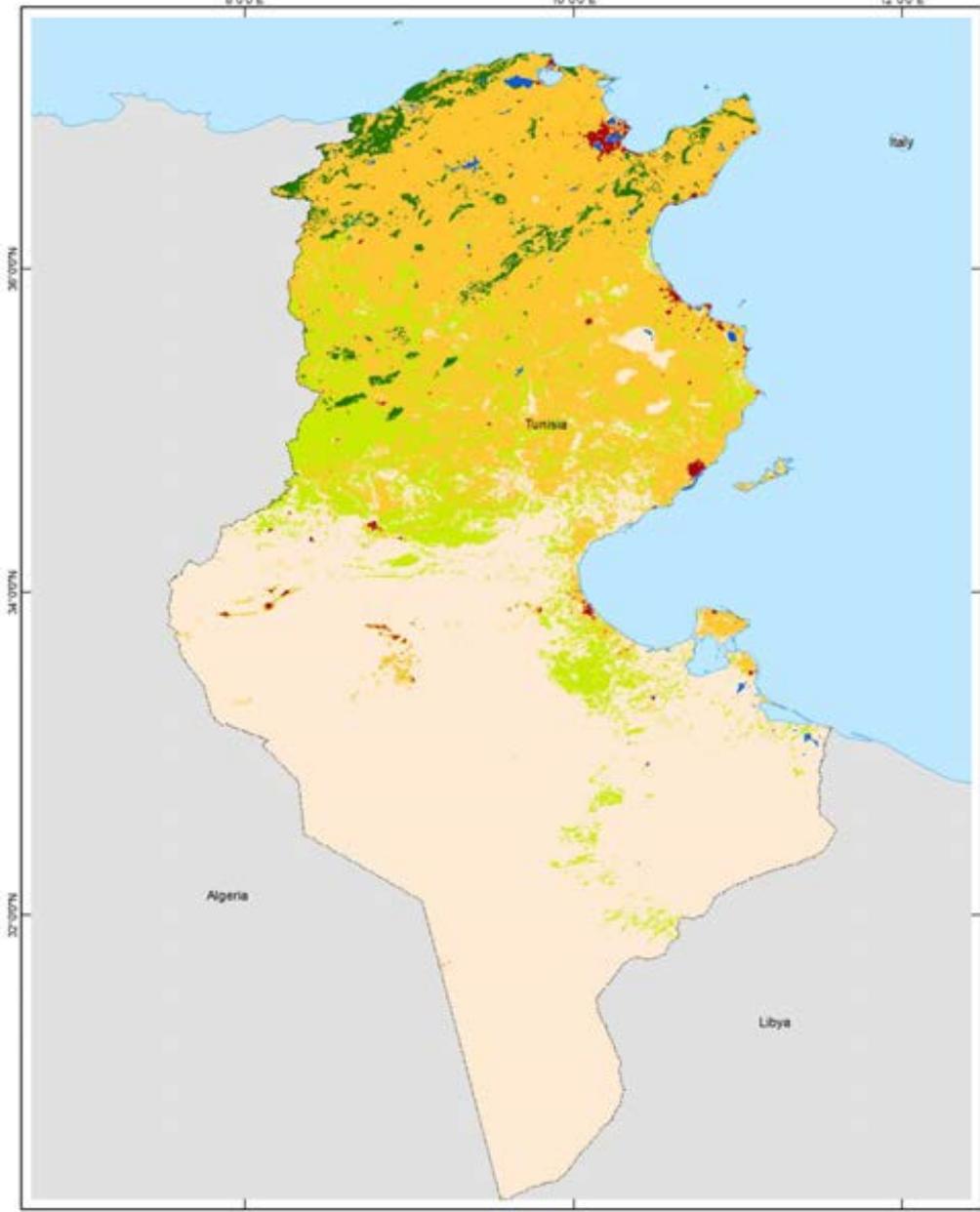
# Accompanying measures

- Institutional
  - National level: CNLD (national commission for CD) supported by the CNDD. The national UNCCD coordinator is designated (*ONC*).
  - SAEZ level: Regional committee for CD made of the representatives of development, social, professionals, NGOs, labor organisms, etc.
  - Province level: Sub-regional committee for CD (CRDA),
  - Local level: extension services
  - Development committees: at the level of villages and douar.
- Training & extension
- Research : Research development programs: participatory approach, aridology, agro-forestry, rangelands, water resources, local know how, etc.





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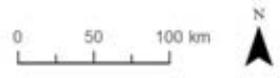
## Tunisia

### Land Cover 2000

#### Legend

- Land Cover**
- Tree-covered areas
  - Grassland
  - Cropland
  - Wetland
  - Artificial surfaces
  - Other land
  - Water bodies
- UN Boundaries**
- Coastline
  - International Boundary
  - Special Boundary line
  - Armistice International
  - Administrative line
  - Other line of Separation
  - Autonomous region boundary

Projection: Decimal Degrees, WGS84



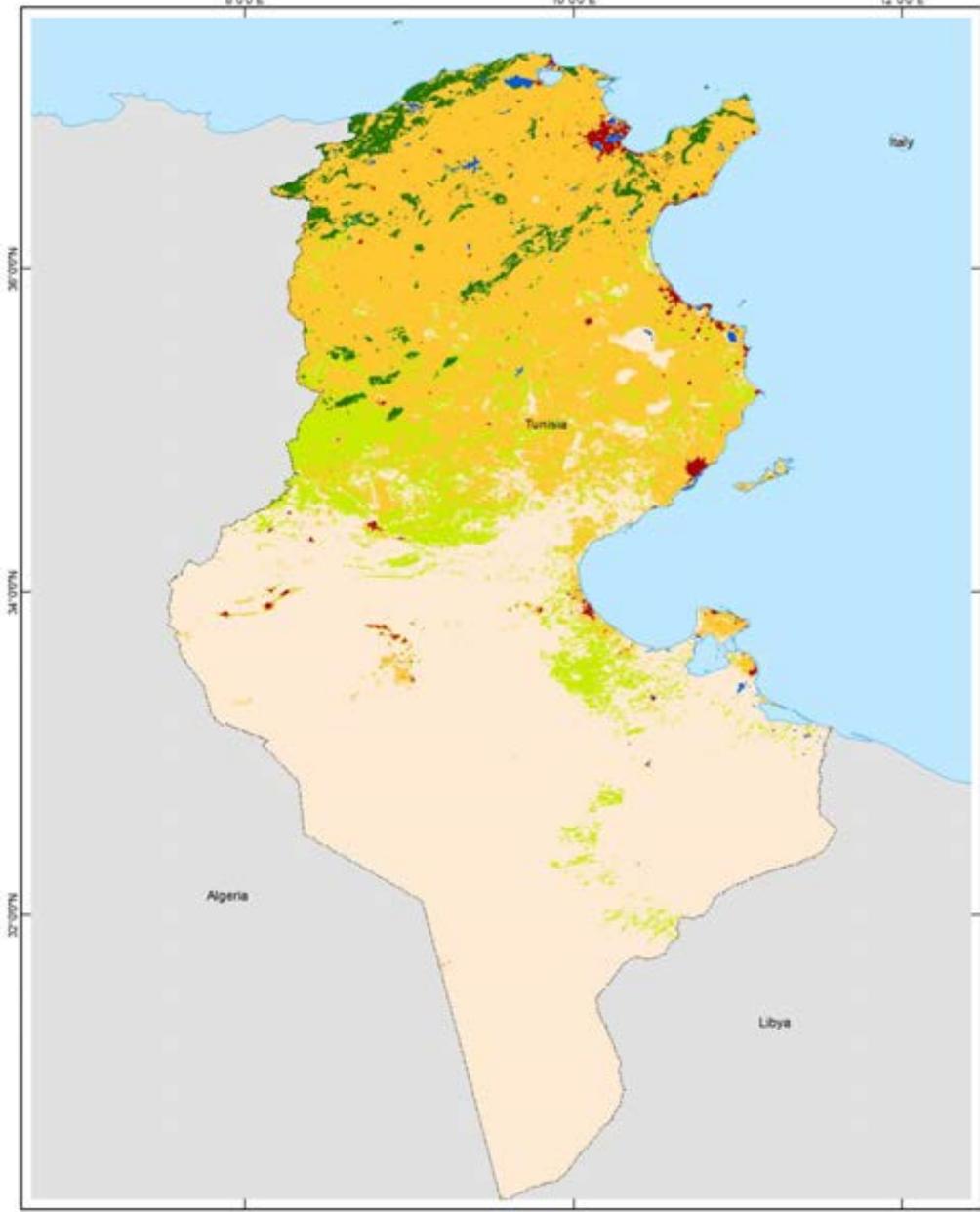
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Data Sources:  
The ESA Climate Change Initiative Land Cover (CCI-LC) annual global land cover time series dataset from 1992-2015, released in April 2017 (v 2.0.7).  
URL: <https://www.esa-landcover-sci.org/>





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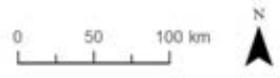
## Tunisia

### Land Cover 2015

#### Legend

- Land Cover**
- Tree-covered areas
  - Grassland
  - Cropland
  - Wetland
  - Artificial surfaces
  - Other land
  - Water bodies
- UN Boundaries**
- Coastline
  - International Boundary
  - Special Boundary line
  - Armistice International
  - Administrative line
  - Other line of Separation
  - Autonomous region boundary

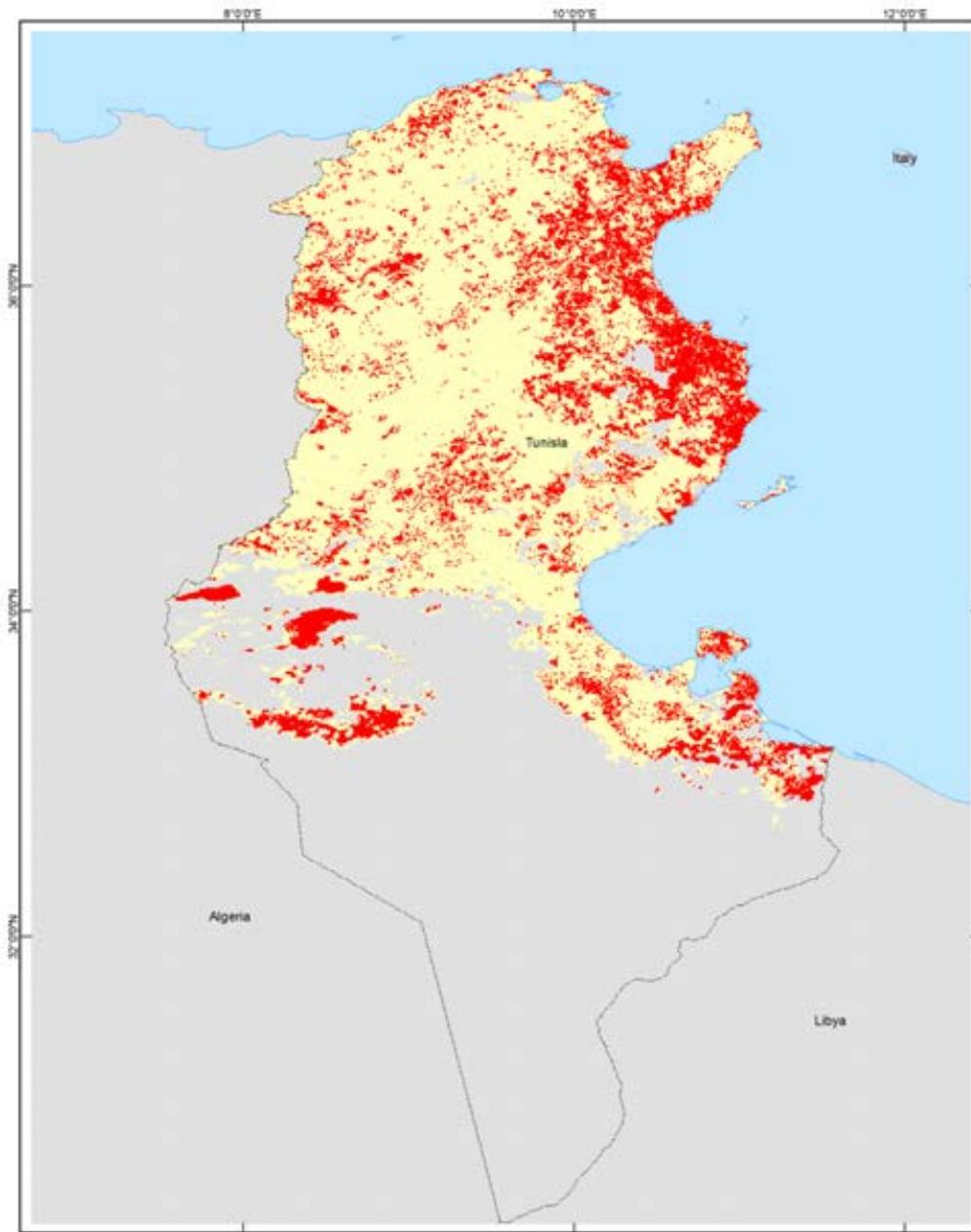
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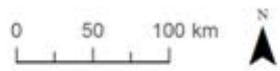
Tunisia

Land Degradation  
2000 - 2015

**Legend**

- Land degradation**
- Degraded land
  - Not degraded
  - No data or other land
- UN Boundaries**
- Coastline
  - International Boundary
  - Special Boundary line
  - Armistice International
  - Administrative line
  - Other line of Separation
  - Autonomous region boundary

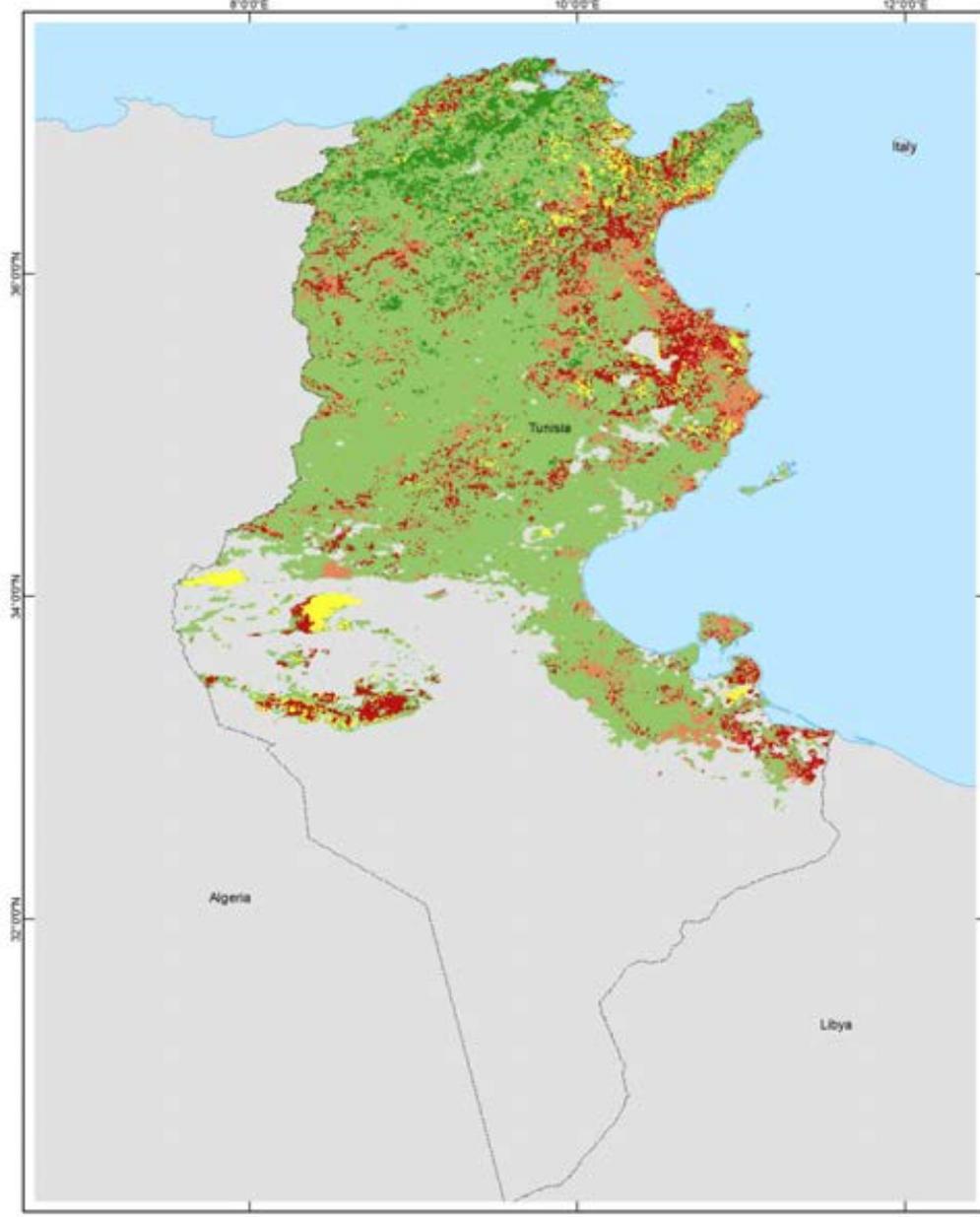
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Data Sources:  
Derived based on definitions in the UNCCD Good Practice Guidelines for calculating land degradation neutrality





