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Management of Ecosystems and Environmental Changes in Arid Lands in Central Asia  
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**Final Sino-German Conference of SuMaRiO**

# **Soil salinity and cotton yield estimation on regional scale in Tarim River Basin using EPIC Model and SOTER approach**

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## Problem Description

### The Tarim Basin is characterized by:

1. Extremely continental desert climate
  - Poor rainfall (50 - 70 mm a<sup>-1</sup>)
  - High ET<sub>p</sub> (2,100 – 3,400 mm a<sup>-1</sup>)
2. Agriculture areas dominated by intensive irrigated cultivation (cotton)
  - Huge water consumption with 60% - 70% water loss
  - Inefficient drainage system (earth channel system)
  - Groundwater level 1 - 2m below soil surface
  - loamy soil texture

### consequence:

- High capillary water movement (loamy texture + high evapotranspiration)
- Accumulation of salt in the root zones and at the soil surface  
=> Problem of soil salinity

## Problem Description

### Scientific challenges:

- Lack of data in the Tarim River Basin
- Data access due to data policy
- Own national classification, methodology and publications (in Chinese)
- Difficult / no access to some areas
- Rapid land use change

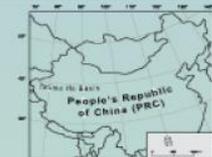
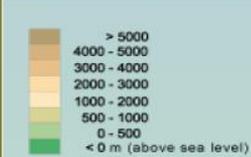
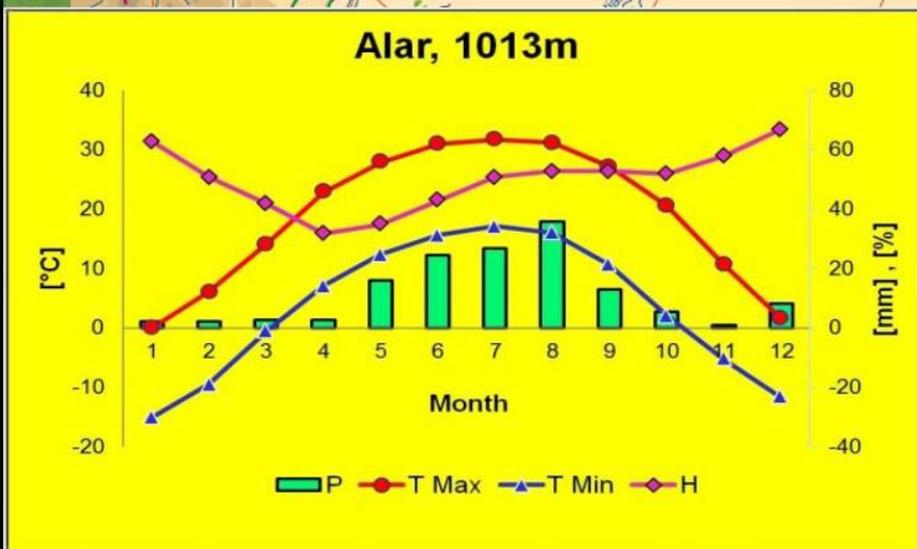
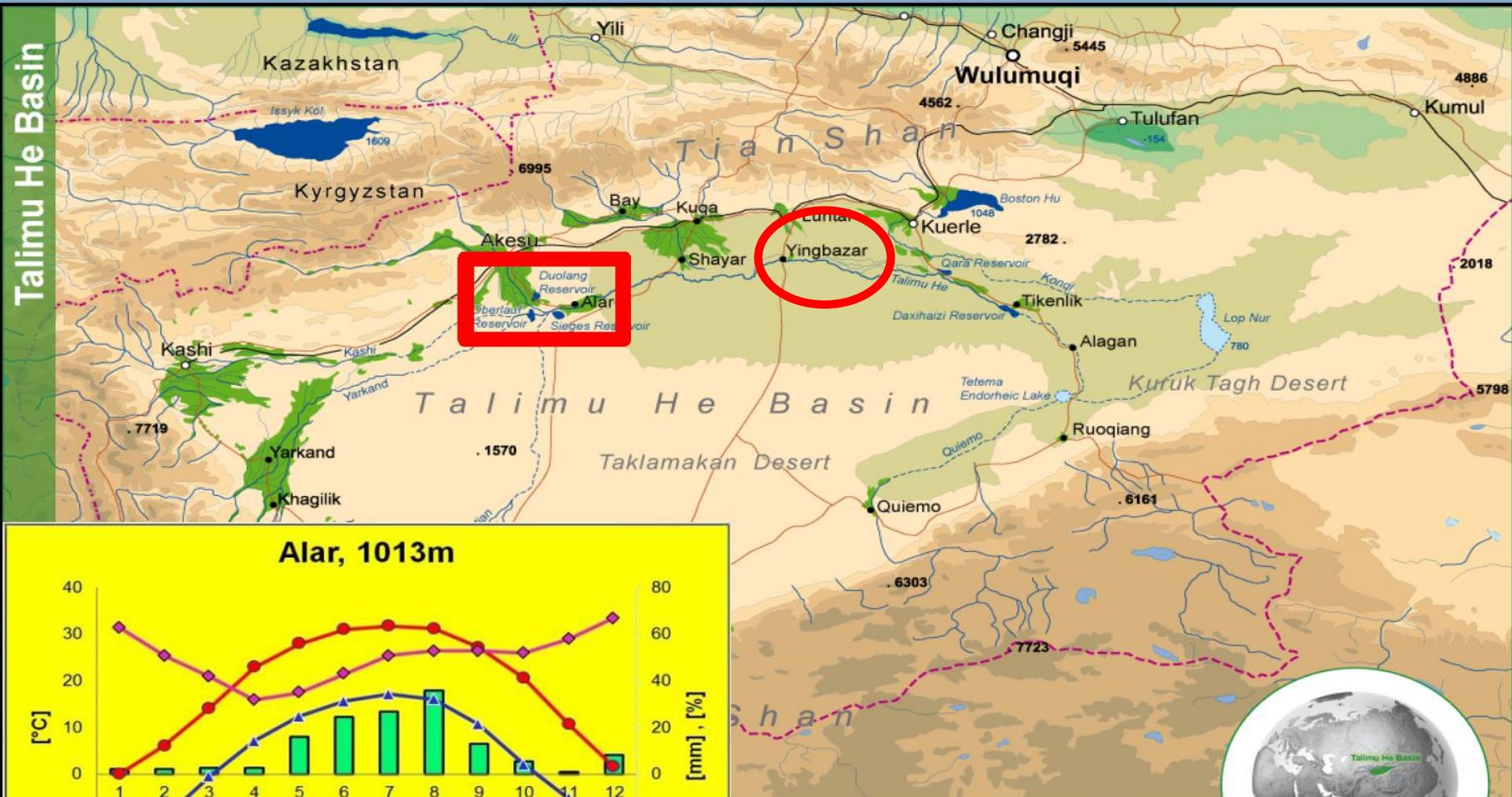
### Overcome:

- Own land survey (soil profiles)
- Remote sensed data (Landsat, SRTM 90m)
- Prediction methods (some parameters e.g.: FC, K)

## Objectives

- **Characterization of the soils in the area** with regard to chemical and physical properties
- **Special task: Assessment and mapping of salinity status**
- **Establishment of SOTER-database** (SOil & TERrain database)
- **Cotton yield estimation on a regional scale** using calibrated and validated EPIC model based on the SOTER database
- **Run several scenarios** under various conditions

## Study Area



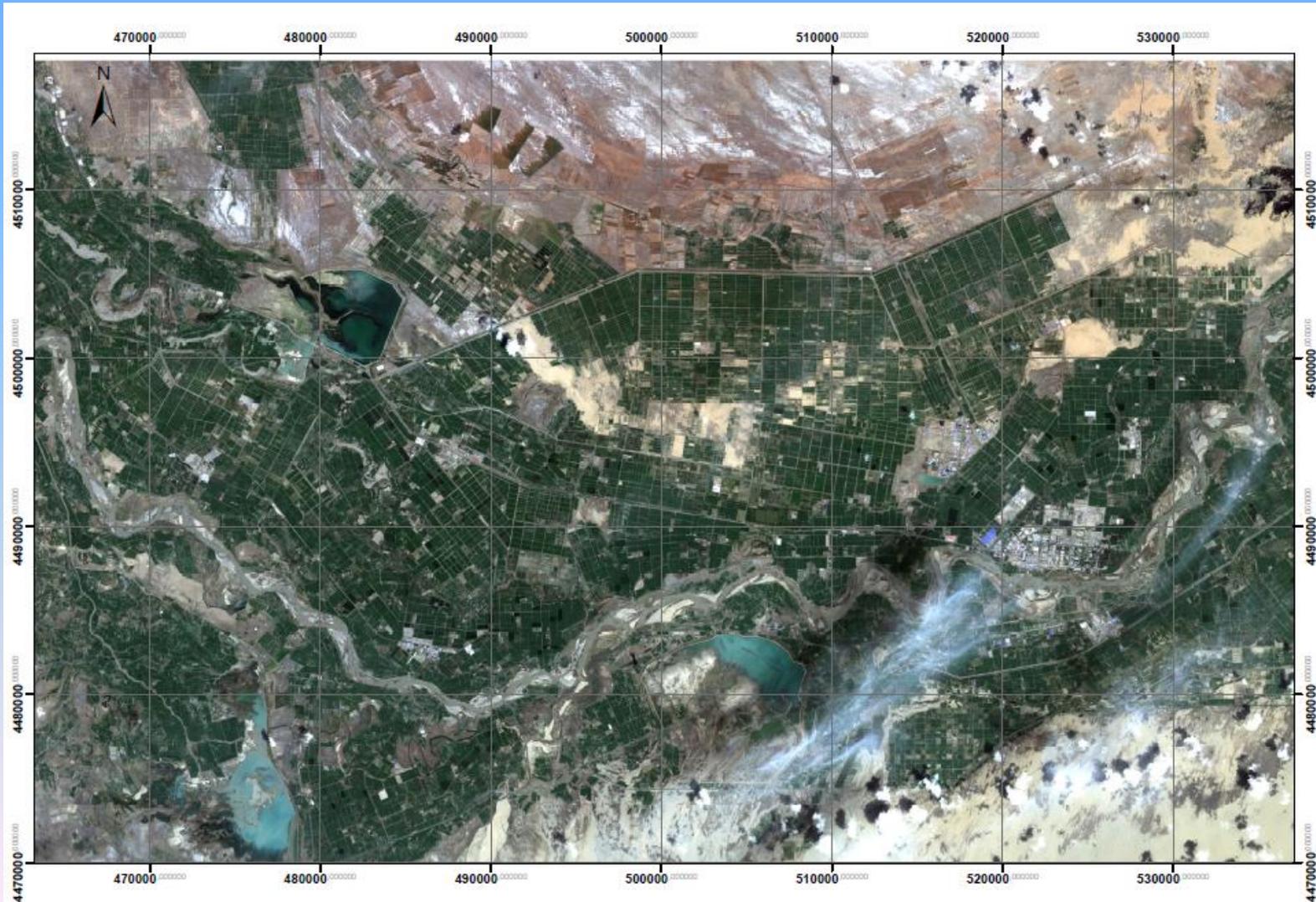
## I. Characterization of the soils in the region

