


Use of GIS and Remote Sensing to assess Soil Erosion in Arid to Semiarid Basin in Jordan

Ibrahim Farhan and Jawad Al-Bakri

Dept. Land, Water & Env.

Faculty of Agriculture,

University of Jordan, Amman, Jordan

friend water

14-18.11.2012

Istanbul, Turkey/Turquie

International Conference
Sediment Transport Modeling in Hydrological Watersheds and Rivers

Conférence Internationale
Modélisation du transport de sédiments dans les bassins-versants et dans les rivières

Main Contents

1- Introduction

2- Approach

3- Main Findings

4- Conclusions

1. Introduction

- Soil erosion is one of the major land degradation processes in arid and semiarid areas.
- Erosion is triggered by a combination of factors such as steep slopes, climate , inappropriate land use patterns.
- The continuous process of soil erosion at rates higher than soil formation will lead to desertification.

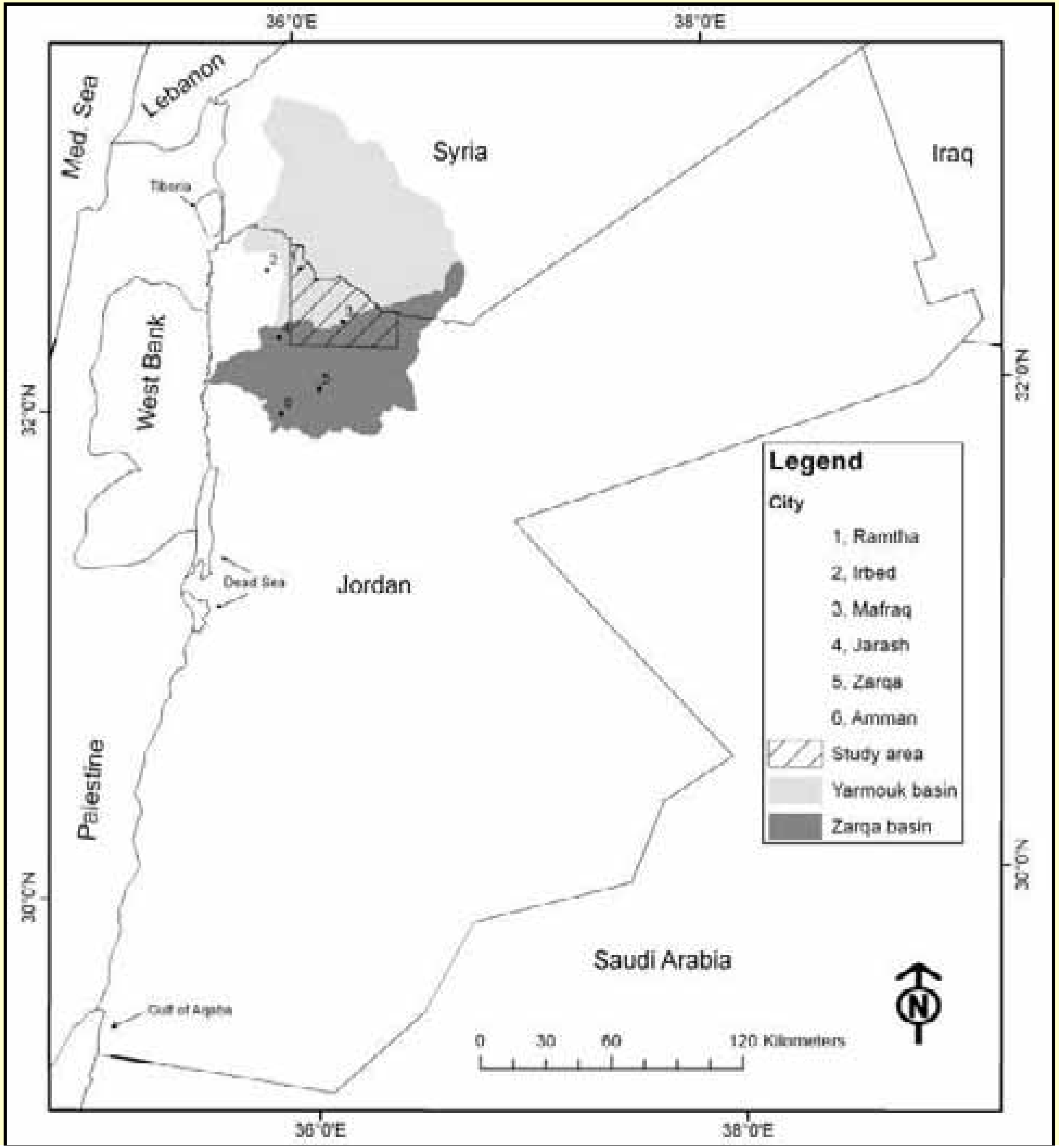
Erosion and desertification

Mapping of erosion by water and wind is needed for assessing potential risks of desertification

Objectives of the study

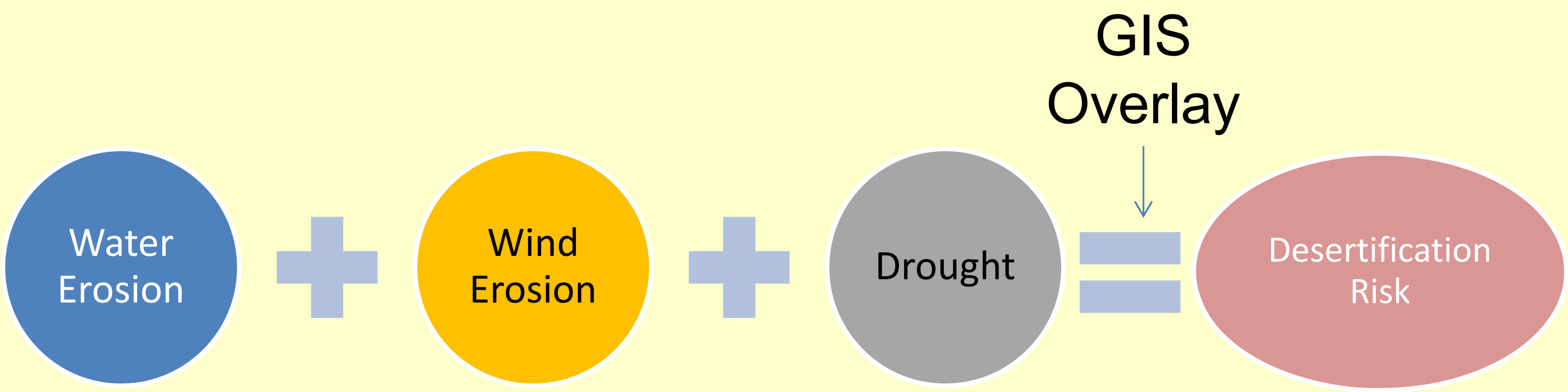
- The study is part of a research initiative to map desertification risk in Jordan, after testing and parameterizing the models of soil erosion by water and wind. The study also integrates soil erosion with maps of droughts to generate maps of desertification risk.
- To study temporal changes in soil erosion using remote sensing data.

Study Area



36°0'E
38°0'E
Med. Sea
Lebanon
Syria
Iraq
Tiberia
West Bank
32°0'N
Dead Sea
Jordan
Palestine
30°0'N
Saudi Arabia
Gulf of Aqaba
Legend
City
1. Ramtha
2. Irbed
3. Mafraq
4. Jarash
5. Zarqa
6. Amman
Study area
Yarmouk basin
Zarqa basin
0 30 60 120 Kilometers
N

