Desertification Assessment and Monitoring System in Arab Countries Using Time Series NDVI Images Analysis

Joint venture cooperation

Arab League ACSAD – GTZ Germany – CNRS Lebanon

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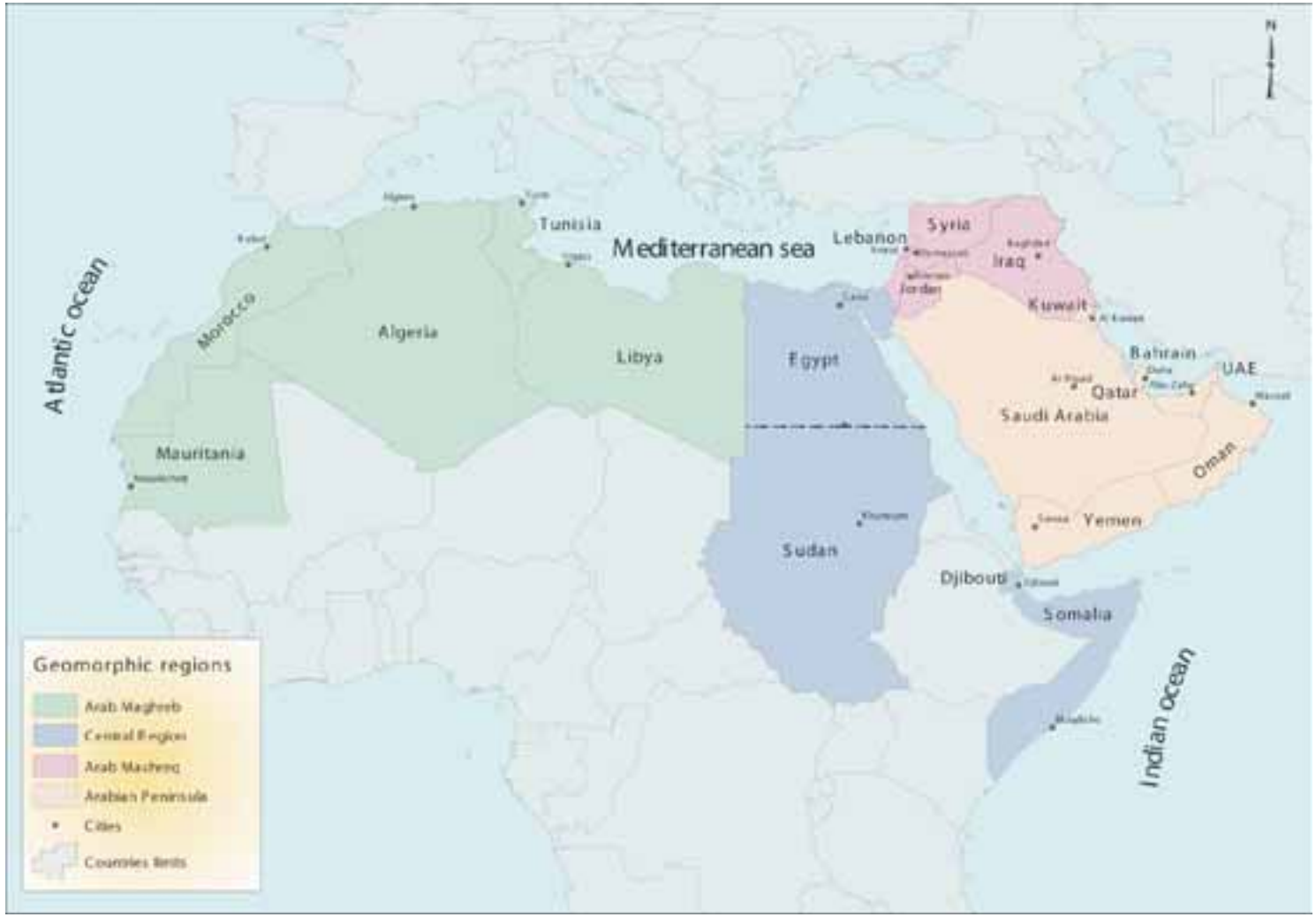
United Nations Austria ESA

SPACE TOOLS AND SOLUTIONS FOR MONITORING THE ATMOSPHERE AND LAND COVE

9-12 september, 2008

GRAZ - AUSTRIA

STUDY AREA


Atlantic ocean
Morocco
Algeria
Tunisia
Mediterranean sea
Libya
Egypt
Lebanon
Syria
Iraq
Jordan
Kuwait
Bahrain
UAE
Qatar
Saudi Arabia
Oman
Yemen
Mauritania
Sudan
Djibouti
Somalia
Indian ocean
Geomorphic regions
Arab Maghreb
Central Region
Arab Mashreq
Arabian Peninsula
Cities
Countries limits

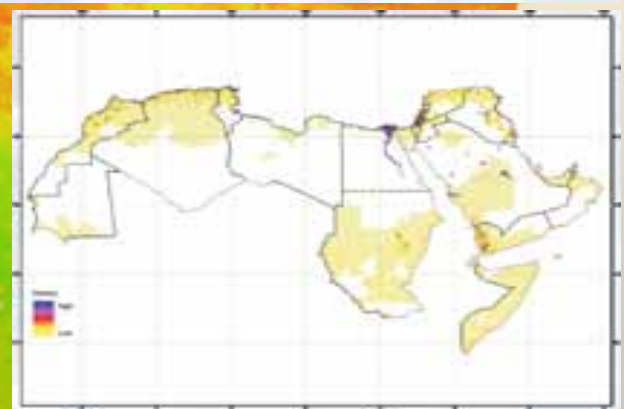
CONTEXT

The Arab region is recently facing land degradation and desertification problems, involving ecosystem deterioration.

These problems are triggered by :

- Climatic changes

- Anthropological activities



OBJECTIVE

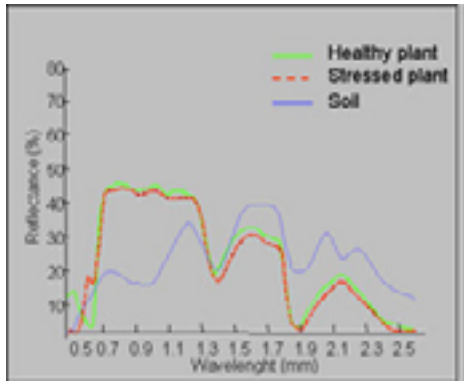
1. Establish a Regional Early Warning system (REWs) for Monitoring Desertification in the Arab World (identify hot spots and broght spots)

2. Desertification Monitoring and Assessment Network (ADMAnet), and standardize and harmonize ADMAnet member's in applying advanced techniques, and recent approaches related to DMA

3. Acsad Desertification Bulletin

NDVI

Vegetation tends to absorb strongly the red wavelengths of sunlight and reflect in the near-infrared wavelengths



NDVI Normalized difference Vegetation Index

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

NDVI is the most common measure of physiological and biochemical plant development

Many satellites have sensors that measure the red and near-infrared spectral bands, and many variations on the NDVI exist