- **26 soil profiles** in Aksu-Alar region
- **23 soil profiles** in Yingbazar
- **In situ description** according to FAO guidelines (2006)
- **Soil classification** regarding to WRB (2006 & 2014)
- **Analysis & assessment** of the chemical and physical soil properties



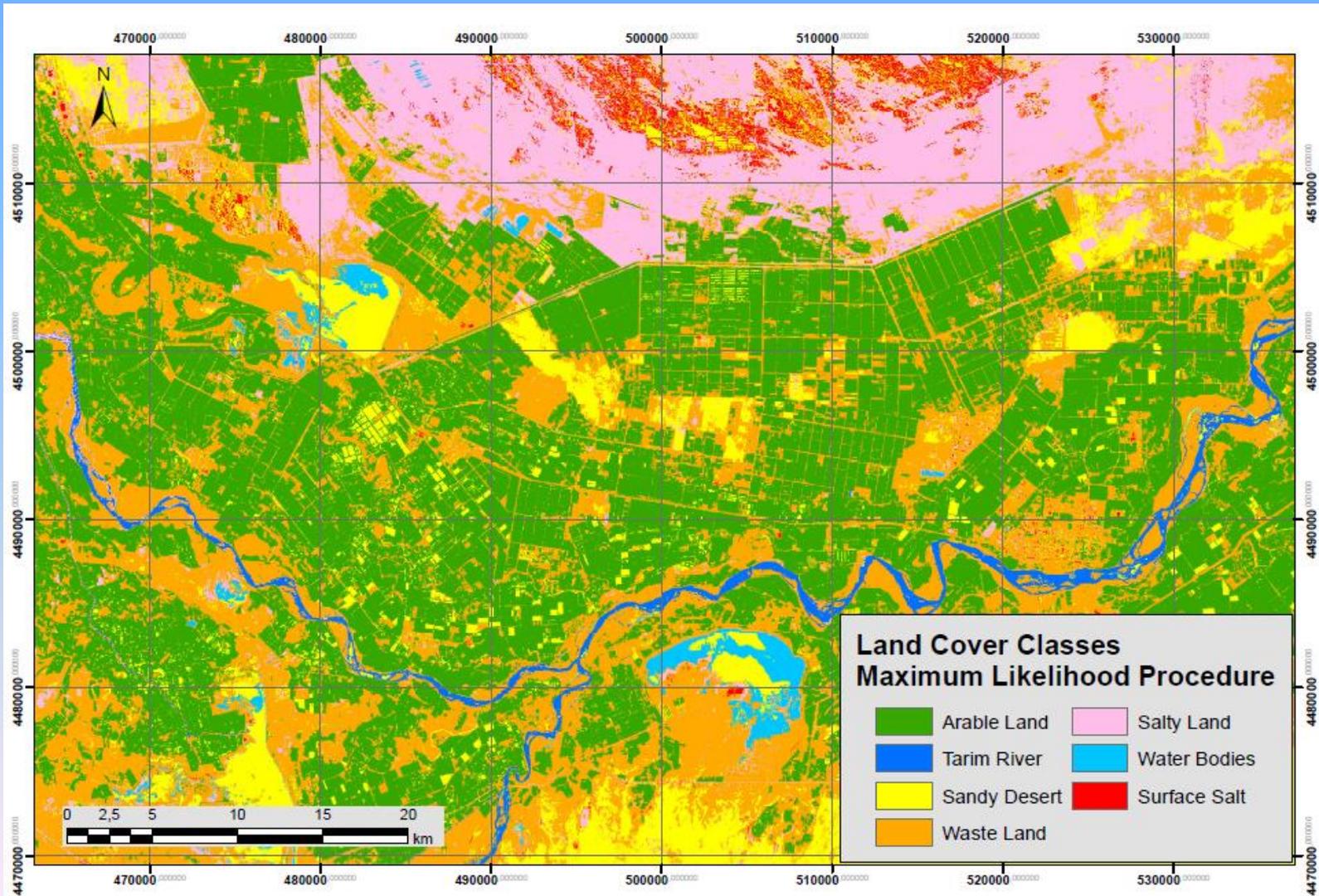
## I. Characterization of the soils in the region

- Preparation of soil map



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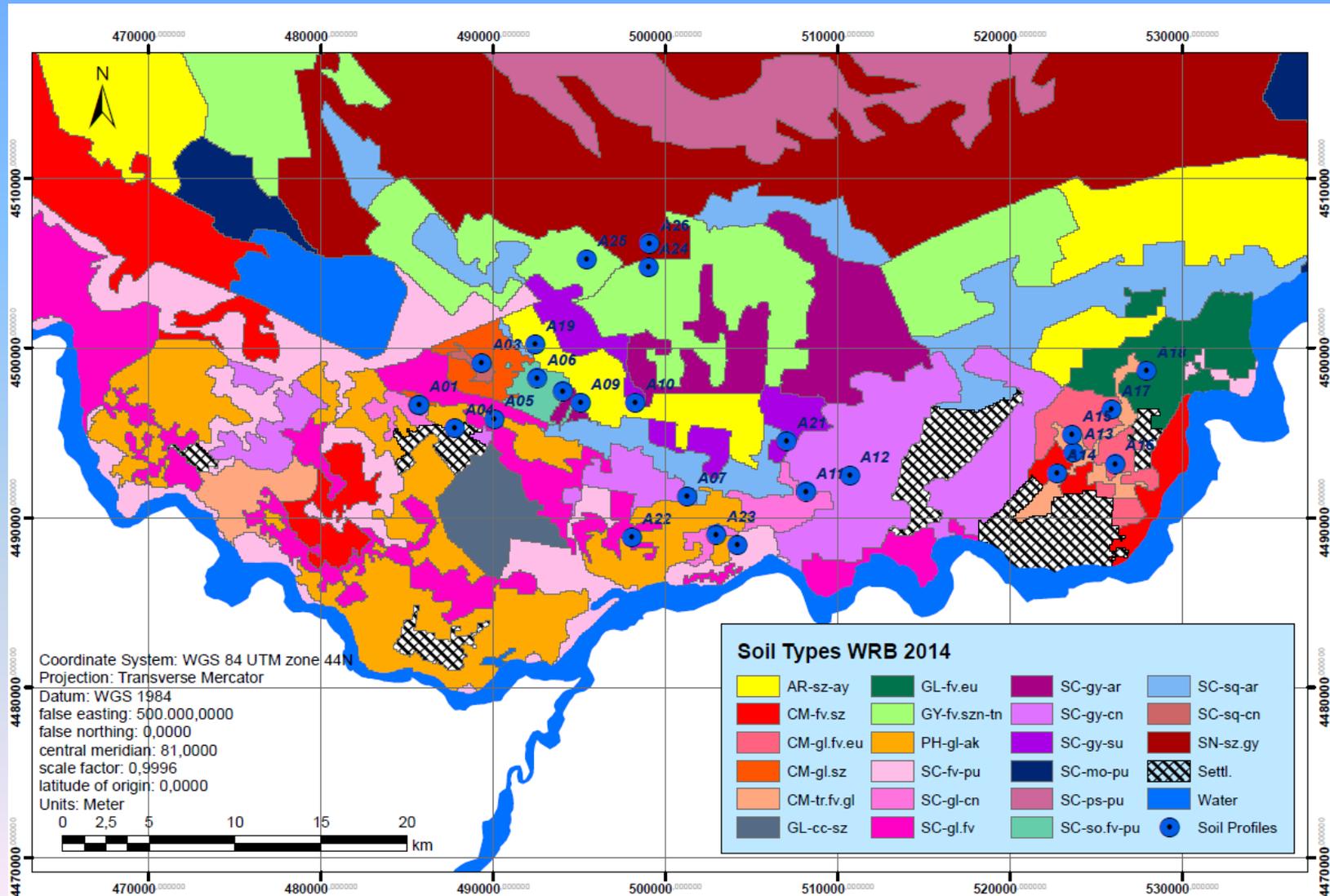
- Preparation of soil map





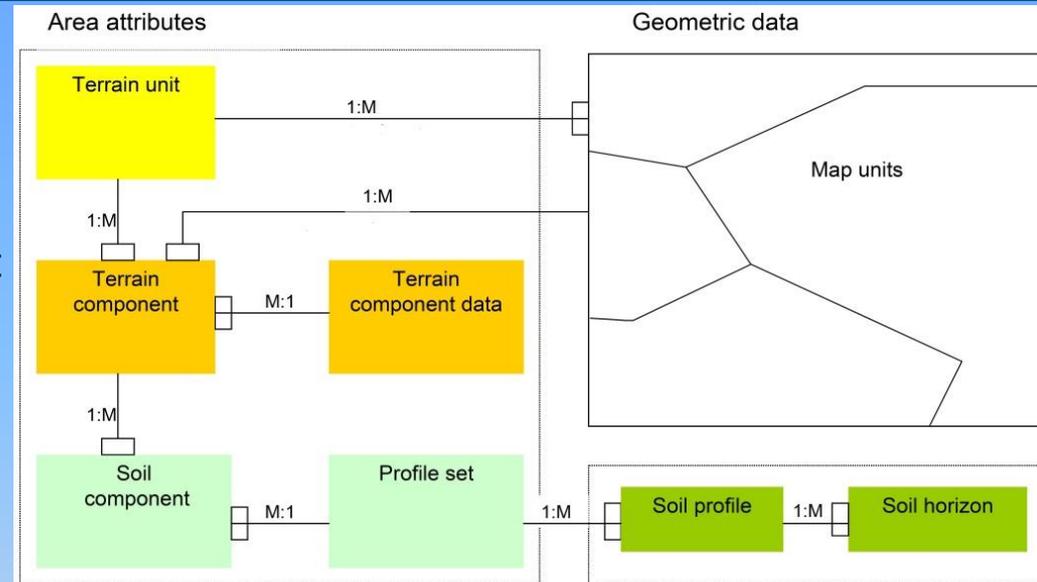
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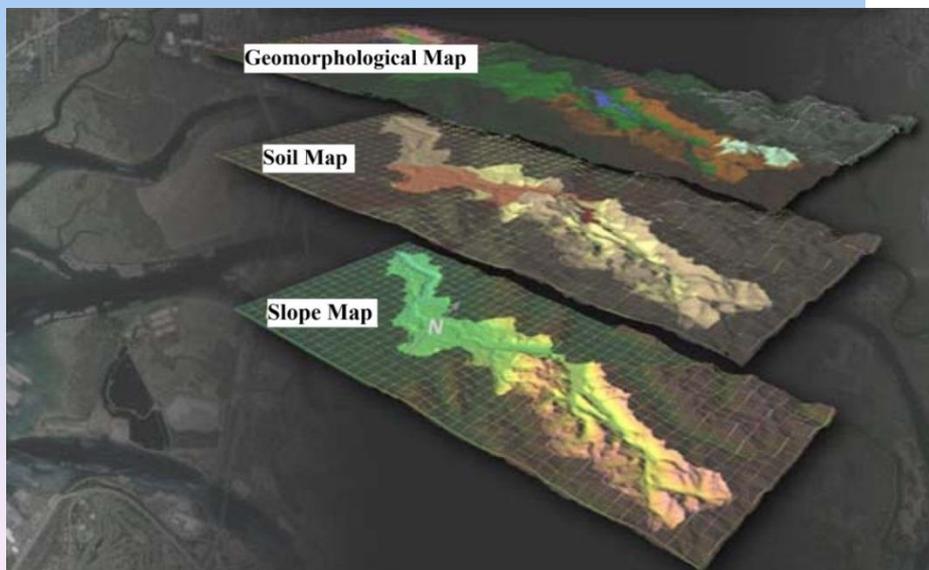


