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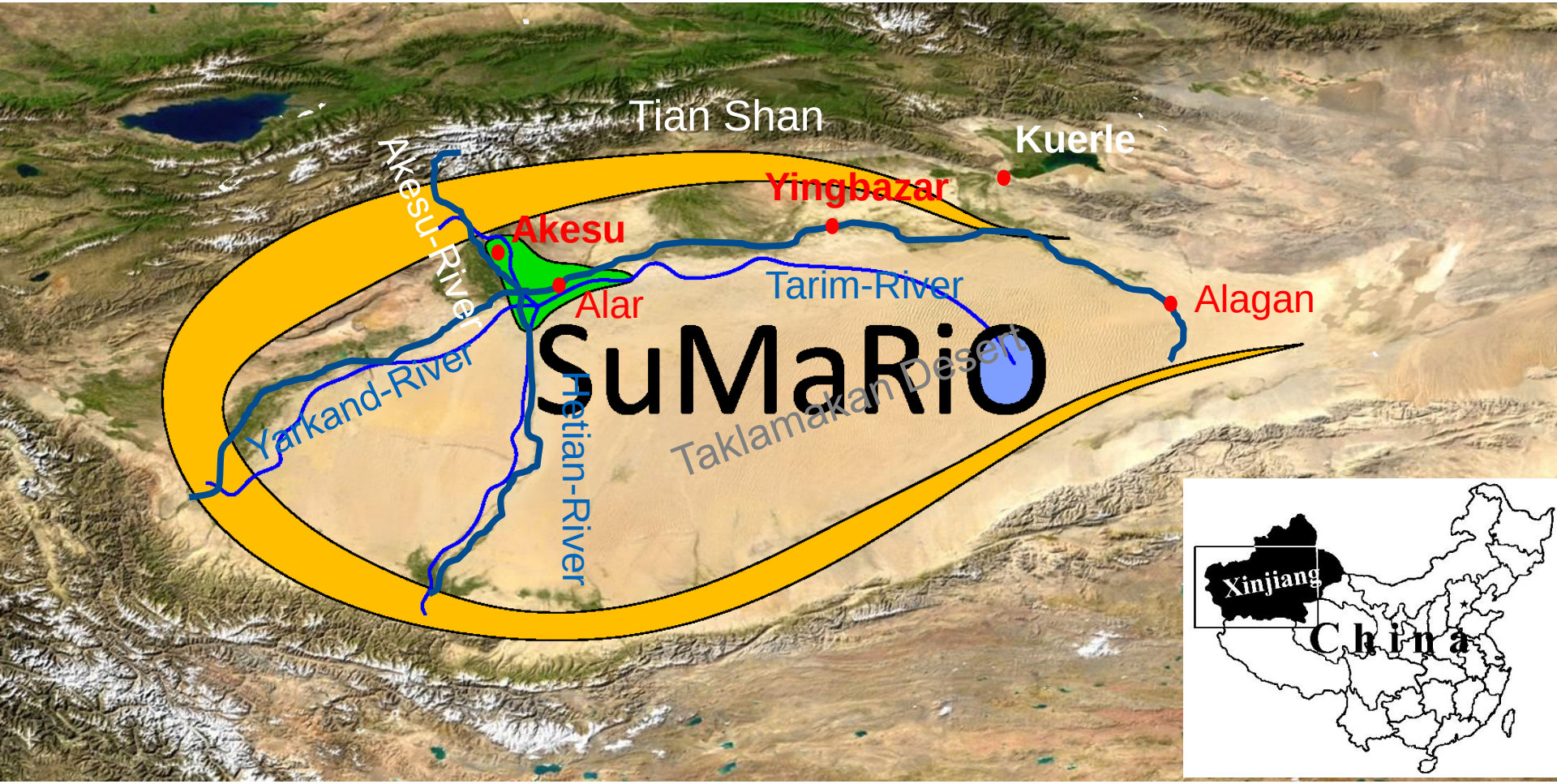
Measuring and modeling on different spatial scales along the Tarim River

Munich, 10th of December, 2015



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LAST CHANCE FOR OASIS IN CHINA´S DESERT

Sustainable oasis management in China's largest cotton-growing region

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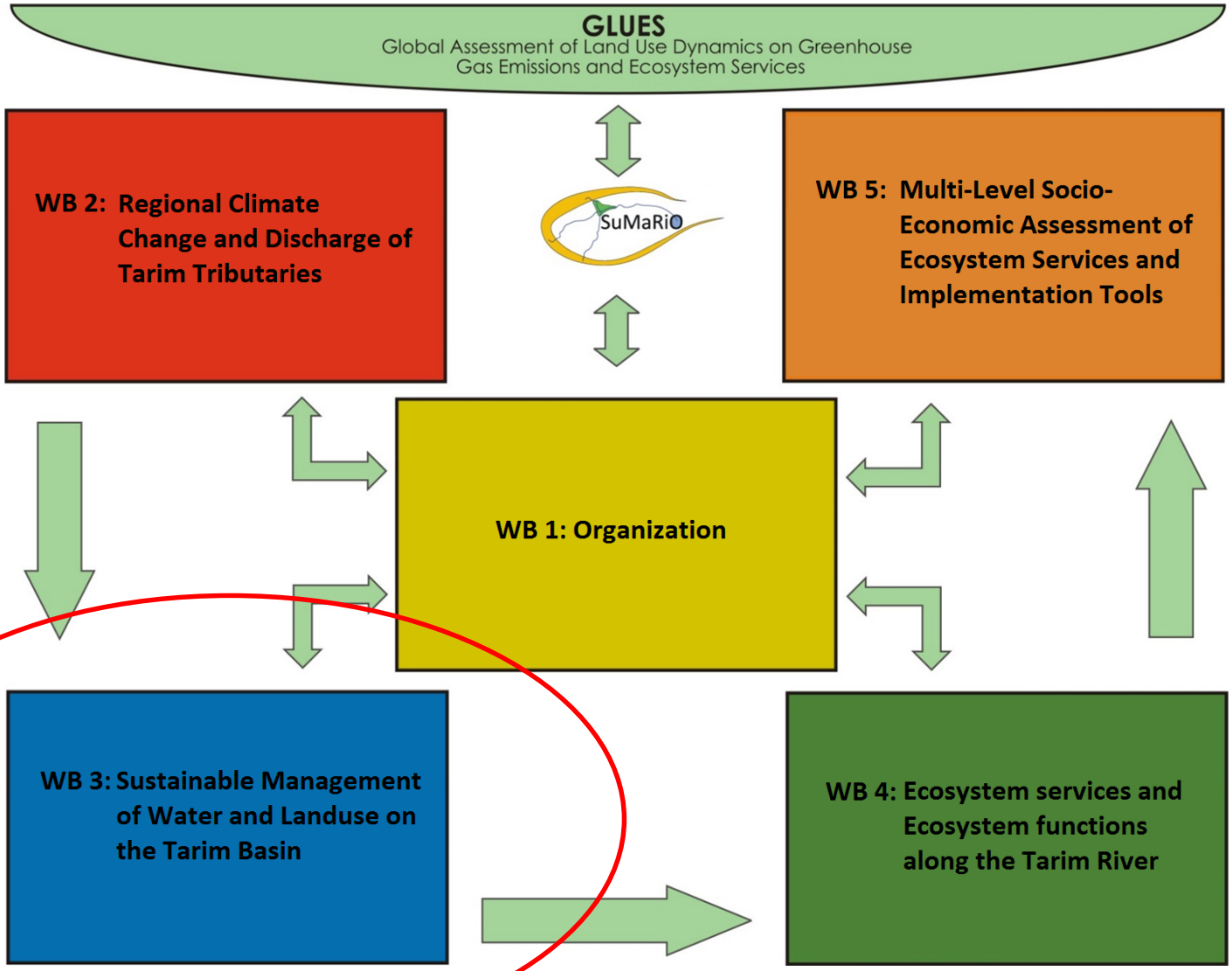
Project structure



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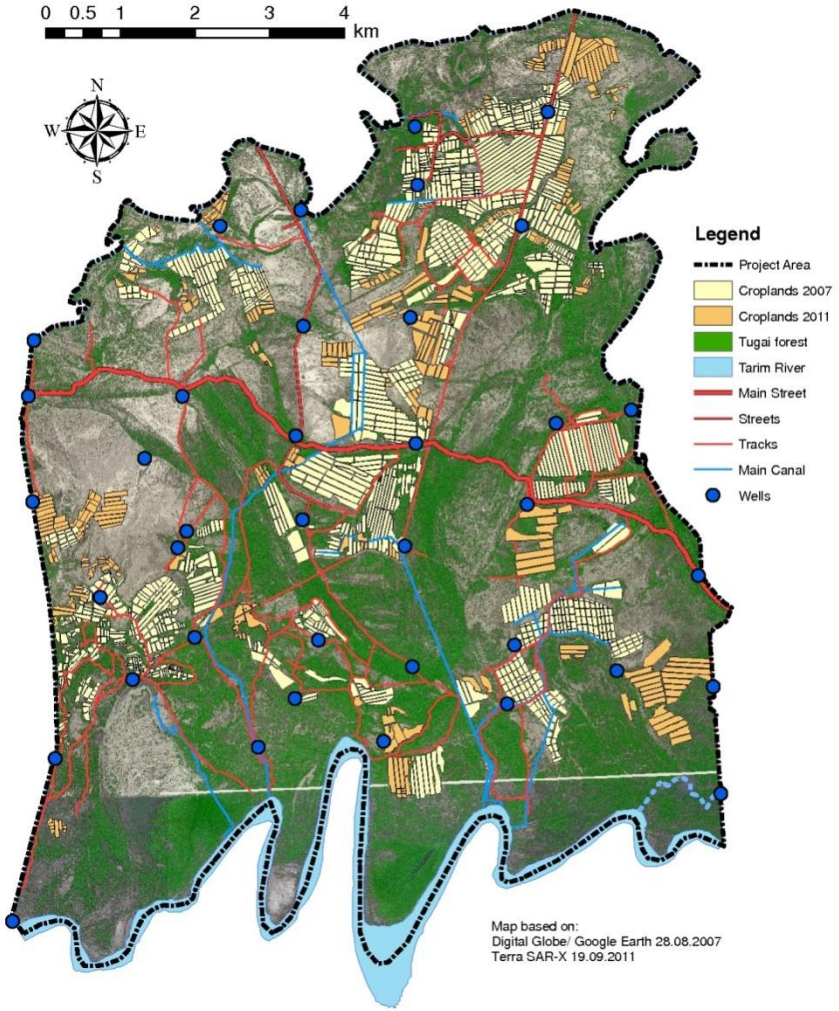
Mesoscale: Project Area Yengibazar

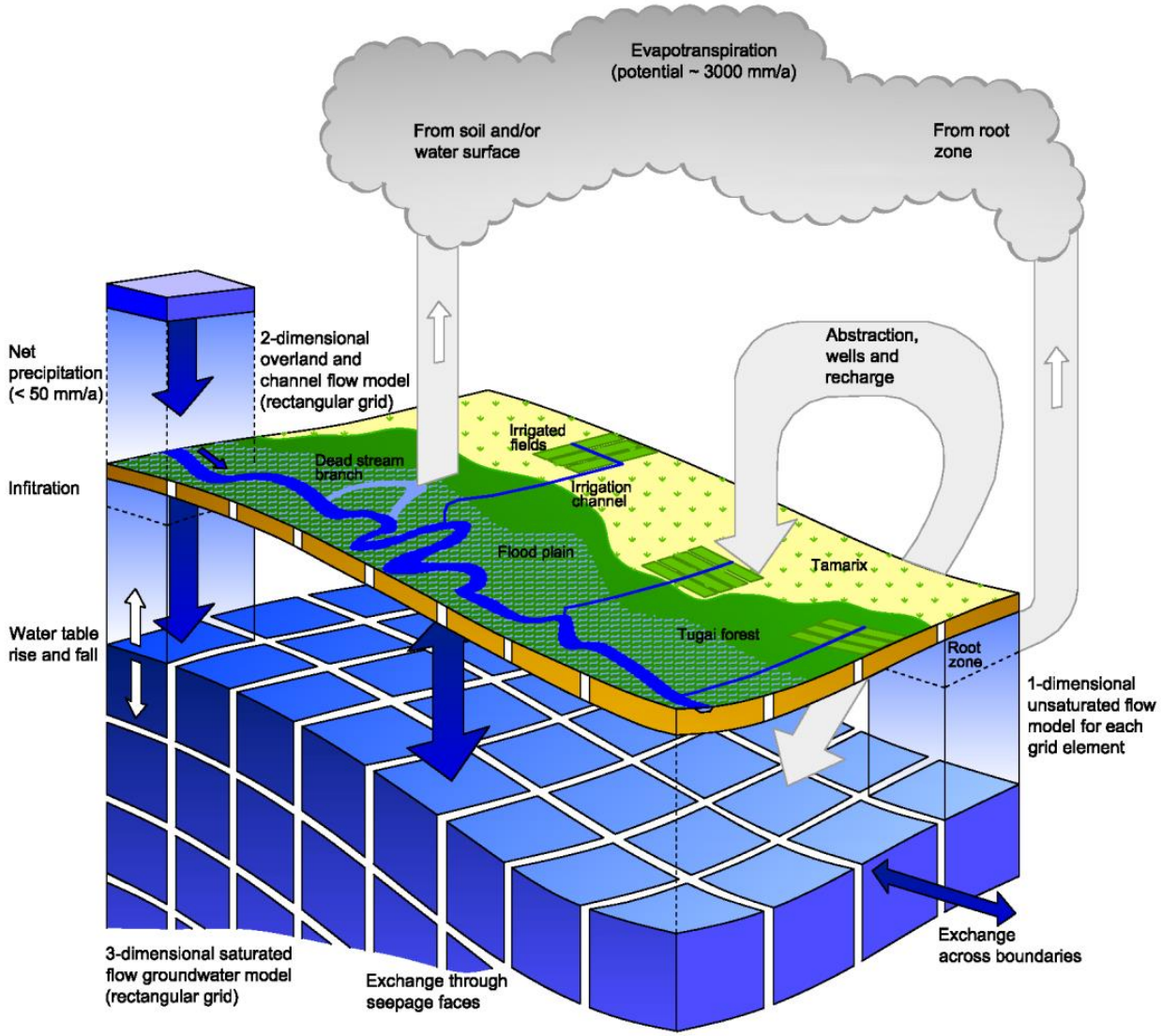


Source: Patrick Keilholz

- area (80 km²) located in the Tarim Populus Euphratica National Forest Park
- land use systems:
  - agriculture
  - natural Tugai-forests
  - desert vegetation
- Huge natural floodplains and direct connection to the Tarim
- dramatic land use change (cotton fields)