Relation between NDVI and Vegetation

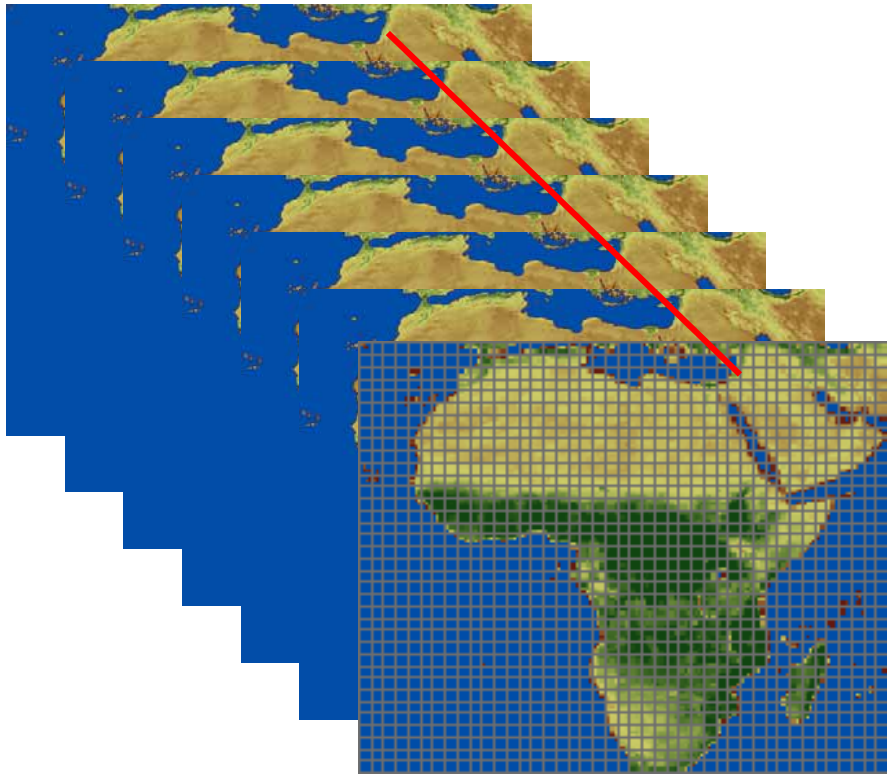
COVER TYPE	NDVI
Dense vegetation	›0.4
Medium Vegetation	0.2 – 0.4
Light Vegetation	0.1 – 0.4
Dry Bare soil	0.025
Clouds	0.002
Snow and ice	-0.05
Water	-0.26

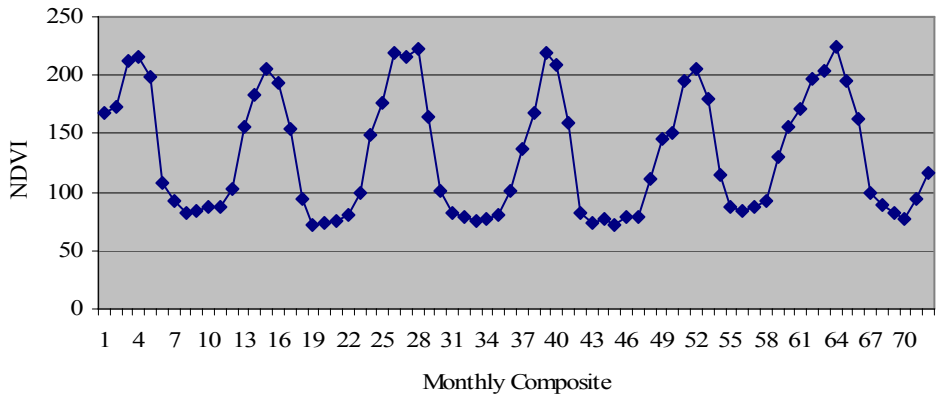
NDVI ratios

Free Archived NDVI Dataset

Sensor	Data Source	Spatial Resolution	Time domain	Temporal Resolution
AVHRR	GIMMS NDVI	8000 m	81-06	15 days monthly
SPOT VGT	VITO	1000 m	98-07	10 days monthly
MODIS NDVI	MODIS-Land	5000 m, 500m	00-04	15 days monthly