## II. Establishment of SOTER Database

- (SOil & TERrain Database) is a **spatial database** with focus on soil and terrain conditions
- **connects various digital maps** of different scales with **their attribute data**
- forms appropriate **input and output data** for simulation models on **regional scale**



1:M = one to many

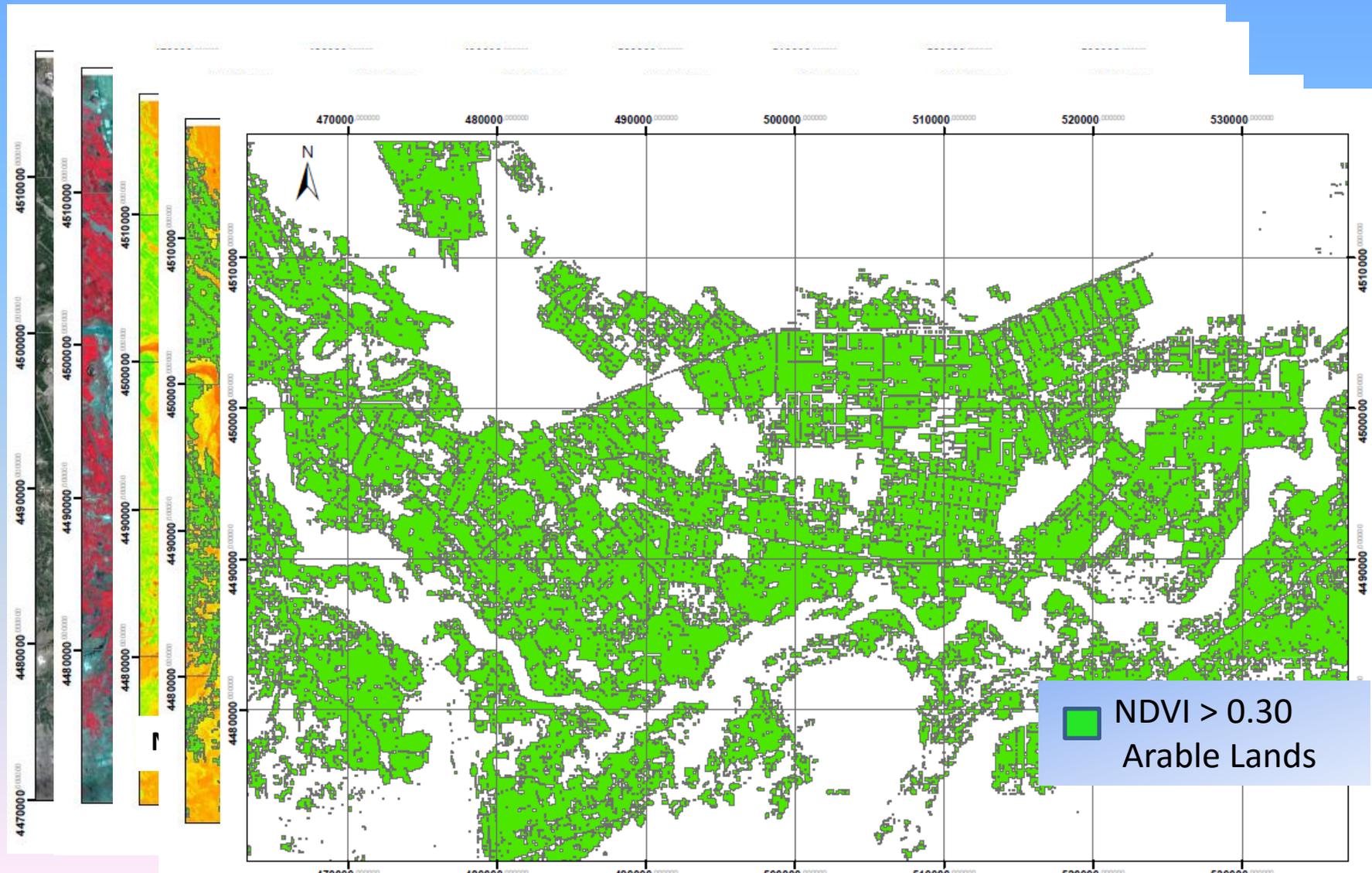


### Required maps:

- Geological maps (available)
- Soil map (prepared)
- Slope map (from SRTM90m)
- Land use map ?
- Soil salinity map ?

## II. Establishment of SOTER Database

- Preparing of the land use map



## II. Establishment of SOTER Database

- **Assessment and mapping of salinity status**
  - Soil salinity can be estimated by measuring the electrical conductivity of the soil solution/ extraction (1:1), (1:2.5), (1:5), ...
  - EC (1:2.5) and EC (1:5) done for all soil samples in lab.
  - The unit is Siemens or Mhos
  - **ECe: The Electrical Conductivity of Saturated paste:**

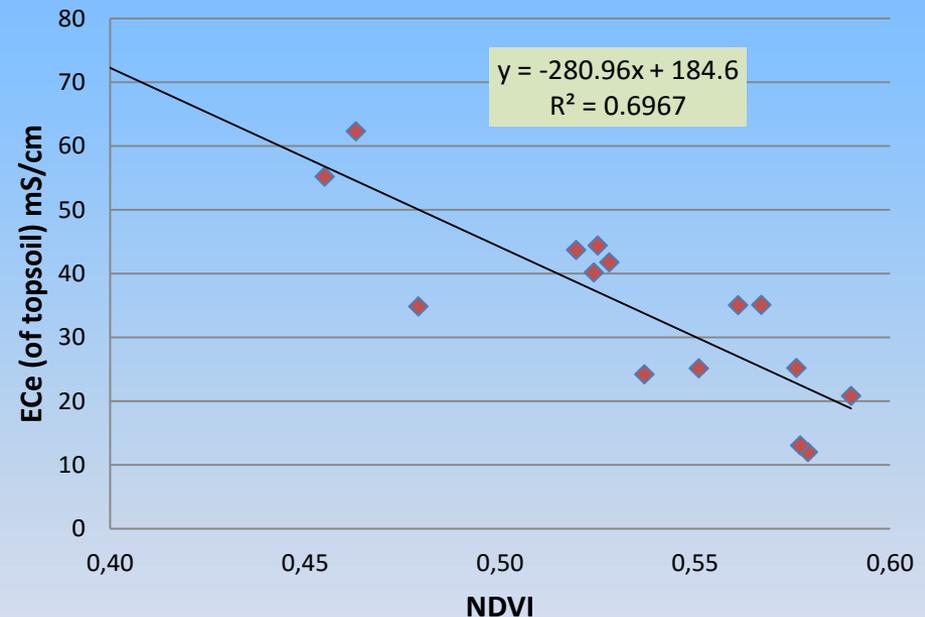
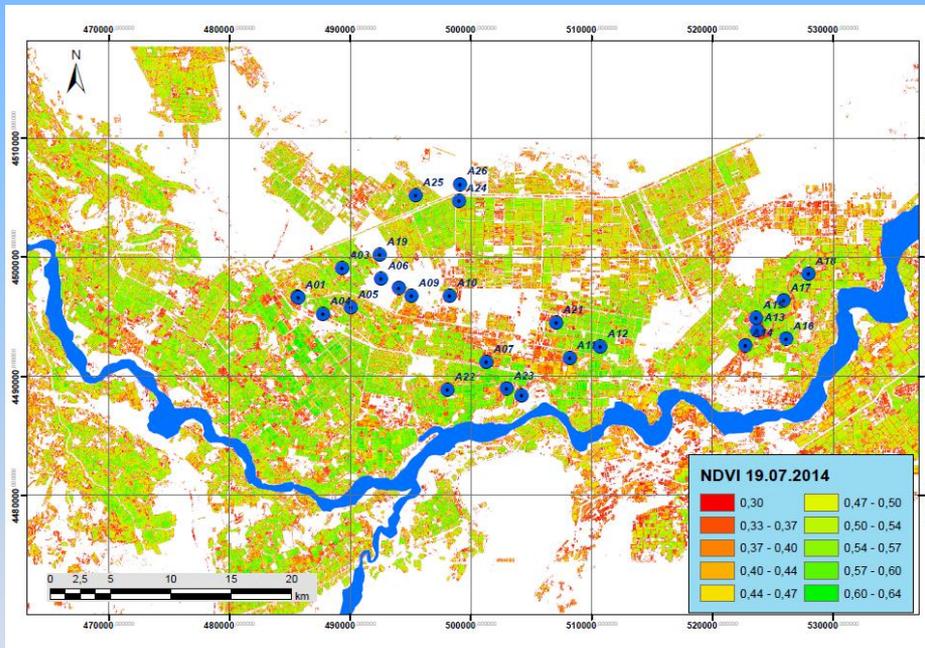
Estimating ECe:

$$ECe = 250 * EC(1:2.5) / FC$$

## II. Establishment of SOTER Database

- Assessment and mapping of salinity status

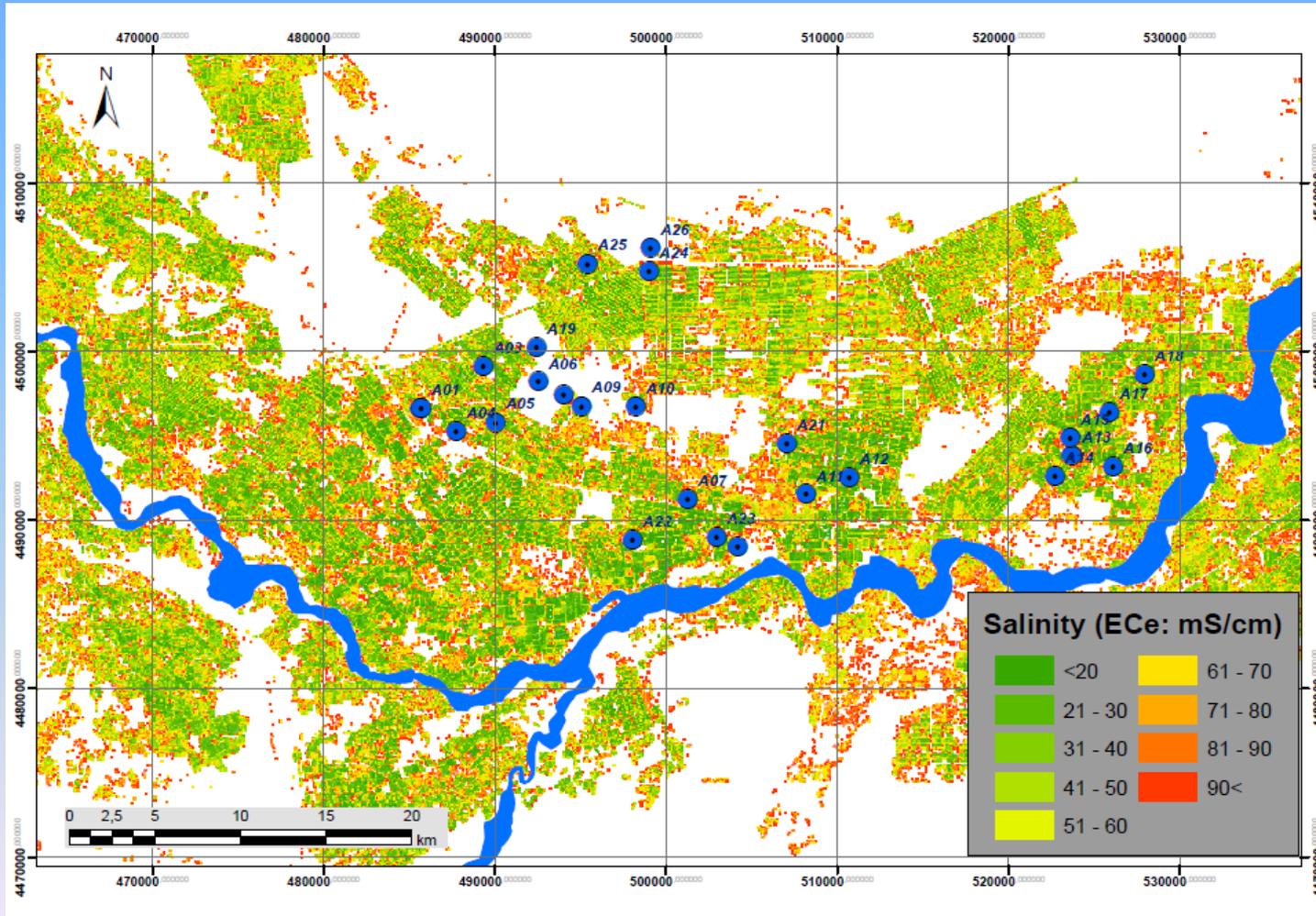
NDVI vs (ECe mS/cm of topsoil) from 15 soil in arable lands



$$ECe = -280.96 * NDVI + 184.6$$

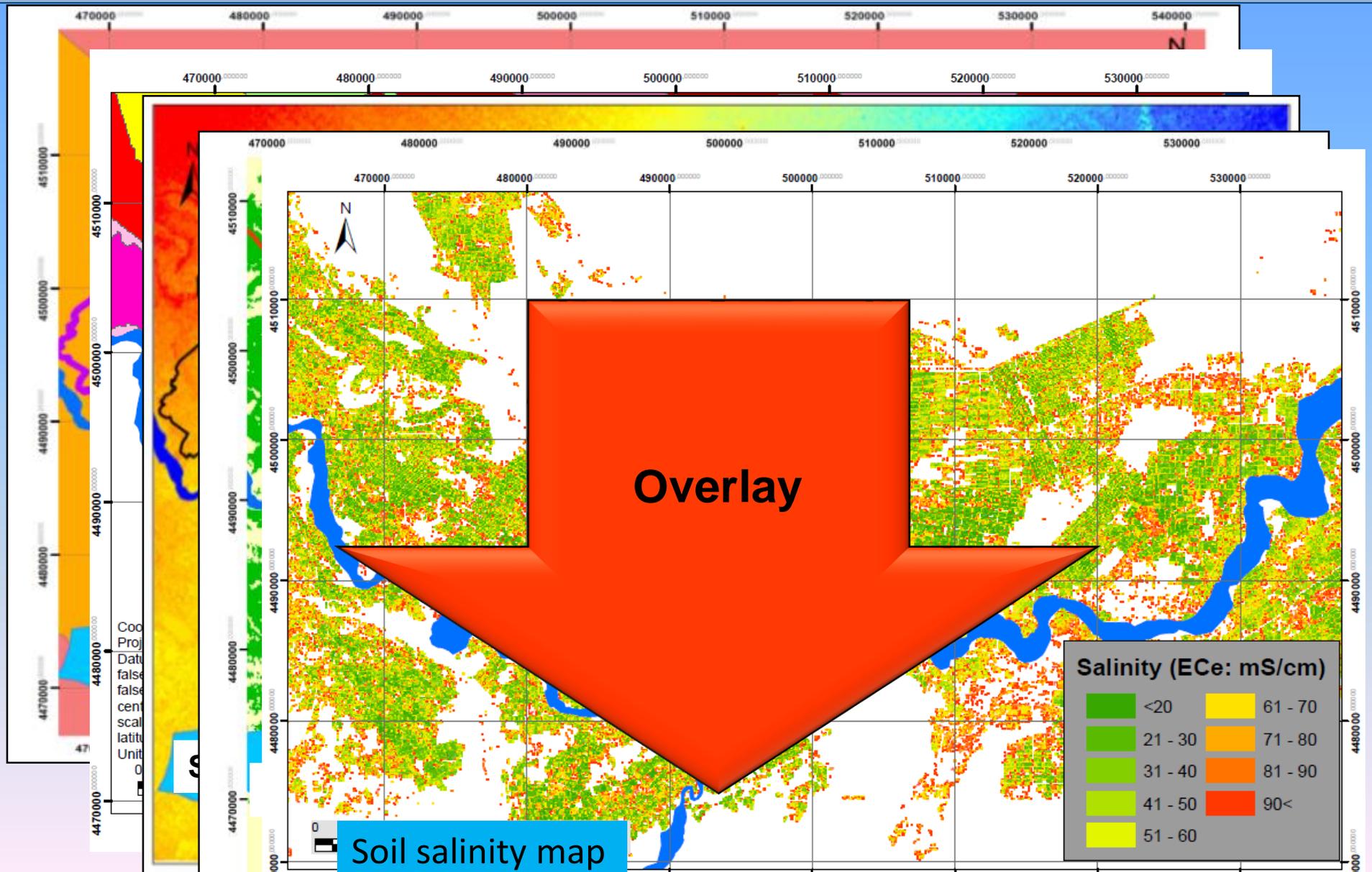
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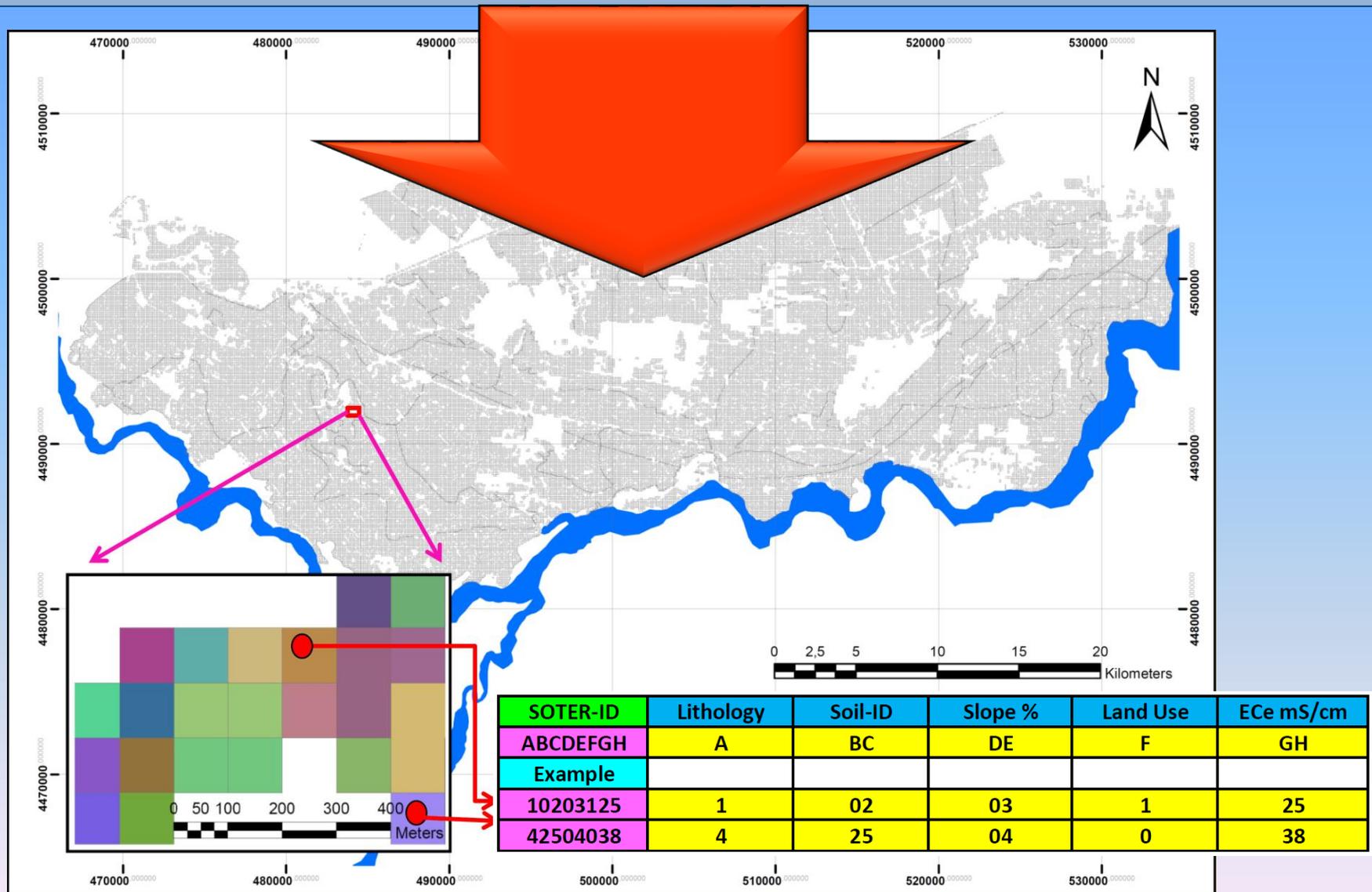


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86,000 Pixel = 86,000 ha

### III. Cotton yield simulation with the EPIC model

#### **EPIC: Cropping systems model**

EPIC (Erosion Productivity Impact Calculator)

EPIC (Environmental Policy Integrated Climate)

#### **for estimation of :**

- crop yield
- soil erosion
- C-sequestration

on fields scale or areas with homogeneous soils, management and climate.