2. Approach

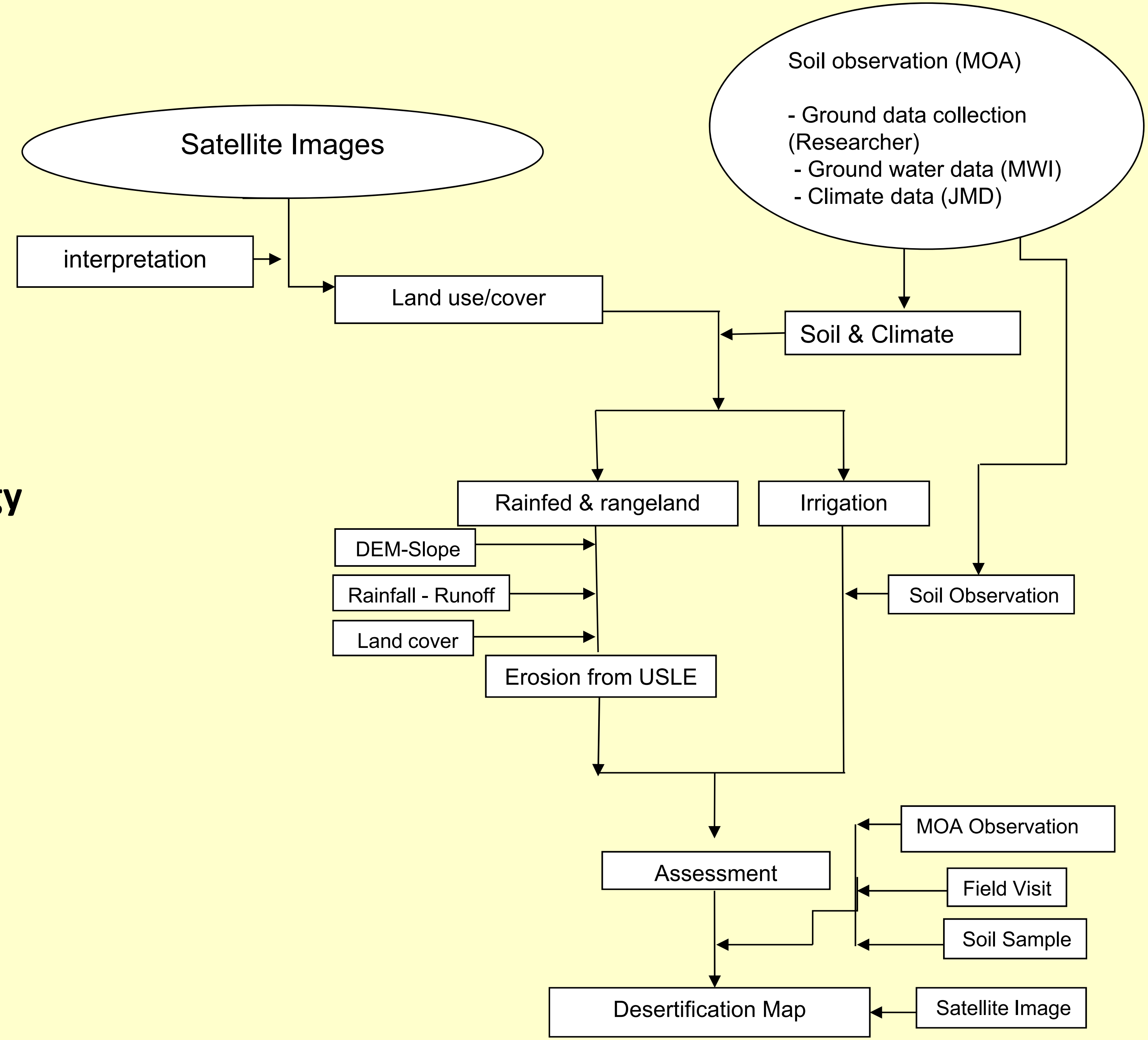


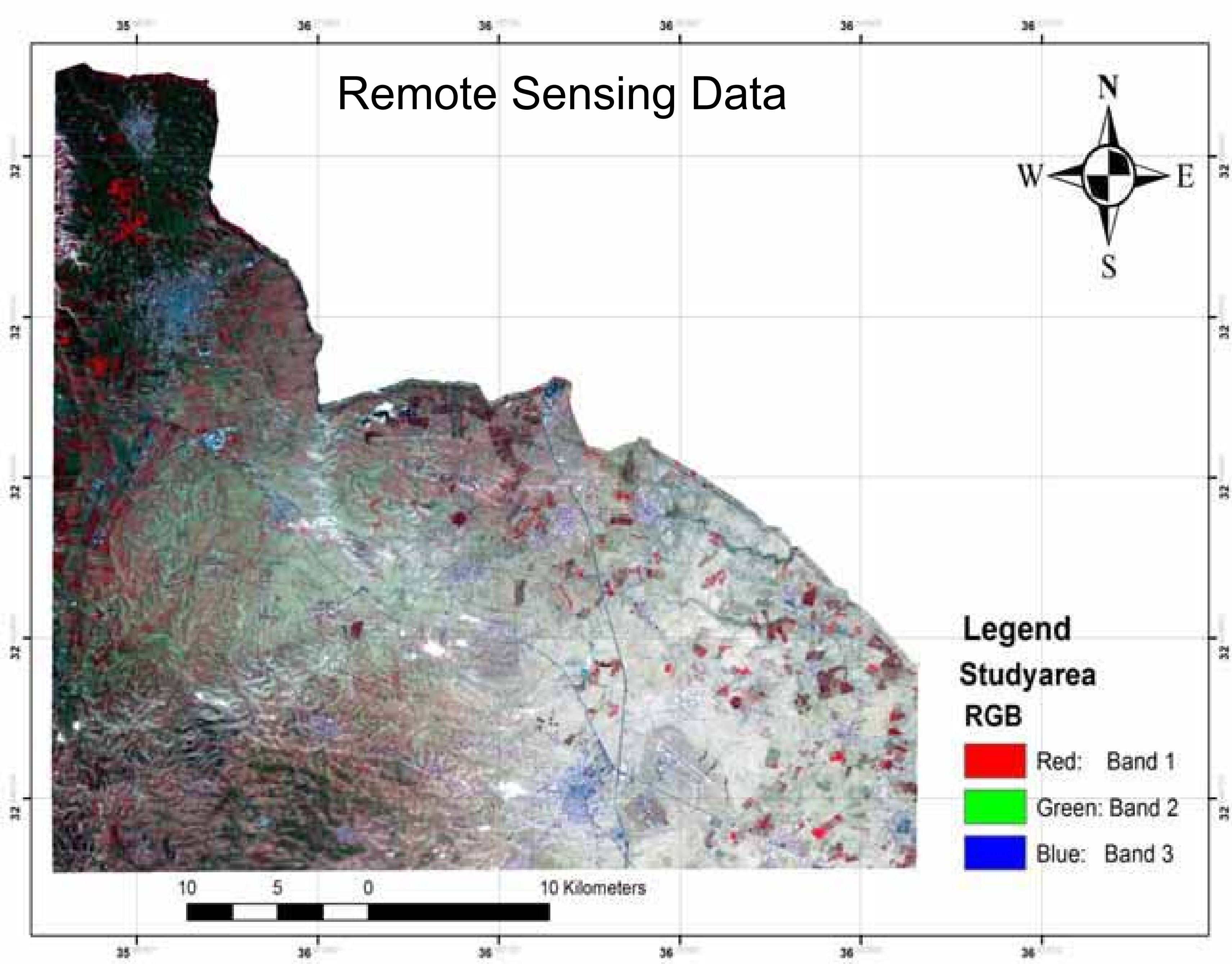
<u>USLE</u>
1- RS data.
2- Ground surveys.
3- Met. Records.

<u>DUST_EM</u>
1- GIS maps.
2- Met. Records.
3- Ground surveys

<u>EWSI</u>
Evapotranspiration Water Stress Index (1-ET/PET) using ALARM model.
1- MODIS RS data.
2- Weather Data.

USLE Methodology

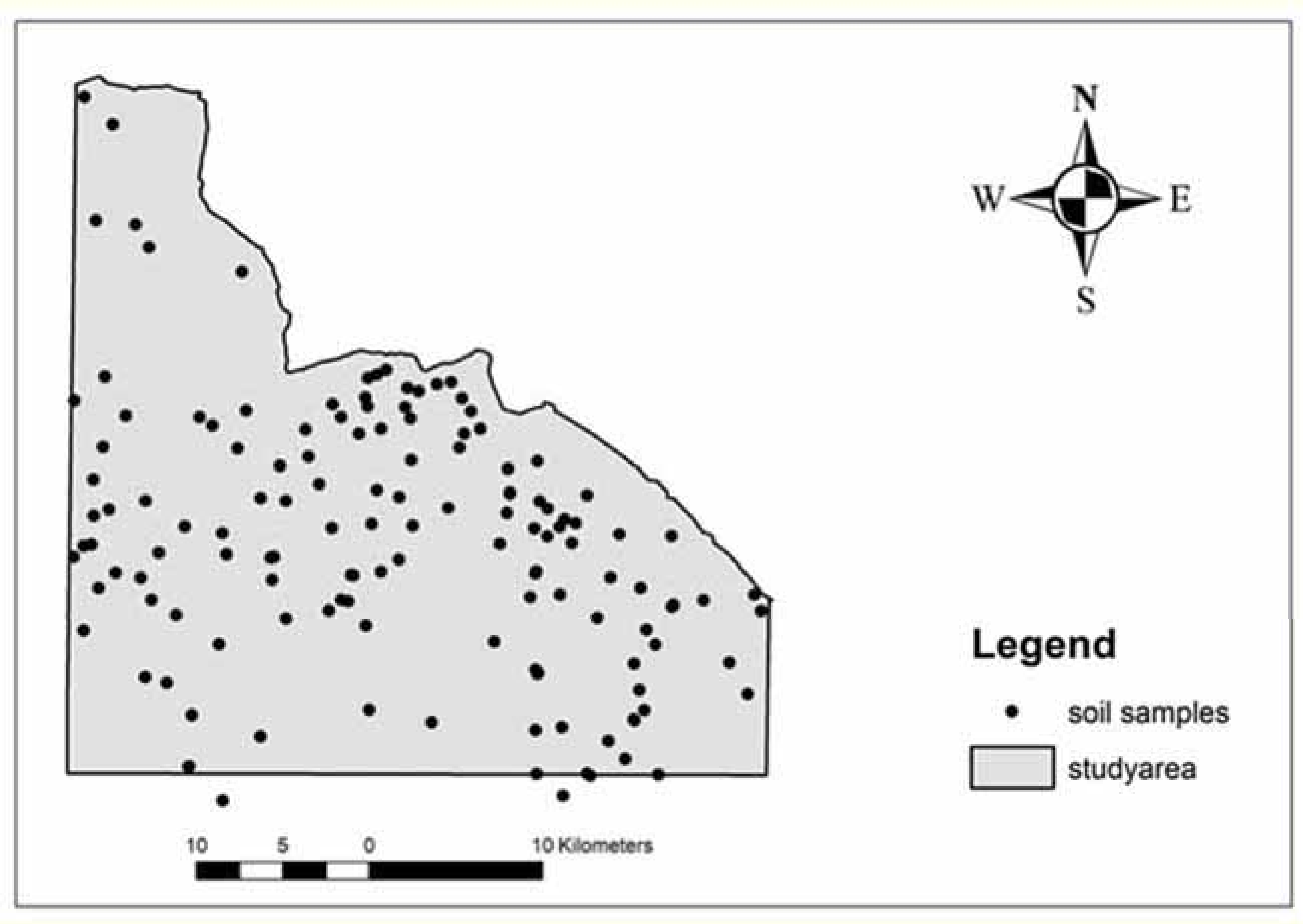



Remote Sensing Data
N
W
E
S
Legend
Studyarea
RGB
Red: Band 1
Green: Band 2
Blue: Band 3
10
5
0
10 Kilometers

Collection of ground data of spectral reflectance

Soil surface spectral reflectance was measured by a multispectral radiometer (CROPSCAN MSR16R) to correct images and to modify C-Factor.