TIME SERIES NDVI

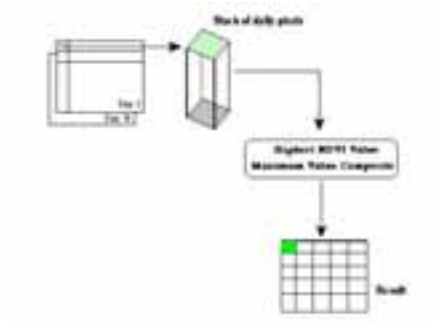




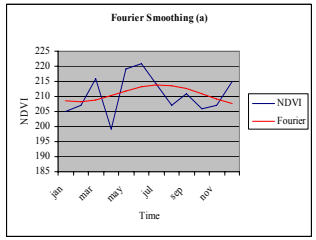
DATA PREPARATION

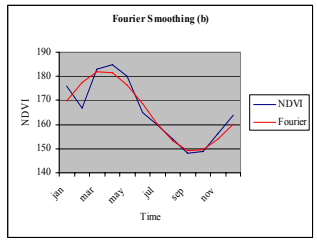
1. Data download and import

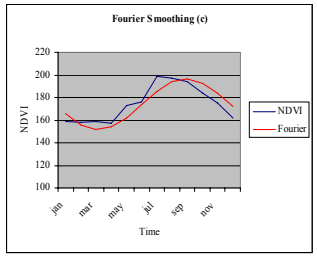
2. Generation of Monthly Dataset

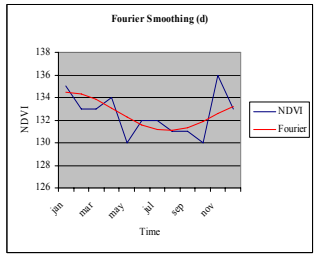


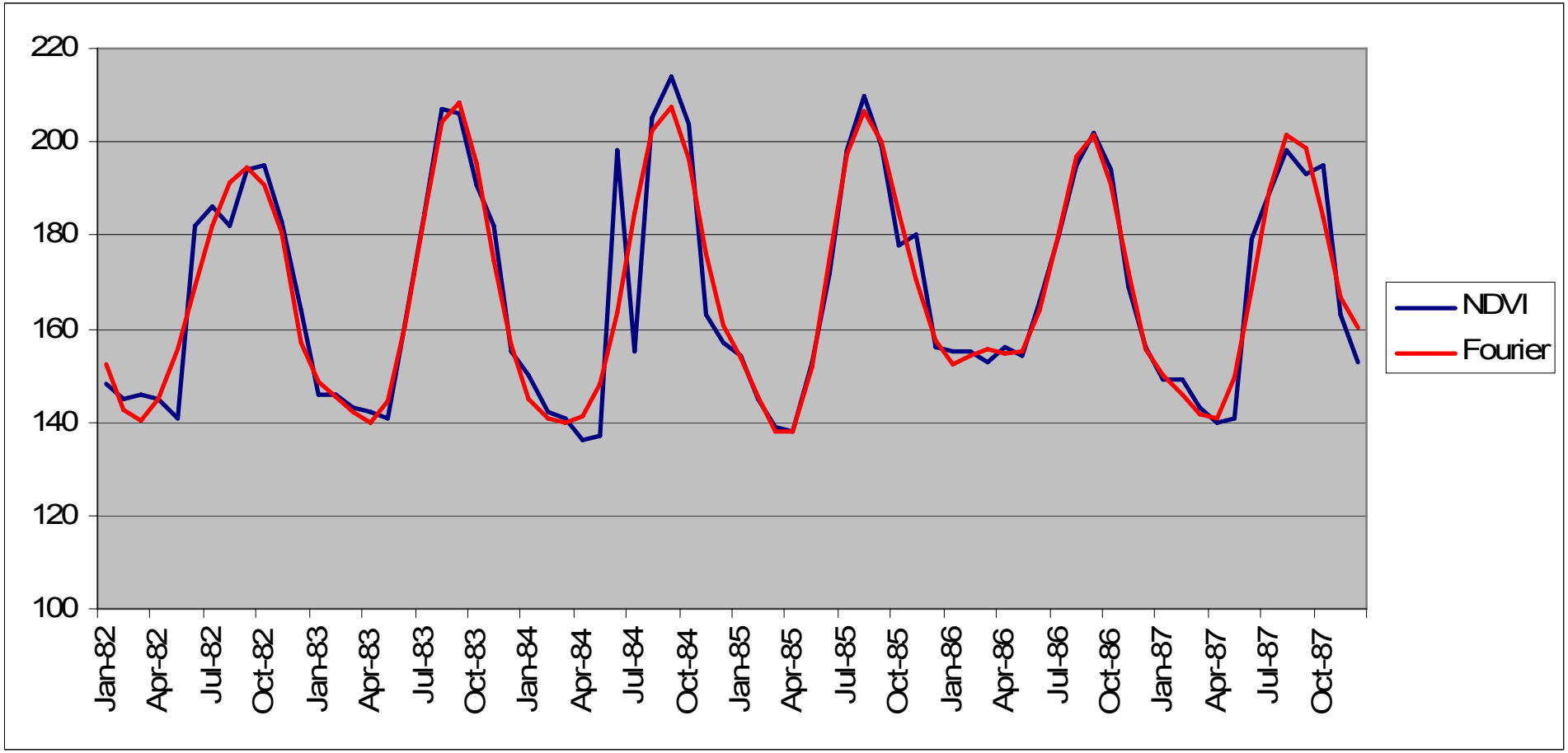
3. Fourier Adjustment





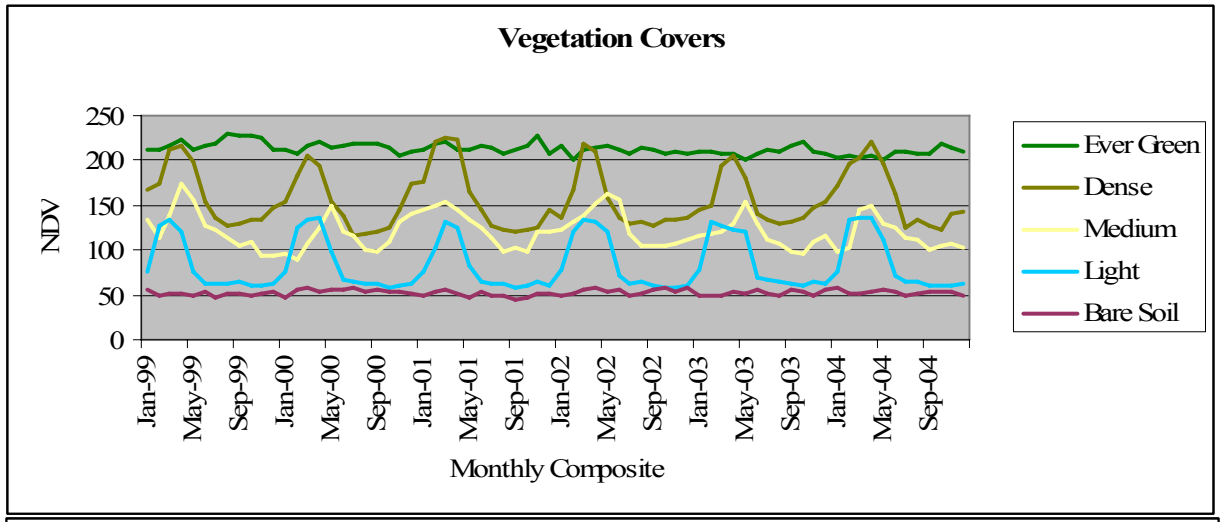


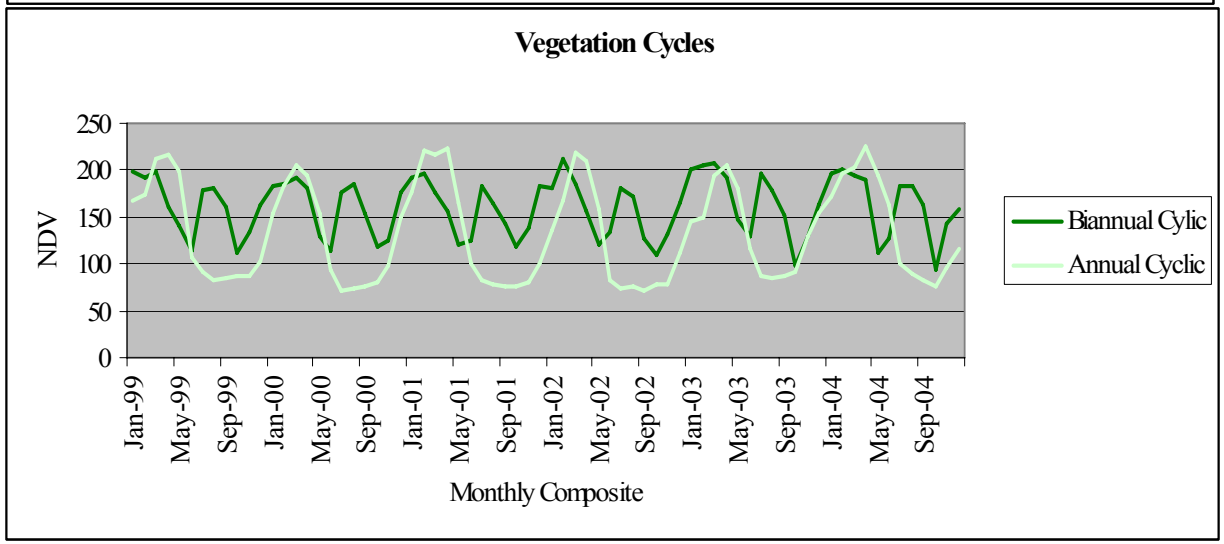



220
200
180
160
140
120
100
Jan-82
Apr-82
Jul-82
Oct-82
Jan-83
Apr-83
Jul-83
Oct-83
Jan-84
Apr-84
Jul-84
Oct-84
Jan-85
Apr-85
Jul-85
Oct-85
Jan-86
Apr-86
Jul-86
Oct-86
Jan-87
Apr-87
Jul-87
Oct-87
NDVI
Fourier

TIME SERIES MODELS

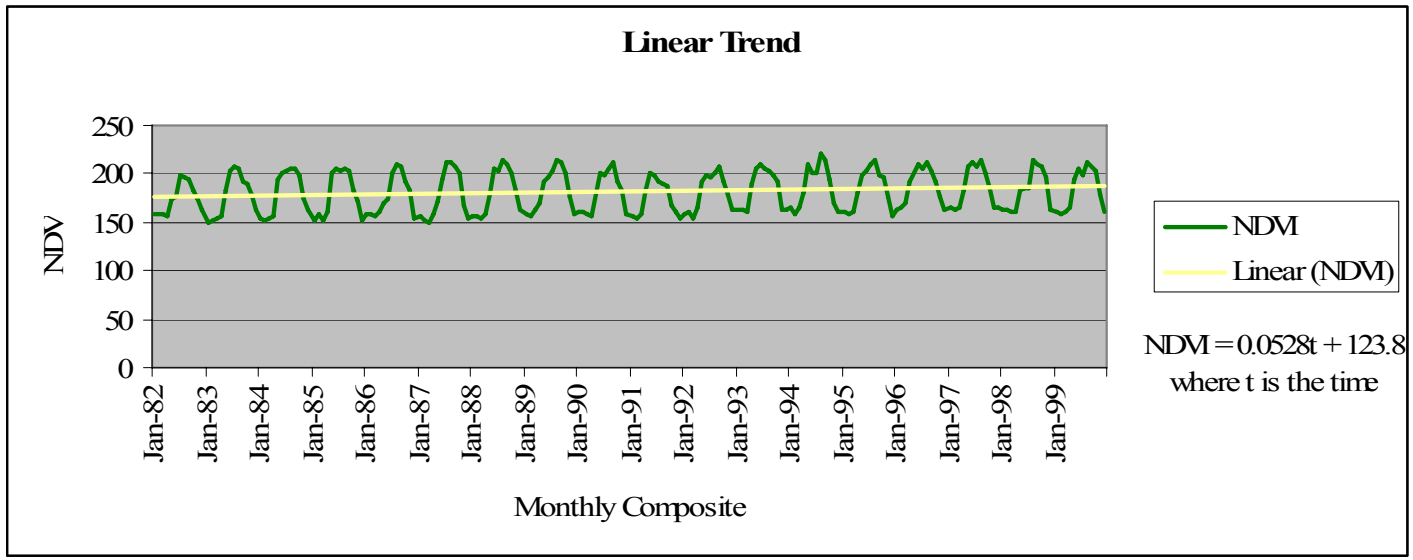
Vegetation Cycle :





TIME SERIES MODELS

Simple model :



The linear model is used to best fit the cyclic vegetation variation into a line; the slope of the line indicates vegetation variation (decrease or increase) and the amount of variation (No change, moderate, severe...).