#### **EPIC input data:**

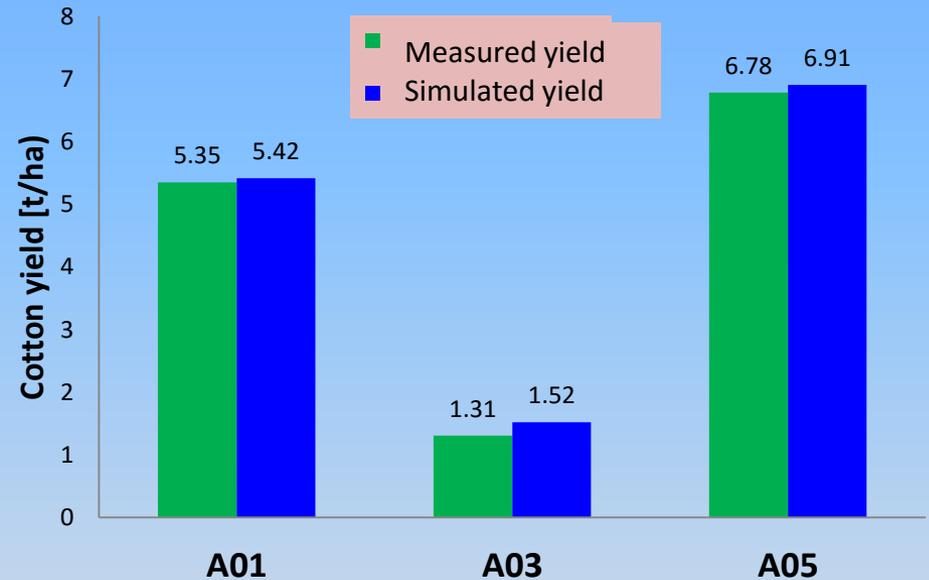
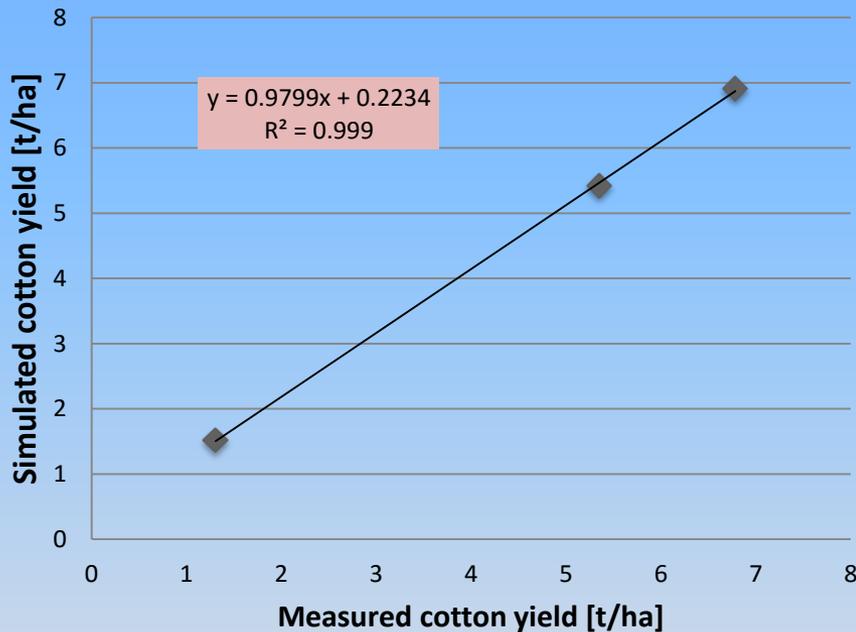
- Soil and terrain data (SOTER-Database)
- Climate data (T-max, T-min, relative humidity, precipitation, rainy days, wind speed)
- Crop requirements (e.g. potential heat units)

#### **Model run**

- A single standard management scenario applied to the whole area

### III. Cotton yield simulation with the EPIC model

#### Calibration of the EPIC-Model

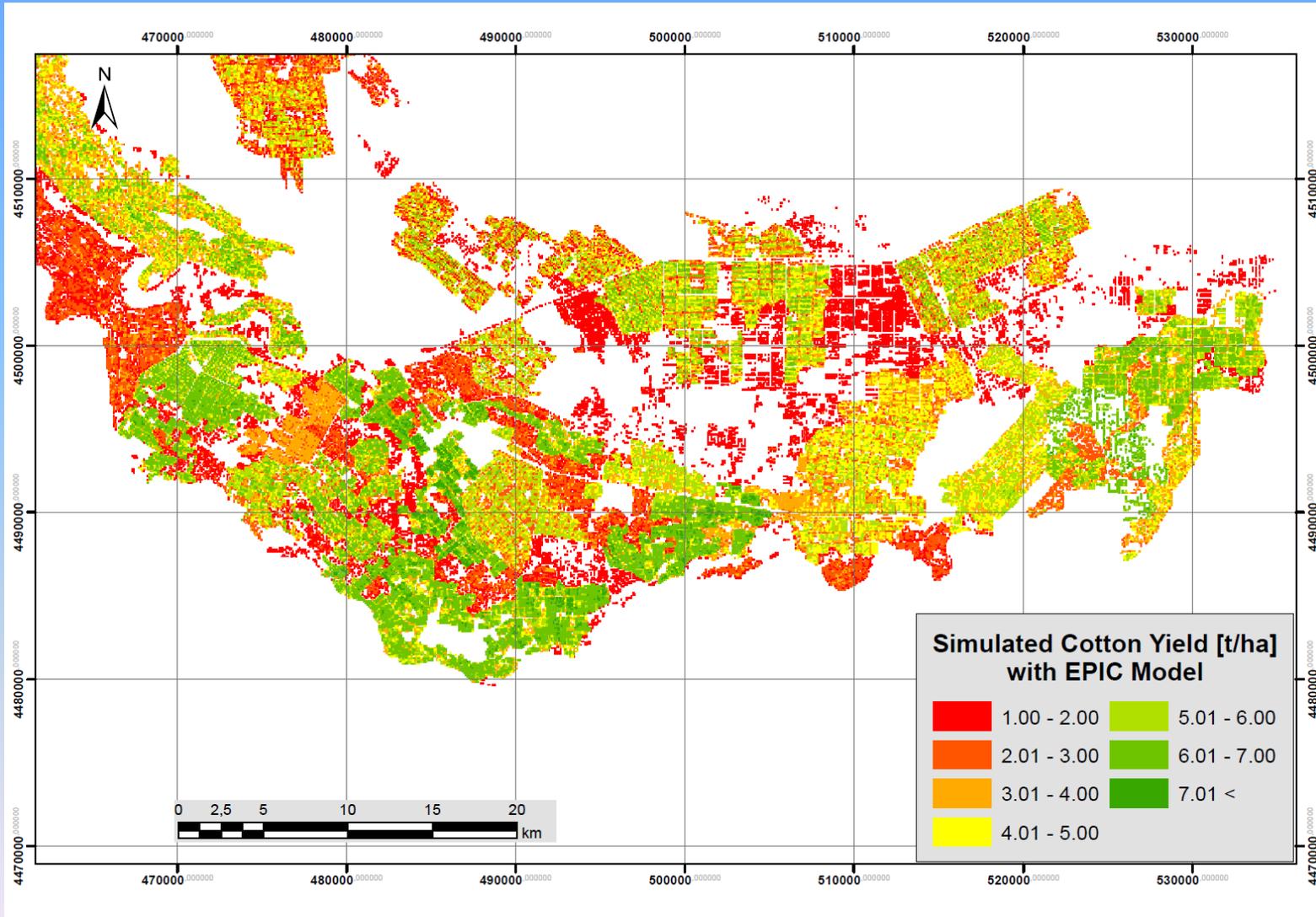


Comparison of the simulated cotton yield to the measured [t/ha].

#### Adapted Parameters:

- Potential heat unit **PHU**: 1800° C
- Radiation Use Efficiency **RUE**: 25 (kg ha<sup>-1</sup>MJ<sup>-1</sup>m<sup>2</sup>)

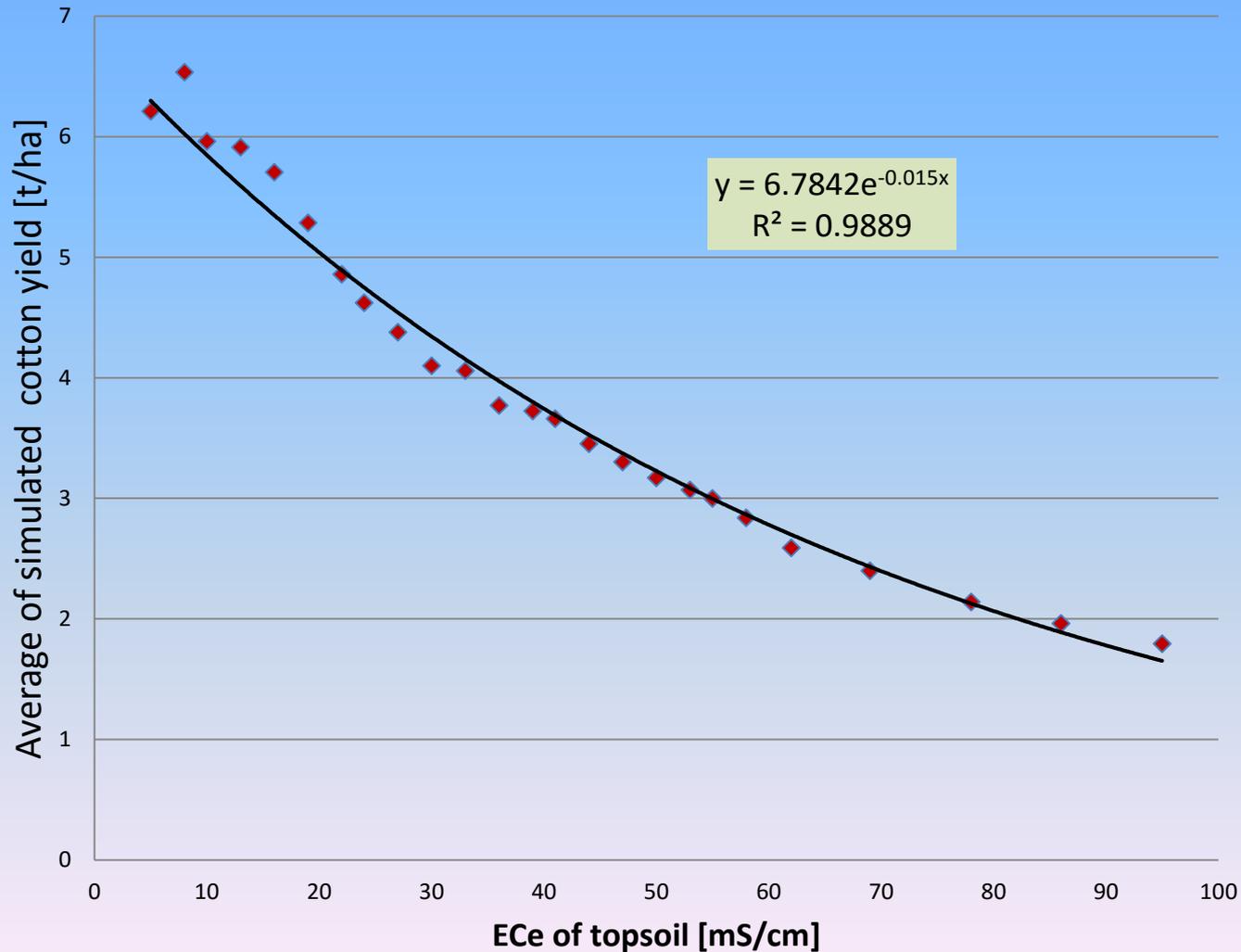
### III. Cotton yield simulation with the EPIC model