# Tunisia

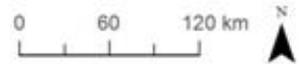
## Land Productivity Dynamics

2000 - 2013

### Legend

- Land Productivity**
  - Declining
  - Moderate decline
  - Stressed
  - Stable
  - Increasing
  - No data or other land
- UN Boundaries**
  - Coastline
  - International Boundary
  - Special Boundary line
  - Armistice International
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Data Sources:  
EC-JRC global 2000-2013 1km resolution SPOT-VGT time series remotely sensed vegetation index.  
URL: <http://wdd.jrc.ec.europa.eu/mapping>



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# THE ROLES OF THE ARID ZONES RESEARCH INSTITUTE



# Profile

## Name

Institut des Régions Arides (IRA – Arid Zones Research Institute)

## Ministry

Ministry of Agriculture and Environment

## Creation law

Law n°6 of 1976 dated 07 January 1976

## Headquarters

El Fjé 22.5 Route de Jorf-Jerba – Médenine

## Staff

355 (53 researchers, 34 engineers, 33 technicians, 40 administration agents, 95 workmen)

## Contacts:

Tel: +216-75-633005 ; Fax: +216-75-633006

Web: [www.ira.rnrt.tn](http://www.ira.rnrt.tn)



# Mandates



**Conduct research for development in arid agriculture, conservation of natural resources and combating desertification in the dry areas**



**Training and capacity building of technicians and specialists in dryland agriculture and combating desertification**

**Contribute to the extension in arid agriculture and conservation and development of natural resources**



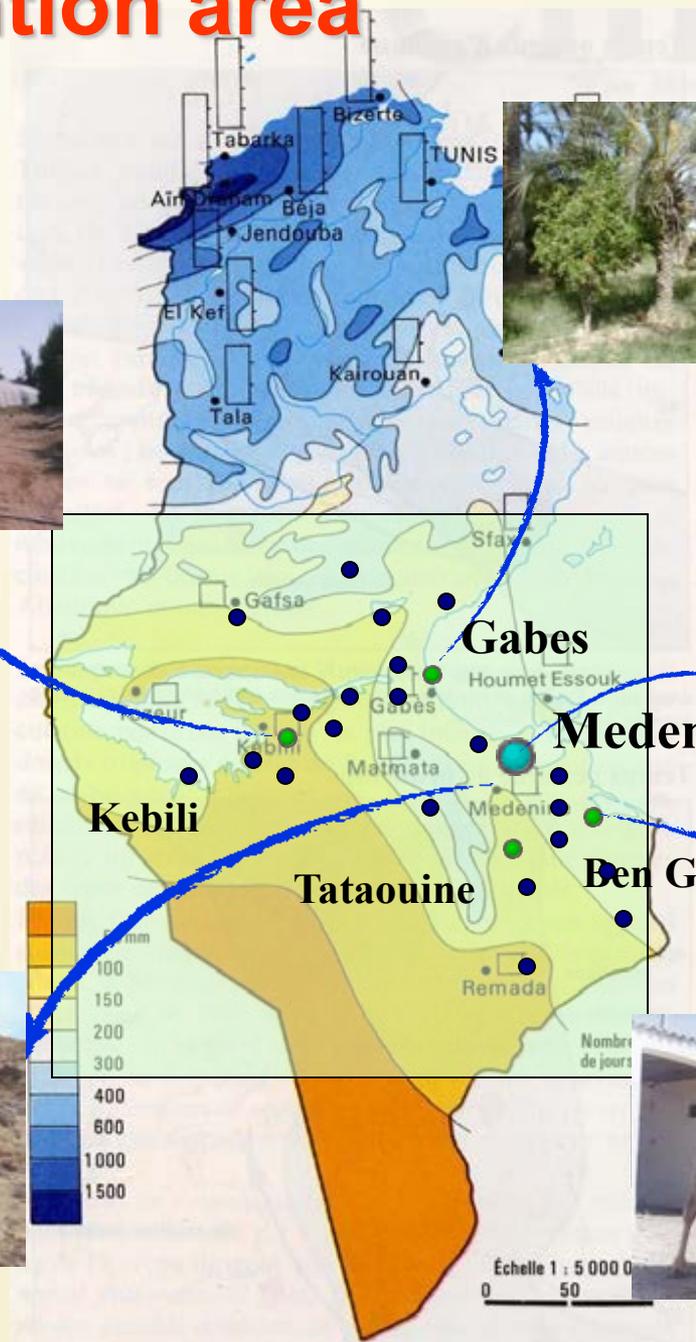
**Provide backstopping and expertise for development projects in the region**



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# Intervention area



Exp. St. ●



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# Research programs

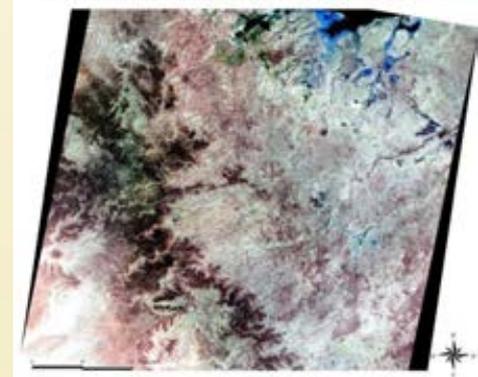
## Laboratory of Eremology & Combating Desertification

### Objectives

Use and application of RS & GIS techniques for desertification monitoring and natural resources development and management

Development of water saving and management techniques

Improvement of the physical and chemical characteristics of soils



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# Laboratory of Livestock & Wildlife of the Dry and Saharan Regions

## Objectives

**Development of suitable methods for the use and exploitation of feed and animal resources**

**Improvement of production potentialities of camel and goat species**

**Contribution to the national efforts for the protection on endangered species**



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# Laboratory of rainfed farming and oasis cropping

## Objectives

**Germplasm protection and selection of salinity and drought resistance species**



**Improvement of production practices and systems**



**Resolving pest management problems in oases and under greenhouses**



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# Laboratory of Rangeland Ecology of the Dry and Saharan Regions

## Objectives

**Germplasm protection**



**Domestication and Improvement  
of the production of MAP**

**Improvement of rangelands and  
combating desert encroachment**



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# Laboratory of Agricultural Economics and Rural Societies

## Objectives

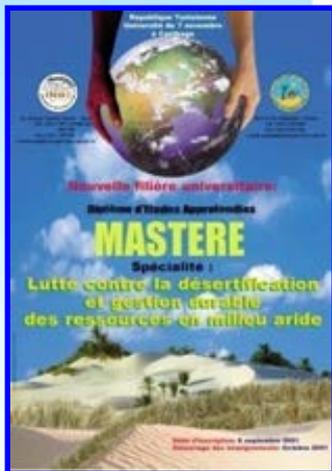
**Study of management and access modes to the natural resources in a dynamic vision which focuses on agricultural, socio-economic and environmental evolutions.**

**Contribute to the evaluation of the development experiences of the arid regions,**

**Provide decision-making tools for development actions based on the integration of the strategies of the various group actors and their regulation capacities.**



# Training & Capacity building



Advanced training courses.



Supervision of students (graduation and post graduation).

*In addition, IRA contributes actively to the implementation of two master degree programs:*



The joint IRA/INAT national master degree program on “techniques of combating desertification and natural resources management in the dry region. This program started in October 2001,



The joint IRA/UNU/CAS/INAT international master degree program on « integrated land management in drylands ». This program started in April 2005.



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# OUTREACH

- IRA contributes to the national and regional development effort by the conception and study of projects.
- The valorization of the research outputs of IRA during the last years is achieved within a contractual framework with the economic actors (signature of partnership agreements), through an integrated approach of extension of the research results (primary and secondary schools),
- Organization of training and information days,
- The assistance of the agricultural sector (laboratory analyses, artificial nursing of camel calves, goat improvement), project studies and audio-visual production.



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# INFORMATION AND DOCUMENTATION

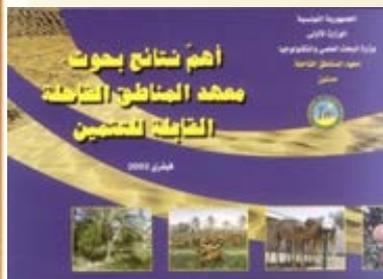
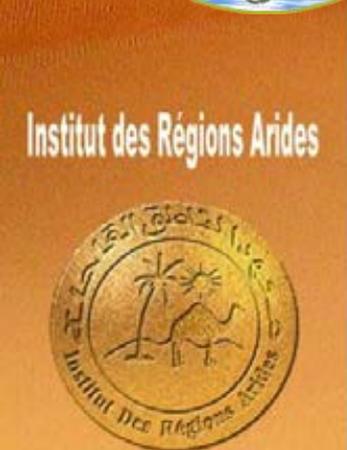
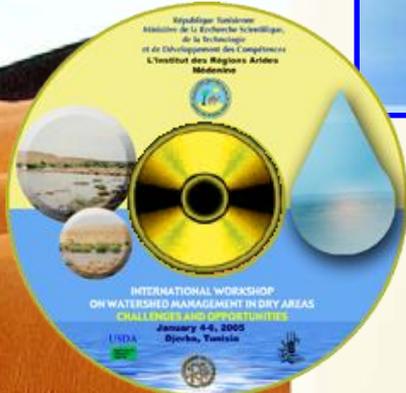
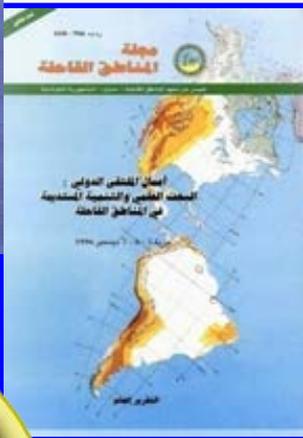
IRA developed since its creation, an information system including:

- Unit of computer system, statistics and data processing.
- Publication unit. This Unit is responsible of the edition and publication of various IRA documents (technical bulletins, books, notes and reports, leaflets and booklets in addition to the reports of activities).

Since 1990 the Revue des Régions Arides (ISSN 0330-7556) became the regular publication for the diffusion of new scientific and technical results of research and studies relevant to aridity and desertification.

- Documentation unit. This Unit developed a gradually database. The library has more than 6000 books, 500 dissertations theses, 60 periodicals.

- Organization of seminars and scientific meetings.



# TECHNOLOGICAL PARK OF THE SOUTH



TS

IRA

CYBER

PEP

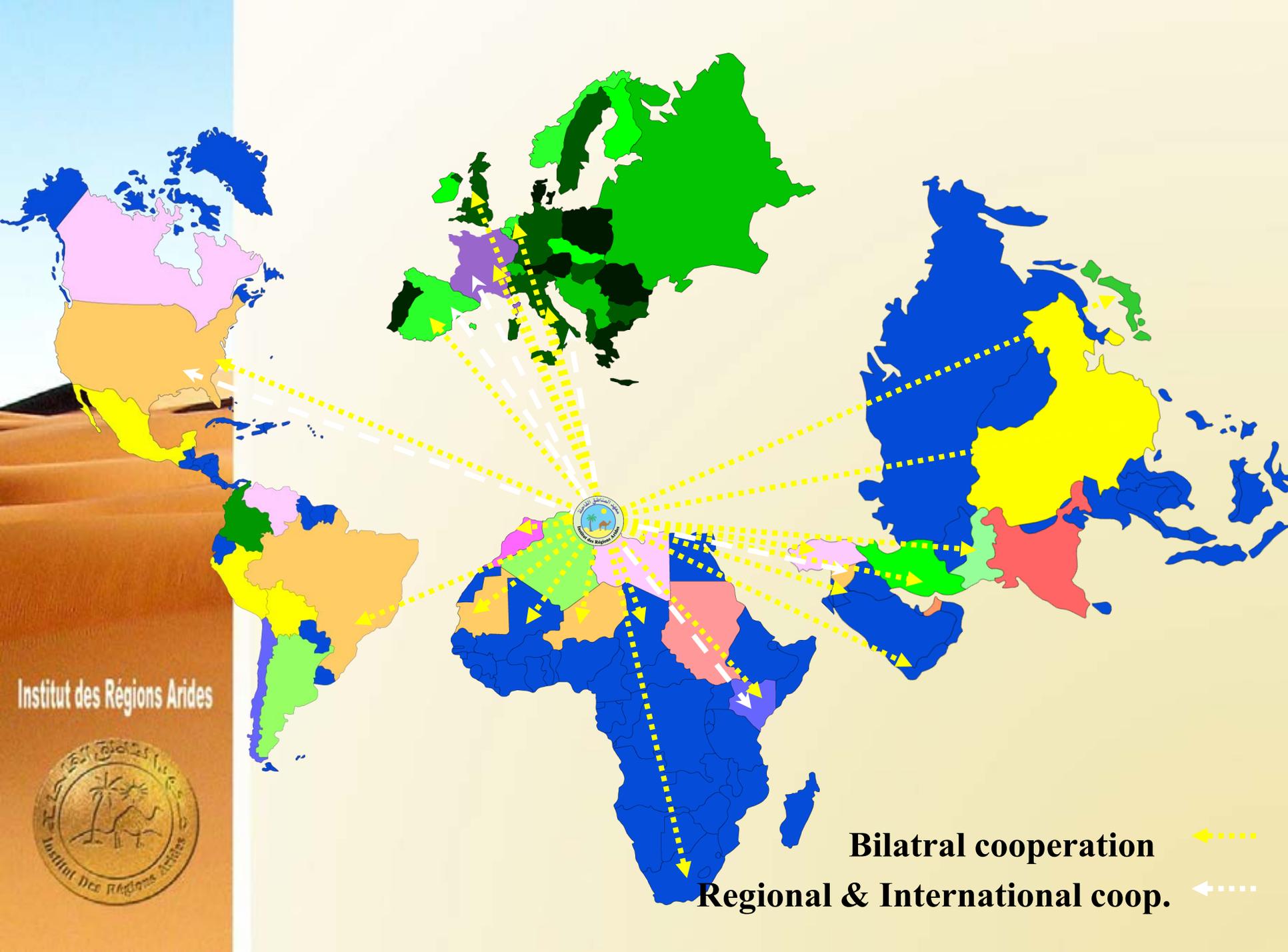
CFRA

ISBAM

ISET

Created in **January 2010** to be specialized in the valorization of the biological and natural resources of the Sahara (arid and desert regions). Targeted fields are:

- *Biological production:*
- *Animal production (especially camel)*
- *Water resources*
- *Renewable energies*