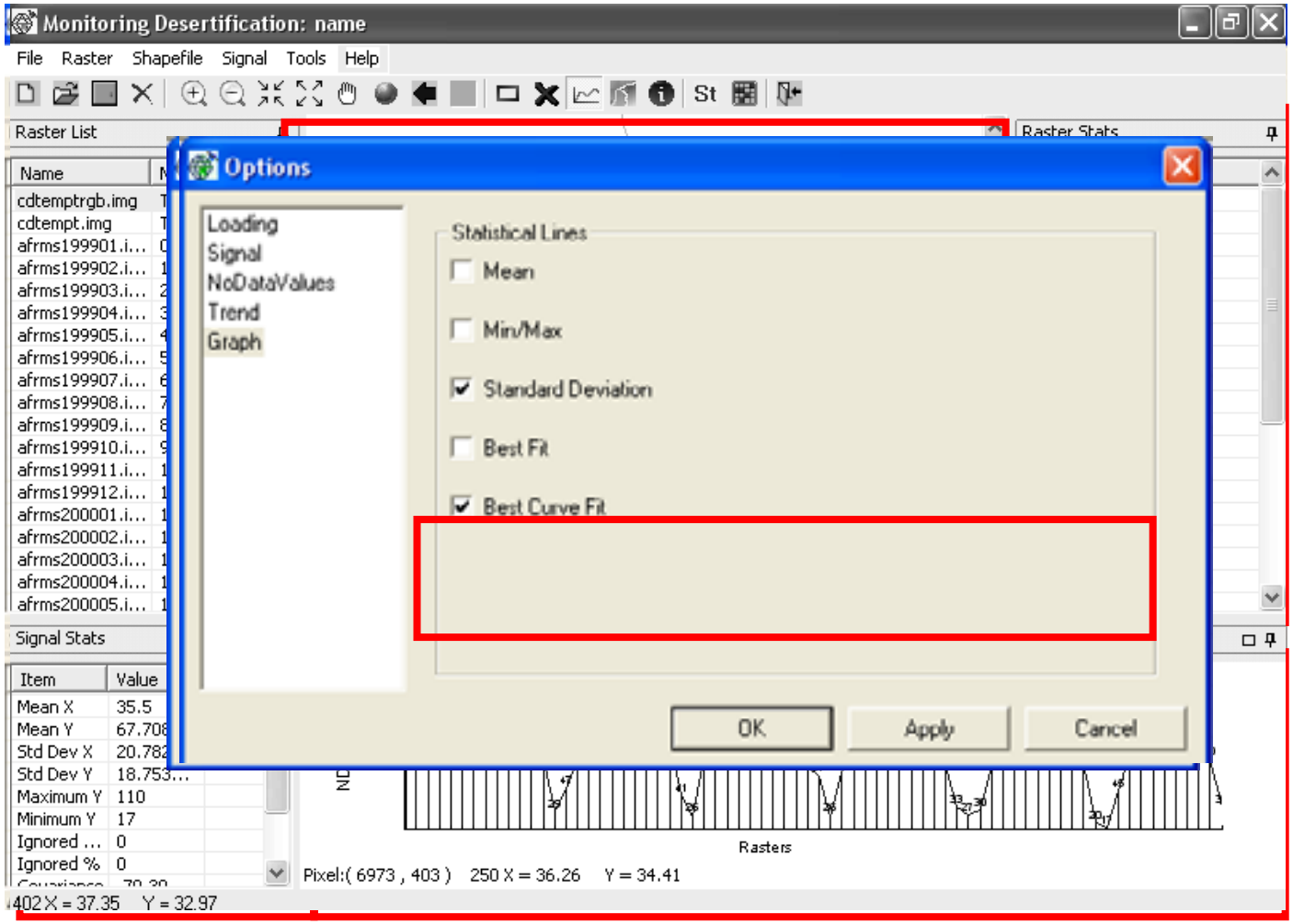
The NDVI linear model is written as :

$$NDVIt = a.t + NDVI_0$$

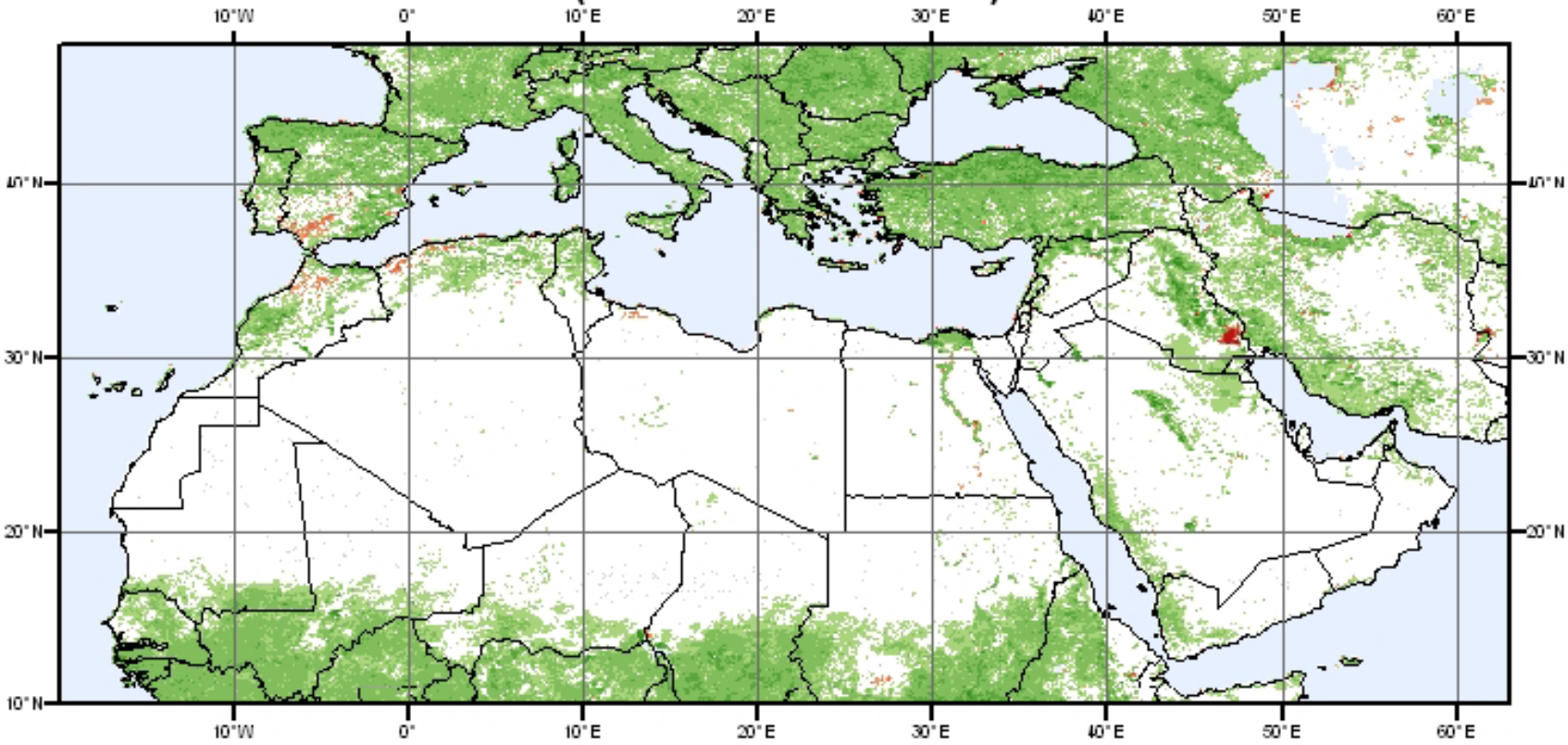
where a (trend) and NDVI0 are constant, t is the time.