YEARS	AREA (km²)	EVOLUTION (%)
2004	11.1651	
2007	14.3025	28.10%
2011	19.4219	73.95%
2012	21.2190	90.05%
2013	25.4196	127.67%

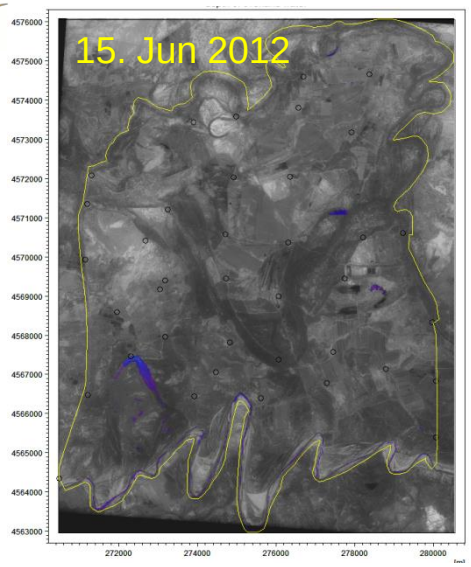
Hydrological models

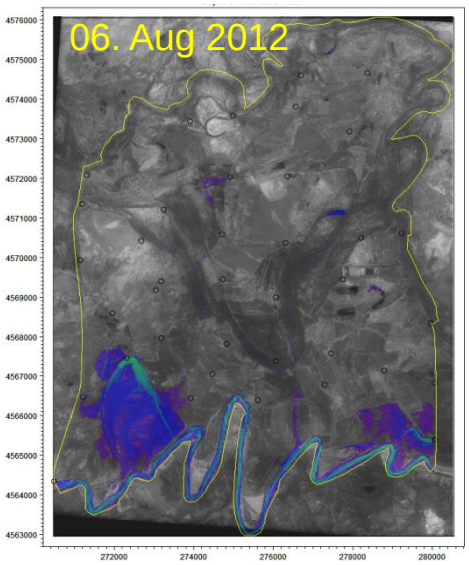


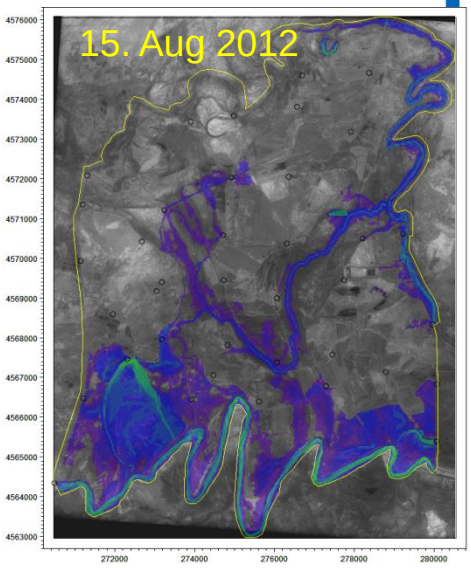
Model: MIKE SHE

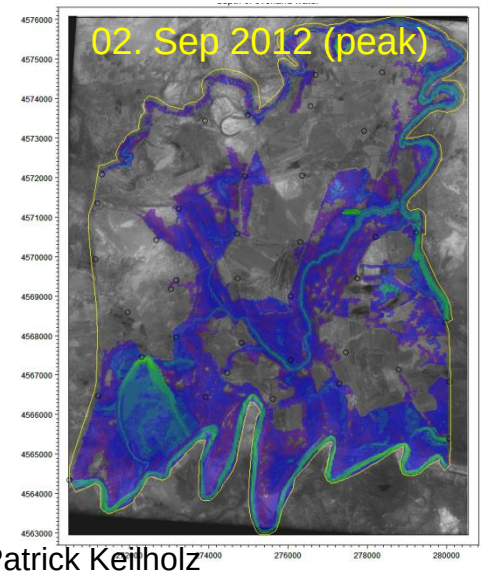
- Modelling 2d-surface water with the diffusive wave
- Groundwater module
- Irrigation module

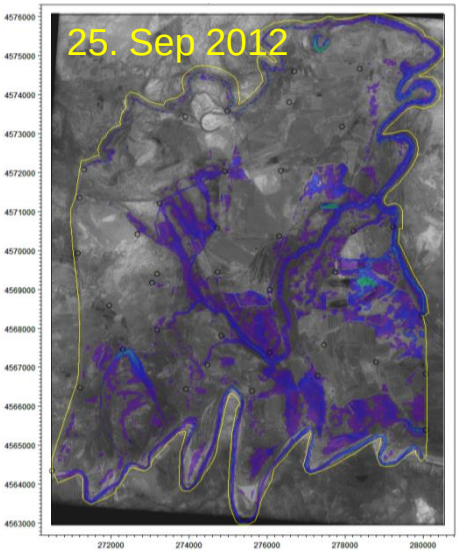
Modeled flooding for the year 2012

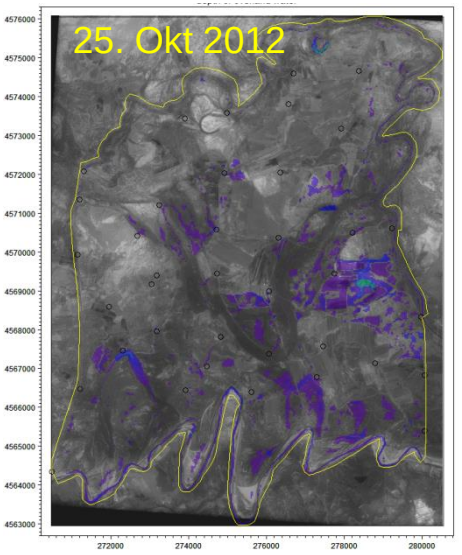


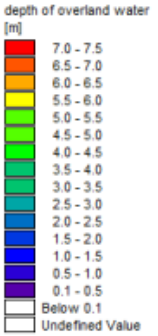






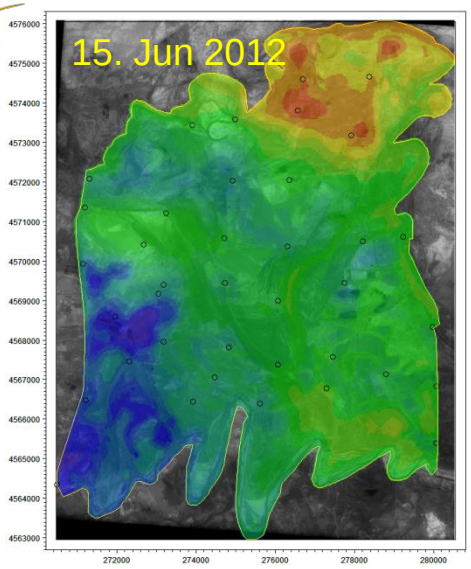


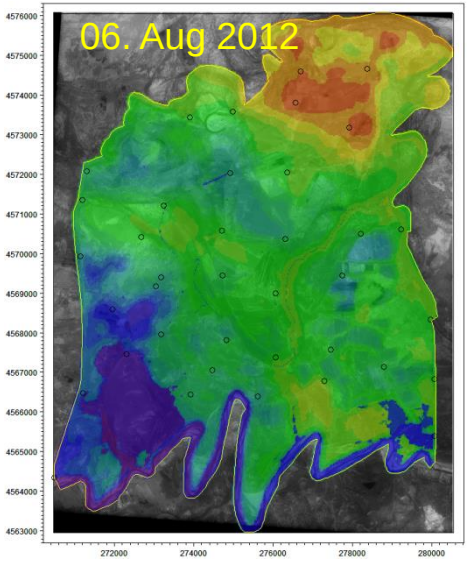


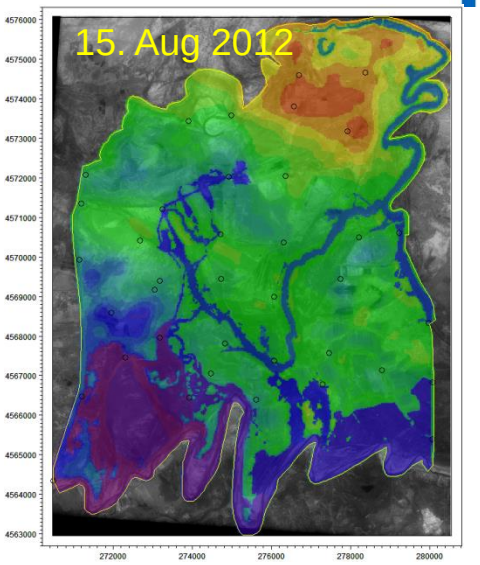


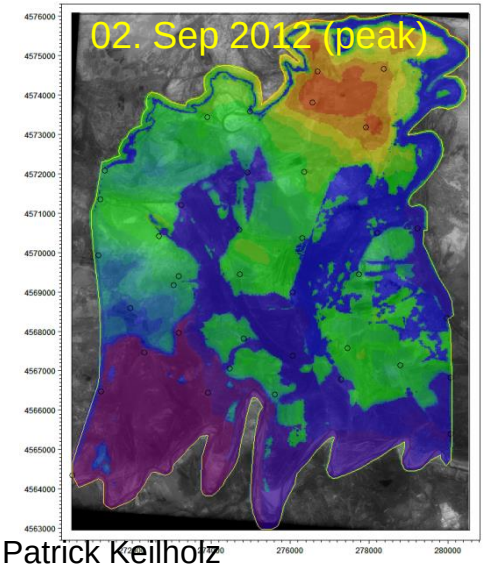
Source: Patrick Keilholz

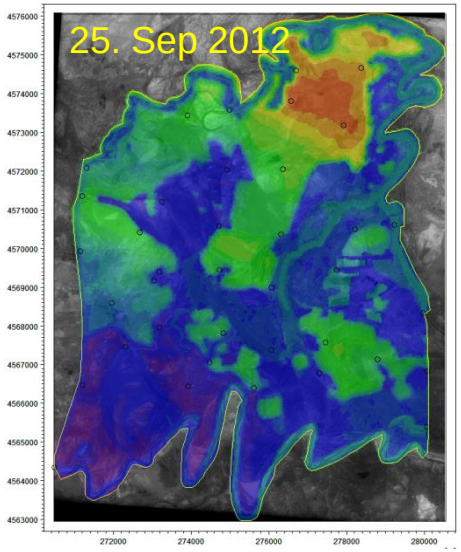
Changes in the groundwater levels (2012)

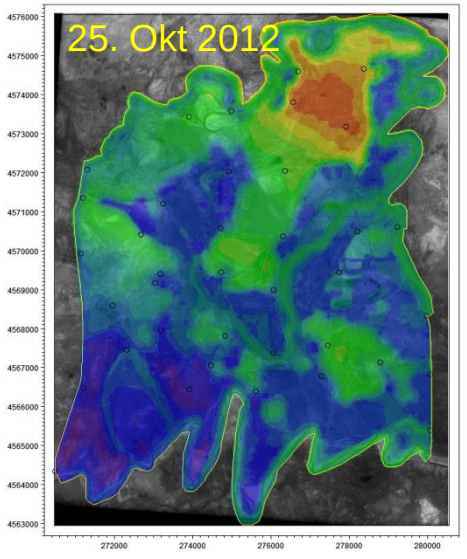


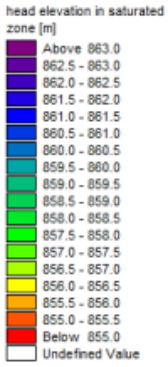












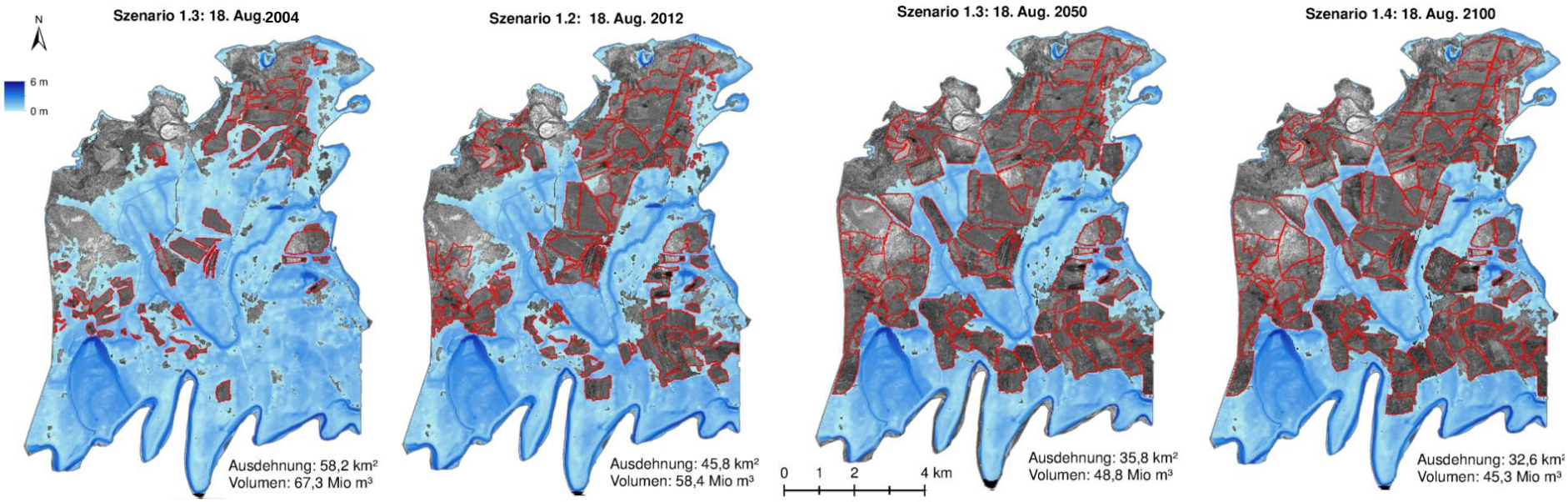
Source: Patrick Keilholz

Landuse- and climate scenarios

Major scenario	Scenario No.	Name	Extension of agriculture	Climate change		
				Tarim-Discharge	Temperature	Rainfall in area winter/sumer
Land use	1.1	Past2004	8,1 km²	MQ	0 °C	0 %
	1.2	Present 2012	19,3 km²	MQ	0 °C	0 %
	1.3	Future 2050 L	32,2 km²	MQ	0 °C	0 %
	1.4	Future 2100 L	34,5 km²	MQ	0 °C	0 %
Climate	2.1 = 1.2	Present 2012	19,3 km²	MQ	0 °C	0 %
	2.2	Future 2050 K	19,3 km²	HQ	+ 2,2 °C	+5 %/ +10 %
	2.3	Future 2100 K	19,3 km²	NQ	+ 3,0 °C	+10 %/ +20 %
Climate & Land use	3.1 = 2.1	Present 2012	19,3 km²	MQ	0 °C	0 %
	3.2	Future 2050 K+L	32,2 km²	HQ	+ 2,2 °C	+5 %/ +10 %
	3.3	Future 2100 K +L	34,5 km²	NQ	+ 3,0 °C	+10 %/ +20 %
Embankment	4.1 = 3.1	Present 2012	19,3 km²	MQ	0 °C	0 %
	4.2	Embankments2012	19,3 km² + dike	MQ	0 °C	0 %