A total number of 134 soil samples were collected and analyzed.



Modeling of soil erosion by water

The USLE equation was used to calculate

$$\mathbf{A=R\times K\times L\times S\times C\times P}$$

Where;

A: is the computed soil loss per unit area (ton/ha.yr).

R: the rainfall and runoff erosivity factor.

K: the soil erodibility factor.

L: the slope length,.

S: the slope steepness factor.

C: the cover and management factor.

P: the support practice factor.

Deriving GIS layers for USLE Model

- **Rainfall- Runoff Erosivity Factor (R)**
- The equation ($\mathbf{R = 29.12 \times e^{0.0049P}}$) was applied on the data of four weather stations in the study areas as shown in table below.

Station	Average Annual Precipitations (P) mm	R Factor (MJ mm ha^{-1} h^{-1} $year^{-1}$)
Midwar	**248**	**98.0**
Ramtha school	**241**	**94.8**
Sabha and subhiyeh	**112**	**50.4**
Um Al-jimal	**104**	**48.4**

- Soil Erodibility Factor (K)

The K factor was computed using the following equation :

$$\mathbf{K} = (27.66 \times \mathbf{m}^{1.14} \times 10^{-8} \times (12-\mathbf{a})) + (0.0043 \times (\mathbf{b}-2)) + (0.0033 \times (\mathbf{c}-3))$$

Where;

K = soil erodibility factor

m = (silt (%) + sand (%)) (100-clay (%))

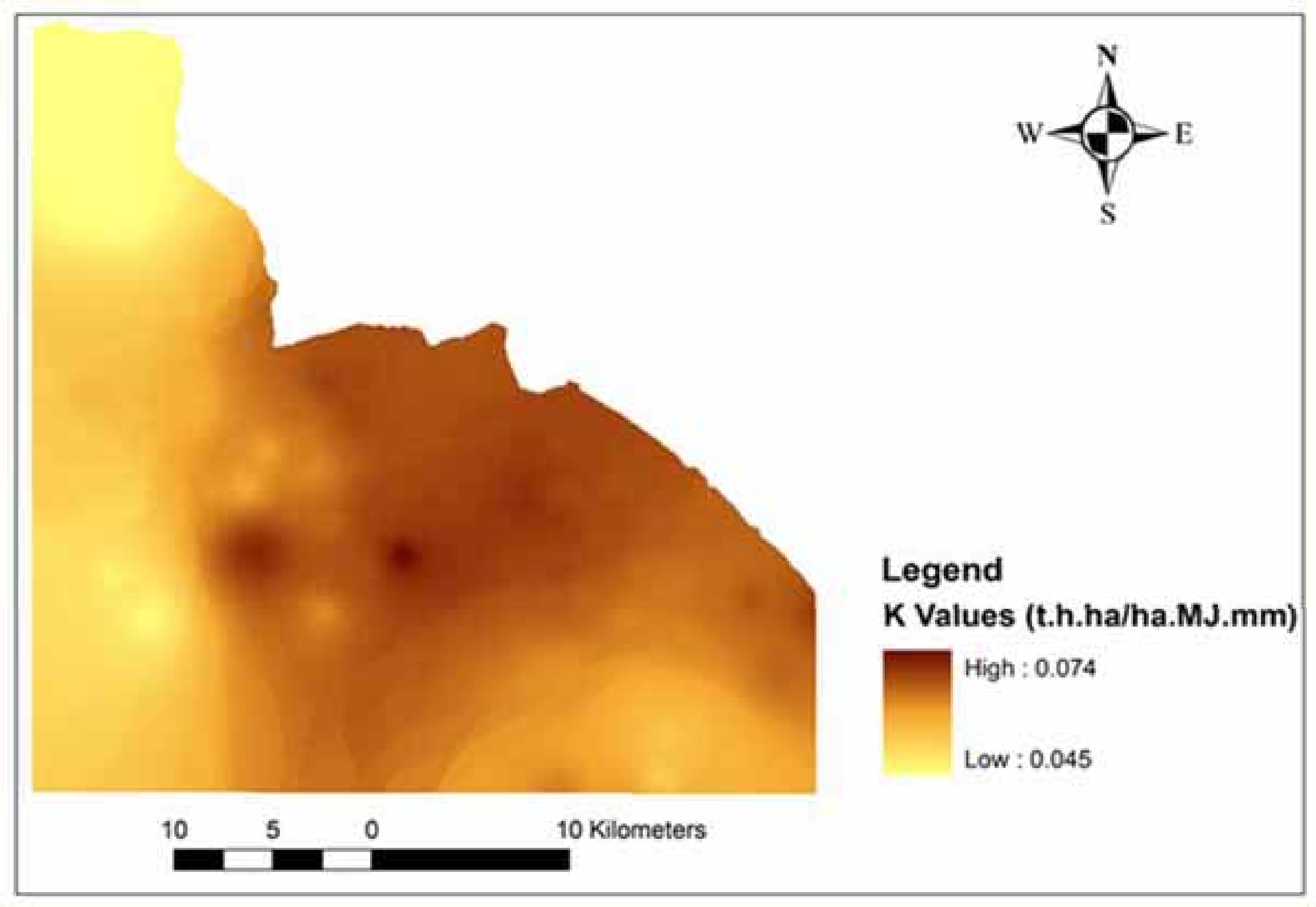
a = organic matter (%)

b = structure type

c = profile permeability code;

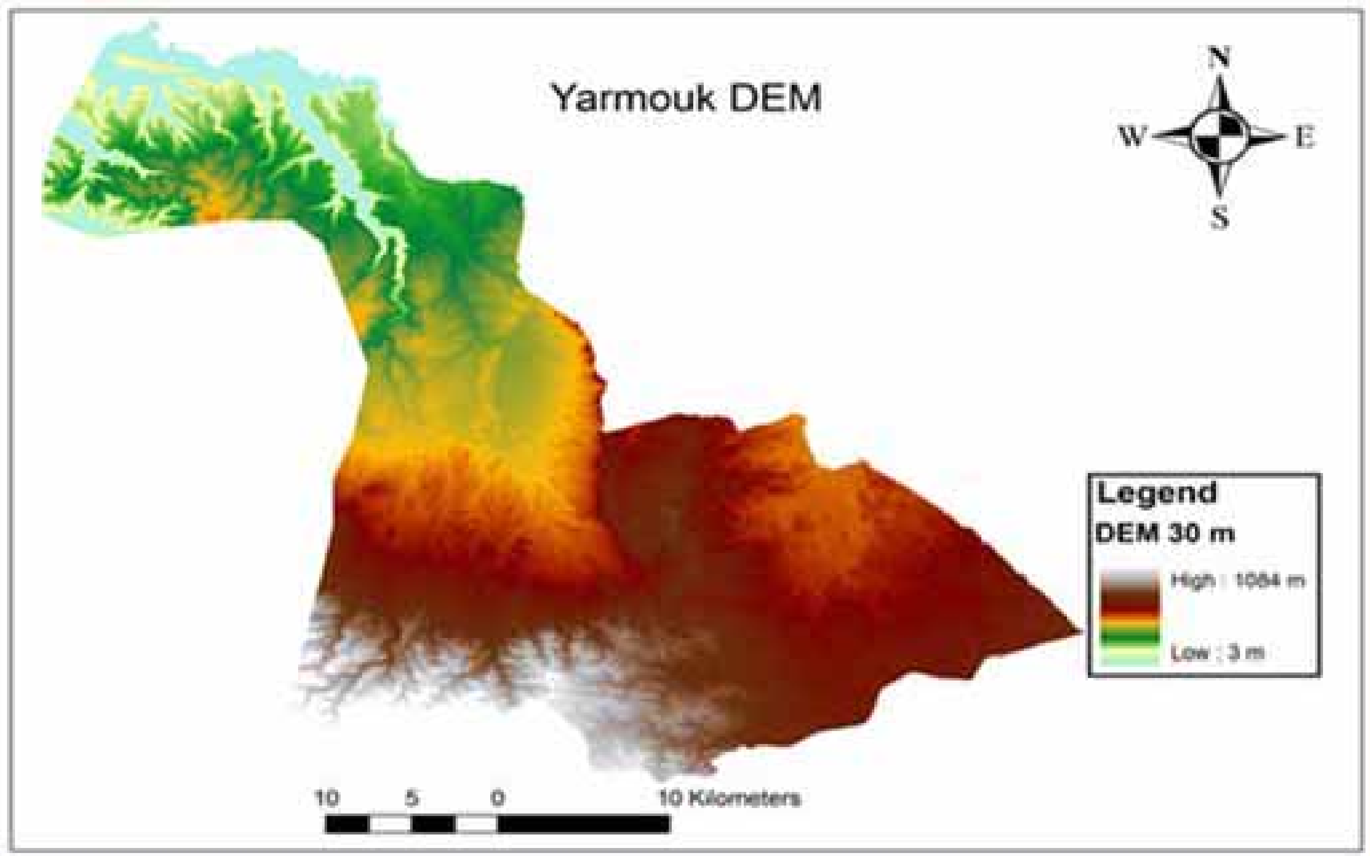
1- rapid, 2- moderate to rapid, 3- moderate, 4- moderate to slow, 5- slow, 6- very slow