MODESERT Software

Trend Maps and Time series were all extracted by the MODESRT Software. Main Software Features are:



Modelled NDVI change Jan. 1982 - Dec. 1999
(linear trend model)



Legend

- < - 0.15
- > -0.15 - -0.10
- > -0.10 - -0.05
- > -0.05 - -0.025
- > -0,025 - 0.025
- > 0.025 - 0.05
- > 0.05 - 0.10
- > 0.10 - 0.15
- > 0.15
- water
- Boundary

N

0 375 750 1.500
Kilometers

Data source:
NOAA-AVHRR - Pathfinder archive
NOAA / NASA Pathfinder Program
Boundaries: ESRI world map

Projection:
Geographic Lat/Long
WGS84

TIME SERIES MODELS

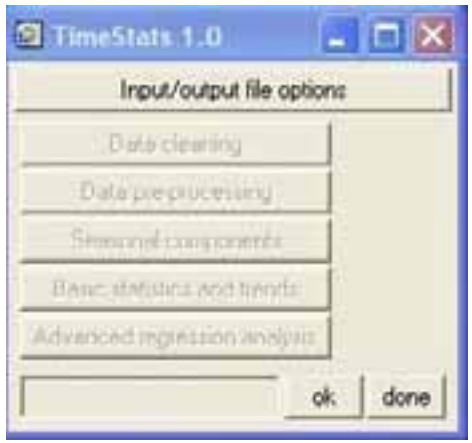
Non Linear model :

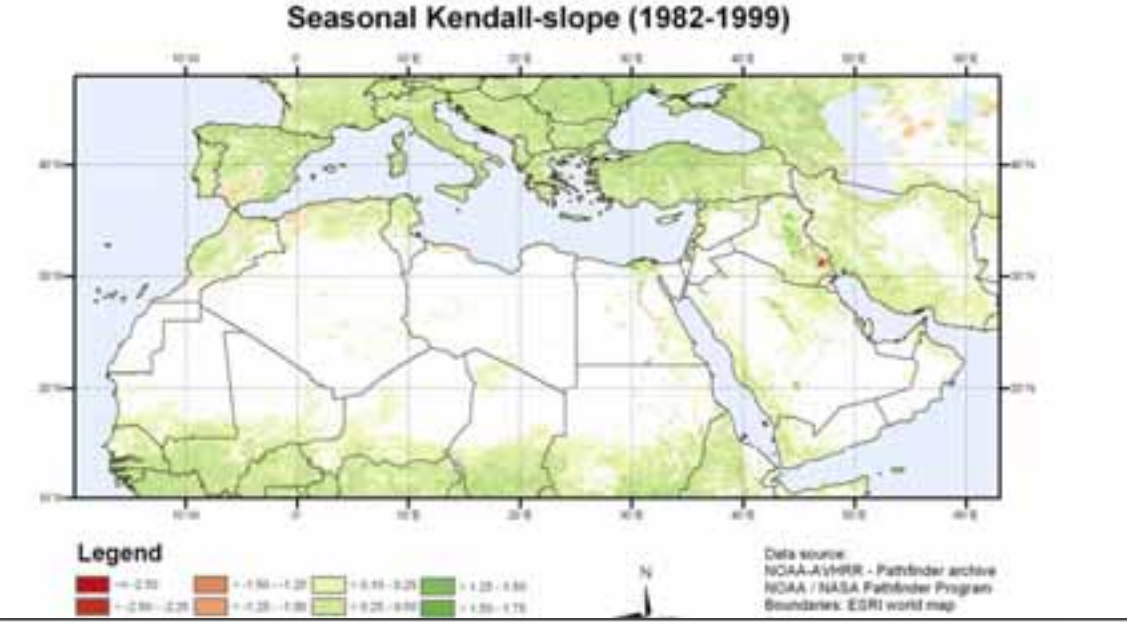
The times series NDVI models are separated into linear trend, seasonal components as well as errors. The equation of the trend developed by Dr. Udelhoven from the University of Trier with seasonal pattern as well as indicator for fitting is:

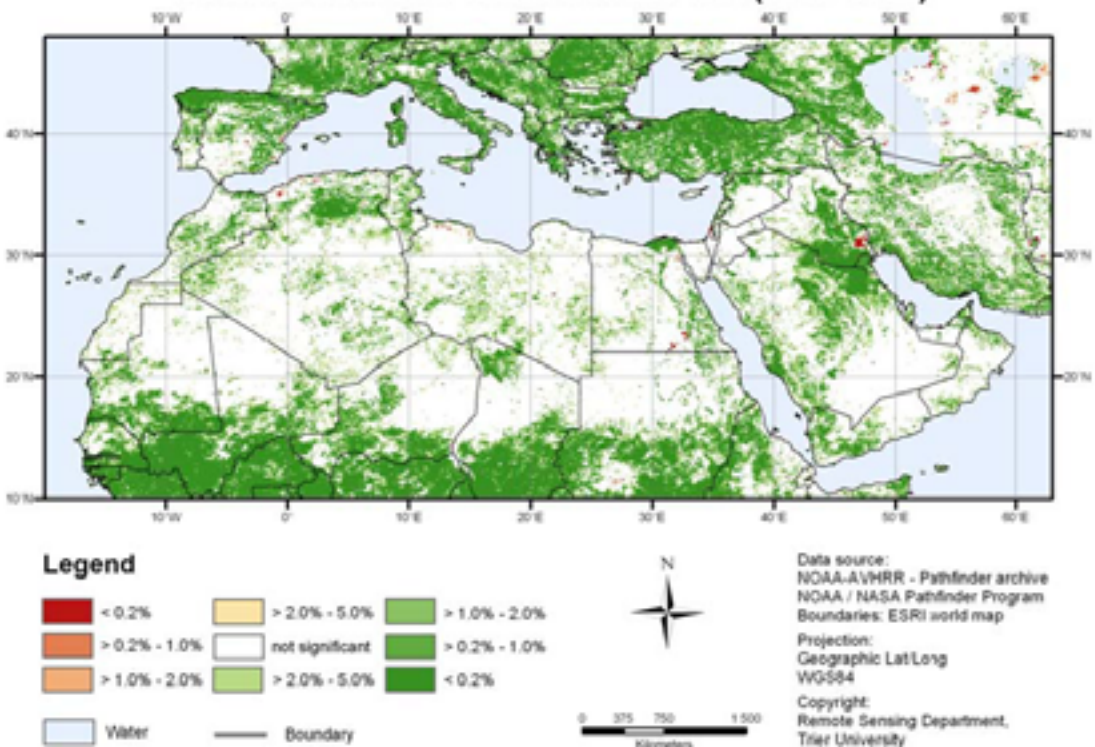
$$NDVI_t = \alpha + \beta_1 \cdot t + \left(\sum_{i=1}^{NoOfLags} \beta_i NDVI_{t-i} \right) + \left(\sum_{j=1}^{NoOfX} \sum_{k=1}^{NoOfLags} \beta_{jk} X_{jk} \right) + \left(\sum_{m=1}^{NoOfHarm} a_m \cos 2\pi \frac{1}{P_m} \cdot t + b_m \sin 2\pi \frac{1}{P_m} \cdot t \right) + \varepsilon$$

	linear trend	Stochastic Component	External variables	Periodic components (cycles, long-periodical trends)	white-noise