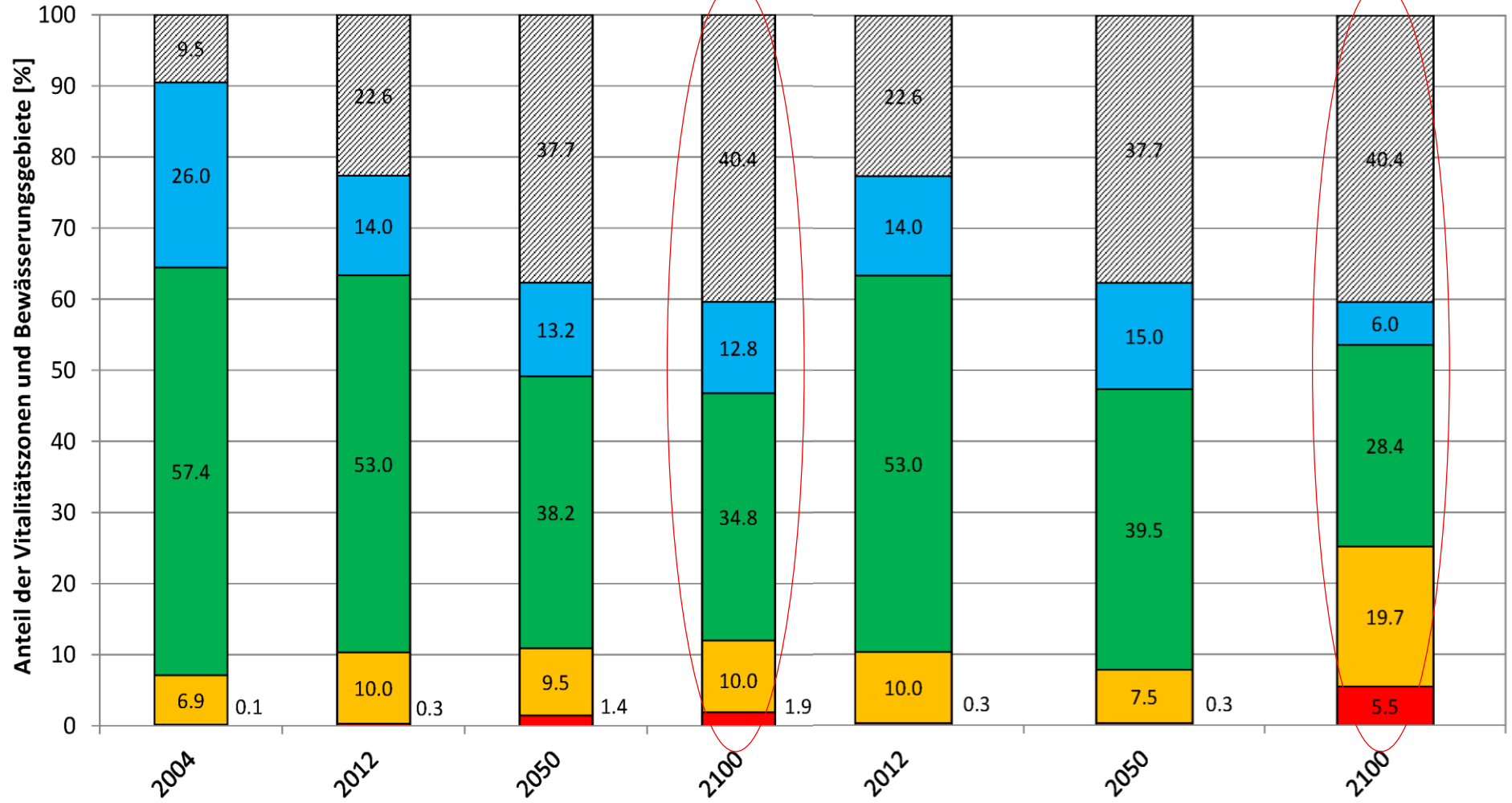
Source: Patrick Keilholz

Changes in the flooding by land use changes



Source: Patrick Keilholz

Effects to the vitality of the natural vegetation by land use changes plus climate changes



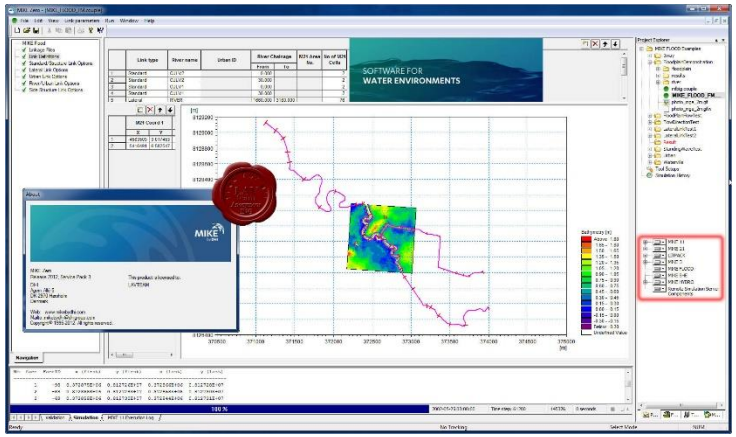
Source: Patrick Keilholz

Macroscale: Tarim River and irrigated areas

- **Water availability & allocation in a sustainable way**
- **Climate and land use changes**
- **Vitality of the Tugai-vegetation at the lower reaches of the Tarim**

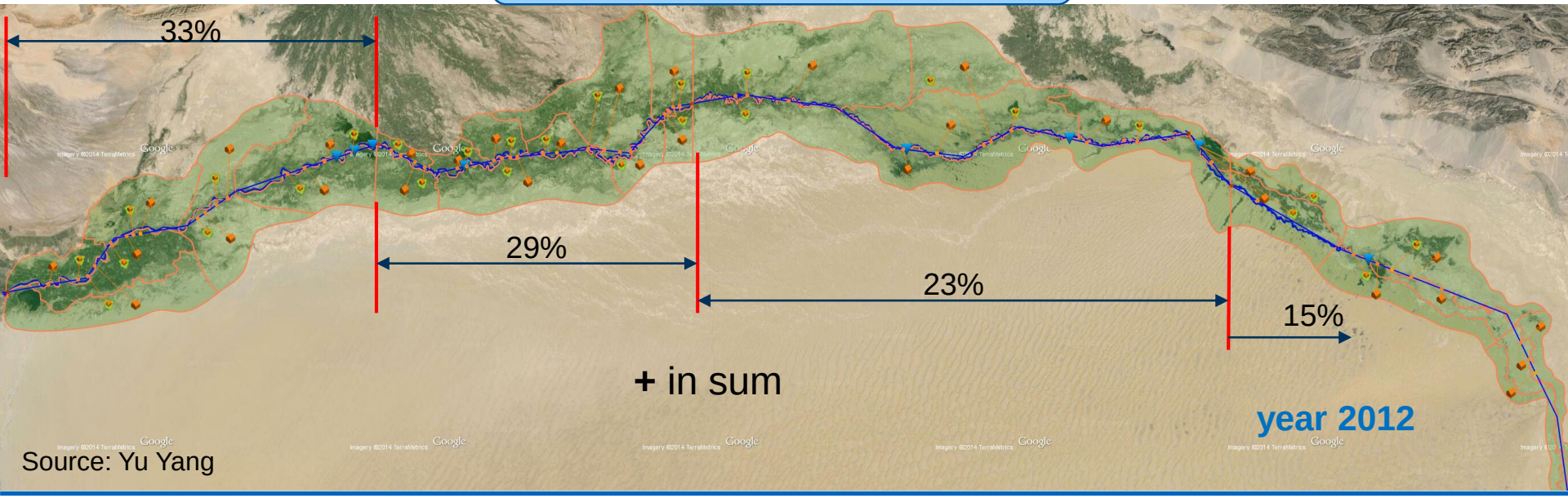
Source: Yu Yang

Macroscale: Tarim River and irrigated areas



Water and Land Management Tool: MIKE Hydro

Agricultural water consumption



Source: Yu Yang

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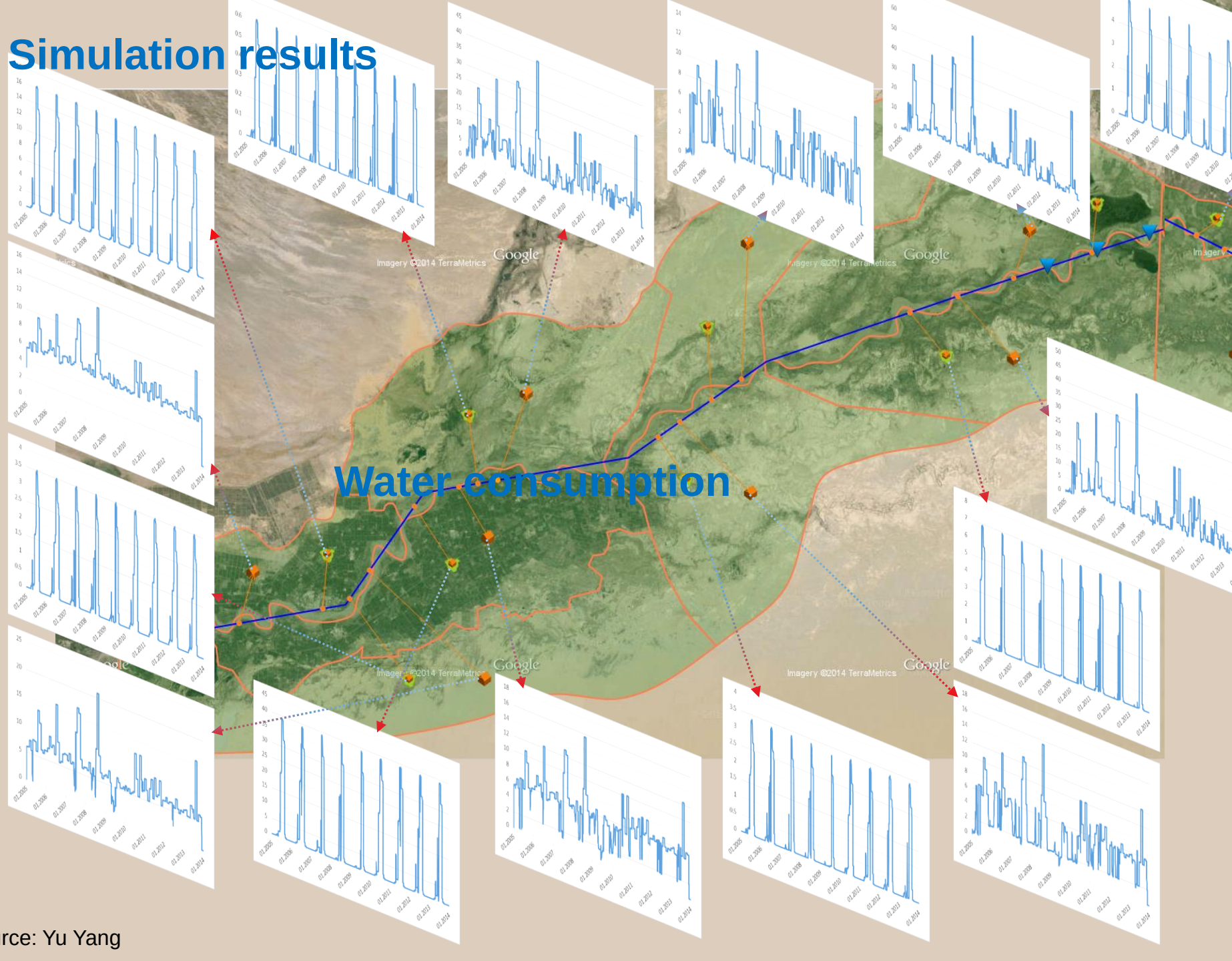
Simulation results