Institut des Régions Arides



**Bilateral cooperation** ←·····  
**Regional & International coop.** ←·····

# **IRA'S ACHEIVEMENTS (Soil & Water)**

Institut des Régions Arides



# GEOMATIC RELATED APPLICATIONS

Institut des Régions Arides



# THE DRONE PIXY

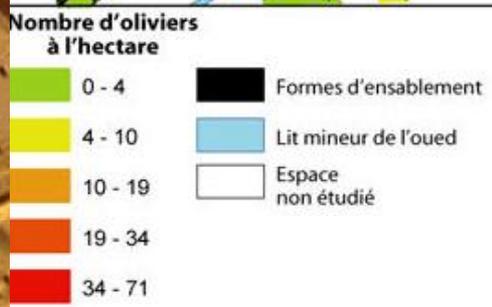
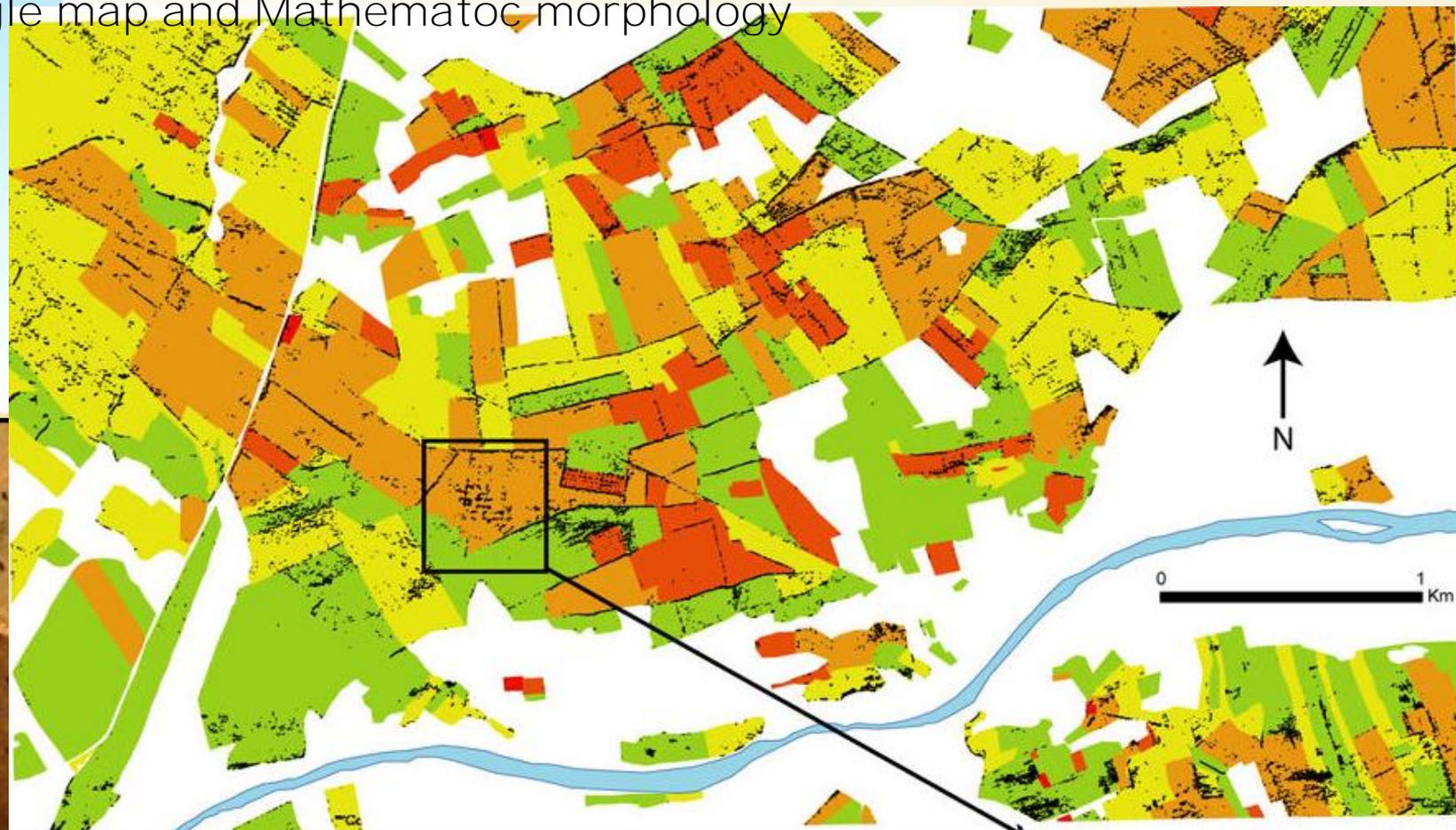




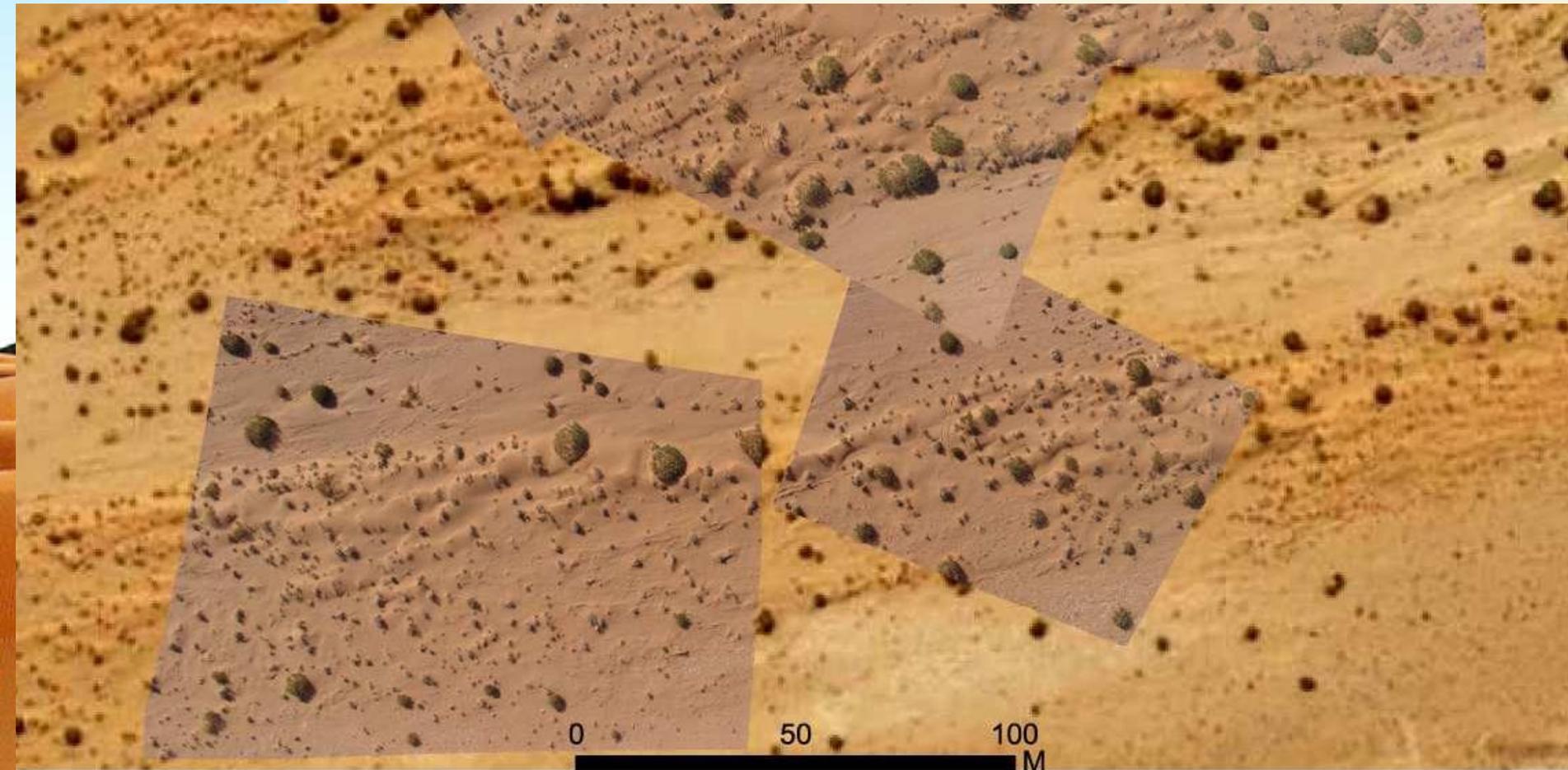
Institut des Régions Arides

The logo of the Institut des Régions Arides is circular and gold-colored. It features a stylized palm tree on the left and a camel on the right, both facing right. The text "Institut des Régions Arides" is written in Arabic script along the top inner edge and in French along the bottom inner edge of the circle.

# Mapping olive groves and sand accumulations using google map and Mathematic morphology

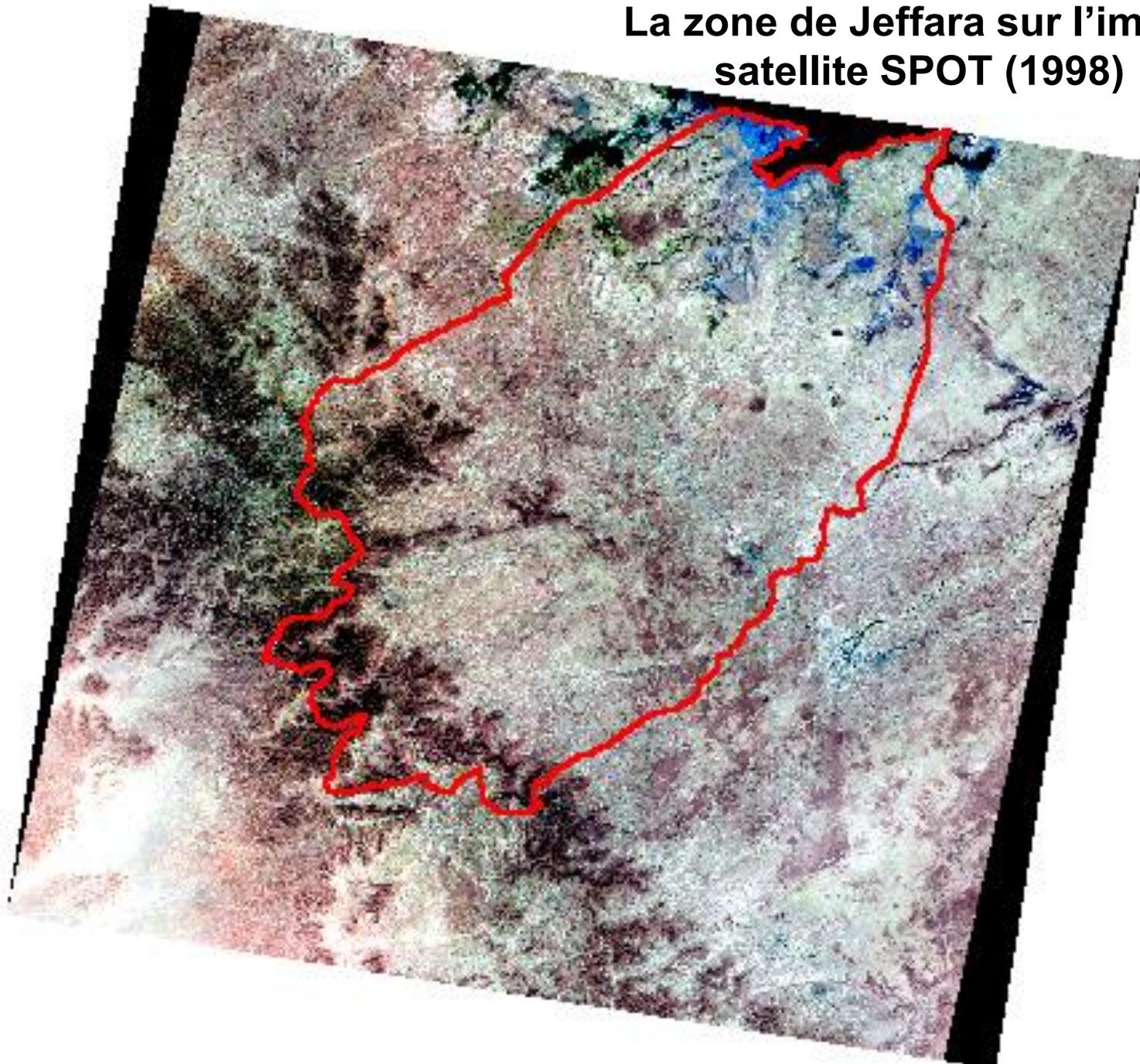


Cédric VENARD, Université Lyon 2 (2008)  
d'après image QuickBird, 2004, extraite depuis Google Earth

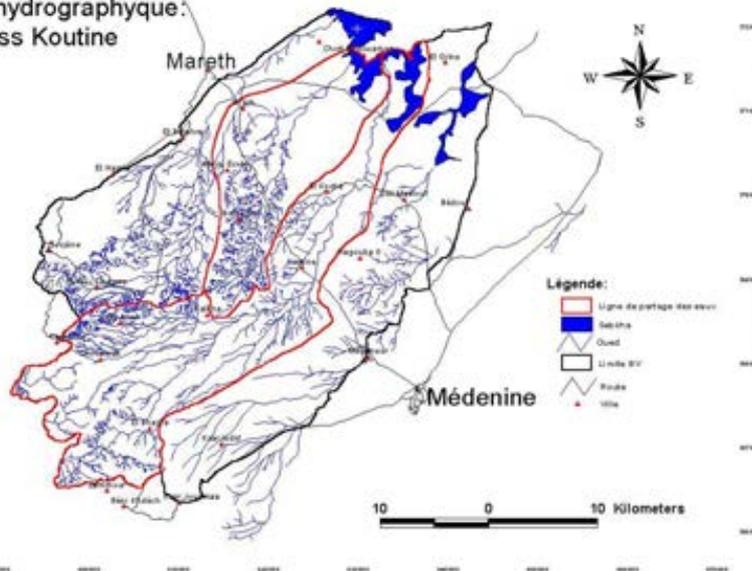


Mosaique des images Google et Pixy  
(Venard et al., 2010)

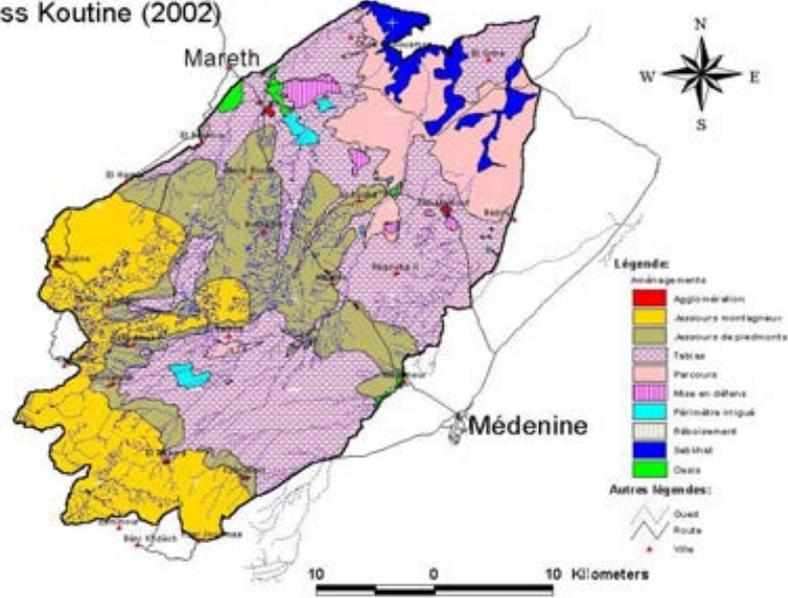
**La zone de Jeffara sur l'image satellite SPOT (1998)**