Map of K factor



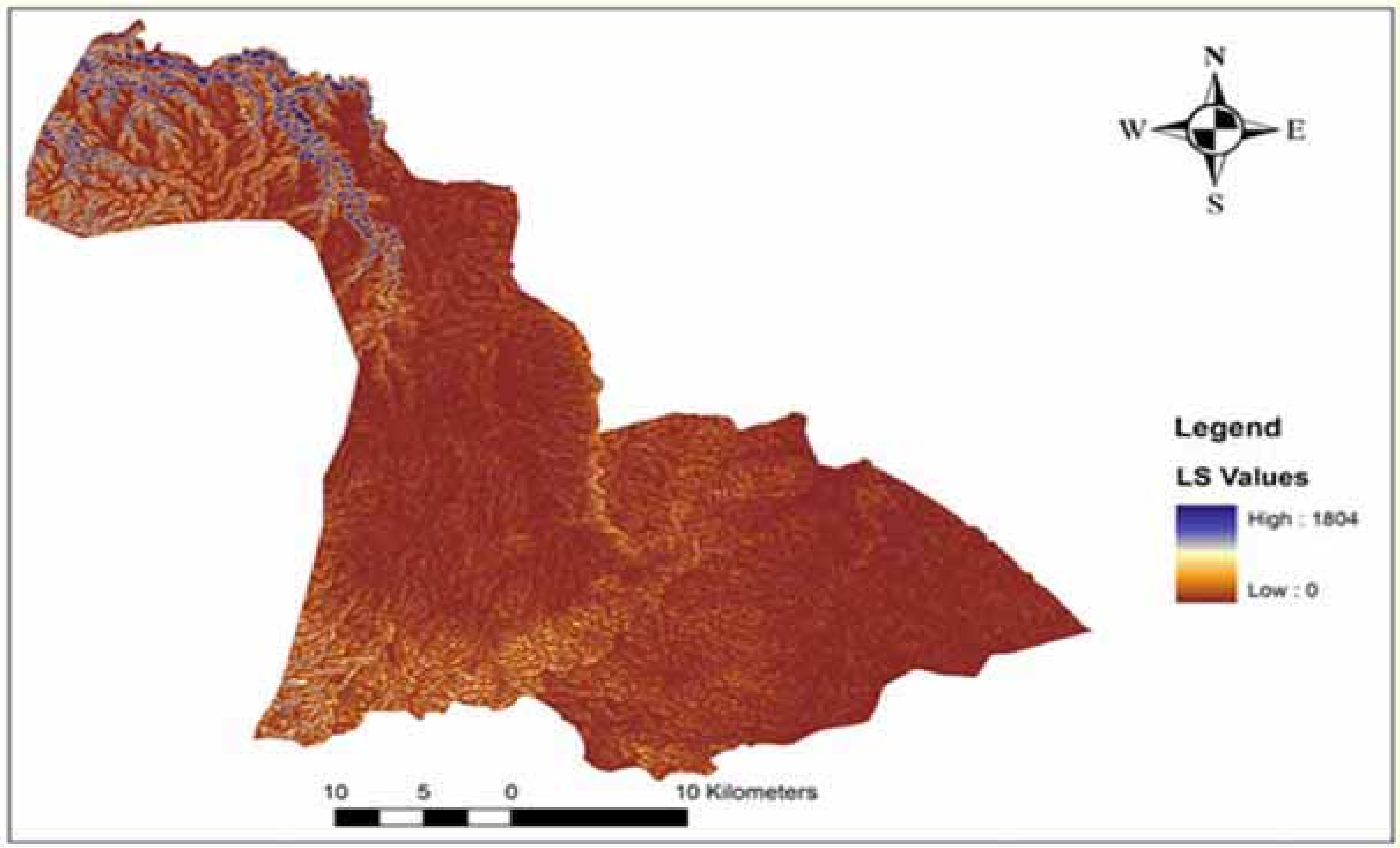
- Slope length and Steepness Factor (LS)

The LS were derived from the Digital Elevation Model (DEM) with a resolution of 30 m (Downloaded from ASTER website)



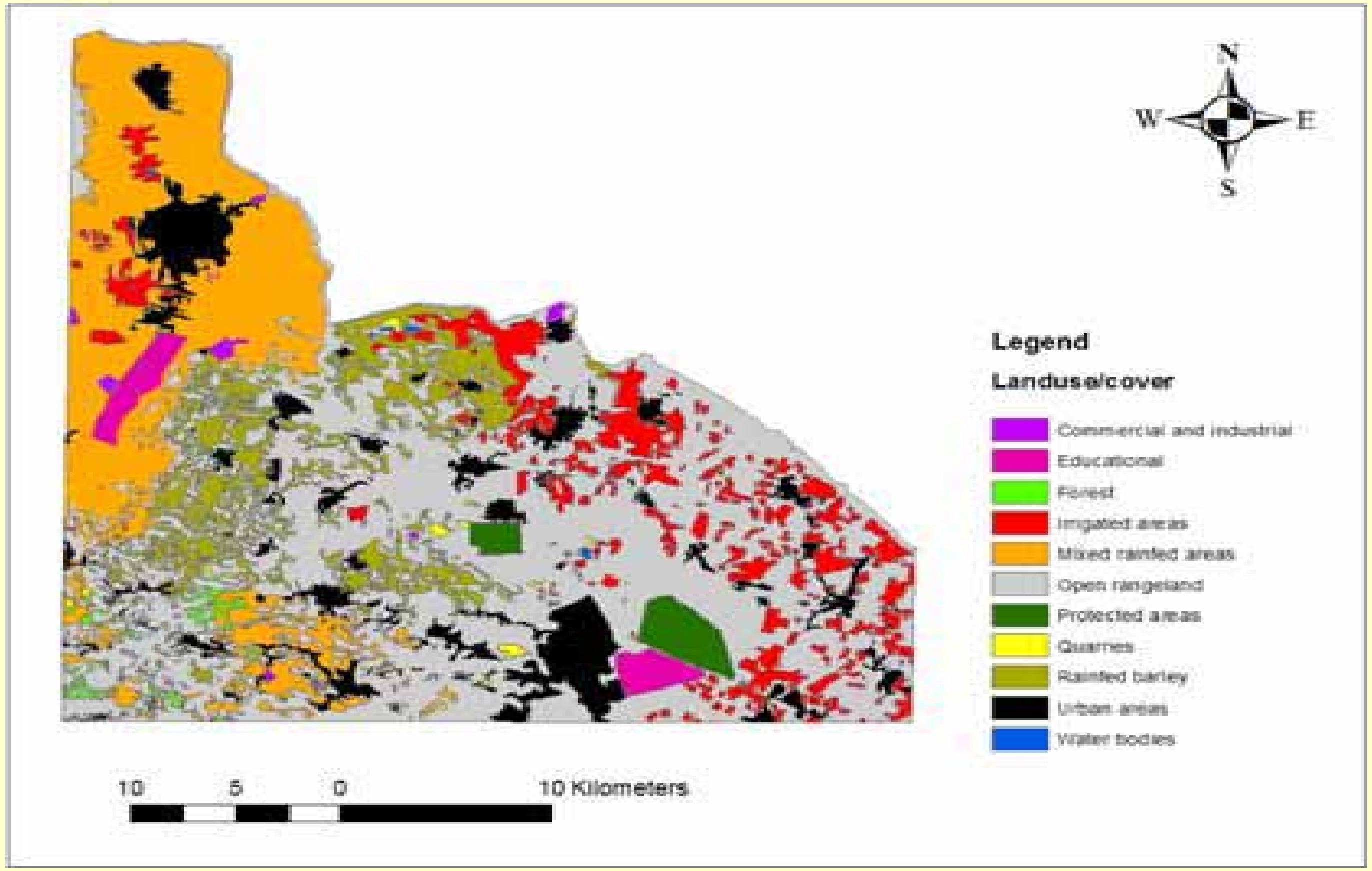
- Slope length and Steepness Factor (LS)

The LS were derived from the Digital Elevation Model (DEM) with a resolution of 30 m (Downloaded from ASTER website)



C –Factor

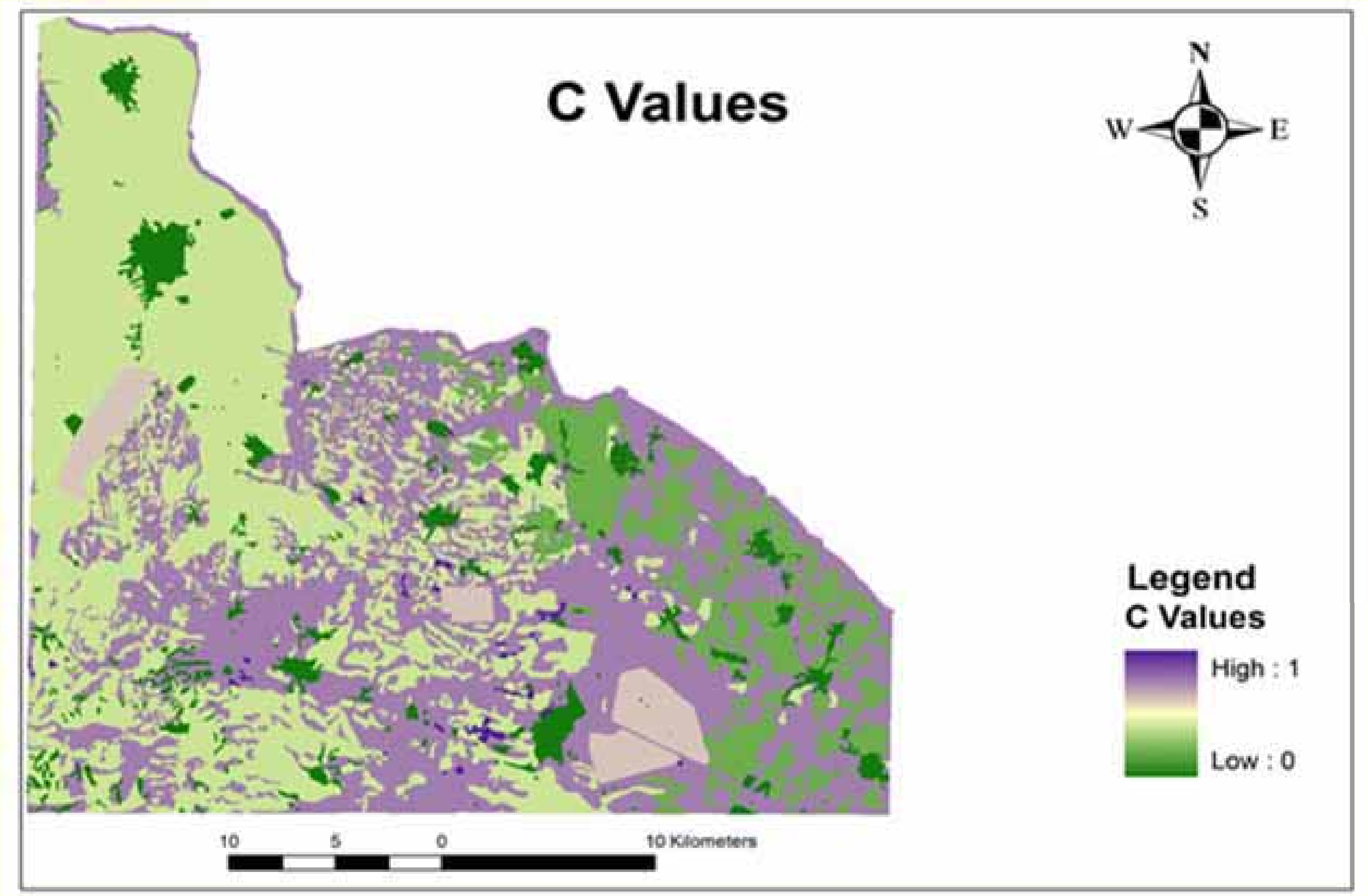
- Derived from the Land use/cover map of the study area.
- The map was derived by visual interpretation and verified during ground surveys.