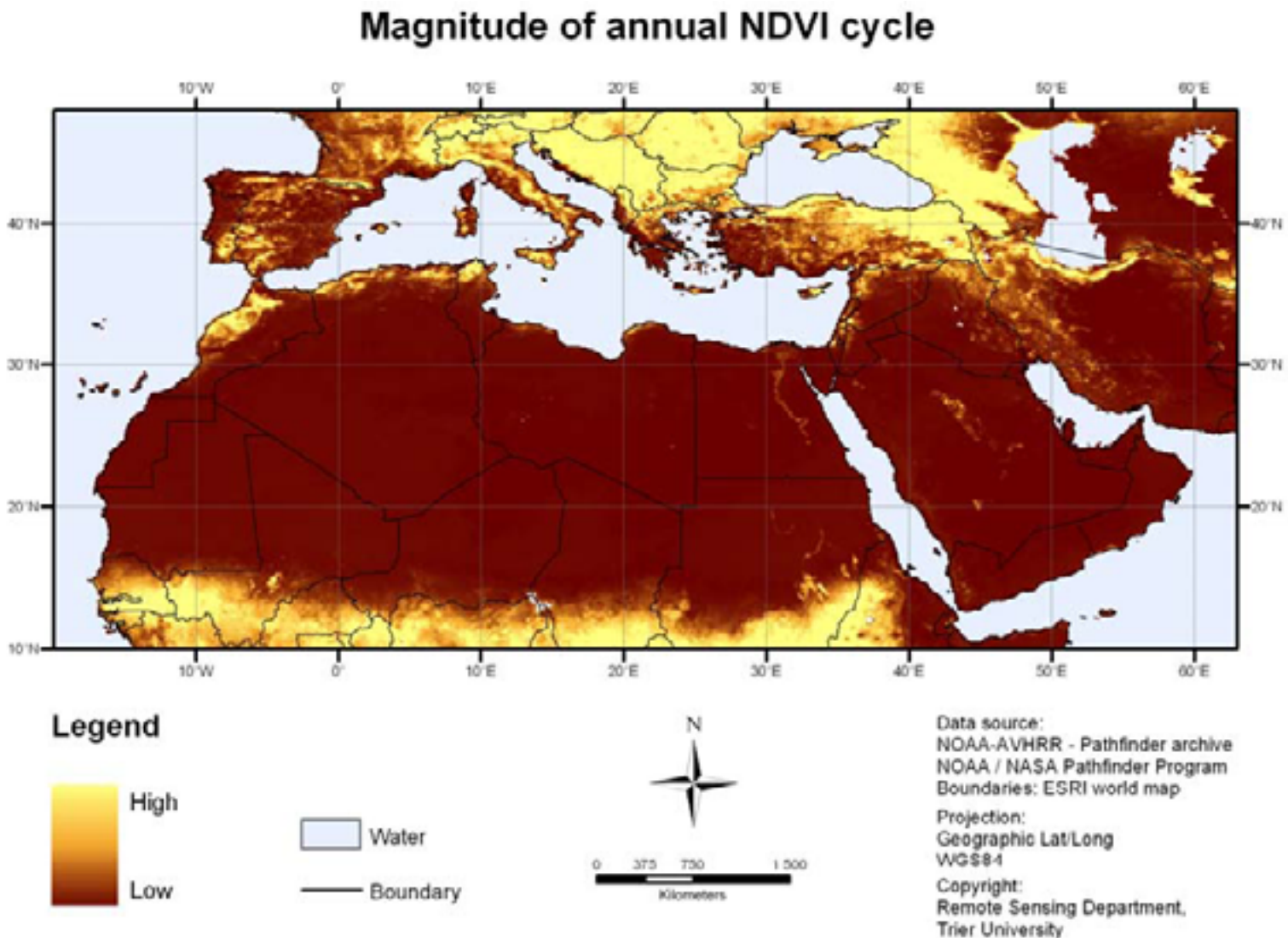
TIMESTAT


TimeStats 1.0
Input/output file options
Data cleaning
Data preprocessing
Seasonal components
Basic statistics and trends
Advanced regression analysis
ok
done

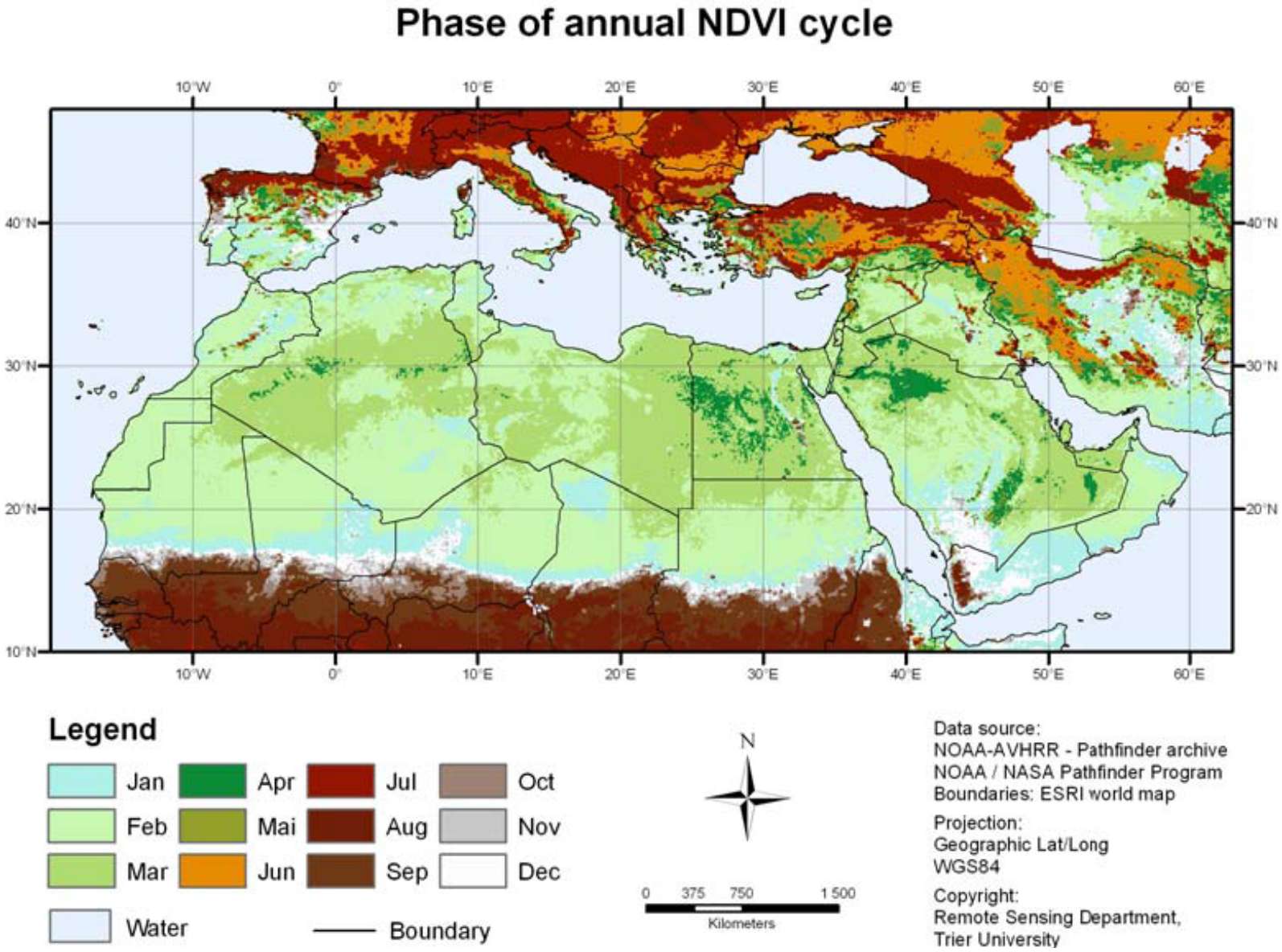

Seasonal Kendall-slope (1982-1999)
Legend
N
Data source:
NOAA-AVHRR - Pathfinder archive
NOAA / NASA Pathfinder Program
Boundaries: ESRI world map