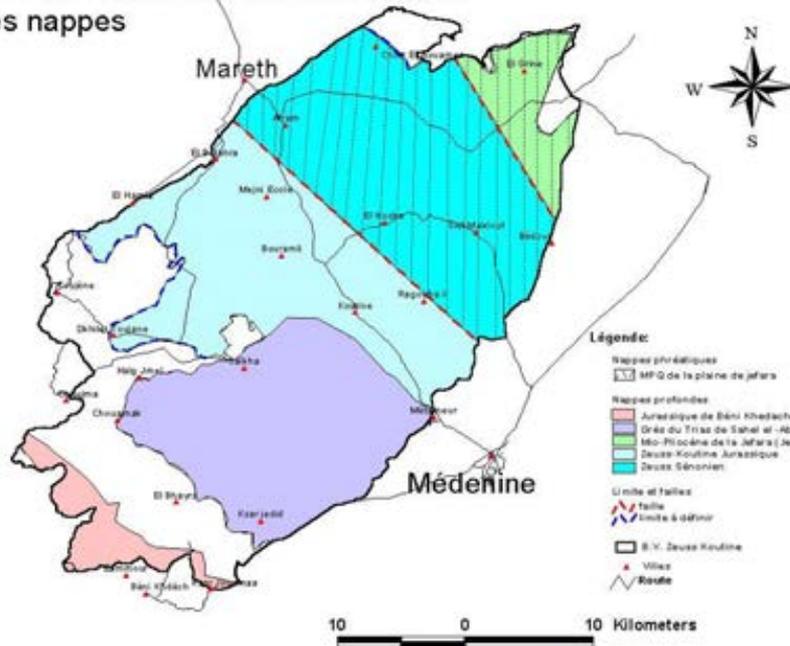
Réseau hydrographique:  
B.V. Zeuss Koutine



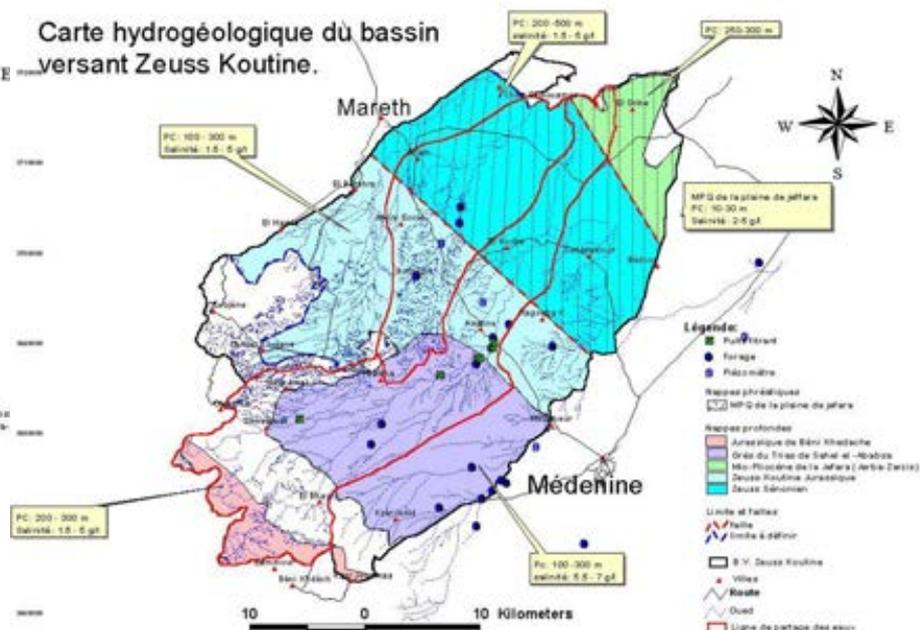
Carte des Aménagements existants:  
B.V. Zeuss Koutine (2002)



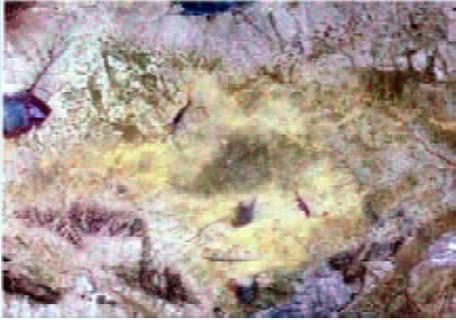
Carte des ressources en eaux souterraines:  
Limite des nappes



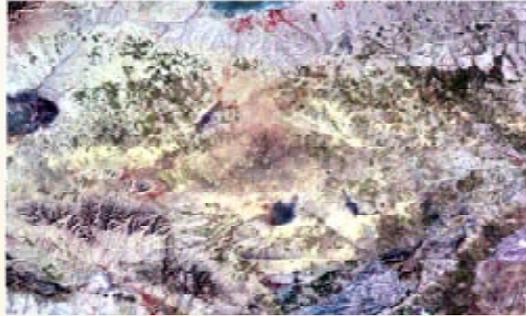
Carte hydrogéologique du bassin  
versant Zeuss Koutine.



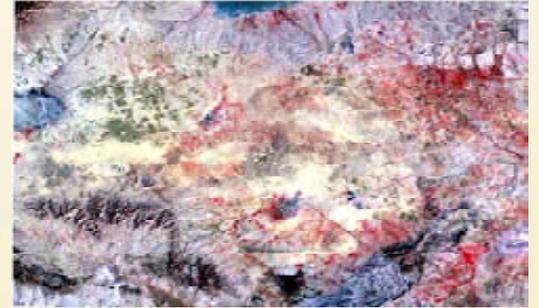
# Menzel Habib



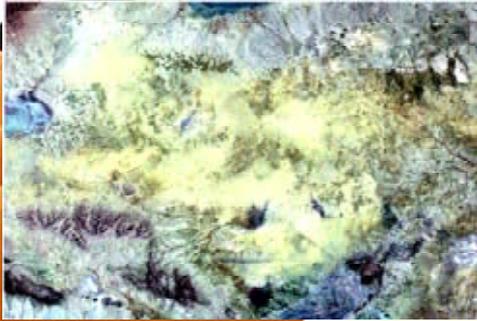
1972



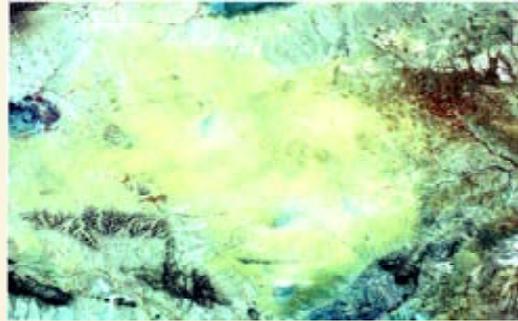
1975



1978



1981



1984



1991

Image satellitale de la zone prise en 1993



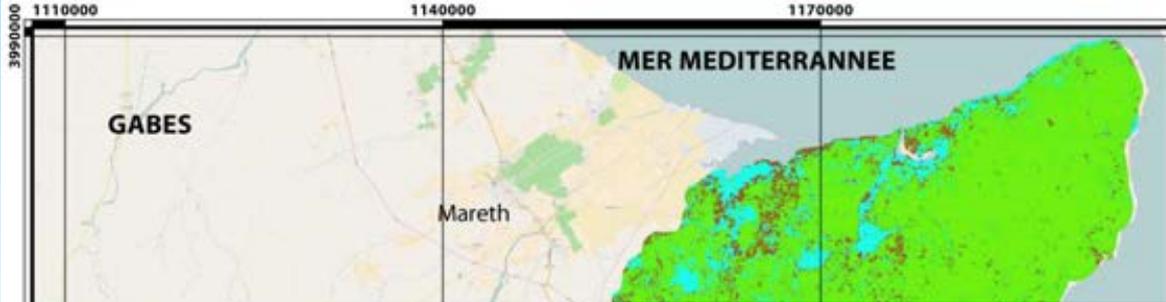
1993



1996

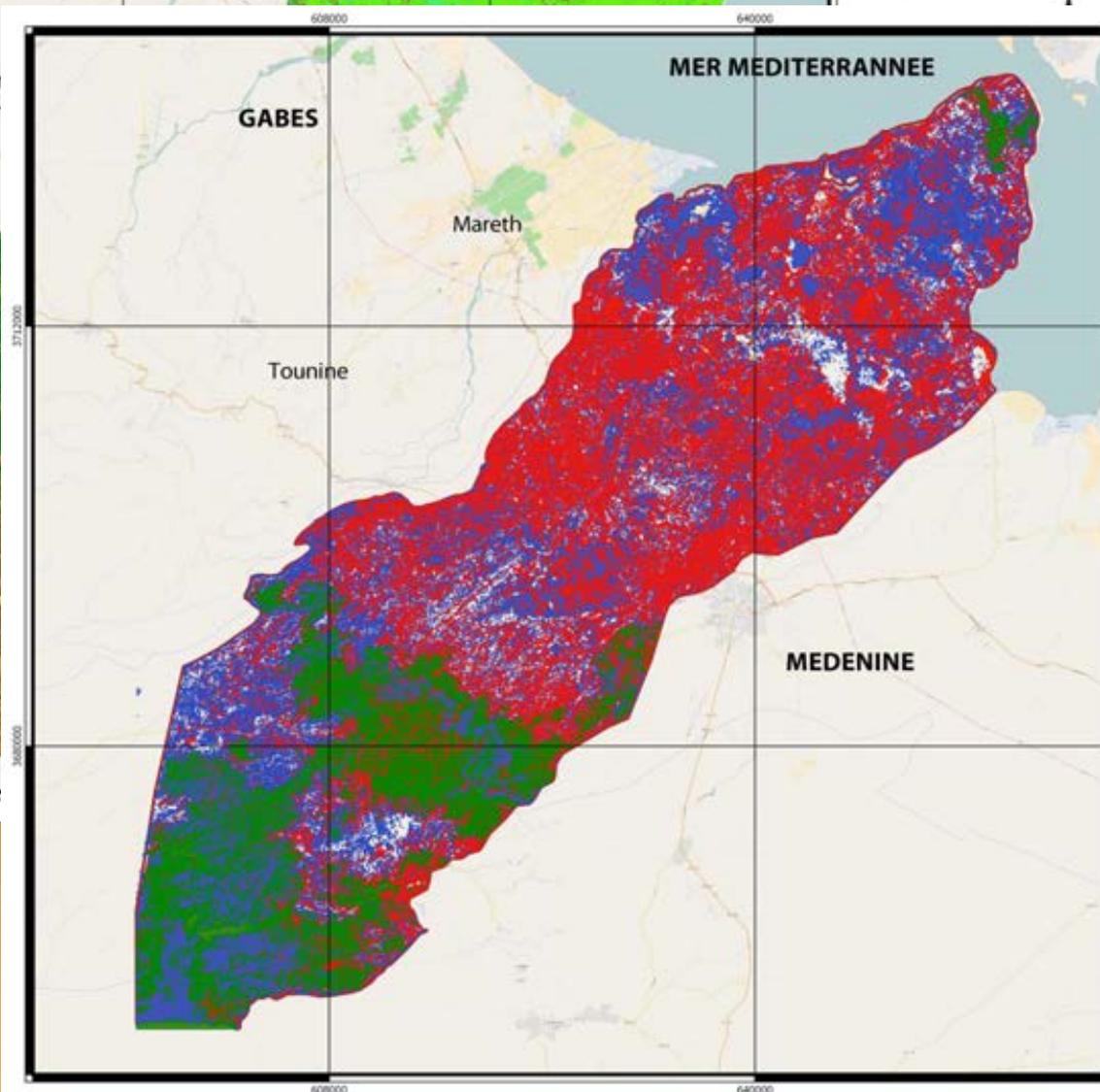
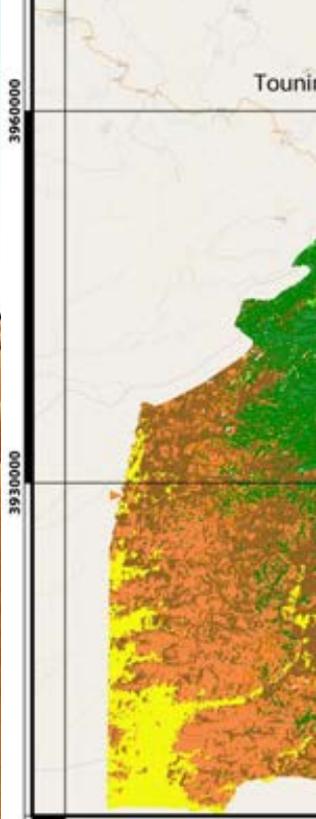


1999



### Légende

- Ensablement
- Agriculture derrière Tabia
- Parcours halophytes
- Parcours et Céréalescultures
- Agriculture derrière Jessour
- Parcours des montagnes



### Légende

- Pas de changement
- Regression
- Progression

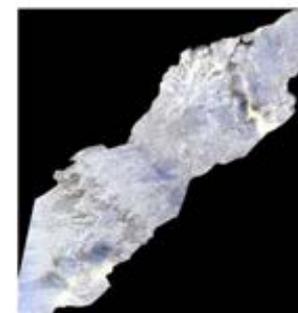


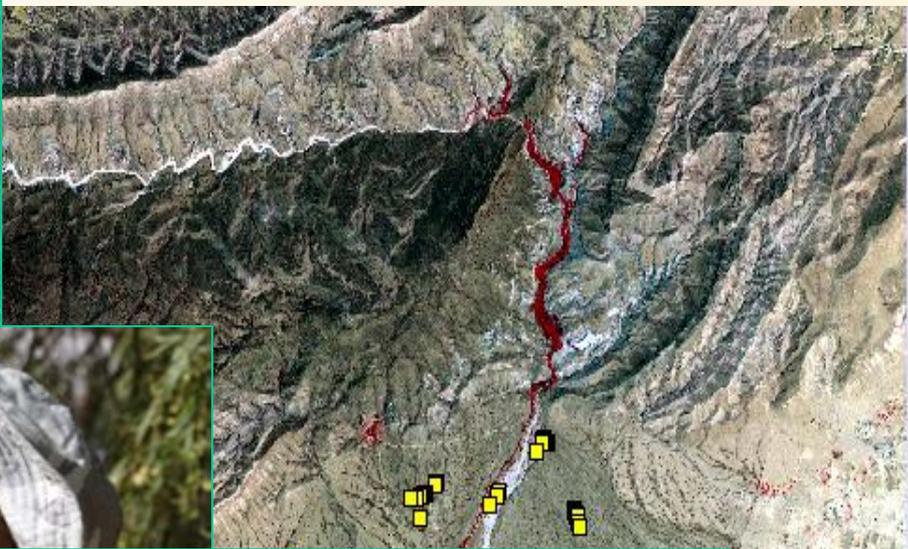
### CARTE DE DIFFERENCE DU CHANGEMENT D'IMAGE DE L'OCCUPATION DU SOL 2000-2014

Dérivée de l'imagerie Landsat 8 (OLI) du 02 April 2014.