The total simulated cotton yield in the region under current conditions = 328,700 t

### III. Cotton yield simulation with the EPIC model

- Soil salinity was the major limiting factor for the simulated cotton yield with the EPIC model



### III. Run of scenarios

#### Scenarios:

#### Current conditions

Total yield: 328,700 t

#### Scenario I

Current conditions +:

T + 1° C

- 20% of irrigation water = 400 mm

+ 2 X TDS (irrigation water) = 1000 mg/l

Total yield: 271,870 t

Loss 17%

#### Scenario II

Current conditions +:

T + 2° C

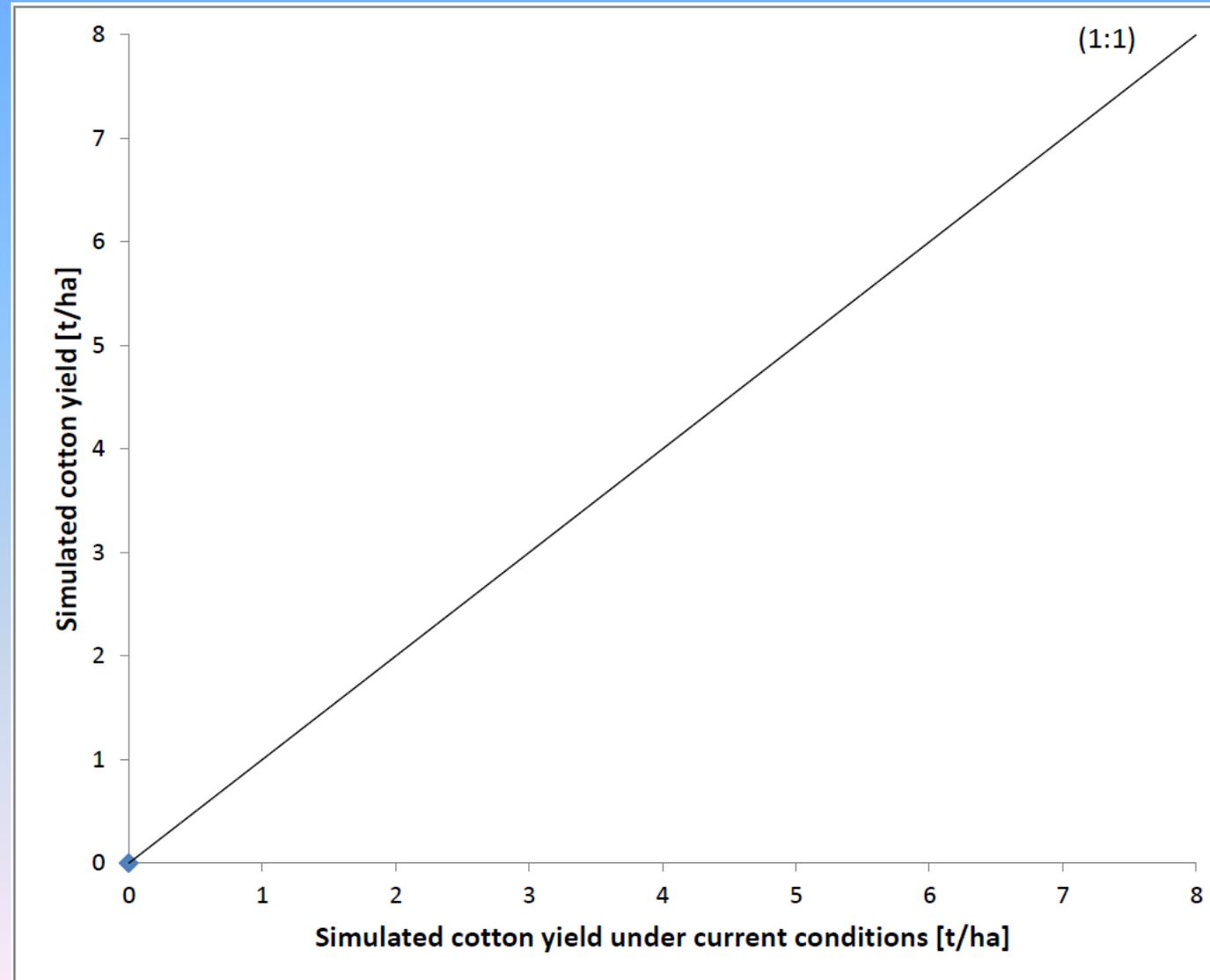
-40% of the irrigation water = 300 mm

+ 3 X TDS (irrigation water) = 1500 mg/l

Total yield: 213,960 t

Loss 35%

n= 86,000



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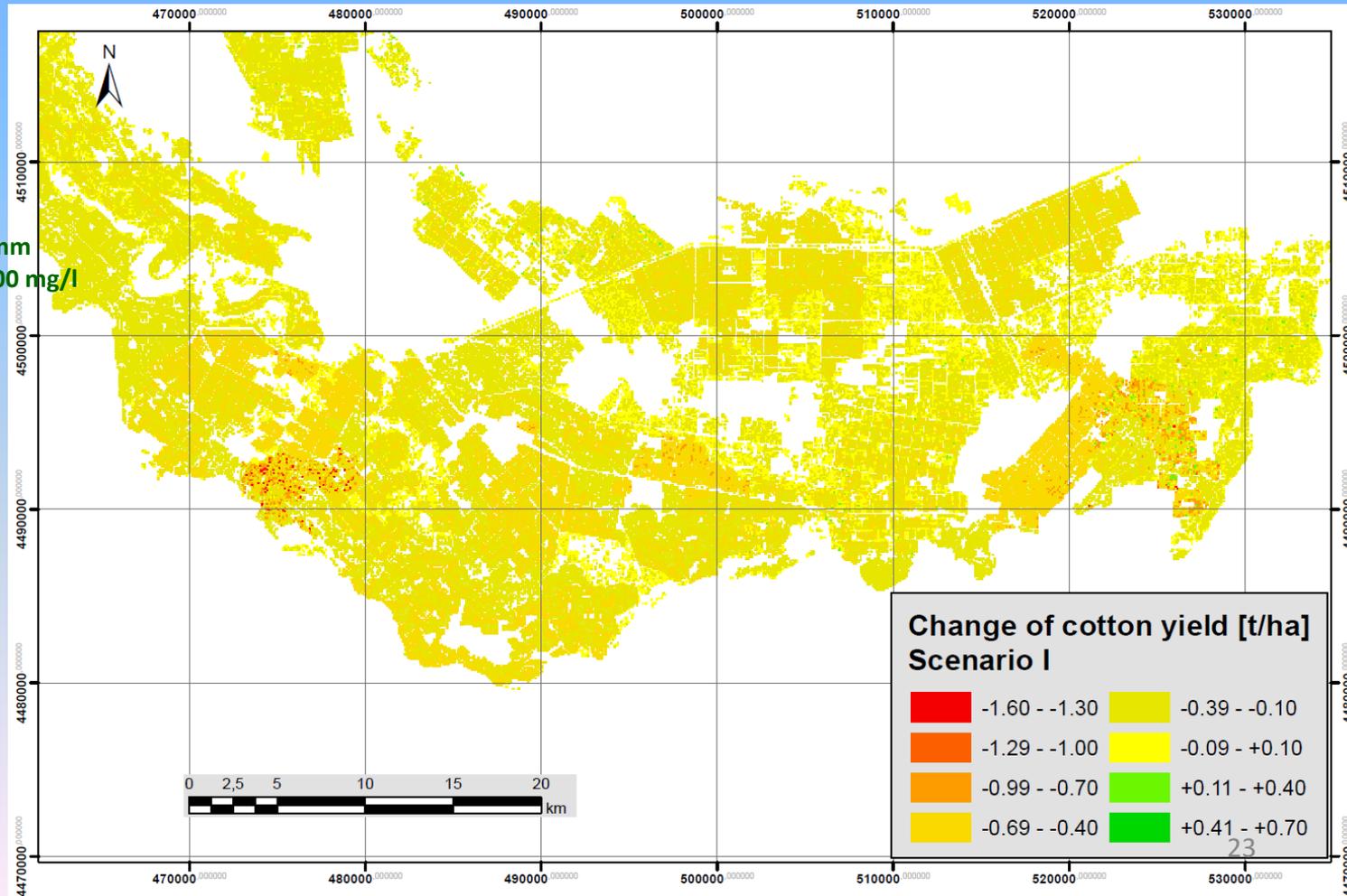
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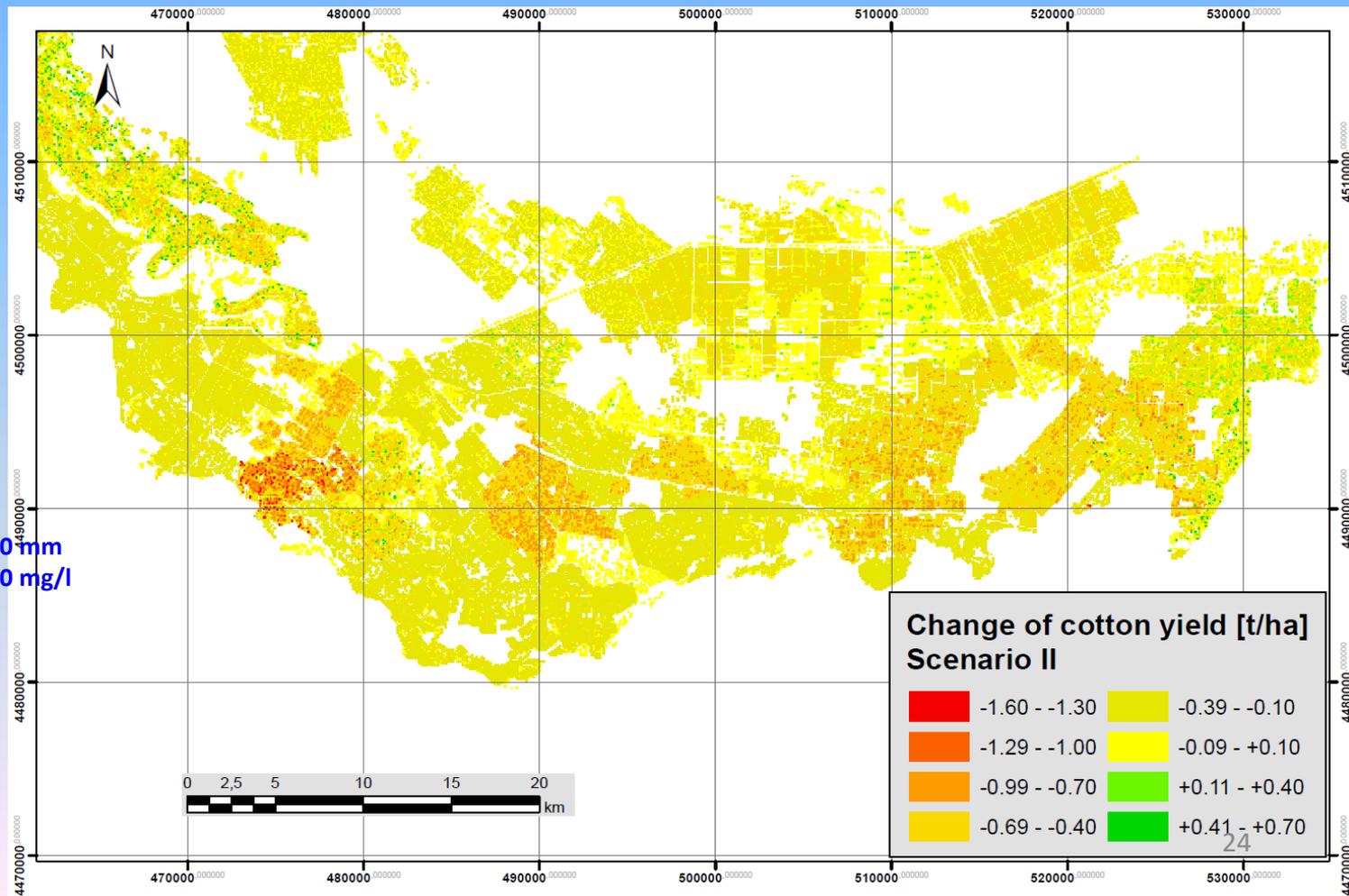
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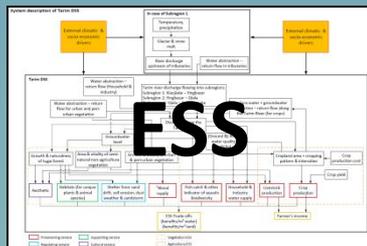
Area = 86,000 ha