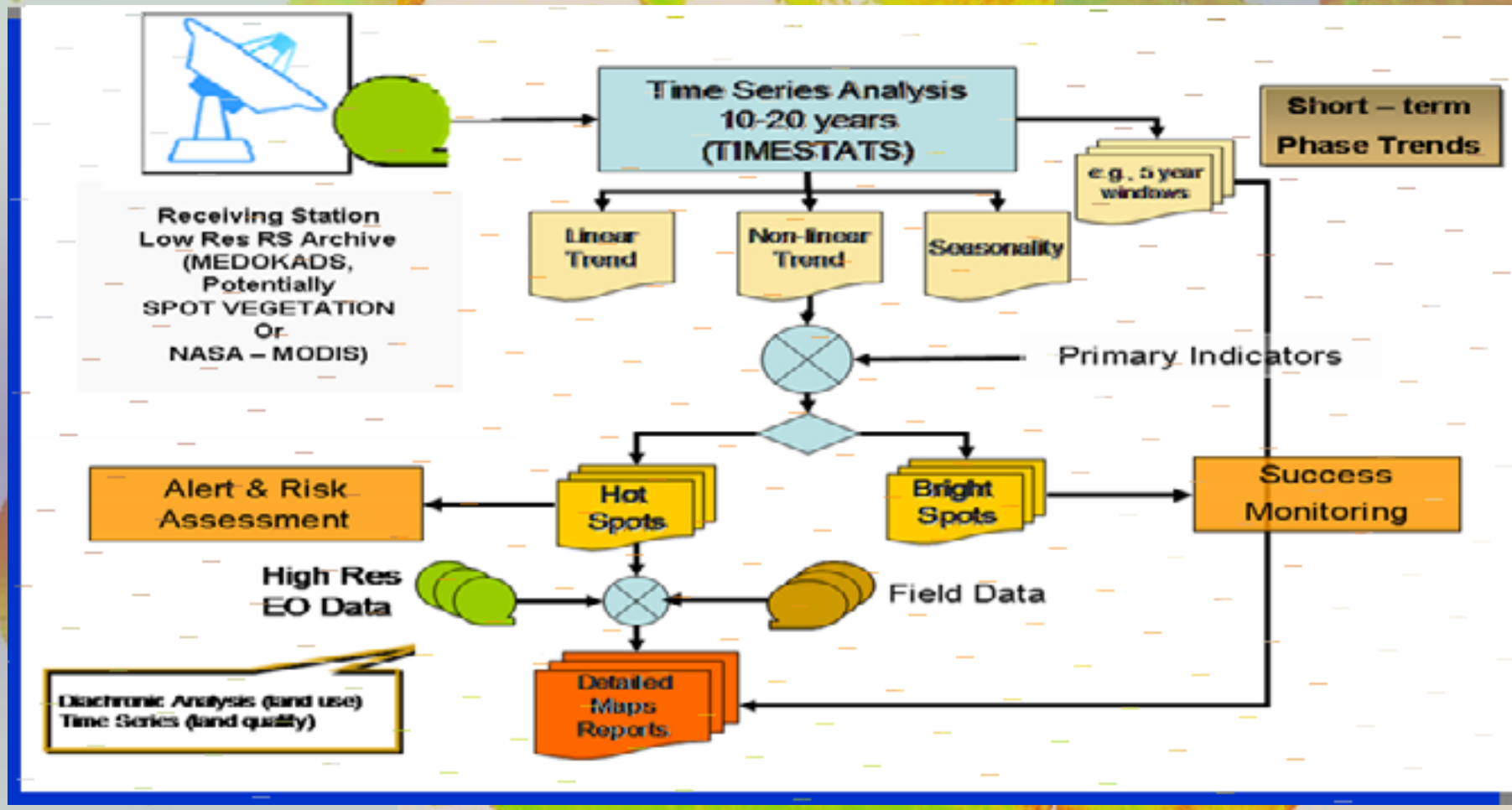

Significance of
Modified Seasonal Mann-Kendall test (1982-1999)
Legend
< 0.2%
> 0.2% - 1.0%
> 1.0% - 2.0%
> 2.0% - 5.0%
not significant
> 2.0% - 5.0%
> 1.0% - 2.0%
> 0.2% - 1.0%
< 0.2%
Water
Boundary
N
0 375 750 1 500
Data source:
NOAA-AVHRR - Pathfinder archive
NOAA / NASA Pathfinder Program
Boundaries: ESRI world map
Projection:
Geographic Lat/Long
WGS84
Copyright:
Remote Sensing Department,
Trier University