Summary of C-Values for the different Land use/cover classes

Code	Class	C Value
1	Open rangeland	0.60
2	Mixed rainfed areas	0.35
3	Protected areas	0.50
4	Irrigated areas	0.22
5	Residential areas	0.01
6	Educational	0.50
7	Commercial and industrial	0.01
8	Forest	0.05
9	Quarries	1.00
10	Water bodies	0.00

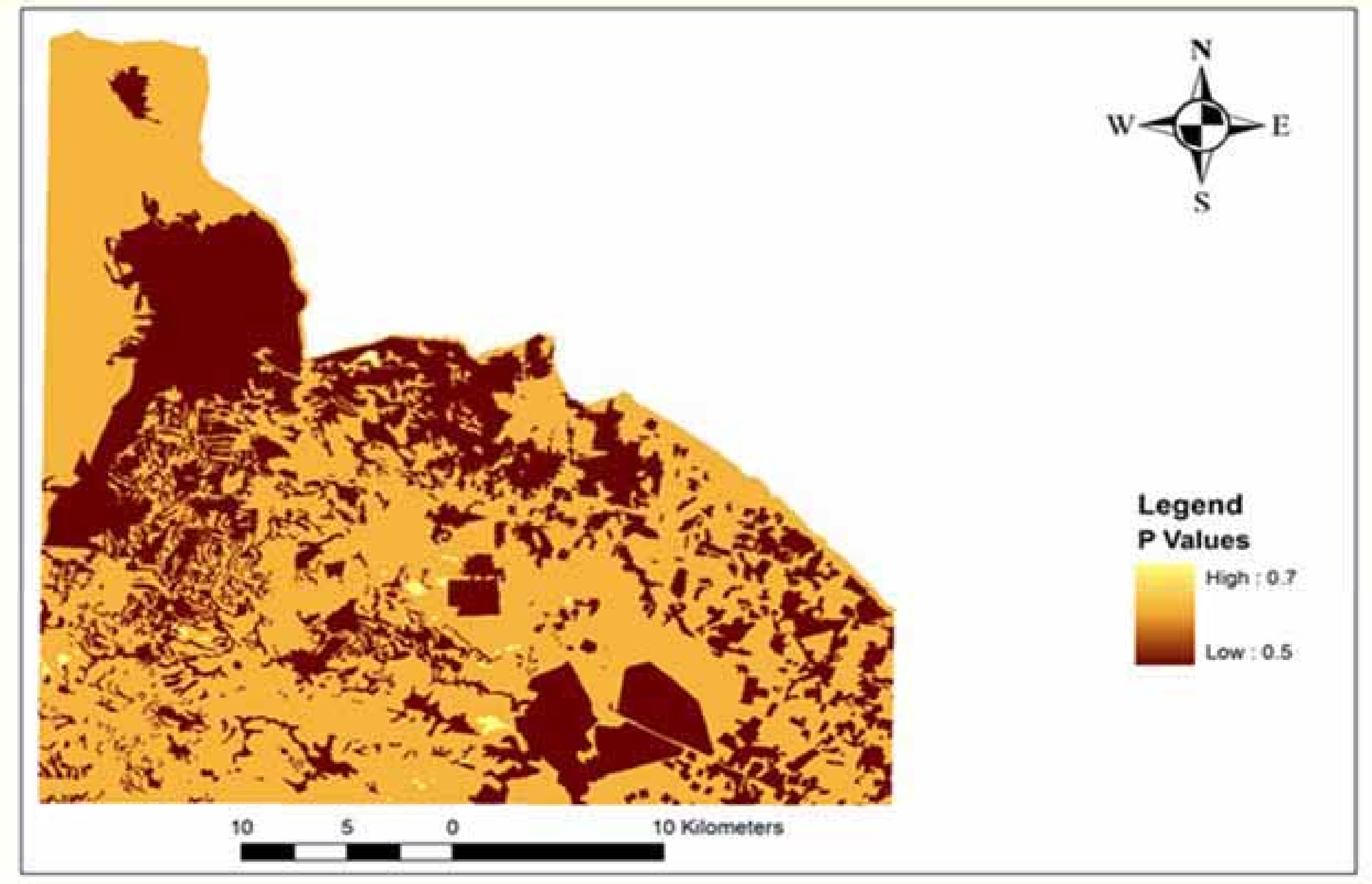
Map of C-Factor



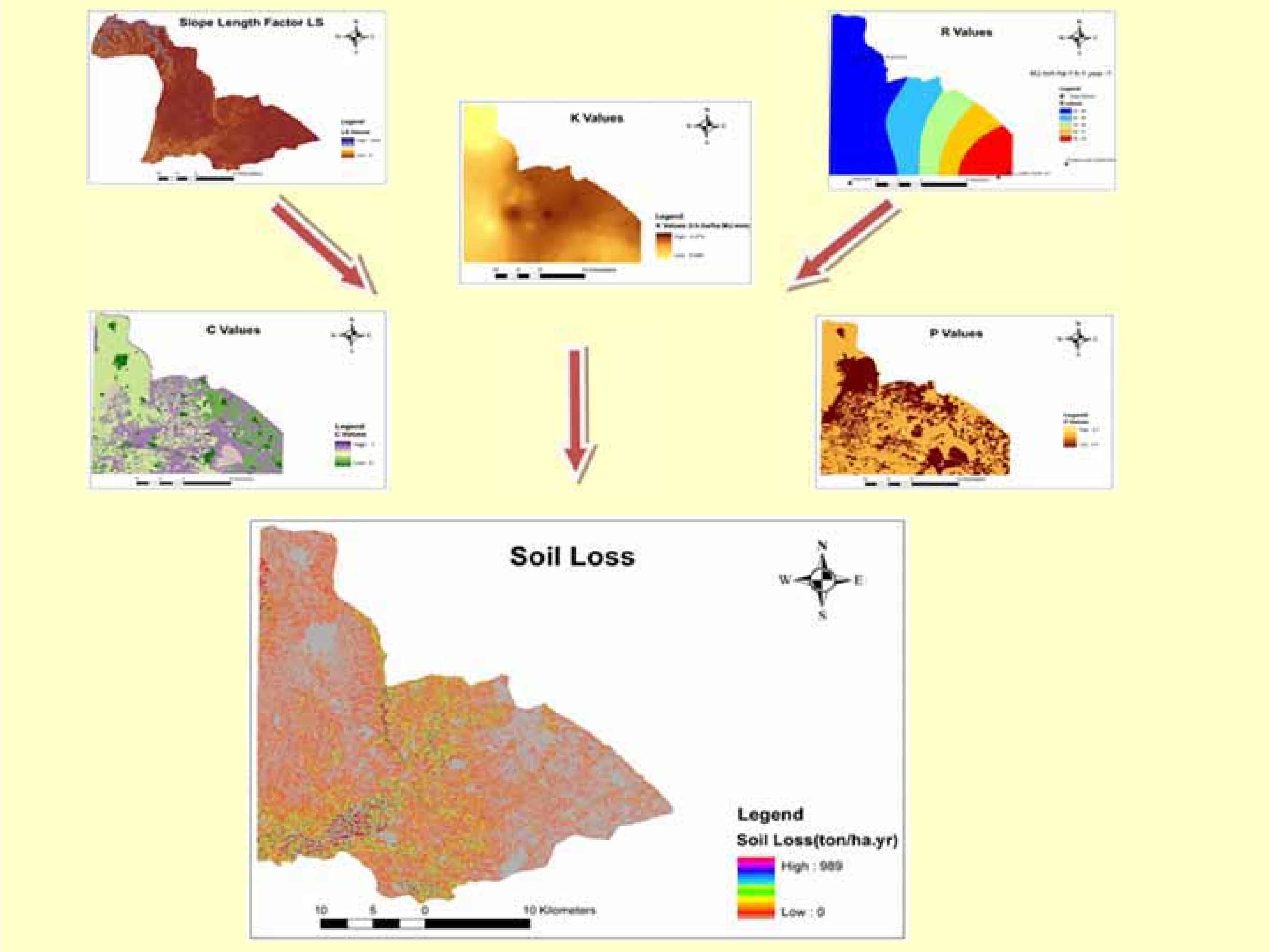
P-Values

Slope %	Residue Cover Less Than 50%	Residue Cover Greater Than 50%	P Value
	Maximum Slope Length Feet		
1-2	400	500	0.6
3-5	300	375	0.5
6-8	200	250	0.5
9-12	120	150	0.6
13-16	100	125	0.7
17-20	100	125	0.8
21-25	90	100	0.9