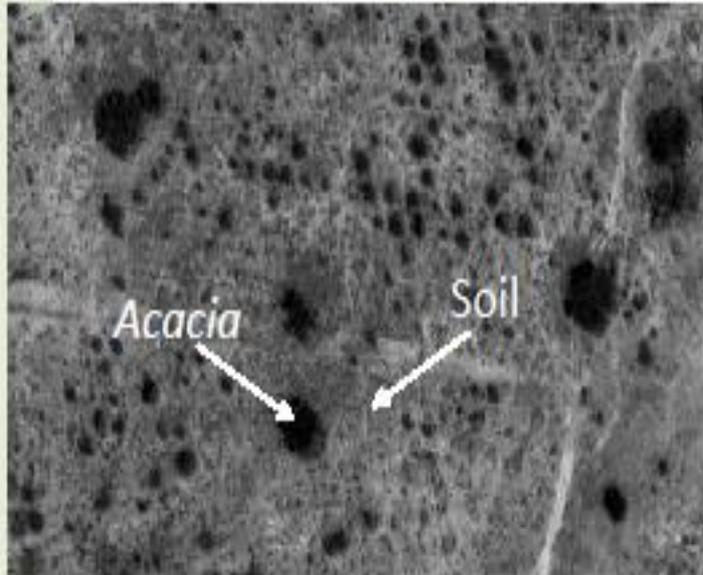
Source: USGS GLOVIS

Conception: M. Ouessar, B. Essifi et M. Henchiri  
 Cartographie: Malak Henchiri



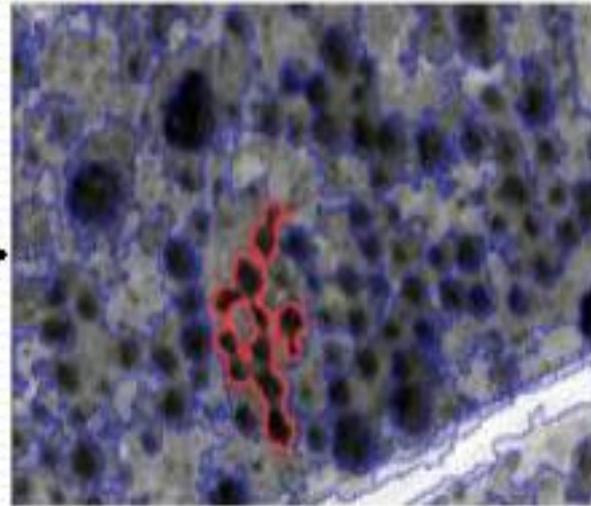


# Image analysis: segmentation

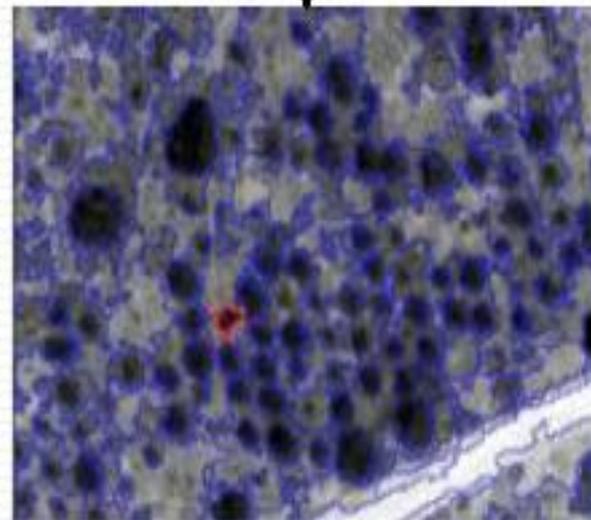


**GeoEye-1  
(panchromatic )**

**Geographic Object-Based  
Image Analysis**

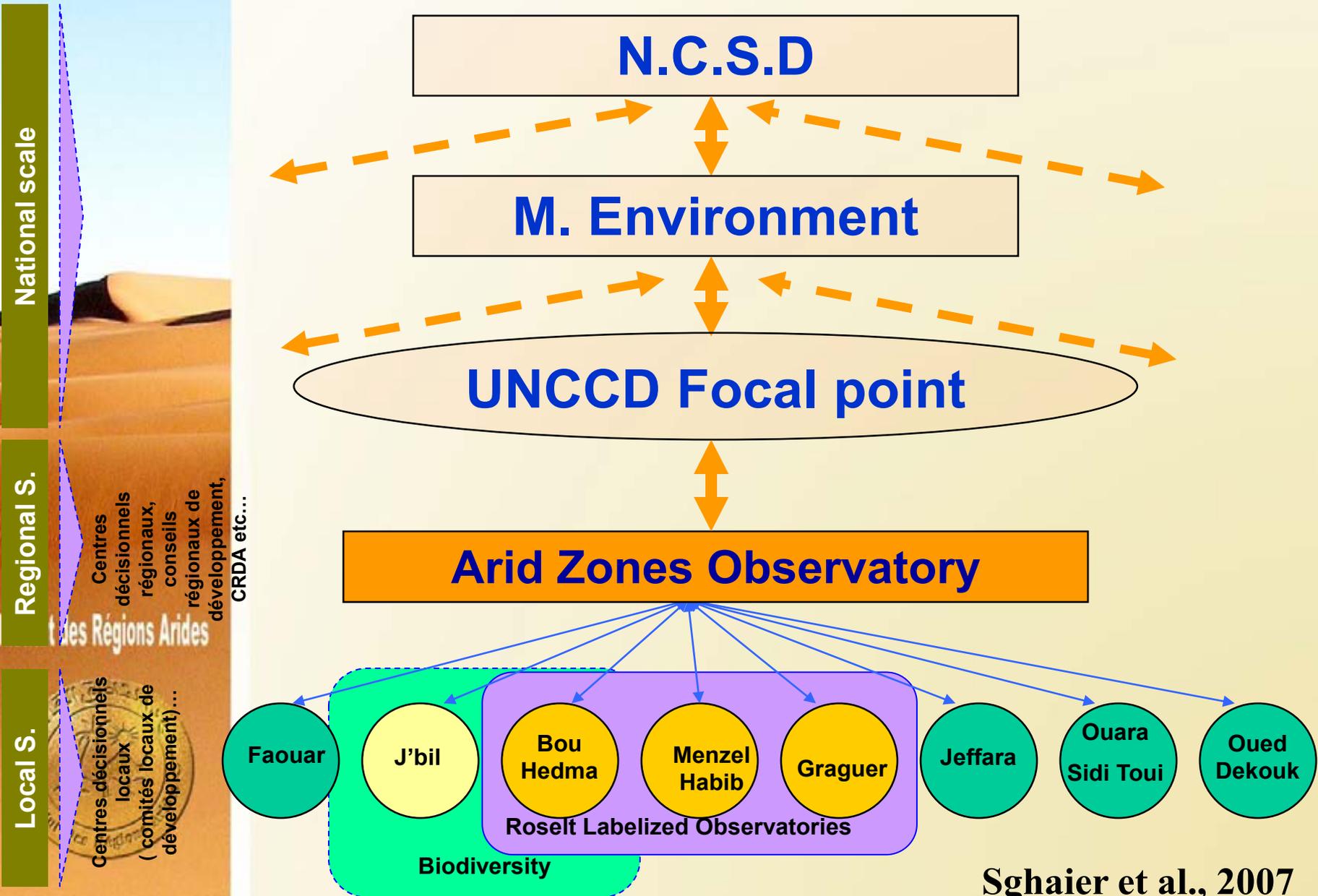


**Multiresolution  
segmentation**

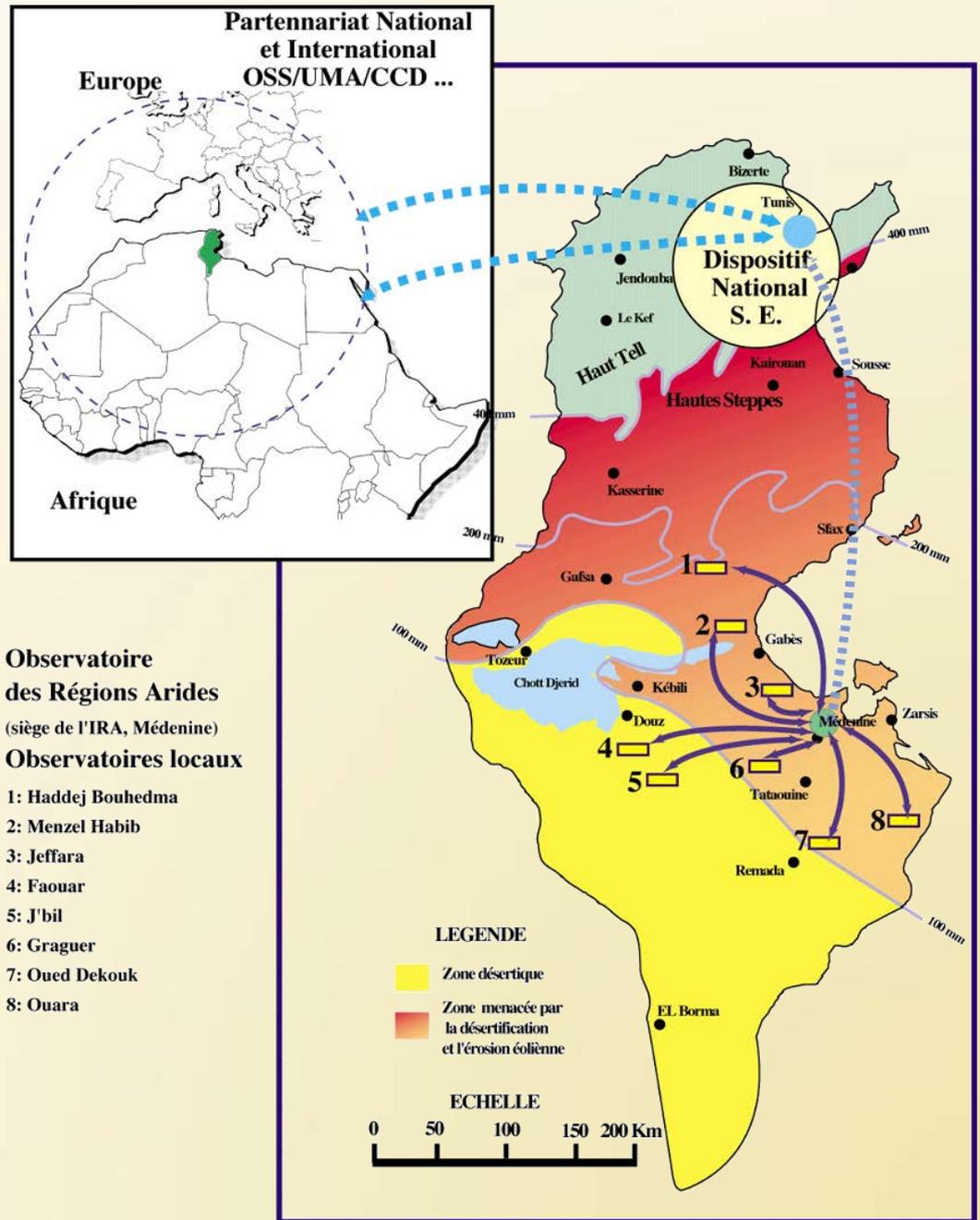


**Contrast split  
segmentation**

# Scheme of integration of the local environmental observation in the Monitoring Evaluation national design in Tunisia



# Arid zone Observatory (IRA, Tunisia)



Institut des Régions Arides





Institut des Régions Arides



Menu Général principal

Déplacer

# INSTITUT DES REGIONS ARIDES MEDENINE

## BASE DE DONNEES NUMERIQUES POUR LES REGIONS ARIDES

**Graphiques**

**Imprimer Etat**

**Quitter**



**Bassin versant**

**Mesure**

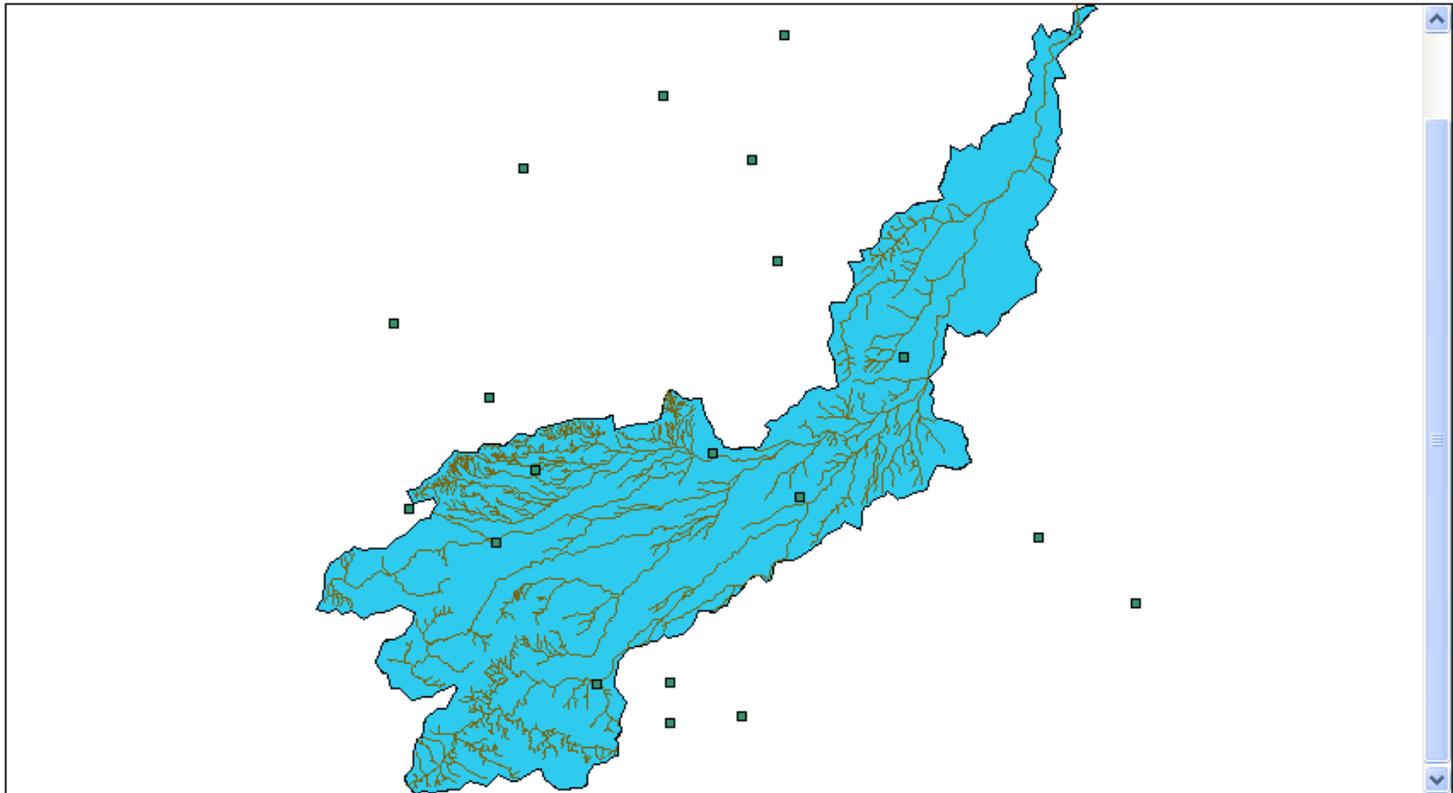
**Afficher la fenêtre base de données**



**BEN ZAIED Mongi:  
ENIT**



- city
- deep\_aquife
- geology
- Hyl\_oum\_ze
- jess-tab
- landuse\_200
- landuses\_199
- road
- shallow\_aqu
- Soil\_1991
- Soil\_2004
- Watershed



E = 587453,844199219    N = 3707950,98229453

**IRA**

**SYSTEME D'INFORMATIONS GEOGRAPHIQUE**

IRA    Medenine Tunisie

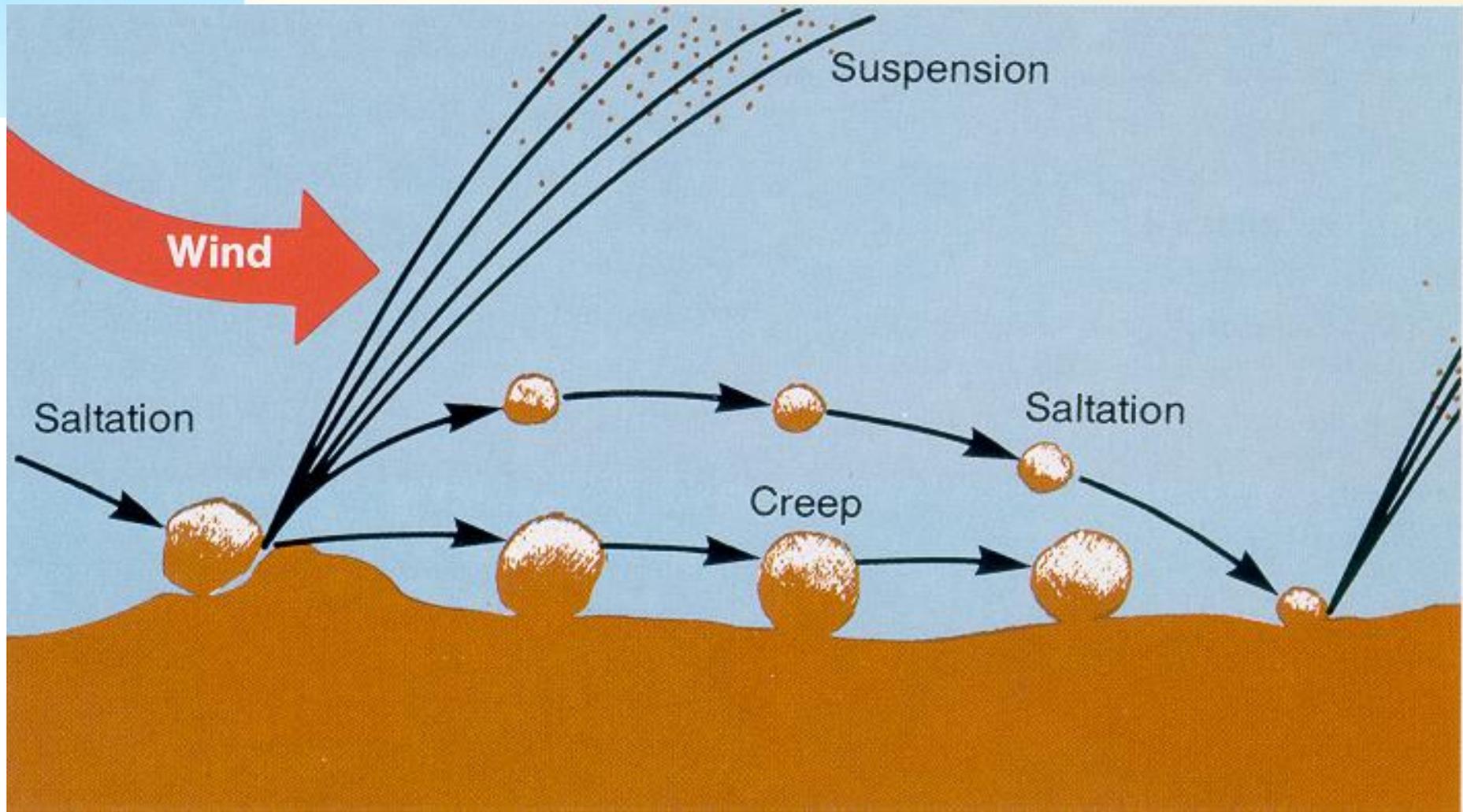
Mastère Spécialisé en  
Géomatique - ENIT