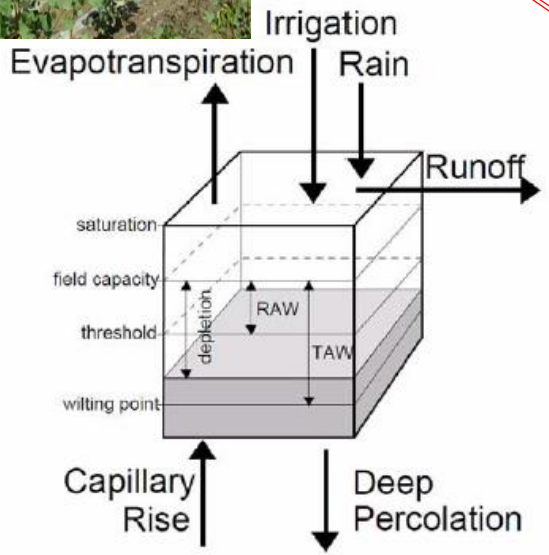
Source: Yu Yang

Tarim Water Allocation module

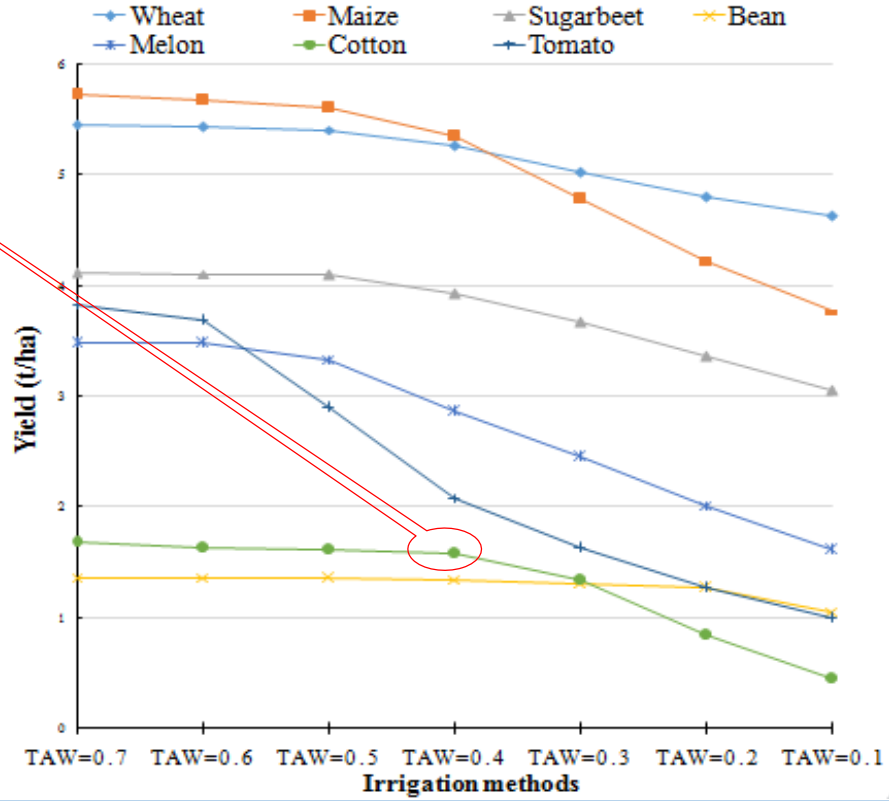
Yield performance of crops

Water use-yield relationship:

$$(1-\frac{Y_a}{Y_m}) = K_y(1-\frac{ET_a}{ET_c})$$



Yield performance of crops based on fraction of total available water (TAW)

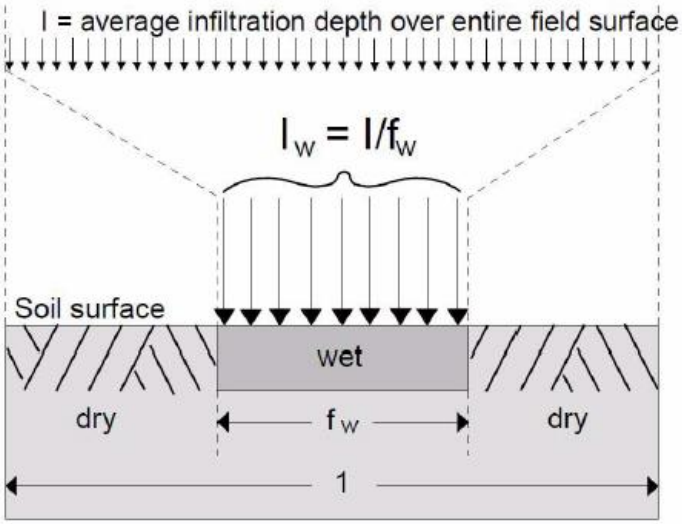


Yang Yu, 2015 (*Water* **2015**, *7*)

Tarim Water Allocation module

Water-saving irrigation

Drip irrigation under mulch (DIUM)



Five DIUM scenarios and simulation results.

% DIUM	% WF	% WS
10	91	6
30	73	17
50	55	25
70	37	32
100	10	40

% DIUM: percentage of applied drip irrigation under mulch in the field.

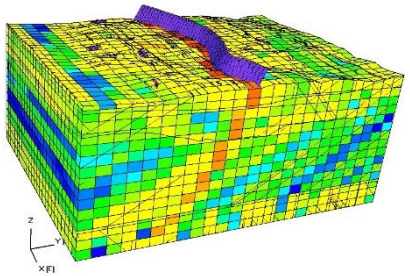
% WF: percentage of wetting fraction.

% WS: percentage of water saving.

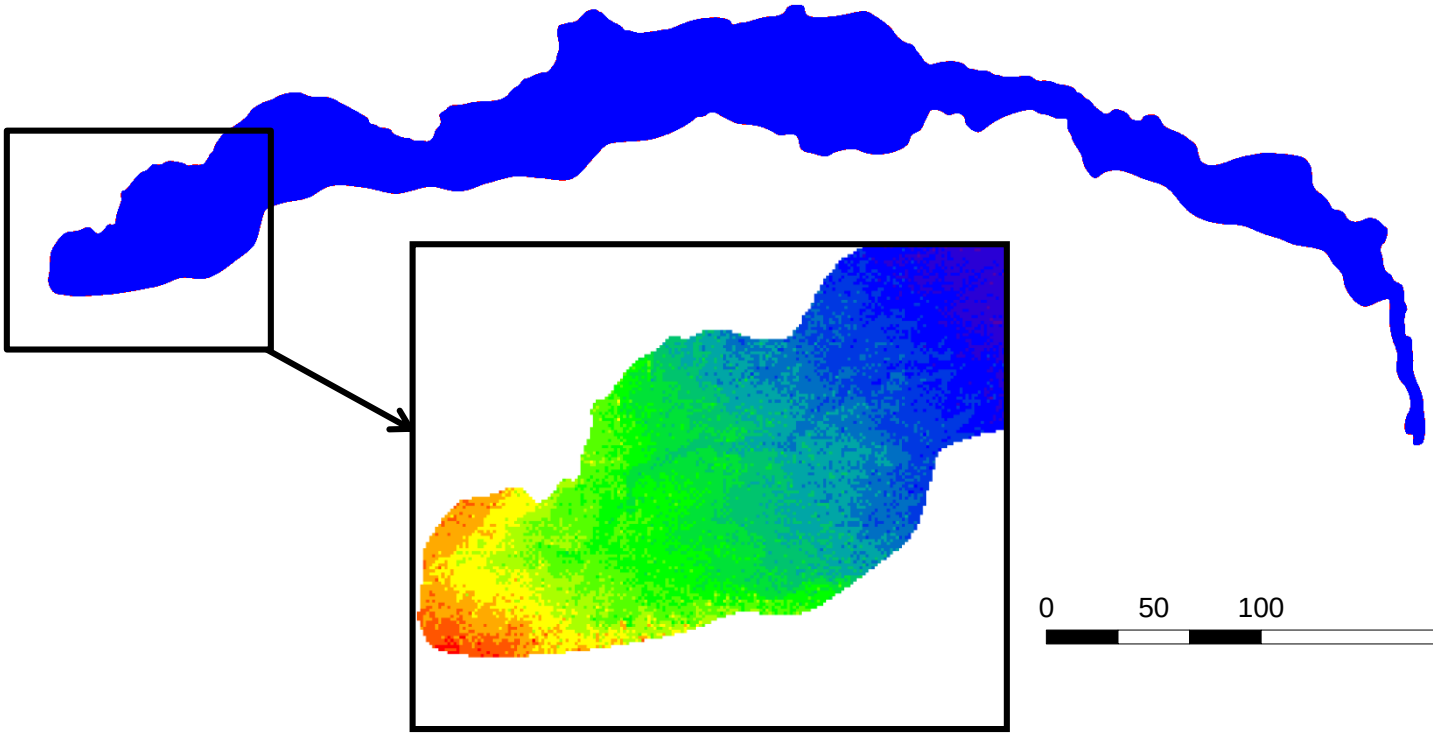
Source: Yu Yang

Macroscale: Groundwater module

- Derived by the groundwater model MODFLOW
- Distinguishes between different groundwater recharge processes

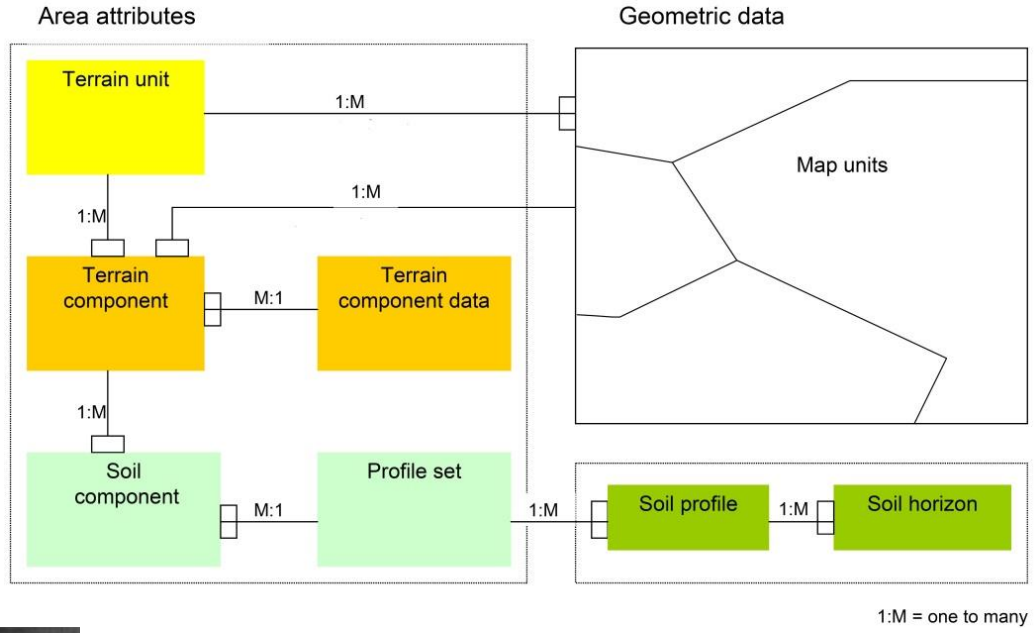


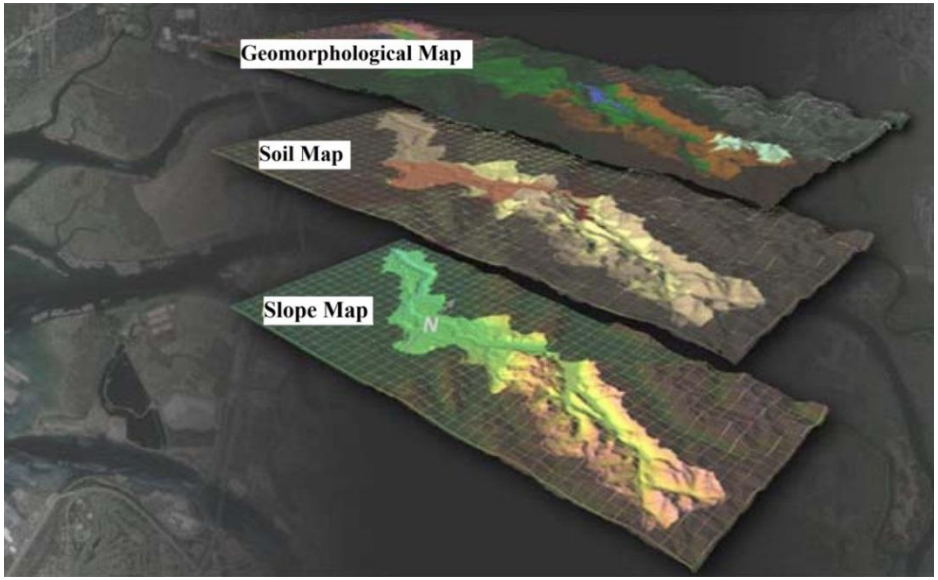
MODFLOW: USGS three-dimensional finite-difference ground-water model



Establishment of SOTER Database

- (**SO**il & **TER**rain 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**