- P-Map



Application of USLE model

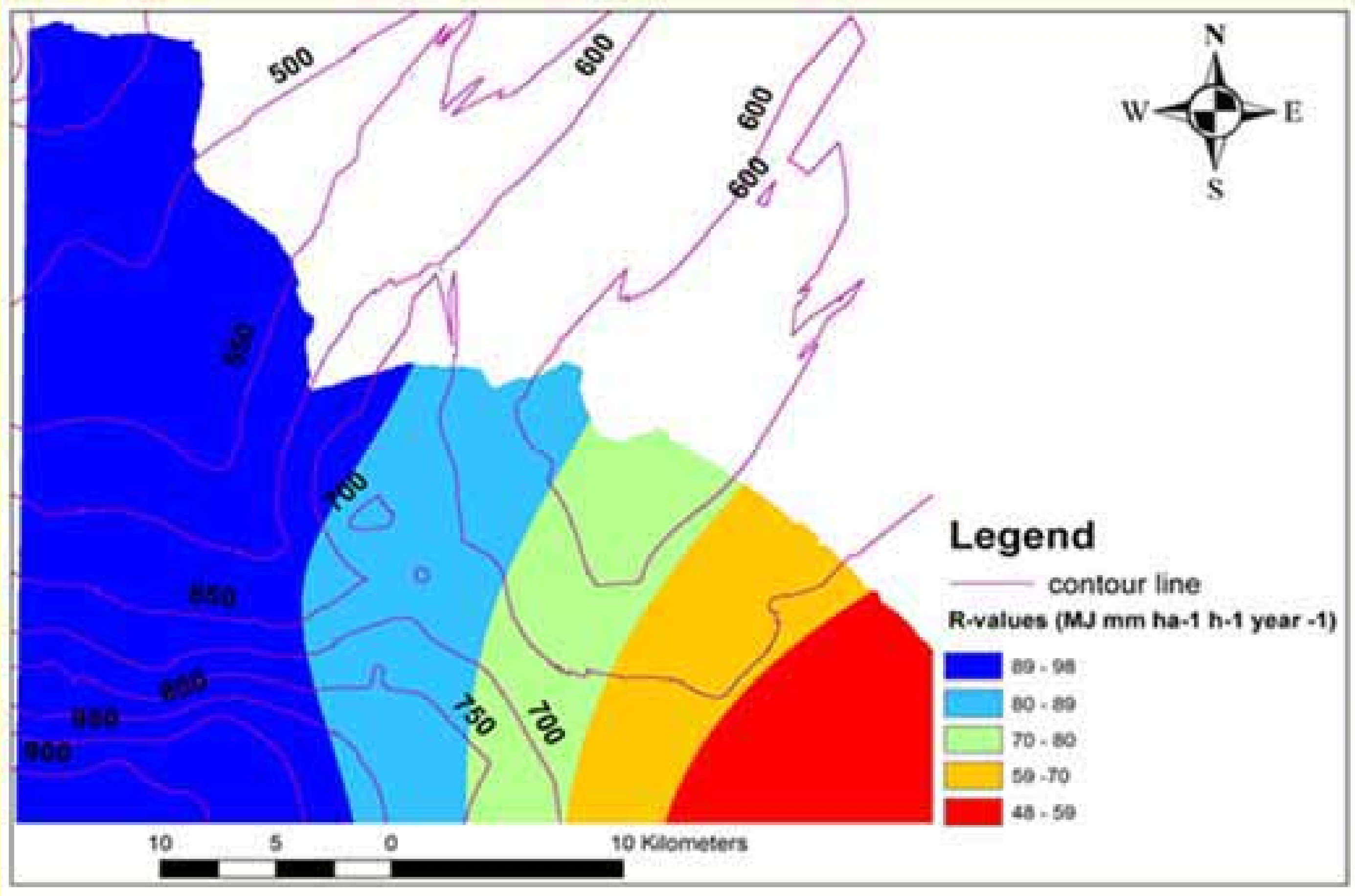

Slope Length Factor LS
K Values
R Values
C Values
P Values
Soil Loss
N
W
E
S
Legend
Soil Loss(ton/ha.yr)
High : 989
Low : 0
10
5
0
10 Kilometers

Main Findings

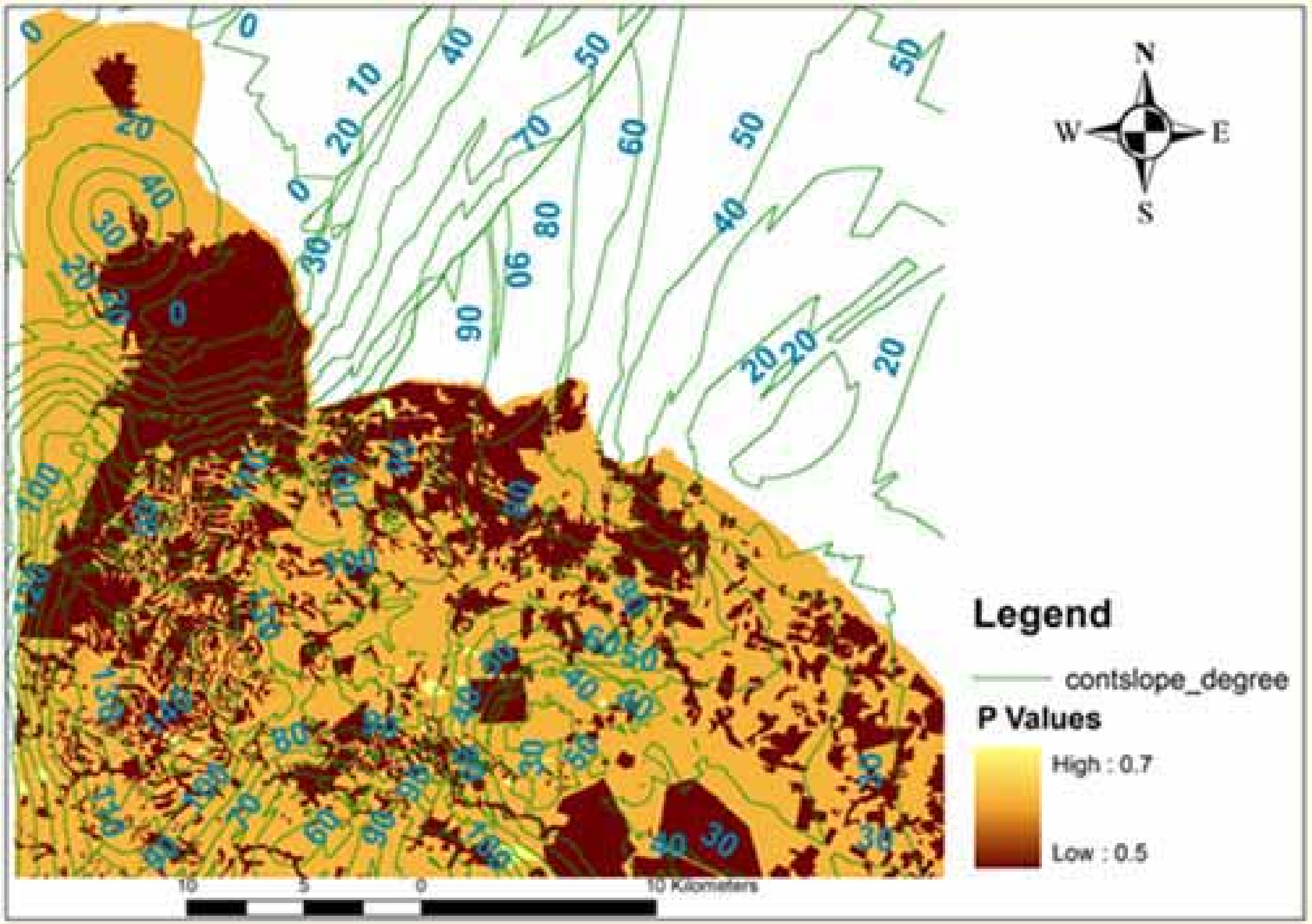
-Mapping the risk of soil erosion by water

- Rainfall and Runoff Erosivity Factor

The R values were calculated from rainfall records for the monthly averages for the period (1990-2010).