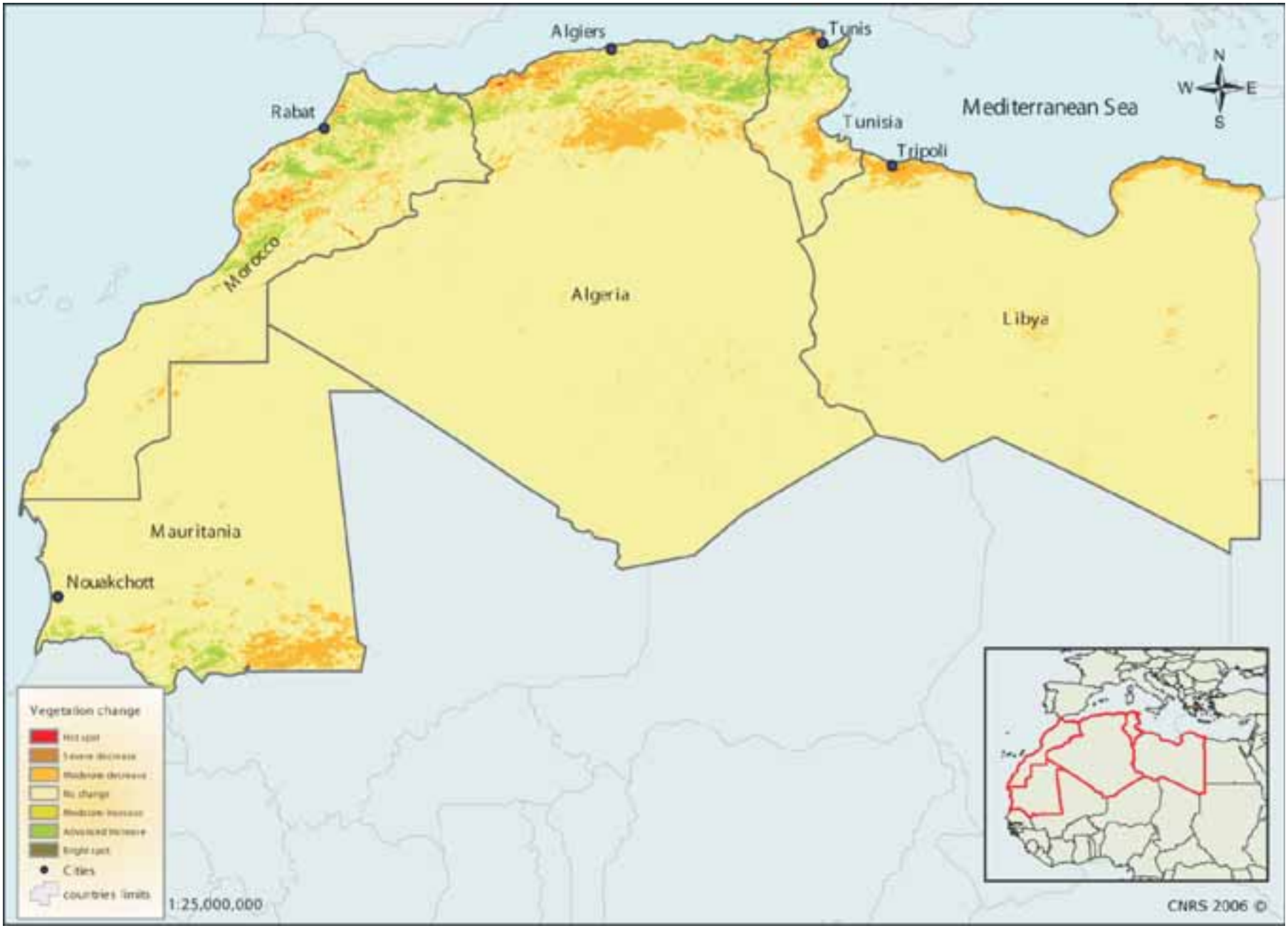
Models to address cyclic components



Models to address cyclic components




Receiving Station
Low Res RS Archive
(MEDOKADS,
Potentially
SPOT VEGETATION
Or
NASA – MODIS)
Time Series Analysis
10-20 years
(TIMESTATS)
Short – term
Phase Trends
e.g., 5 year
windows
Linear
Trend
Non-linear
Trend
Seasonality
Primary Indicators
Alert & Risk
Assessment
Hot
Spots
Bright
Spots
Success
Monitoring
High Res
EO Data
Field Data
Detailed
Maps
Reports
Diachronic Analysis (land use)
Time Series (land quality)


Algiers
Tunis
Rabat
Mediterranean Sea
N
W
E
S
Tunisia
Tripoli
Morocco
Algeria
Libya
Mauritania
Nouakchott
Vegetation change
Hot spot
Severe decrease
Moderate decrease
No change
Moderate increase
Advanced increase
Bright spot
Cities
countries limits
1:25,000,000
CNRS 2006 ©

Geomorphic regions	Countries	Area	total -f trend		total +f trend		Change	(+/-)
			Km²	%	Km²	%		
Arab Maghreb	Mauritania	1030700	610590	59.24	101634.7	9.86	-508965	(-)
	Morocco	446550	337984	44.78	64832	8.59	-273152	(-)
	Algeria	2381740	914525	38.40	39162	1.64	-875363	(-)
	Tunisia	163610	38044	23.25	19928	12.18	-18116	(-)
	Libya	1759540	579819	32.95	4308	0.24	-575511	(-)
Central Region	Egypt	1001450	445923	44.53	8097	0.81	-437826	(-)
	Sudan	2505810	842112	33.34	929600	36.81	87488	(+)
	Djibouti	23000	2267	9.86	3733	16.23	1467	(+)
	Somalia	637657	45306	7.11	132575	20.79	87269	(+)
Arab Mashreq	Jordan	92300	67671	73.32	523	0.57	-67148	(-)
	Lebanon	10400	2907	27.95	2963	28.49	56	(+)
	Syria	185180	64538	34.85	45254	24.44	-19284	(-)
	Iraq	437072	97212	22.24	89203	20.41	-8010	(-)
Arabian Peninsula	Kuwait	17820	796	4.47	2756	15.46	1960	(+)
	Saudi	1960582	309290	15.78	79229	4.04	-230061	(-)
	Bahrain	665	1	0.18	1	0.18	0	(+)
	Qatar	11437	257	2.25	386	3.37	129	(+)
	Emirates	82880	4730	5.71	9529	11.5	4799	(+)
	Oman	212460	2548	1.2	7310	3.44	4762	(+)
	Yemen	527970	80599	15.27	51119	9.68	-2948	(-)

Table 4: Distribution of positive and negative changes in the Arab countries during the period extending from 1982 to 2003

ACSAD

DESERTIFICATION Bulletin

Desertification Monitoring and Assessment In the Arab World

Using satellite imageries between 1982 and 2005

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Spot Vegetation 2005

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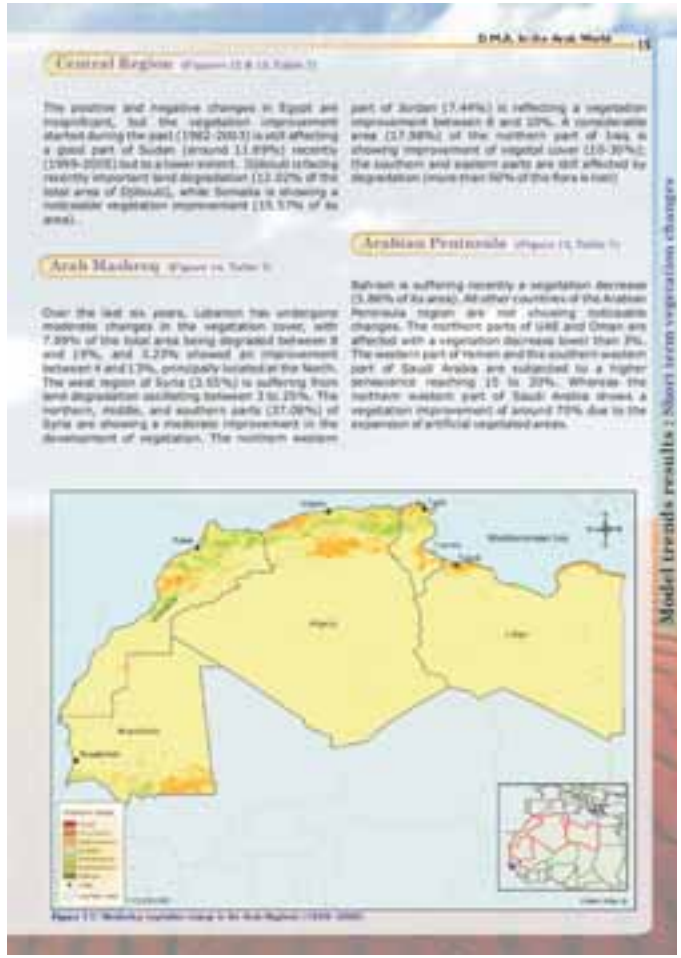
ACSAD desertification monitoring and assessment role was supported by a partnership started in 2003 with the German Technical Cooperation (GTZ) in order to establish a Regional Early Warning system (REWs) and a Desertification Monitoring and Assessment Network (ADMAnet), and standardize and harmonize ADMAnet member's in applying advanced techniques, and recent approaches related to DMA. This cooperation provided exploration and development of joint research activities, connected with desertification and exchange of knowledge and materials in the fields of contemporary issues on desertification aiming at supporting the establishment of a regional desertification monitoring system at the current stage and a national one at later stage. The effective Monitoring and Assessment of Desertification (DMA) should integrate spatio-temporal vegetation changes of Arab Countries, detect their degradation status and identify the involved land degradation/desertification processes and their severity. It can be served very effectively with the use of remote sensing (RS) techniques. Their major benefit is related to their convenient cost, their time saving and their observation of remotely large areas on a regular basis. In the context of defining strategies for combating desertification in Arab countries, this work has been held in collaboration between ACSAD and GTZ asking for the determination of the trend line in terrestrial vegetation change in these countries depending on long term satellite data between the period extending from 1982 and 2005. This bulletin illustrates explicitly the different phases of the work achieved and highlights the positive or negative national changes in the different parts of the Arab world during the mentioned period.



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