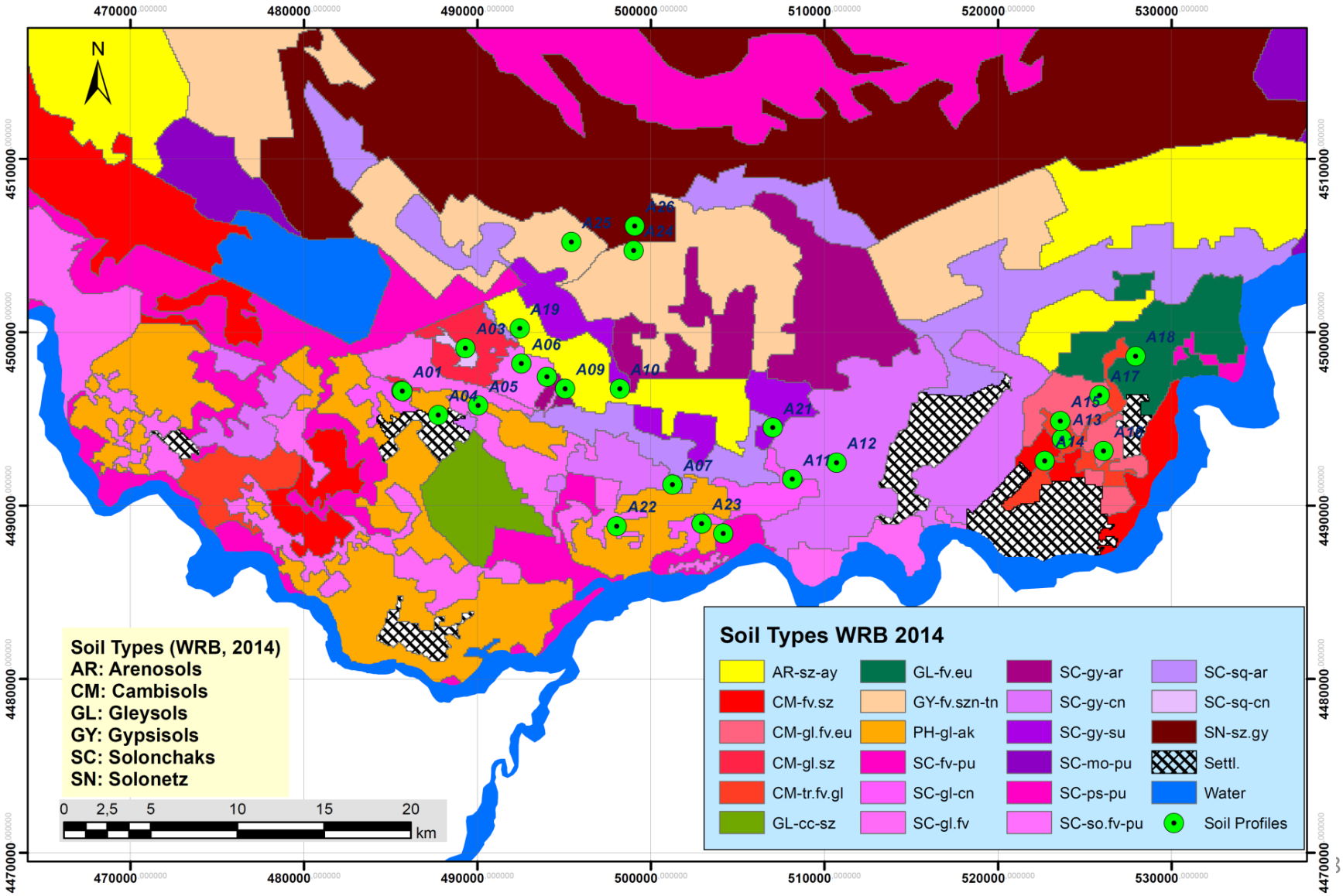




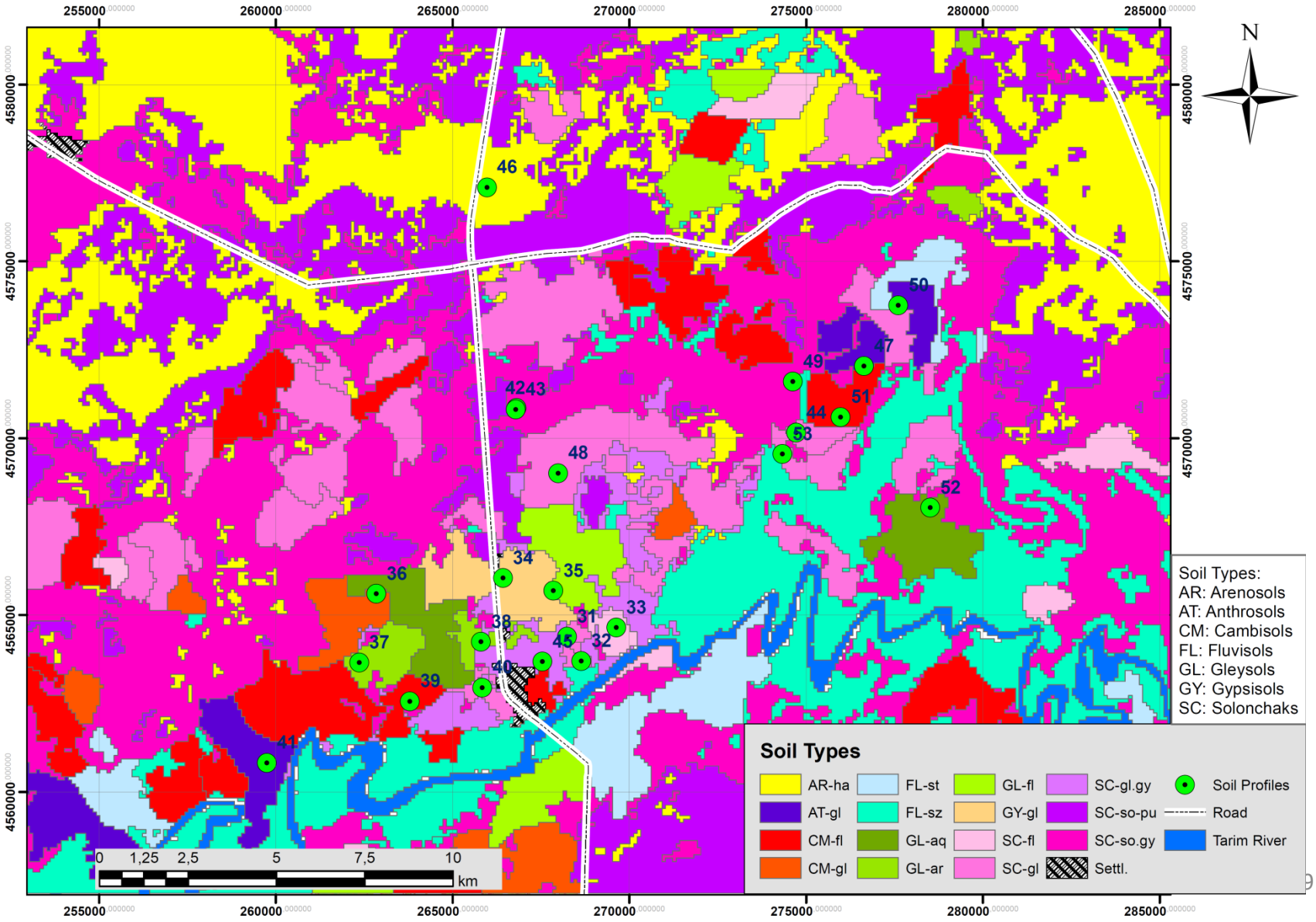
Constructed by overlaying maps:

- Geological maps (available)
- Soil maps (prepared)
- Slope maps (from SRTM90m)
- Land use / land cover maps (Landsat)
- Map of soil salinity