# WIND EROSION & SOIL DEDRADATION CONTROL

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FINE SAND GRAIN  
BEGINS TO ROLL

FINE SAND GRAIN  
JUMPS INTO AIR

WHEN GRAIN HITS,  
IMPACT KNOCKS SILT  
OR CLAY INTO AIR

IMPACT MAY ALSO  
PUSH COARSE  
SAND GRAIN

**Saltation**

**50-70%**

**Reptation**

**5-25 %**

**Suspension**

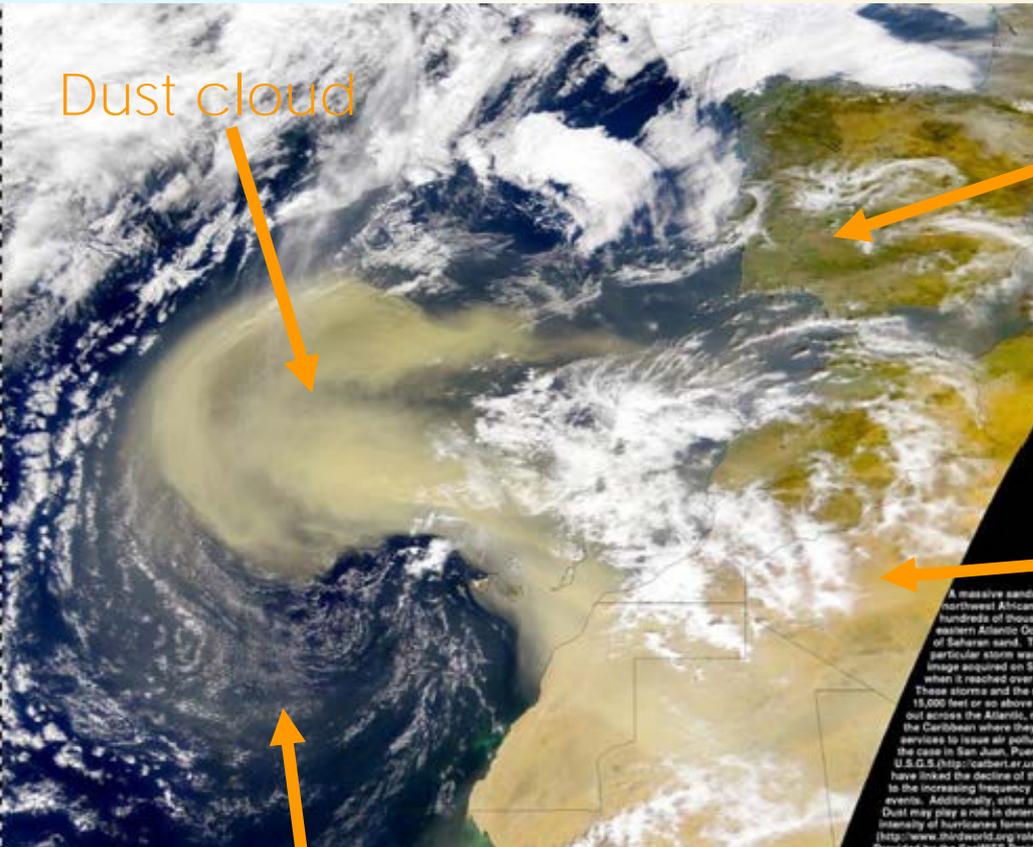
**3-40%**

**Chepil (1941)**

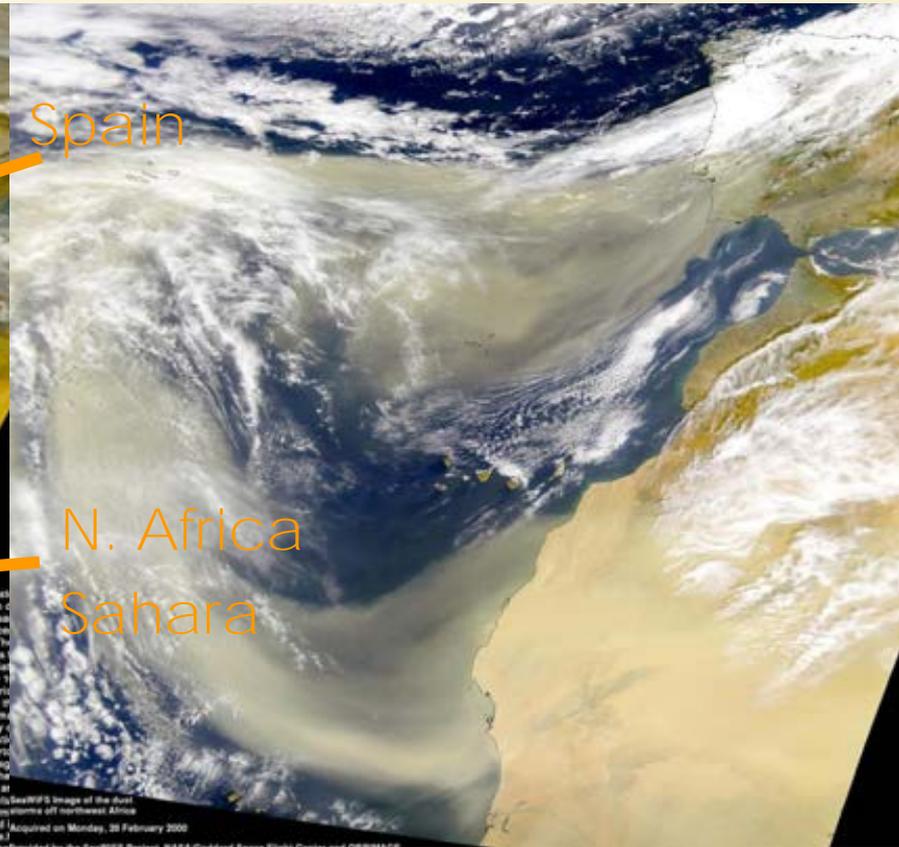
Institut des Régions Arides







Dust cloud



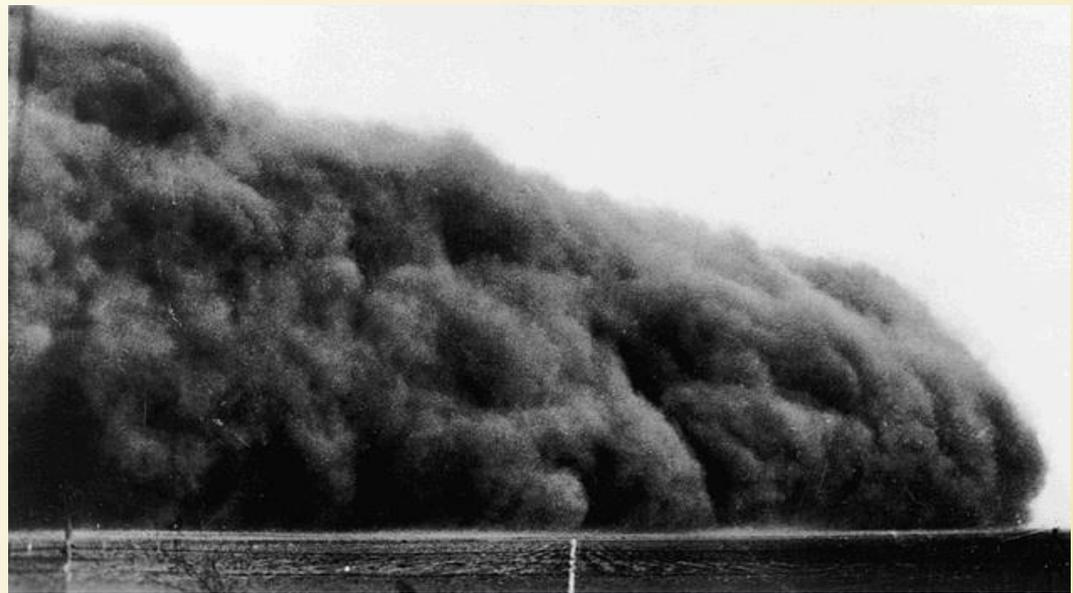
Spain

N. Africa  
Sahara

A massive sandstorm from northwest Africa carried hundreds of thousands of tonnes of Saharan sand. The particular storm was imaged on Sat when it reached over the Atlantic. These storms and the dust they carry rise 15,000 feet or so above the ground and travel out across the Atlantic, the Caribbean where they can be seen from space. The case in San Juan, Puerto Rico, is a good example. U.S.G.S. (<http://calbert.er.usgs.gov>) have linked the decline of the intensity of hurricanes to the increasing frequency of these events. Additionally, other scientists believe that dust may play a role in determining the intensity of hurricanes formed in the Caribbean. Acquired on Monday, 30 February 2000 (<http://www.thirdworld.org/>) Provided by the Southwest Science Data Center, University of Colorado

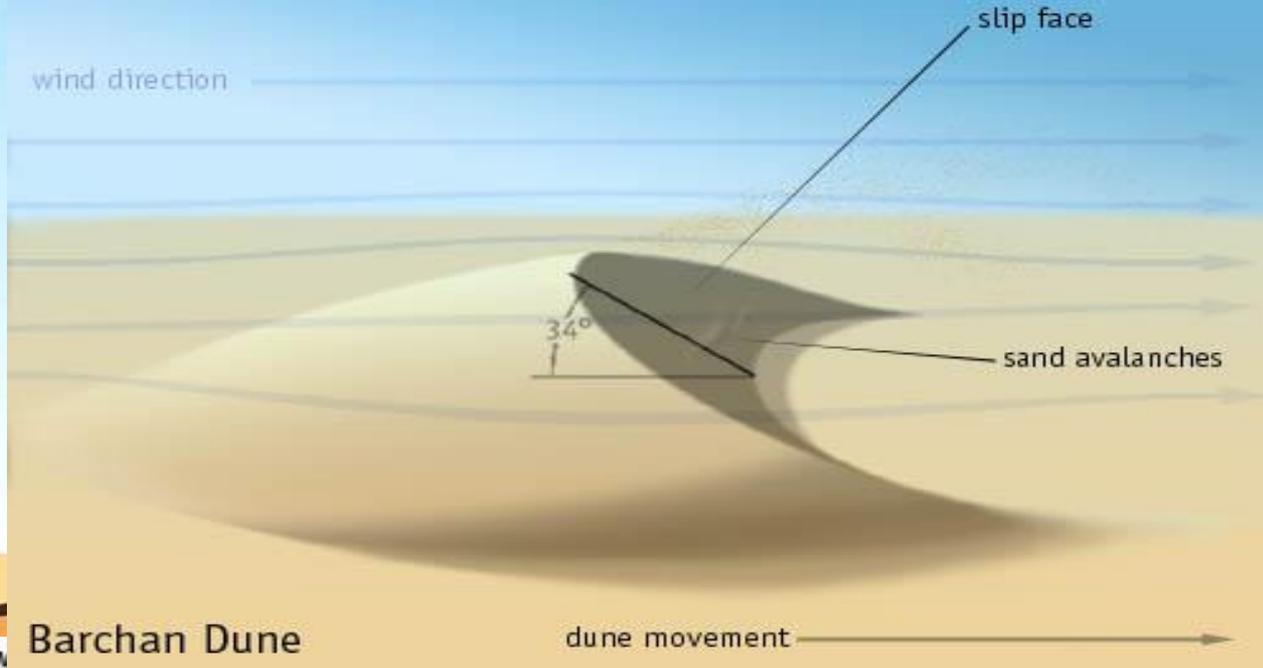


Atlantic Ocean

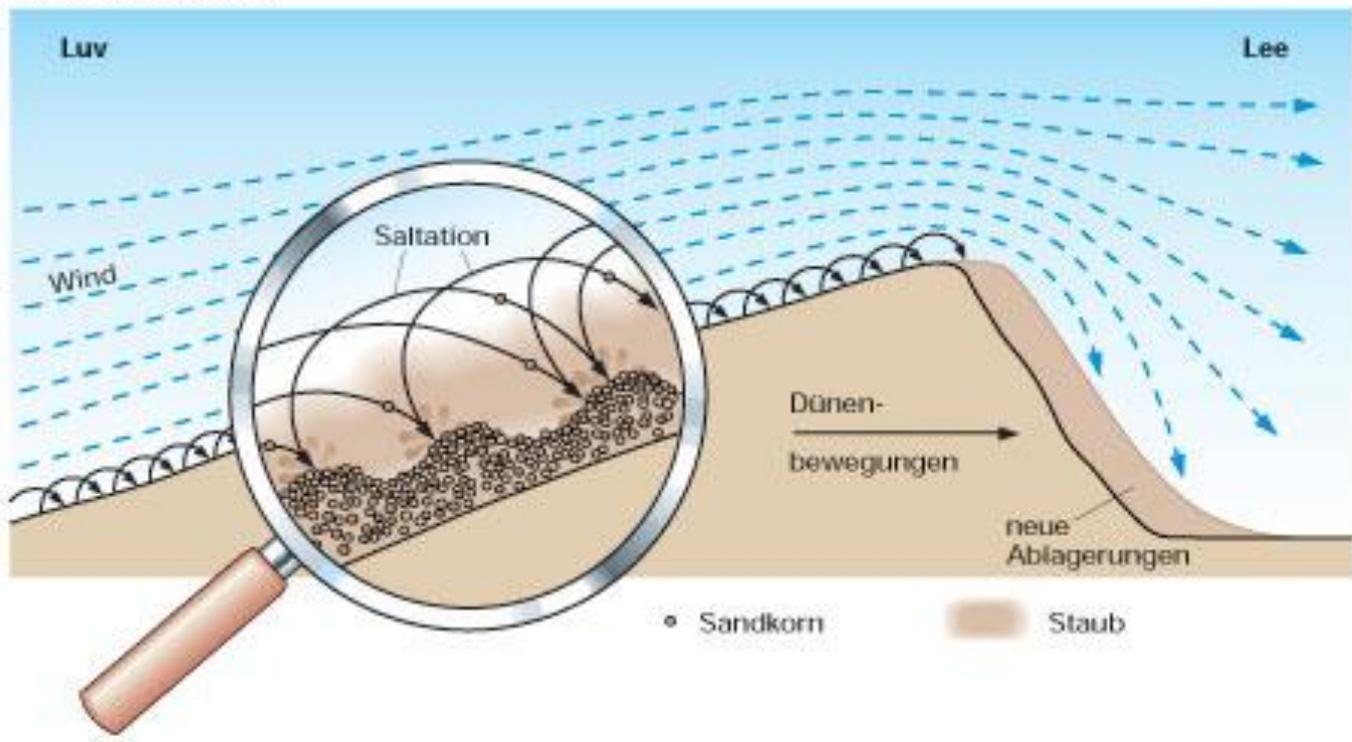


Dust bowl (USA, années 30)