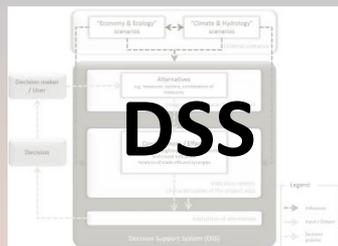
## Conclusion

- The **spatial database applied** is a useful tool for **storage and inquiry of soil and terrain data** at various conditions
- **EPIC** can be a helpful tool for **regional planning** and for the **decision support system**, thus the EPIC model assesses the **impact of climate change** and **management strategies** on crop yield production.
- More **calibration data** and **ground check** will enhance the simulation results.
- For the **sustainability of cultivation system** in the Tarim River basin several **estimations and scenarios of land management, fertilizing and alternative crops** should be done.
- More irrigation water does not mean more yield, hence **water saving techniques (deficit irrigation)** enhance the **water use efficiency** and with a **proper drainage systems** will keep **the water table deep under the root zone**.

# Research contribution to Ecosystem Services (ESS) in the Tarim Basin and the contribution to the SuMaRiO-Decision Support System (DSS)



- Estimation of agricultural biomass production



- Assessment of soil salinity

A scenic view of the Andes mountains, featuring a range of peaks in shades of red, orange, and grey. The foreground is a desert landscape with sparse green and brown shrubs. The sky is a clear, bright blue with a few wispy white clouds.

*Thank You for Your Attention*



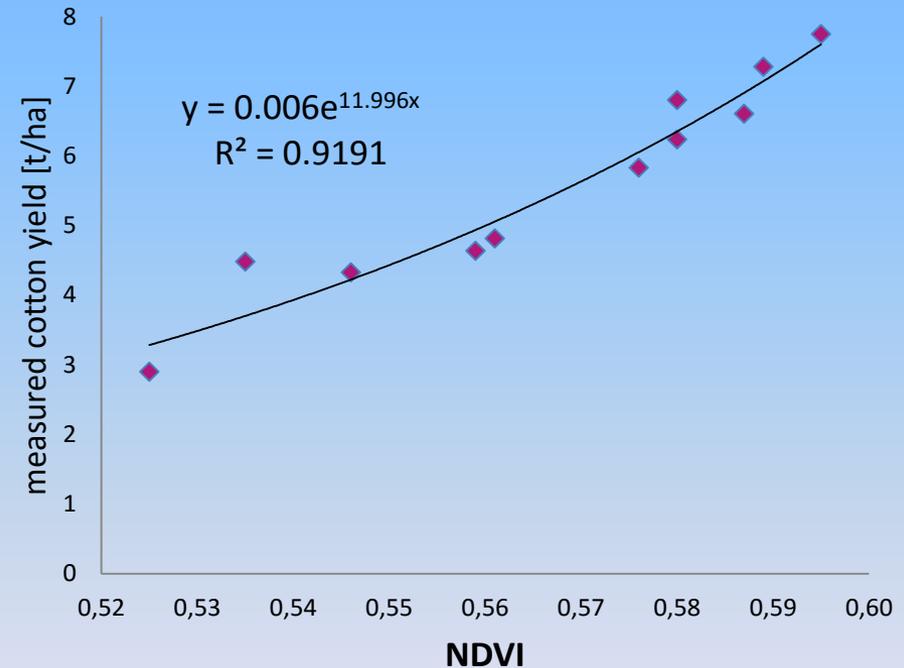
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#### Validation of the EPIC model

- NDVI vs measured cotton yield [t/ha] on 11 sites ( Sep. 2014)

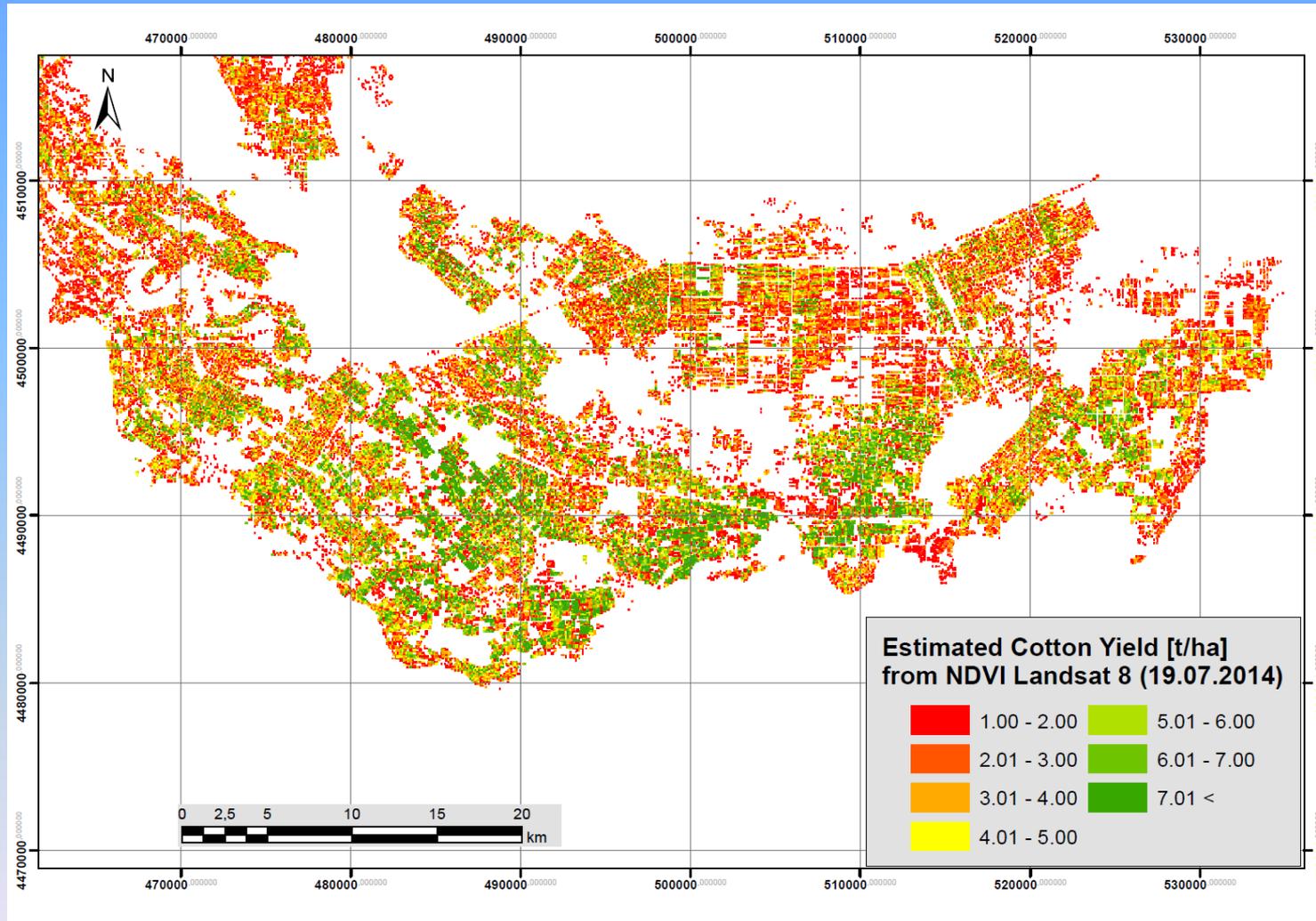


NDVI (19.07.2014)