The soil map of Aksu-Alar region



The soil map of Yingbazar region



Soil survey: Dominant Soil Types

Gleyic Solonetz

Salic Solonetz

Puffic Solonchaks

Soil survey: Dominant Soil Types

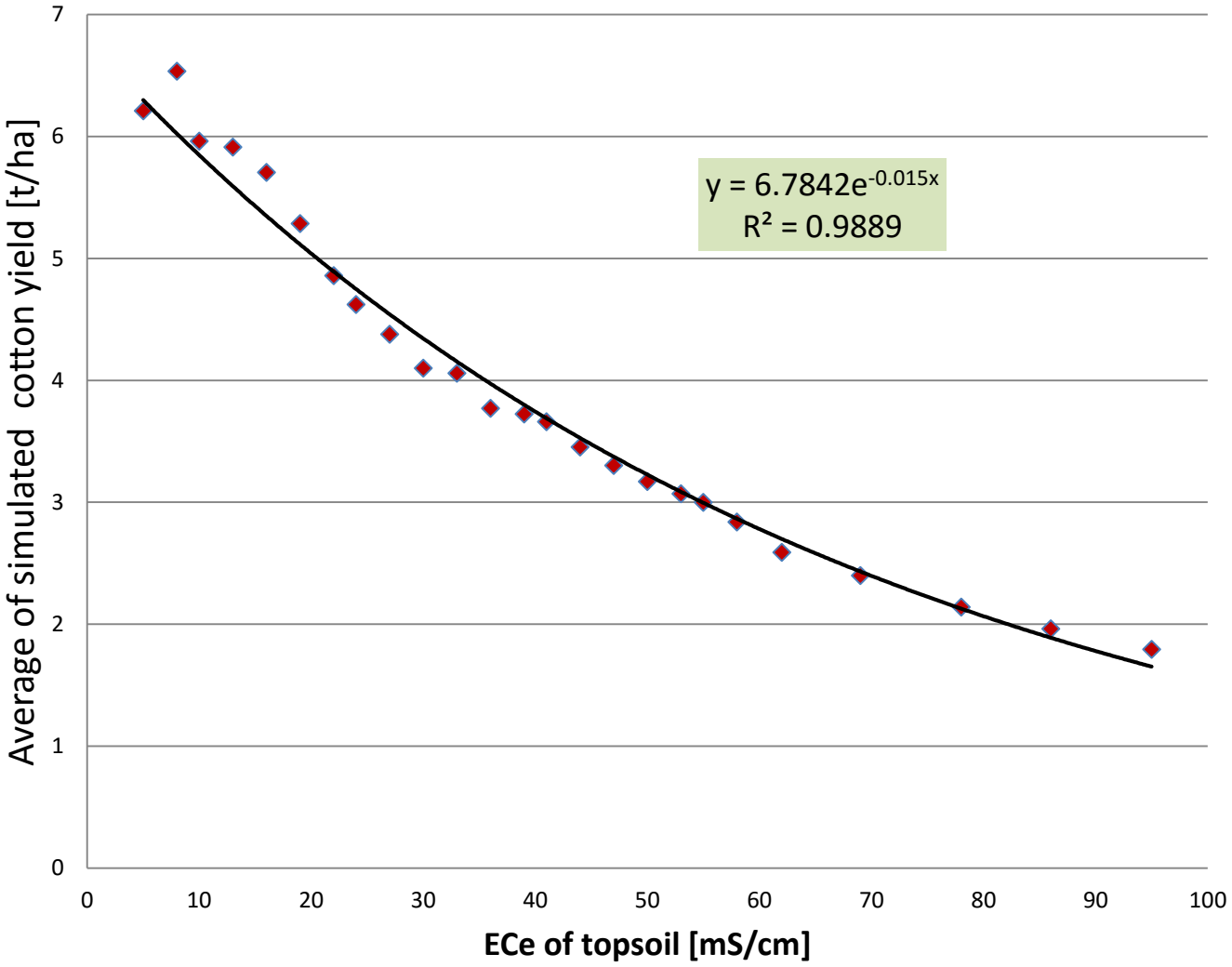
Calcic Gypsisols

Calcic Gleysols

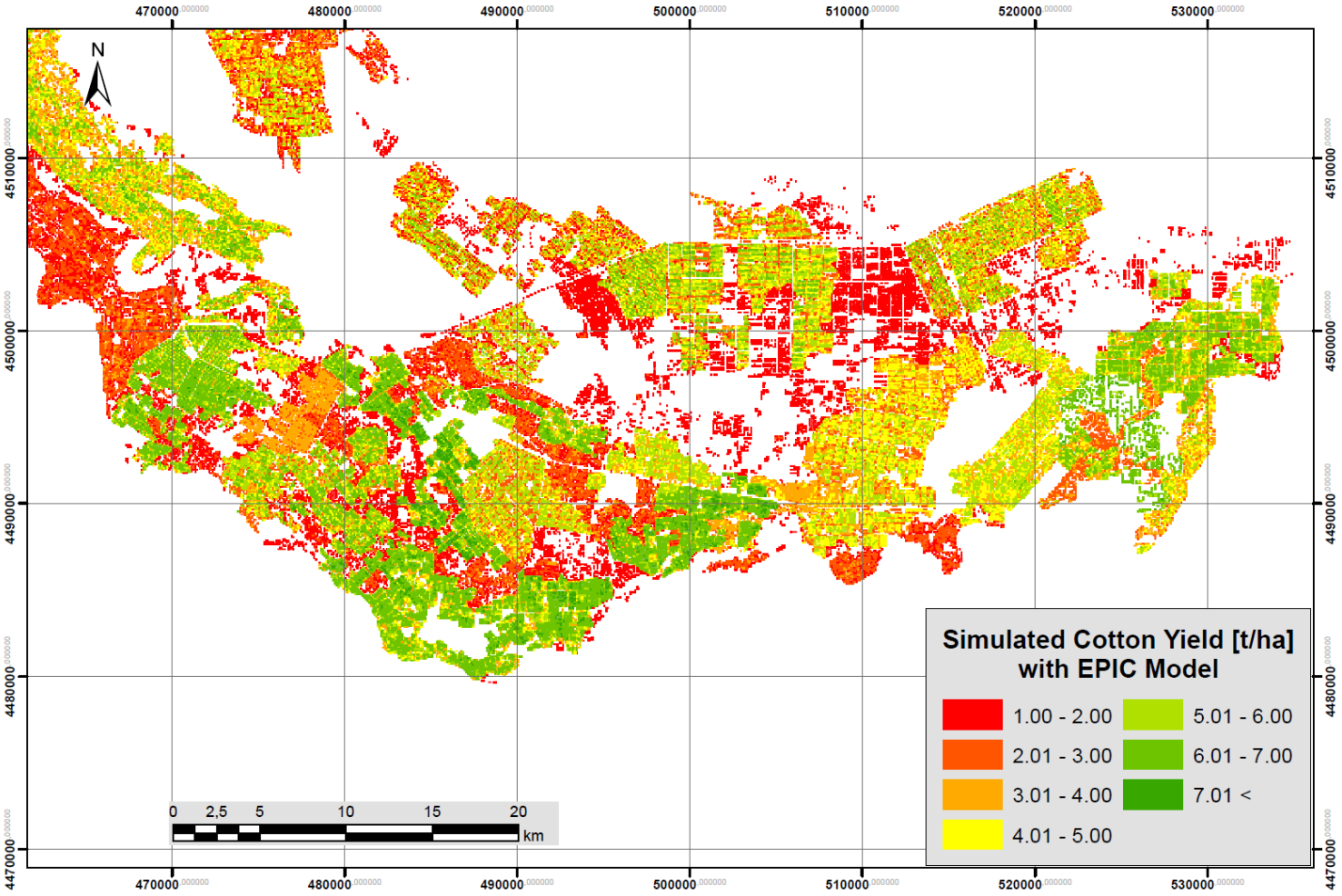
Gleyic Fluvisols

Cotton yield simulation with the EPIC model

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

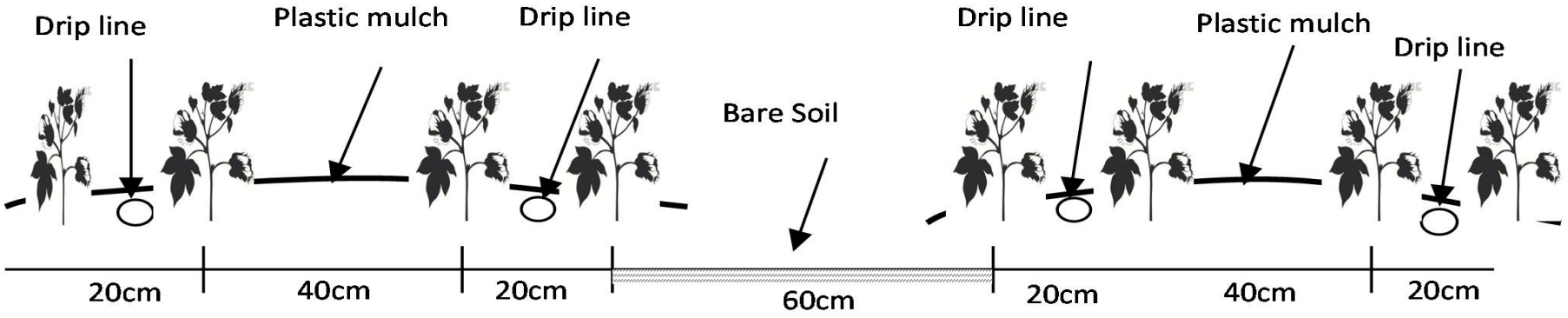


Cotton yield simulation with the EPIC model

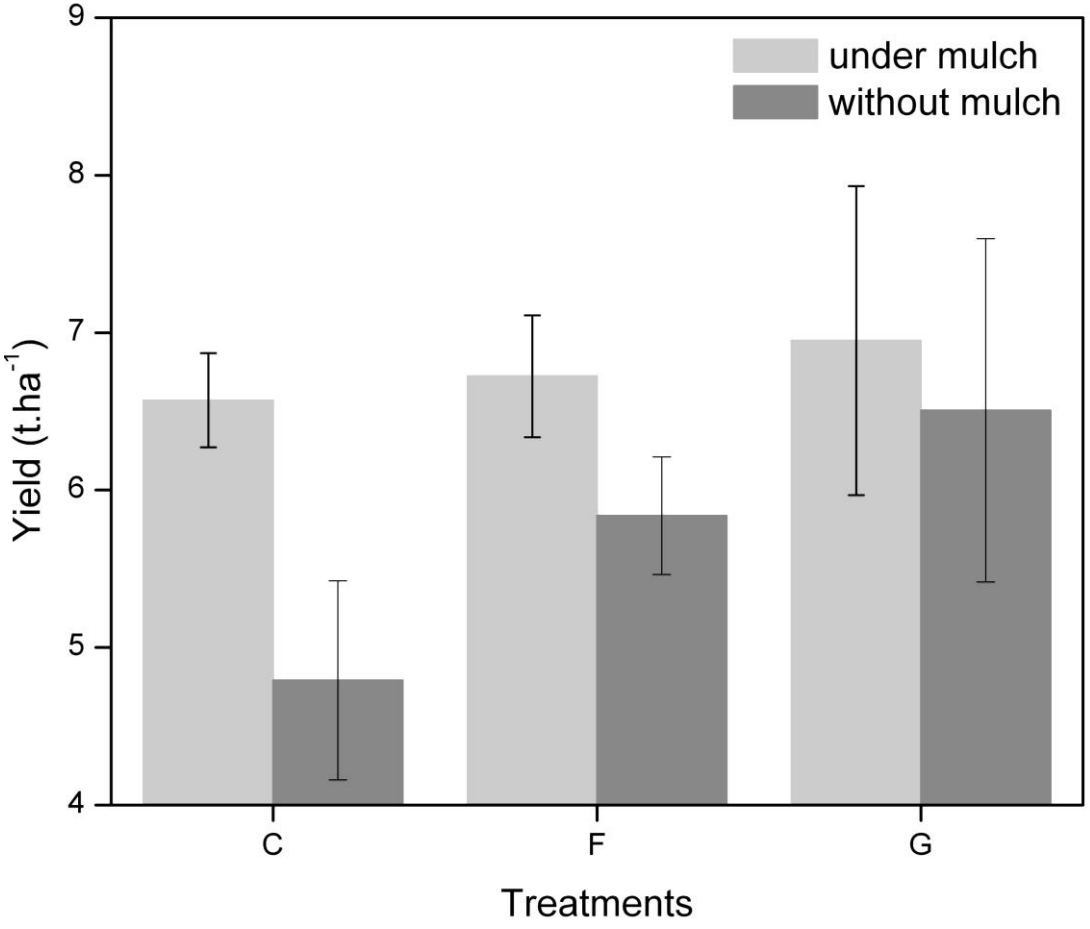


The total simulated cotton yield in the region under current conditions = 328,700 t

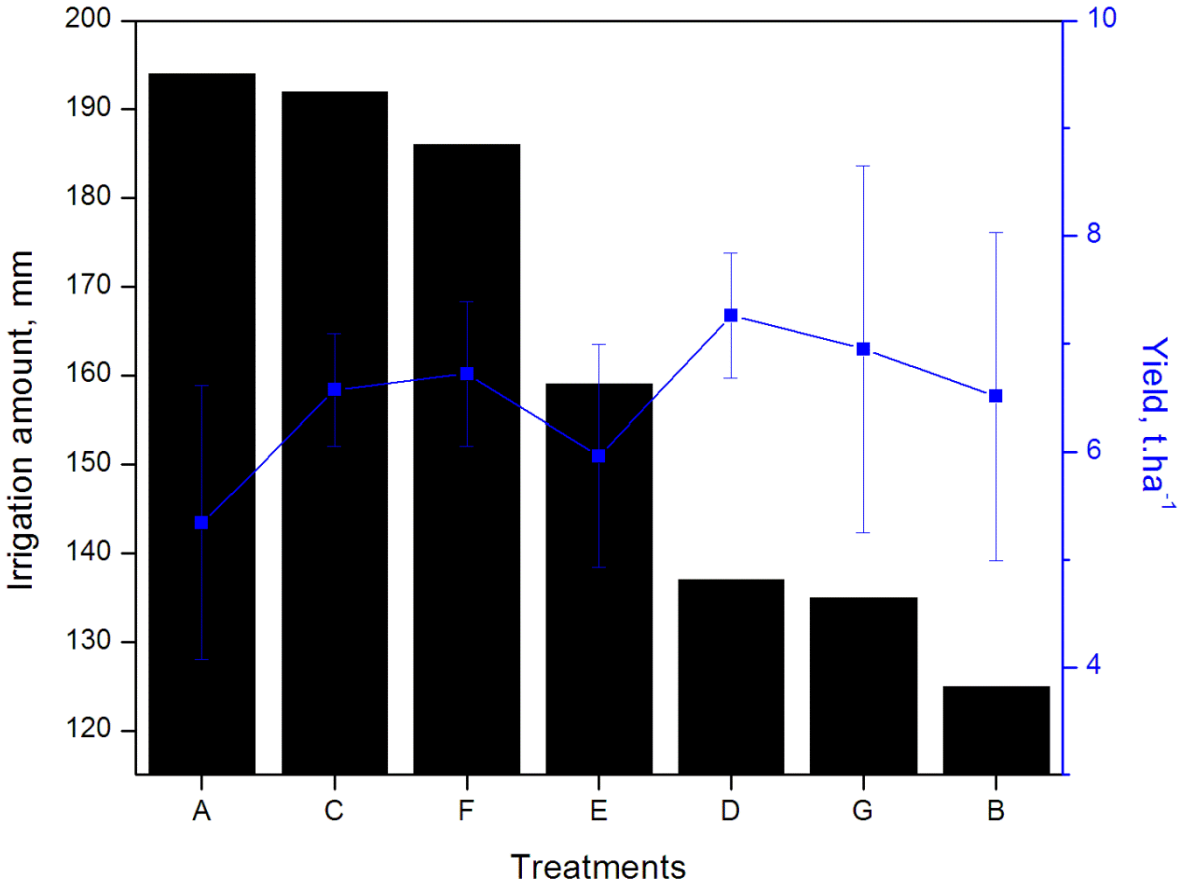
Drip irrigation under plastic mulch



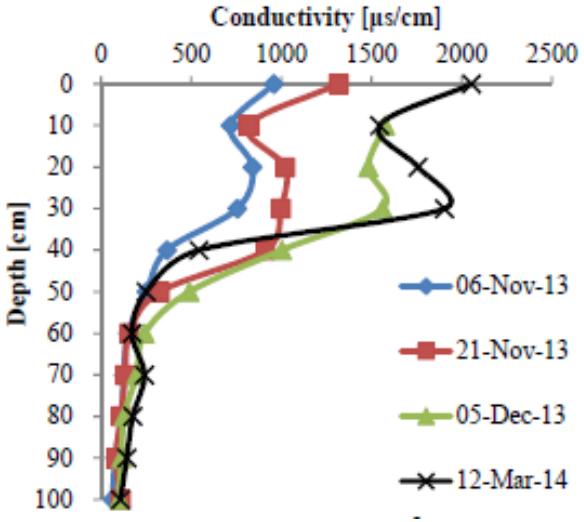
Effect of plastic mulch on yield



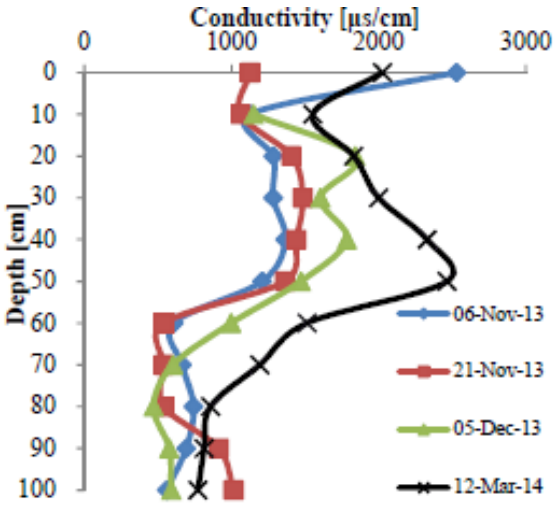
Deficit irrigation



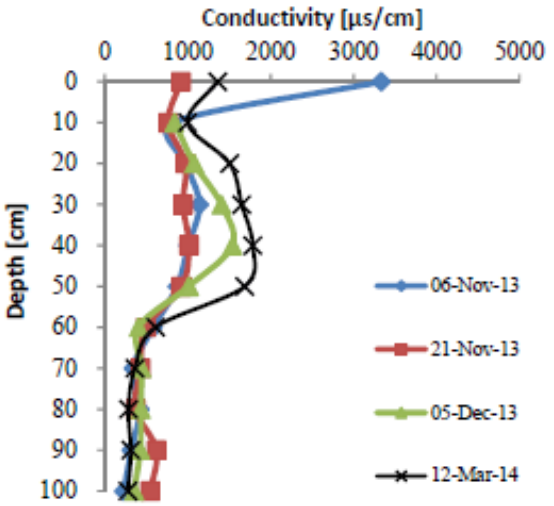
Salinity after winter leaching



Control

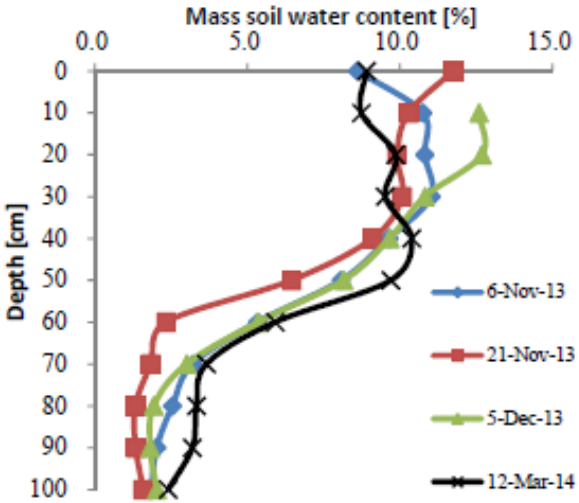


1200 $m^3.ha^{-1}$

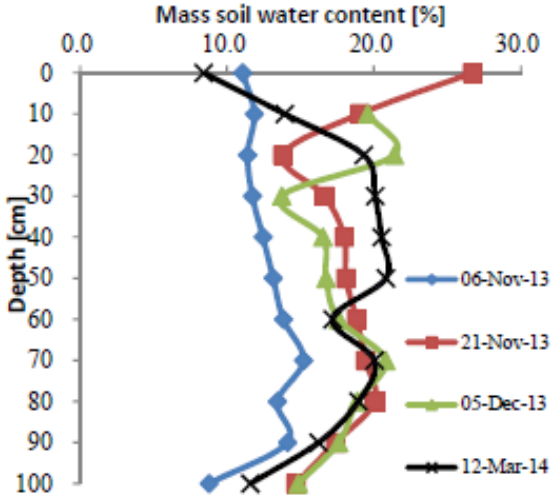


3600 $m^3.ha^{-1}$

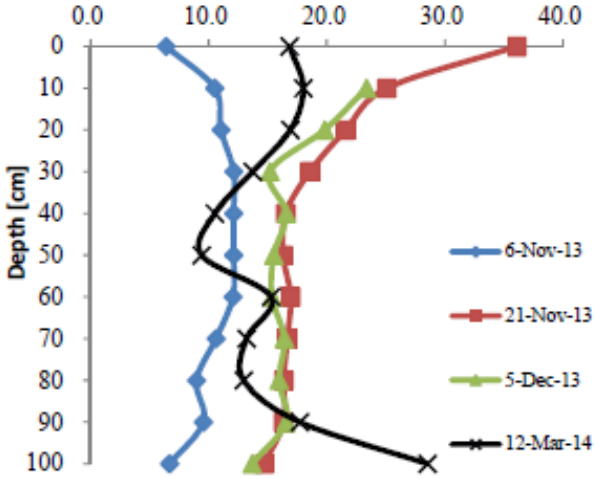
Soil moisture content after winter leaching