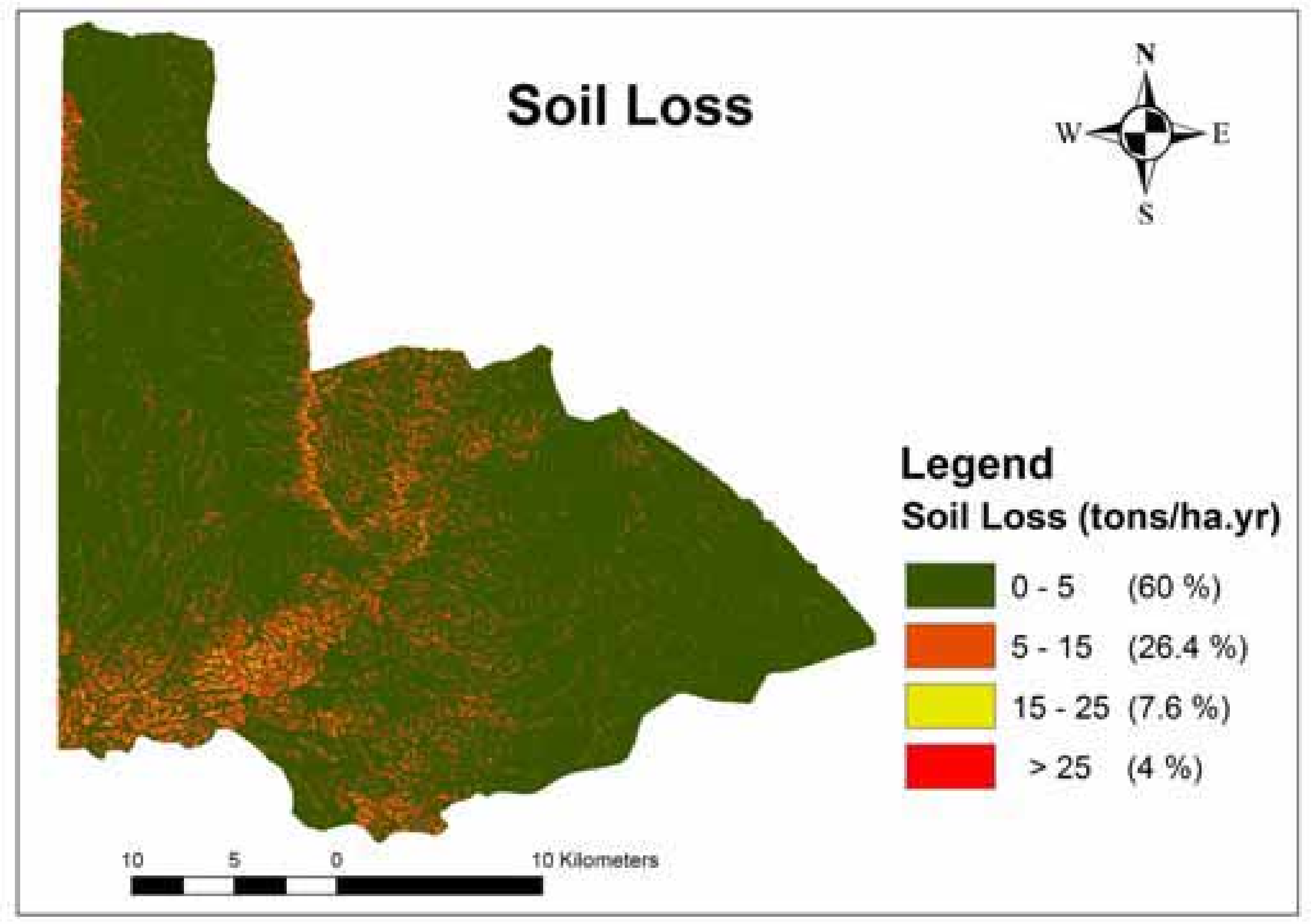


- Support Practice Factor (P): variations as related to land use.



- Modeling of soil erosion by USLE

-All factors represented by layers of R, LS, K, P, and C, computed and spatialized previously by the use of GIS functions, were combined together to obtain a map of soil loss rate.



Comparison with studies from literature

Case study	The main factor controlling soil loss	Min-Max (ton/ha/yr)
Vietnam	Rainfall and Runoff Erosivity Factor	**100 - 1500**
lower Himalayas, India	Rainfall and Runoff Erosivity Factor	**1 - 61**
Tunisia	No single factor	**2.5 - 10**
Mangilao	Rainfall and Slope length and slope steepens factor	**6.1- 2892**
South Korea	Rainfall and Runoff Erosivity Factor	**1 - 760**

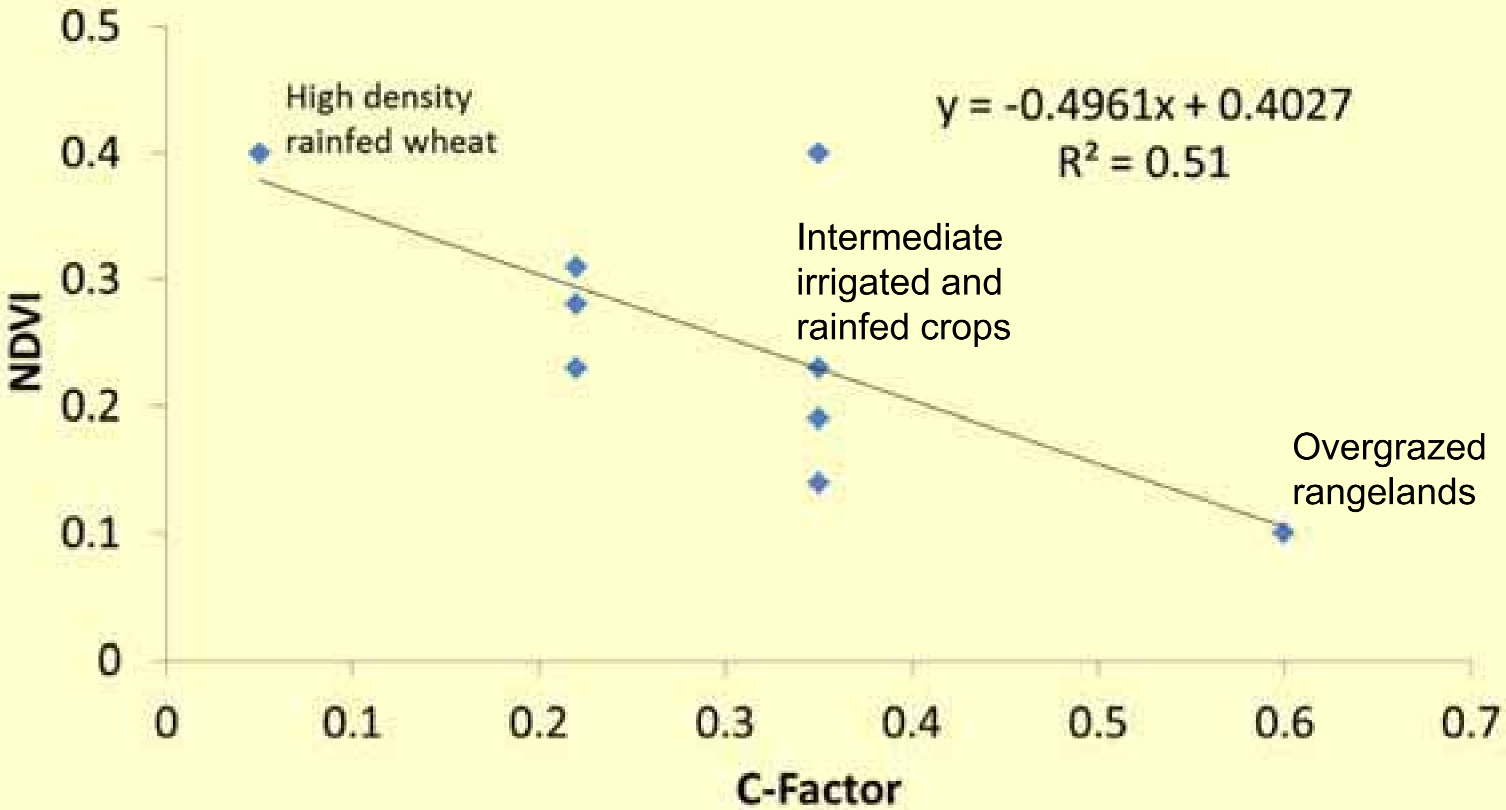
Possibility to derive C-Factor directly from Remote Sensing data

- The use of simple vegetation indices to derive the C-factor enables the us to assess historical changes in soil erosion.
- The most commonly used and archived index at different scale is the NDVI

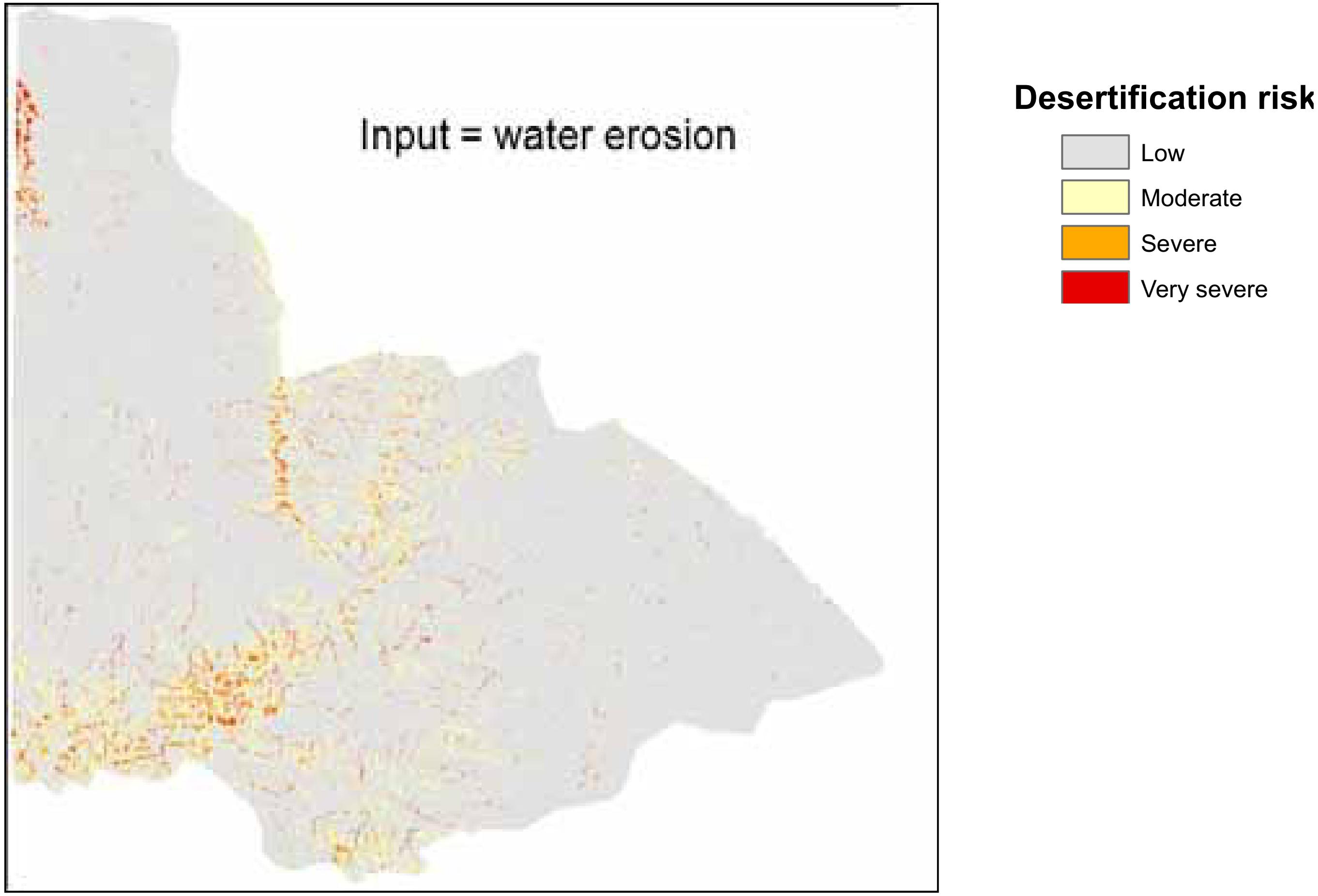
Normalized Difference Vegetation Index (NDVI) =