Barchan Dune



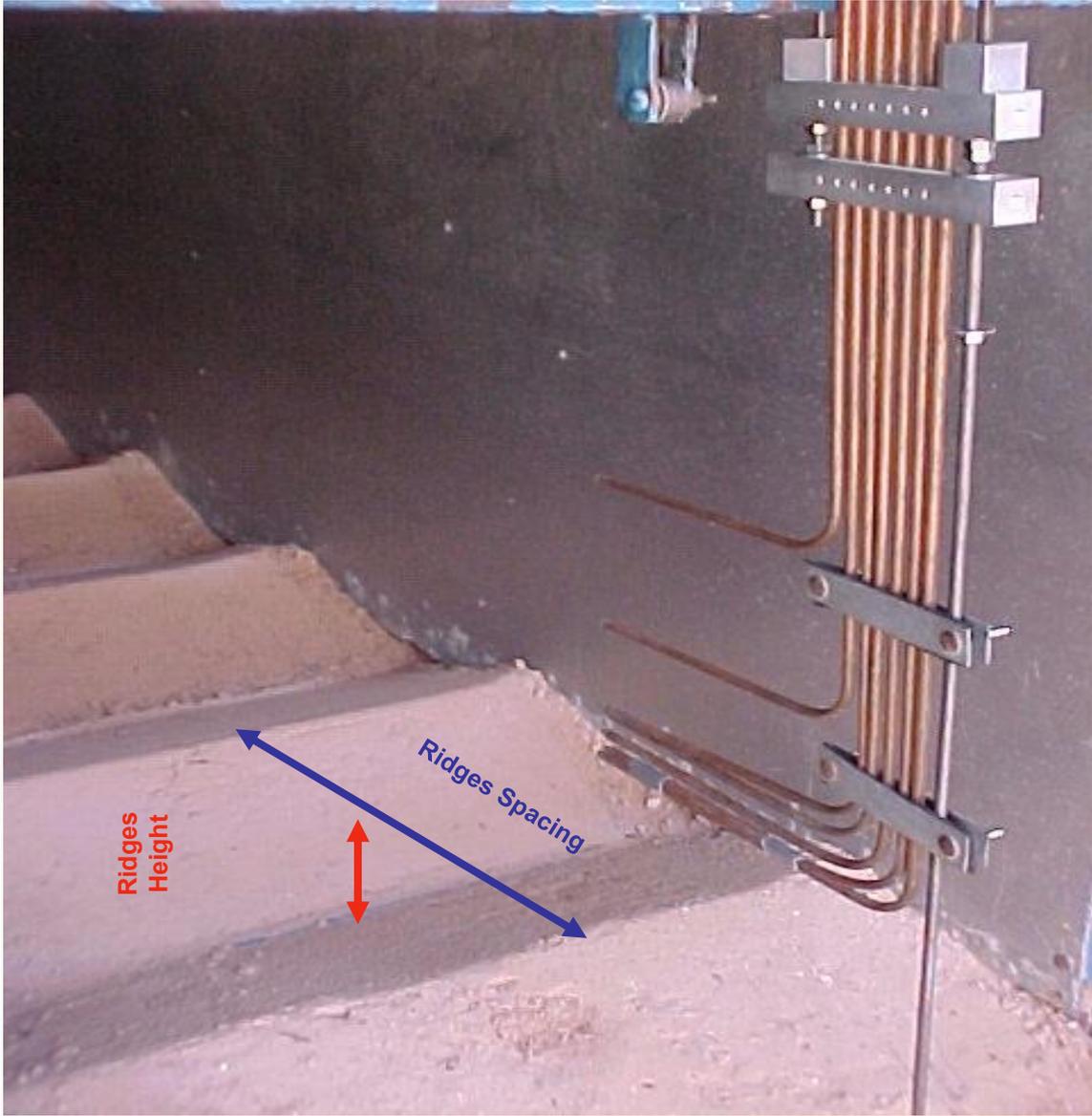
Institut des R







Institut des Régions Arides



Ridges Height

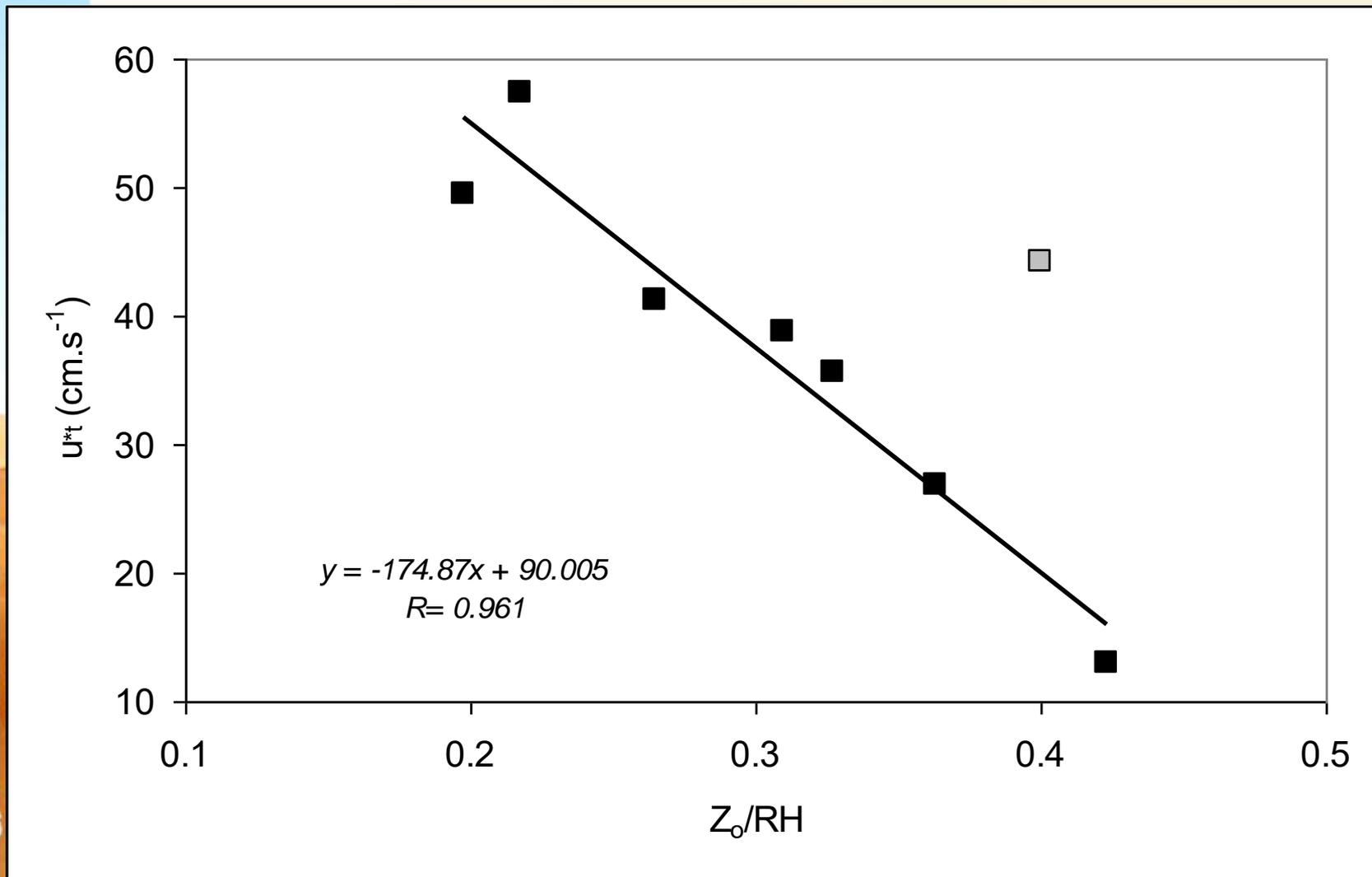
Ridges Spacing

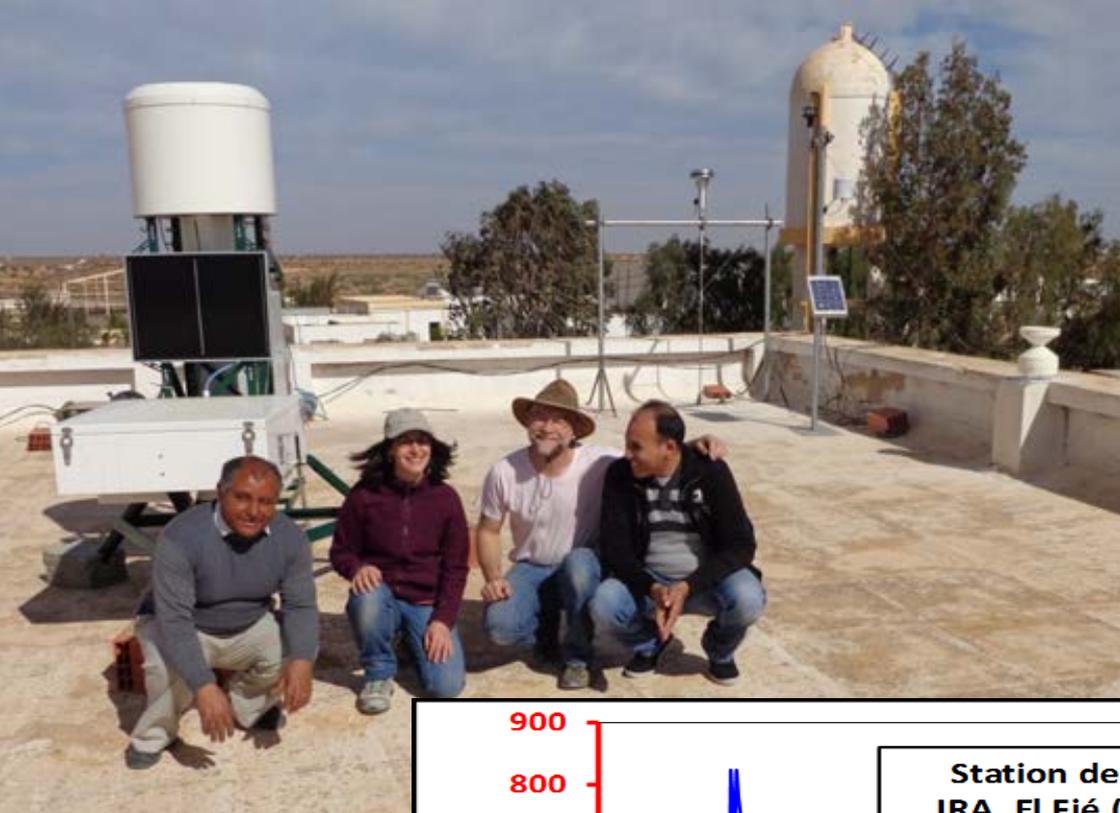


30-01-03  
Série 2-3

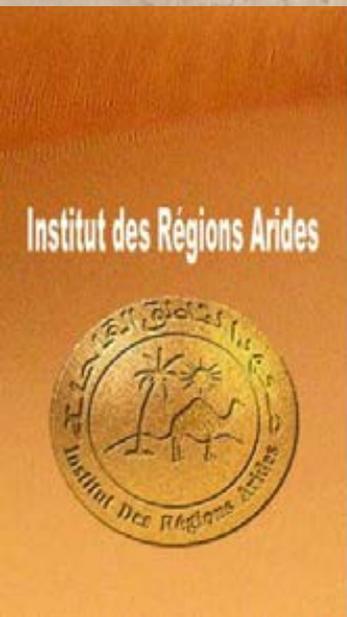
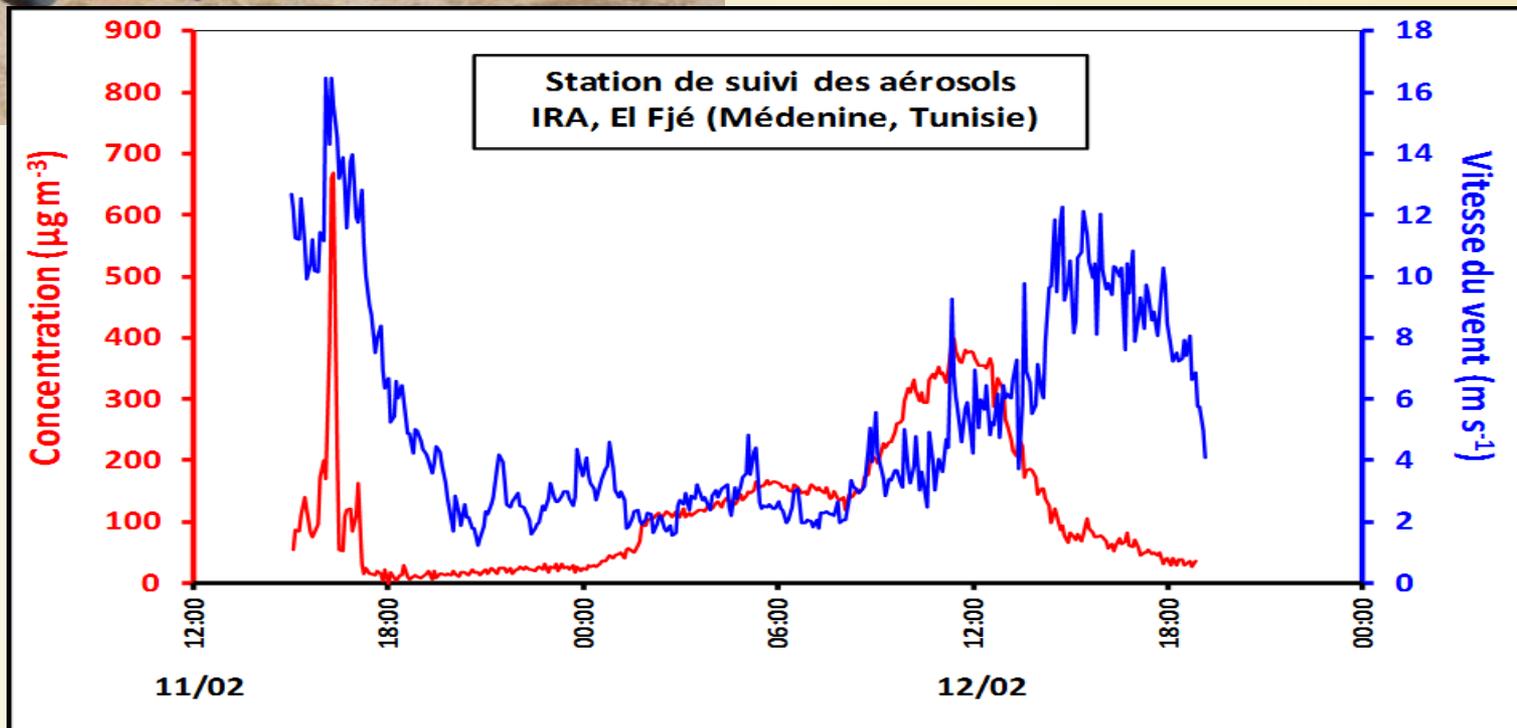