Control



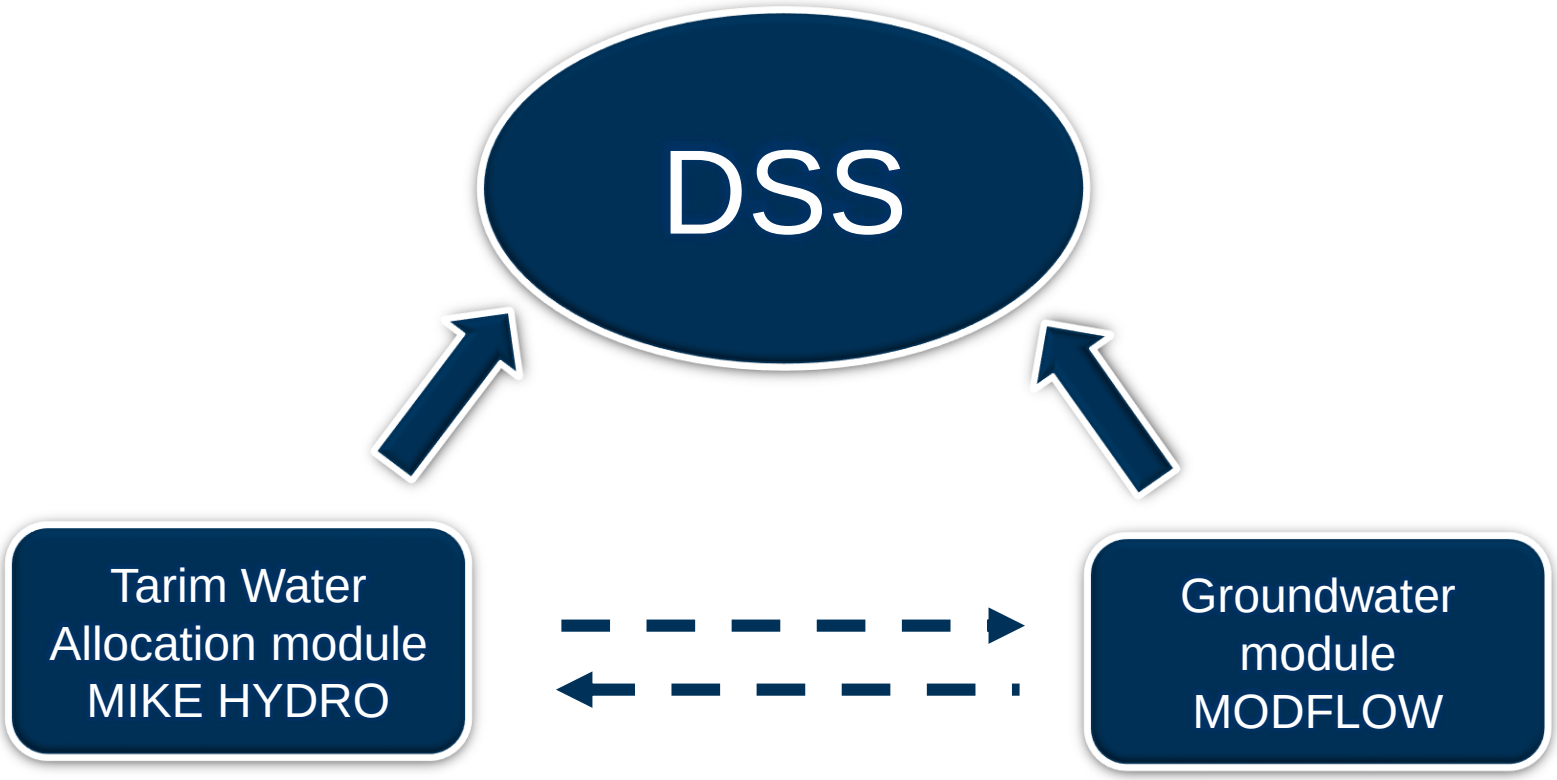
1200 $m^3.ha^{-1}$



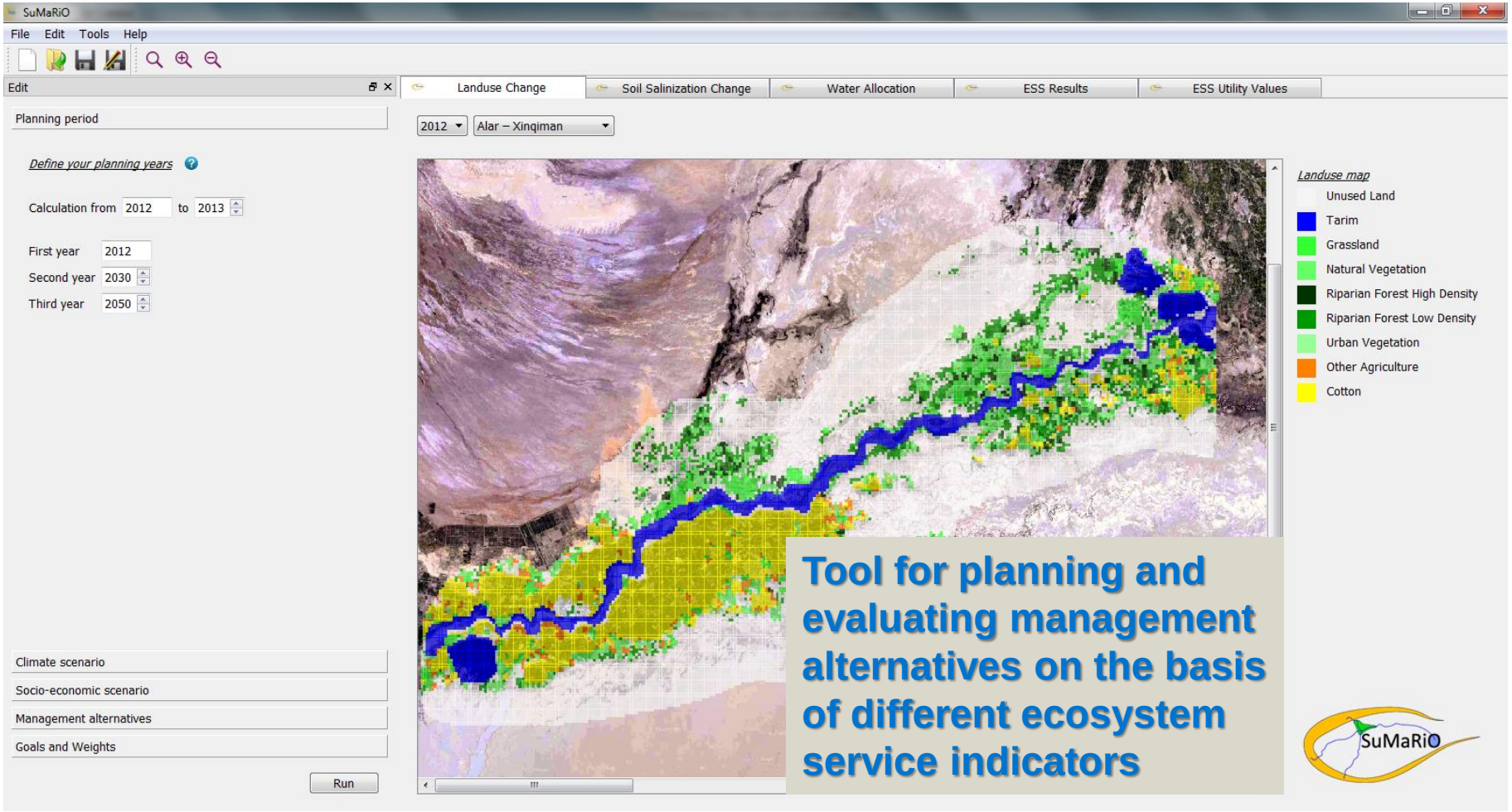
3600 $m^3.ha^{-1}$

Input for the Decision Support System (DSS)