$$\frac{NIR - R}{NIR + R}$$

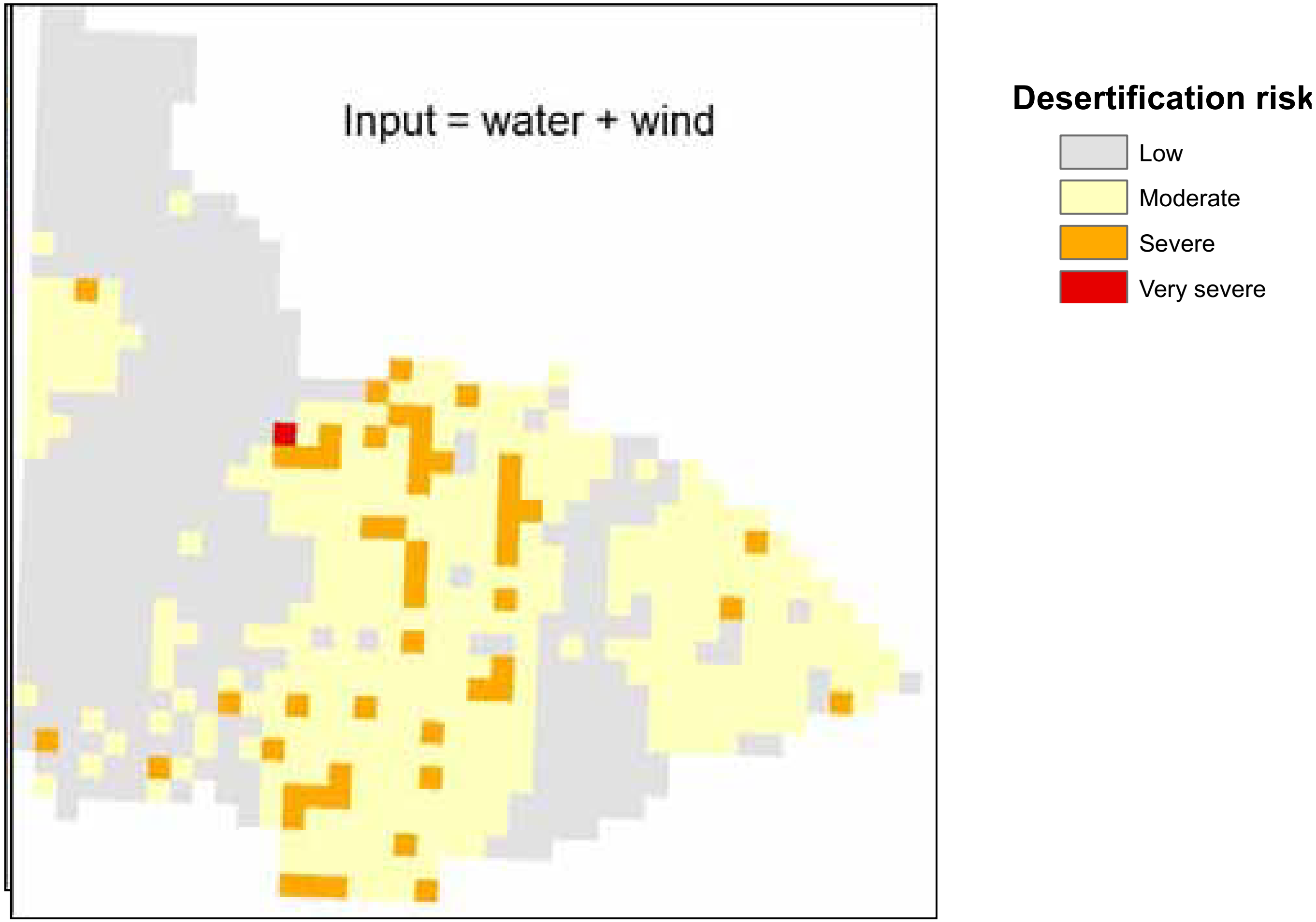
Initial findings



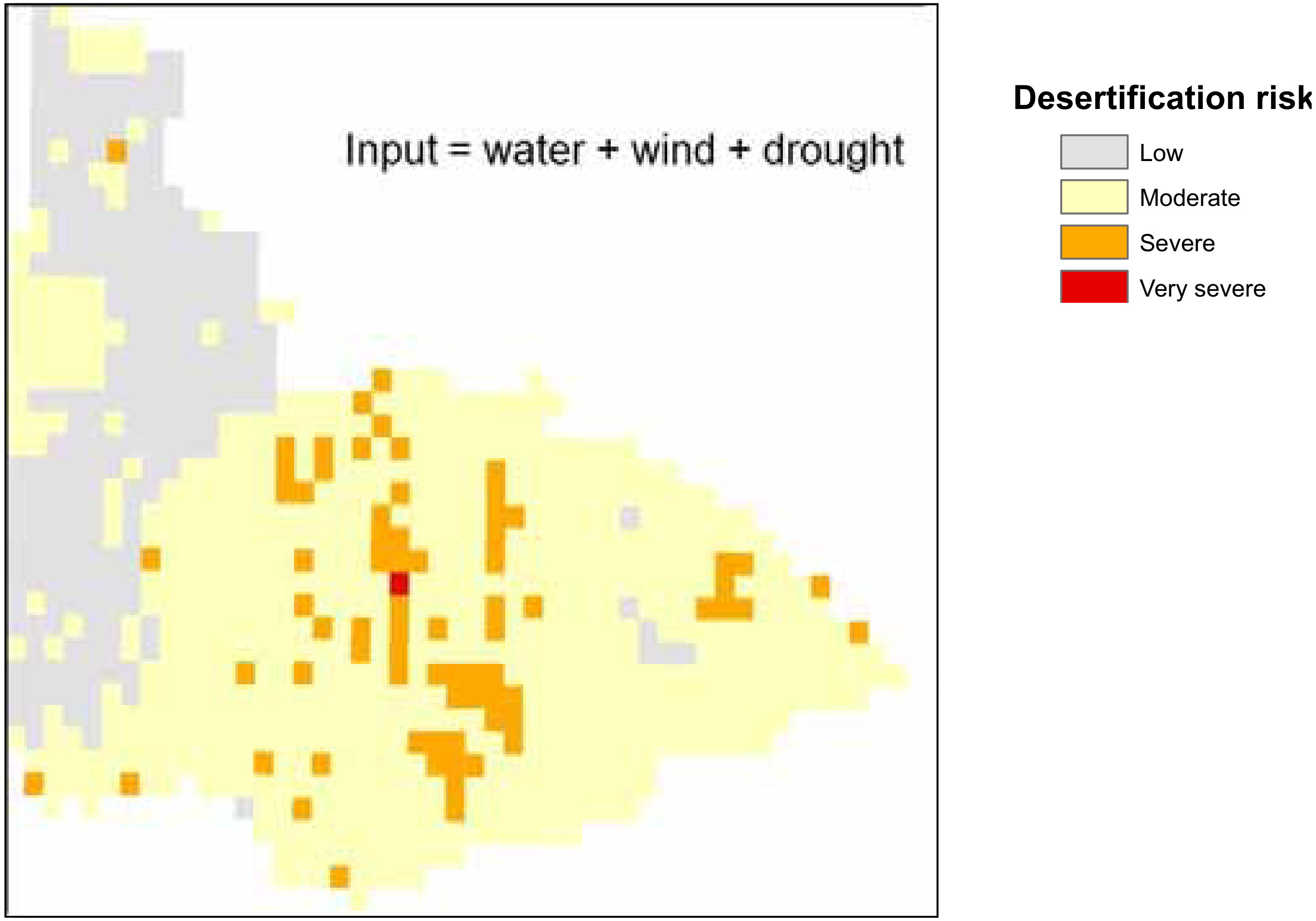
Desertification model: Initial results



Desertification model: Initial results



Desertification model: Initial results



Conclusions

- USLE within GIS environment proved to be sufficient for tracing the spatial variability of soil erosion.
- High rates of erosion were observed in the open rangelands with moderate to steep slopes.
- The rainfall –runoff calibration might be needed before extending the model to other parts of the country.
- The interaction between land management and topography controlled the levels of soil erosion in this Mediterranean environment.
- Regarding desertification modeling, it is important to integrate results of water and wind erosion models.

Acknowledgement

This research is supported by the NATO's Science for Peace Program, project SfP-983368 (2009-2012) "Assessment and monitoring of desertification in Jordan using remote sensing and bioindicators".

NATO OTAN

This project is supported by: The NATO Science for Peace and Security Programme

Thank you