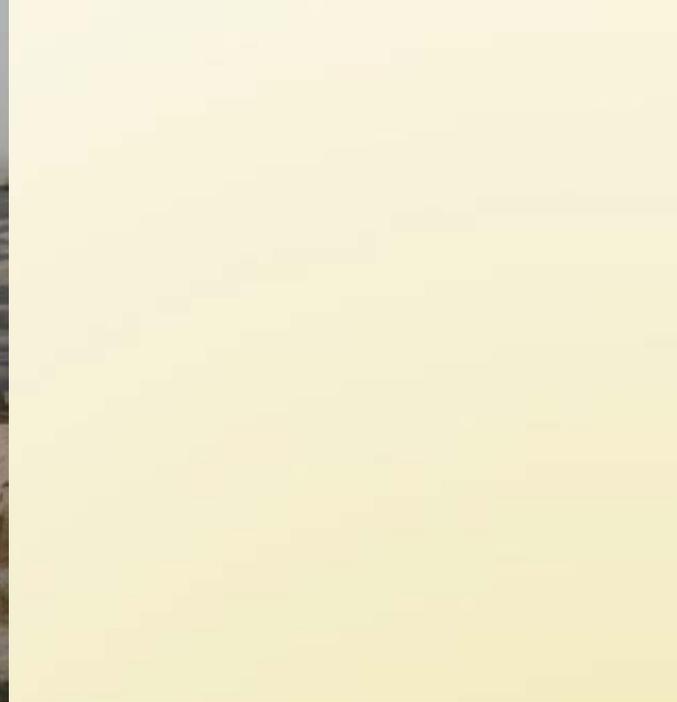






Labiadh et al., 2017

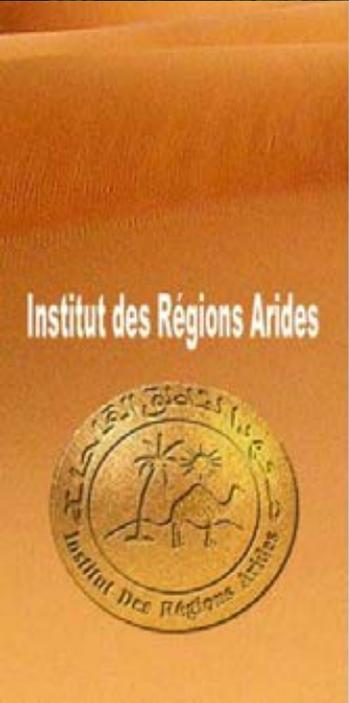




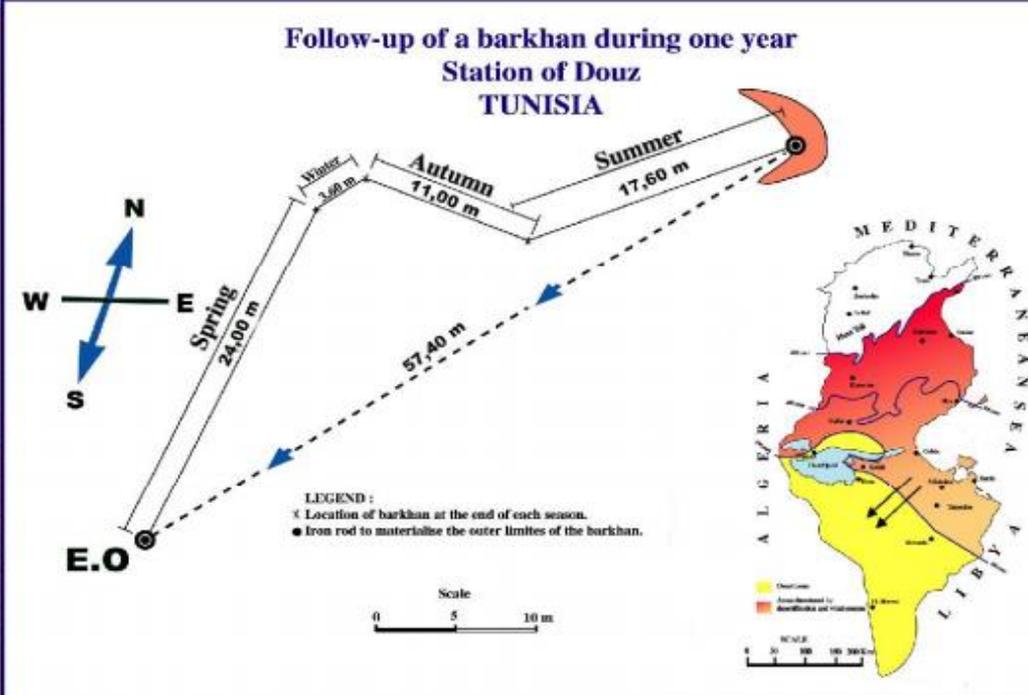
Institut des Régions Arides

The logo of the Institut des Régions Arides is a circular emblem. It features a camel and a palm tree in the center. The text "Institut des Régions Arides" is written in Arabic at the top and in French at the bottom of the circle.





Khatteli, 1996, 2002



Plow	Soil loss (ha/year)	Cereal production (ha/year)
Disk plow	180 tons	4,2 q
Traditionnel plow	33 tons	4,4 q
Sock plow	60 tons	4,6 q
Tiller	75 tons	2,5 q

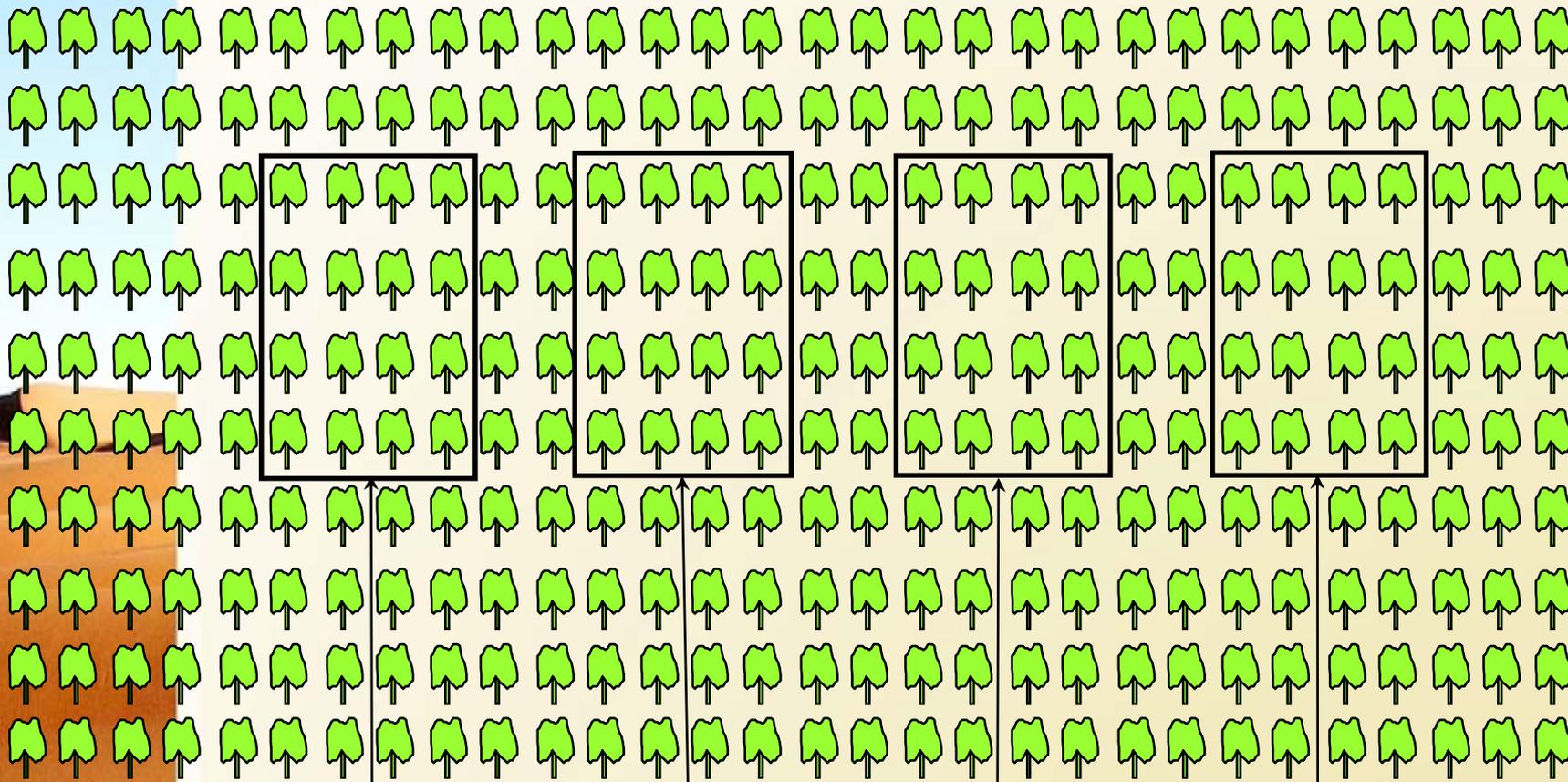


T0

T1

T2

T3



Témoins (0 m<sup>3</sup>/ha)

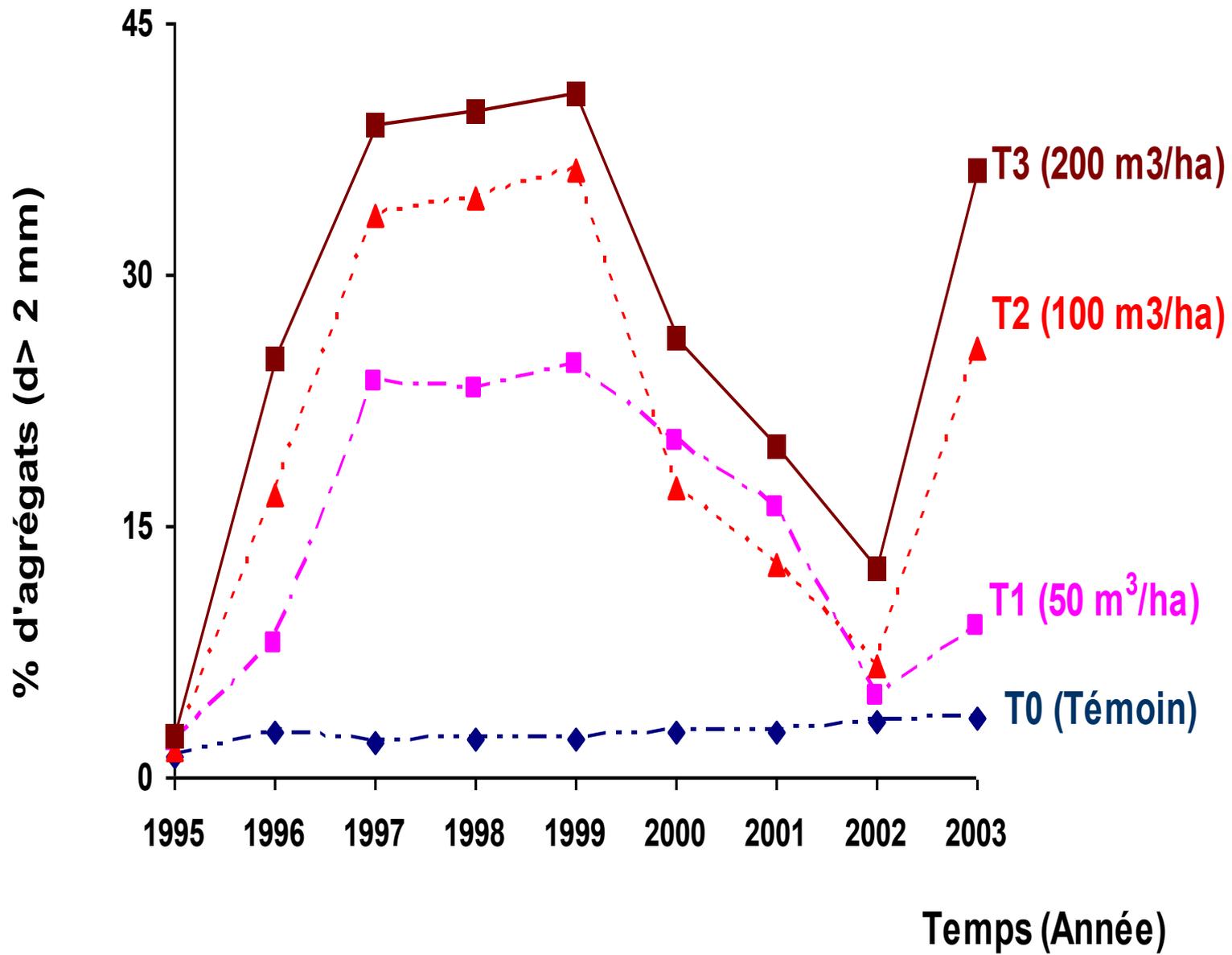
Traitement 1 (50 m<sup>3</sup>/ha)

Traitement 2 (100 m<sup>3</sup>/ha)

Traitement 3 (200 m<sup>3</sup>/ha)

Institut des Régions Arides





# WATER SAVING

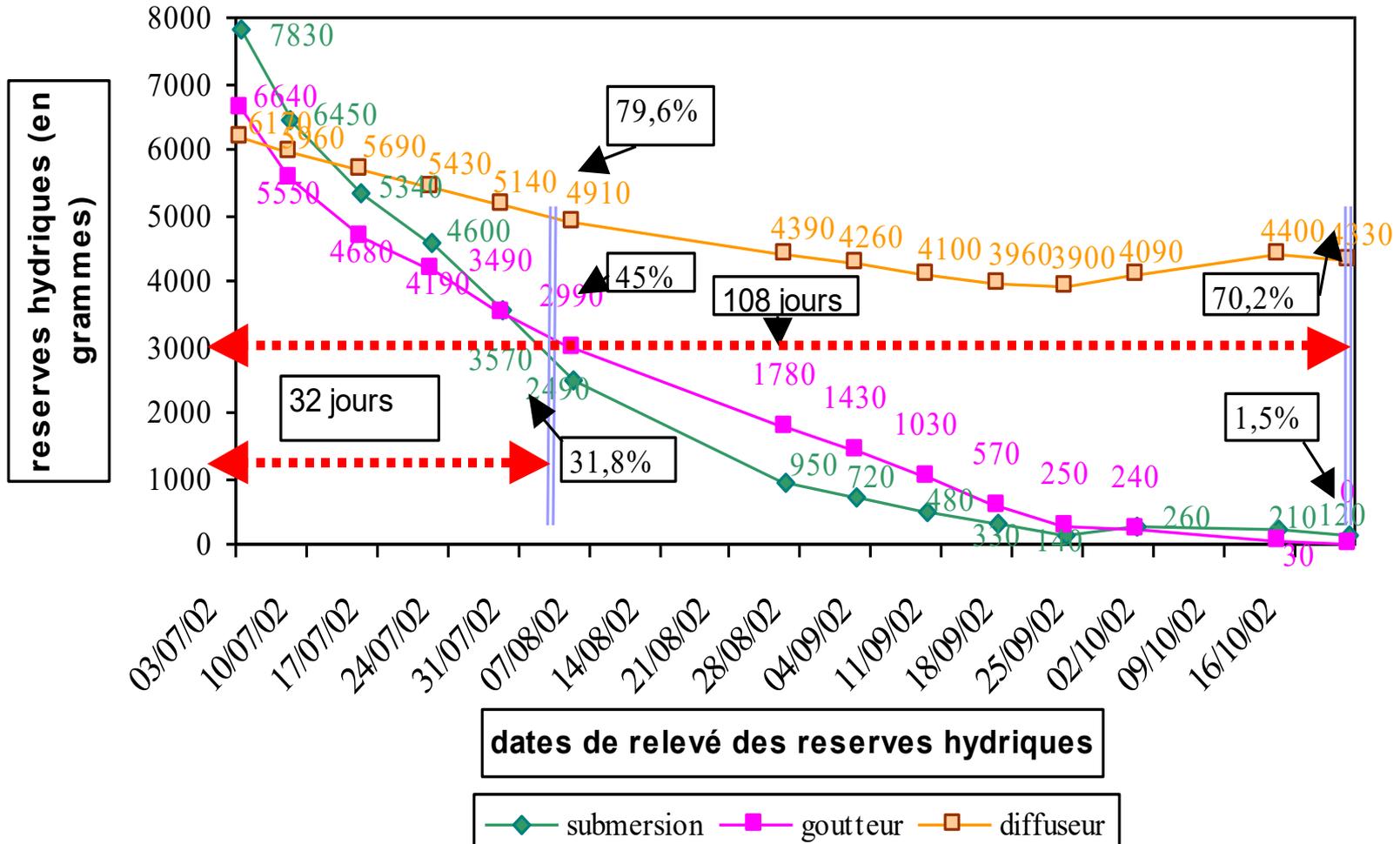
Institut des Régions Arides







comparaison de l'irrigation( par submersion, par goutteur et par diffuseur) des pots pour plantes ornementales, mis à l'extérieur, sur le toit d'un local( laboratoire)



Thank you

Grazie

*We love deserts .... but ... we combat desertification*