$$\text{Cotton yield (t/ha)} = 0.006e^{(11.996 \cdot \text{NDVI})}$$

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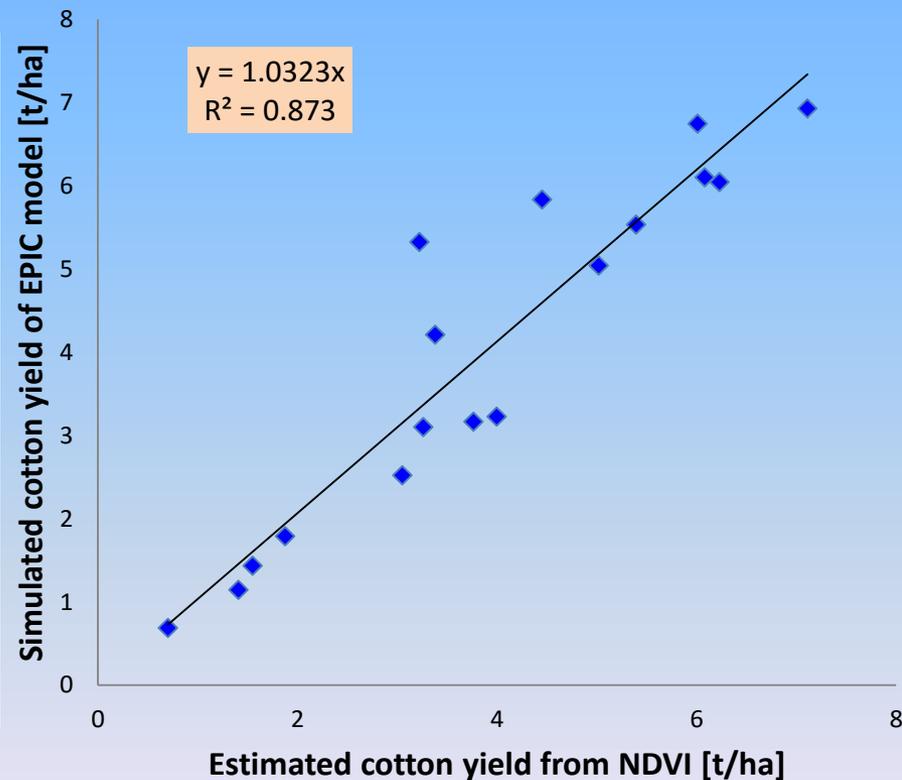
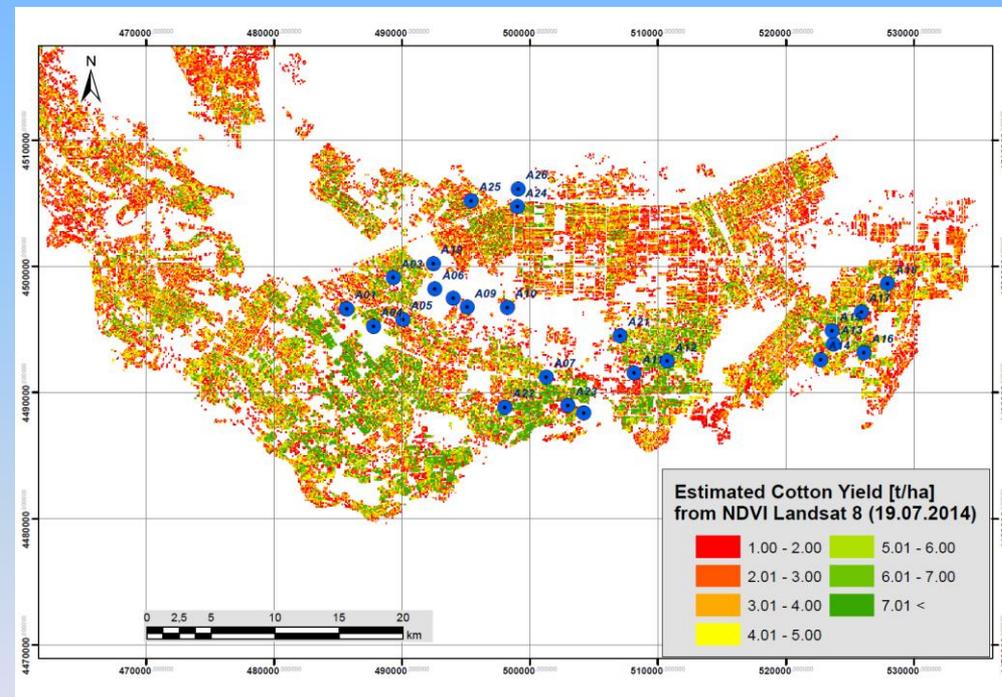
Estimated cotton yield from NDVI [t/ha]

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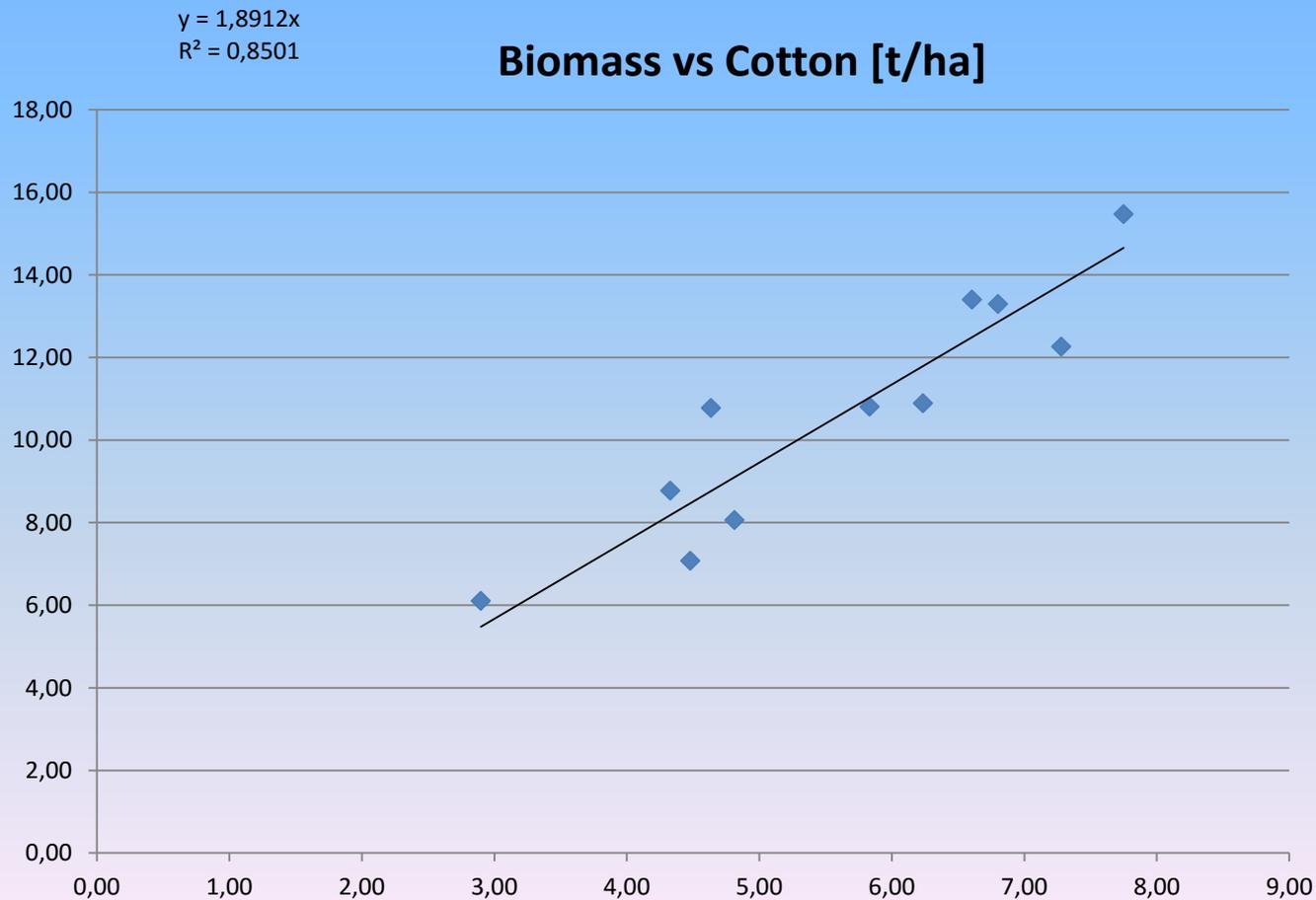
Comparison between the simulated cotton yield of EPIC model with the estimated cotton yield from NDVI on 17 arable sites (soil profiles)



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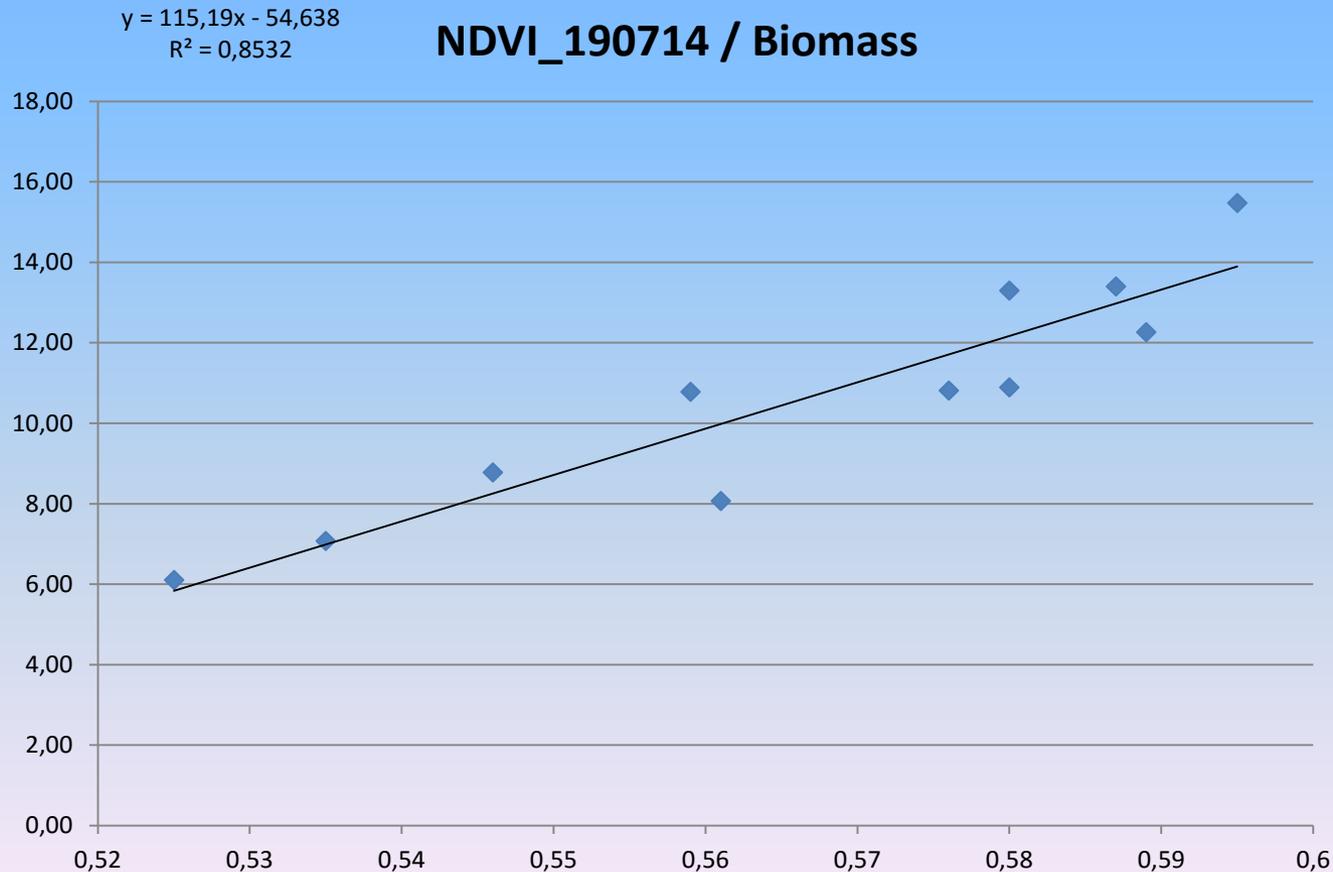
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# The soil map of Yingbazar region