Two connected branches of computation



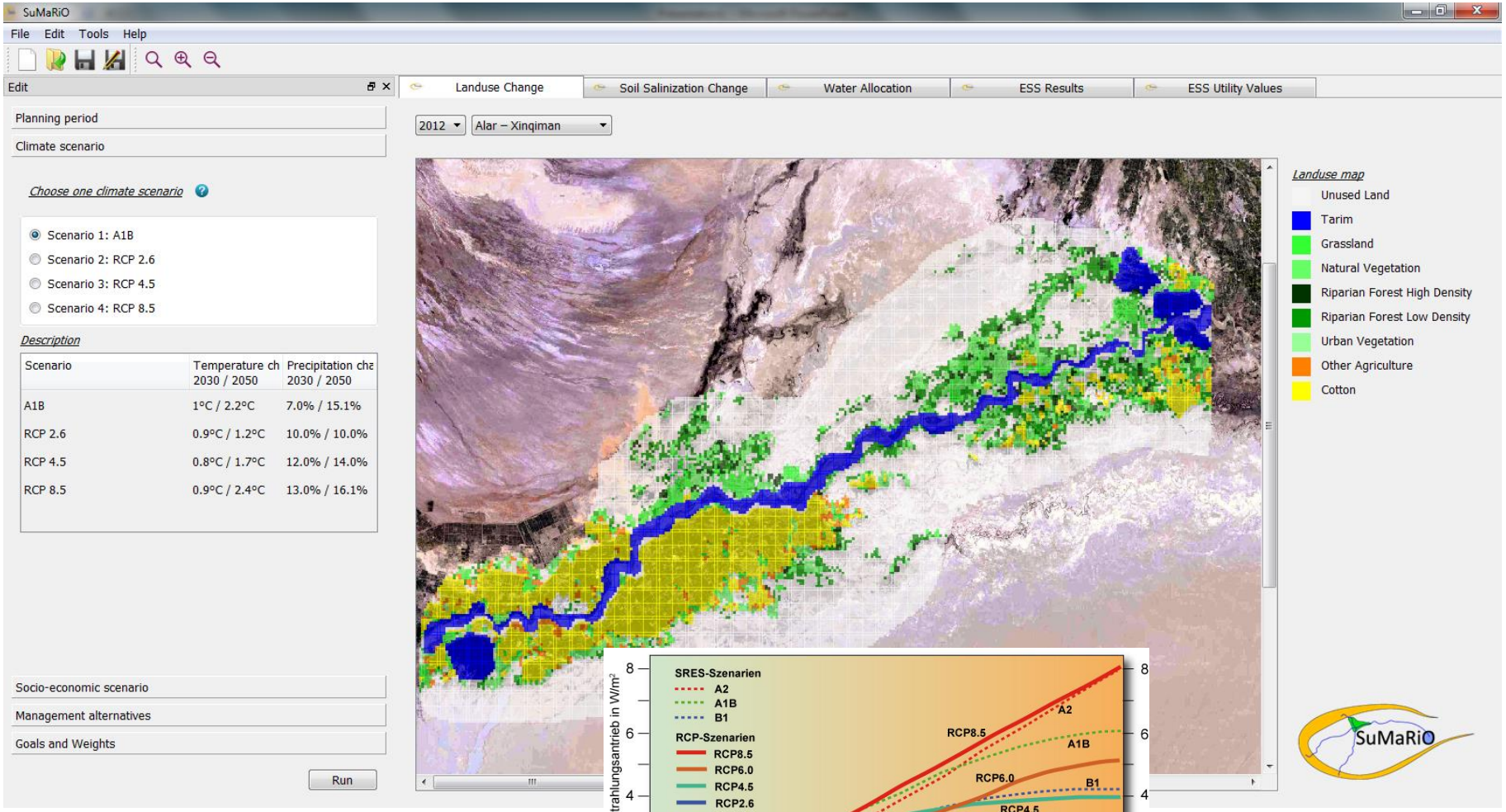
SuMaRiO DSS



Source: Marie Hinnenthal

SuMaRiO DSS

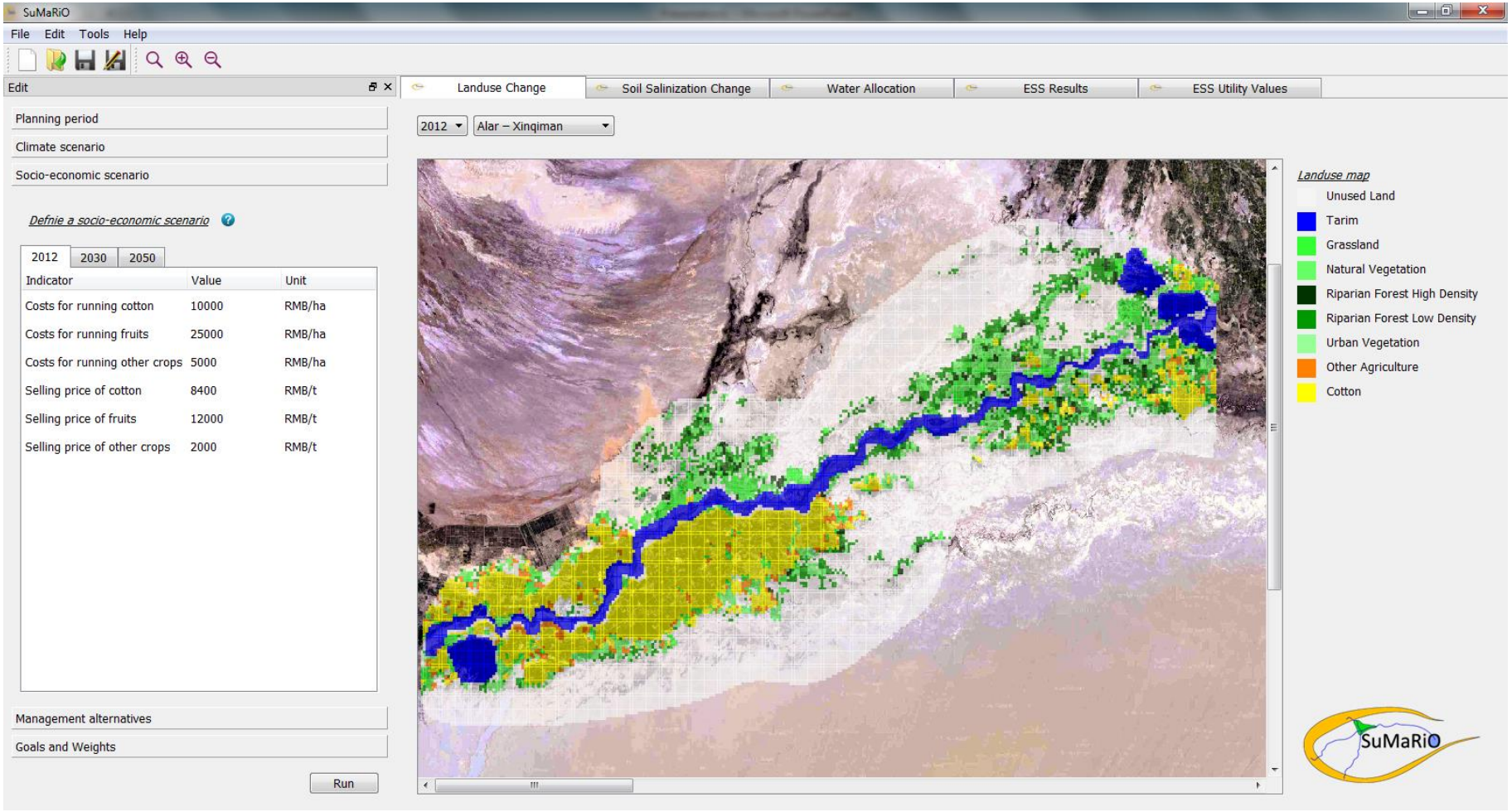
User input: Climate scenario



Source: Marie Hinnenthal

SuMaRiO DSS

User input: Socio-economic scenario



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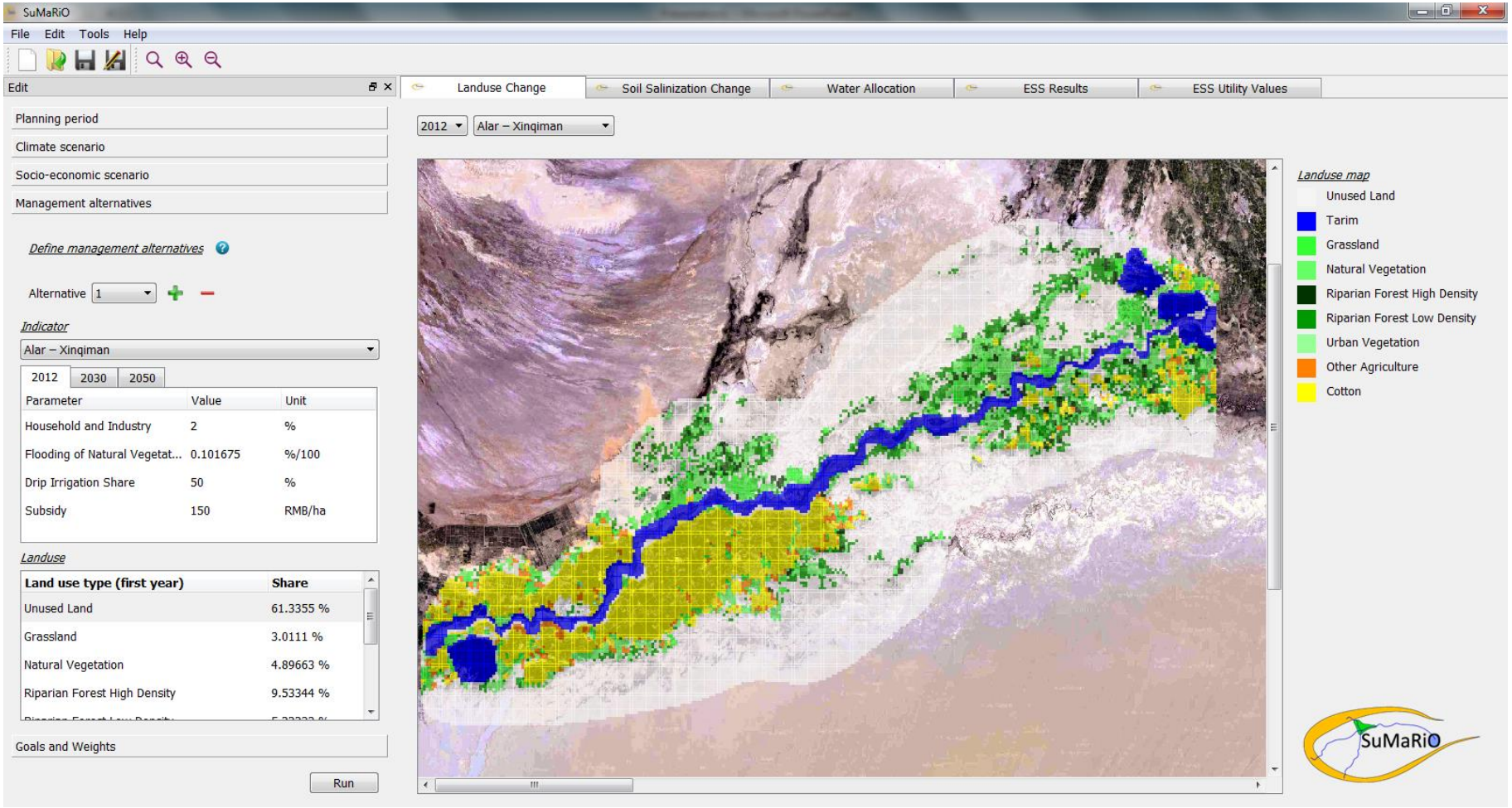
User input: Management alternatives



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: Weights and Goals

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View Tools

Setup

Planning period

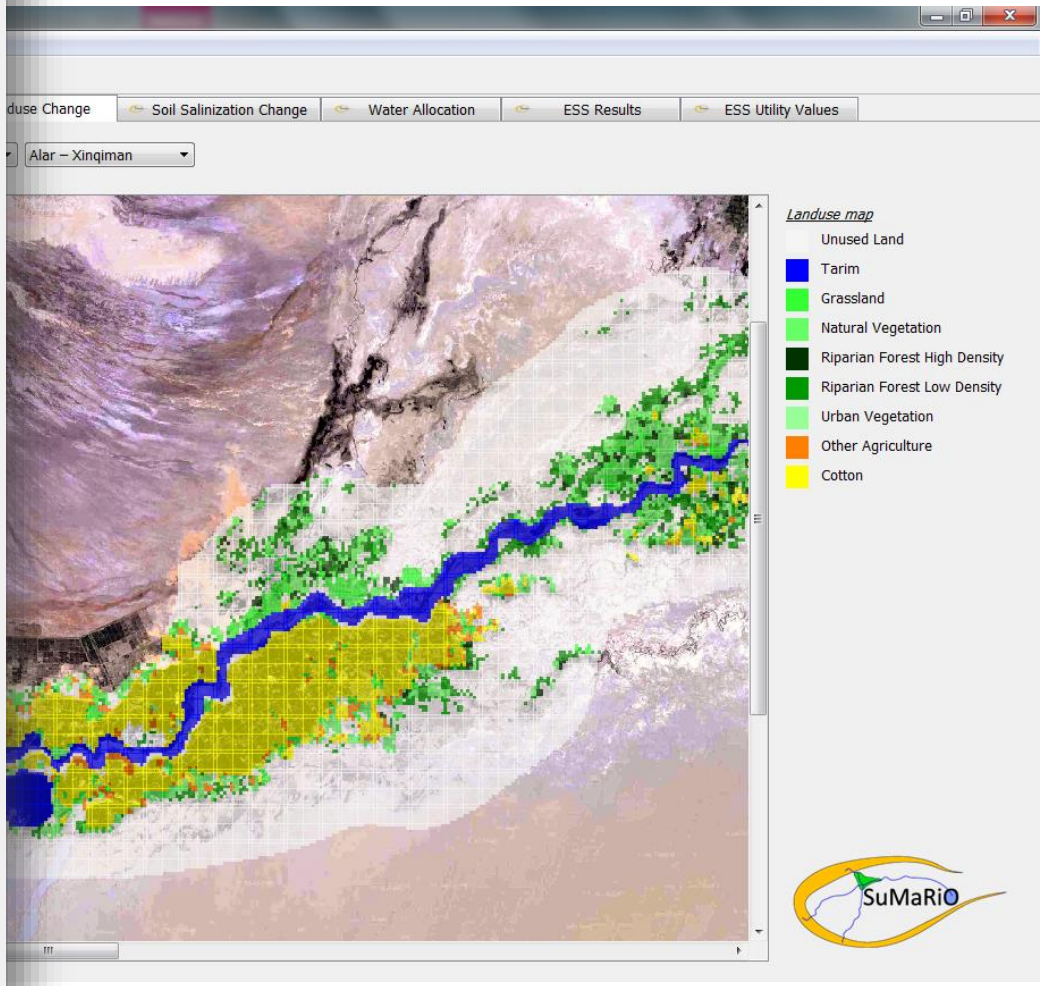
Socio-Economical Indicators

Management alternatives

Goals and Weights

Alar – Xinqiman

Indicator	Weight	Goal	Unit
Agriculture	4,00		
Provisioning se...	5,00		
Cotton pro...	4,00	0,00	million t
Fruit produ...	4,00	0,00	million t
Production ...	5,00	0,00	million t
Farmers inc...	5,00	0,00	million RMB
Riparian Forest	3,00		
Provisioning Se...	2,00		
Biomass pr...	2,00	0,00	million t
Regulating Serv...	4,00		
Drifting dus...	4,00	0,00	kg
Sand mobili...	4,00	0,00	million t
Wind control	3,00	0,00	attenuation
Carbon seq...	3,00	0,00	million t
Supporting Ser...	4,00		
Species	3,00	0,00	number
Grassland	4,00		
Provisioning Se...	3,00		
Apocynum ...	3,00	0,00	million t
Reed produ...	3,00	0,00	million t
Regulating Serv...	4,00		
Drifting dus...	4,00	0,00	kg
Sand mobili...	4,00	0,00	million t



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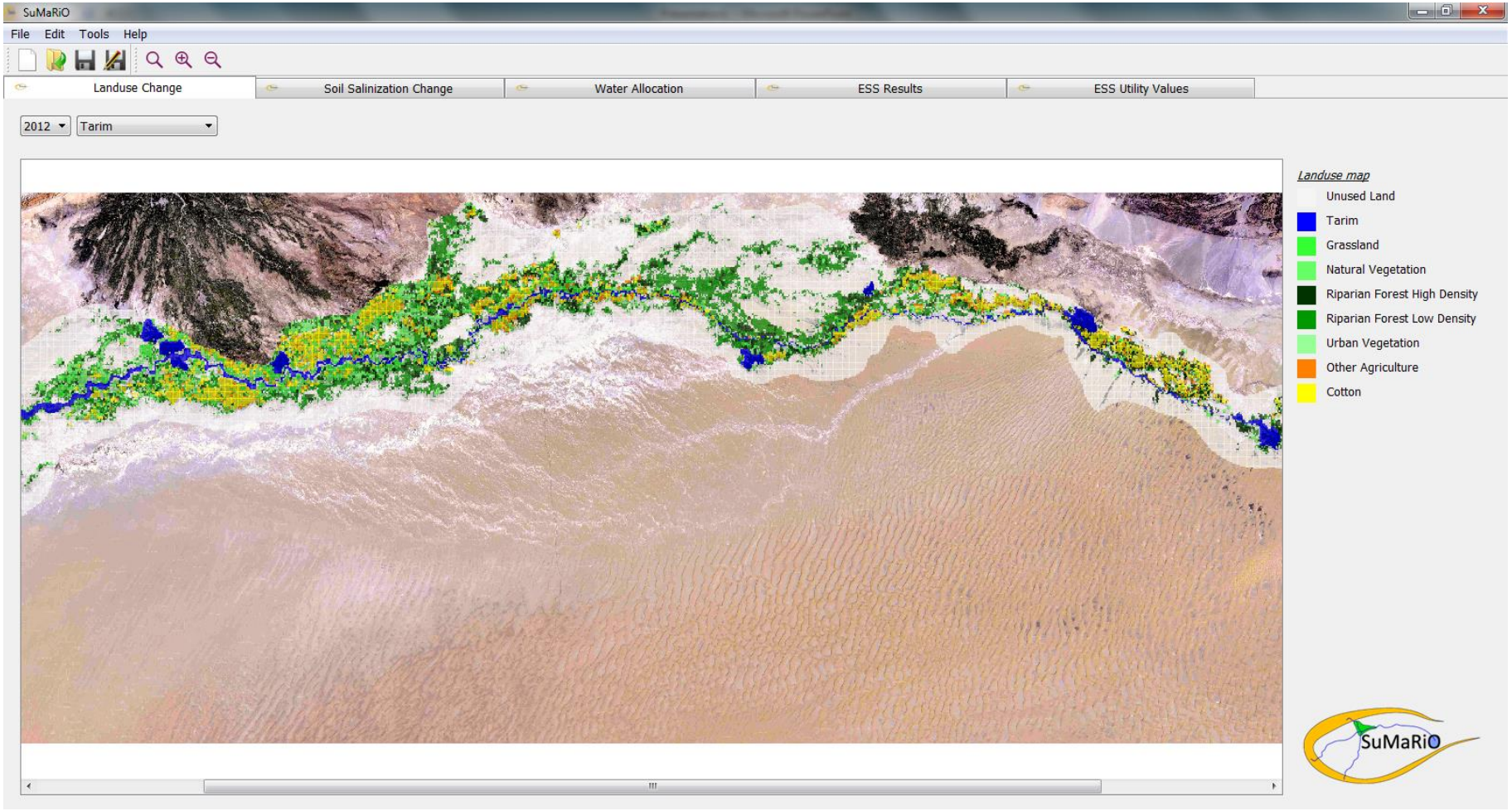
Output: Landuse changes



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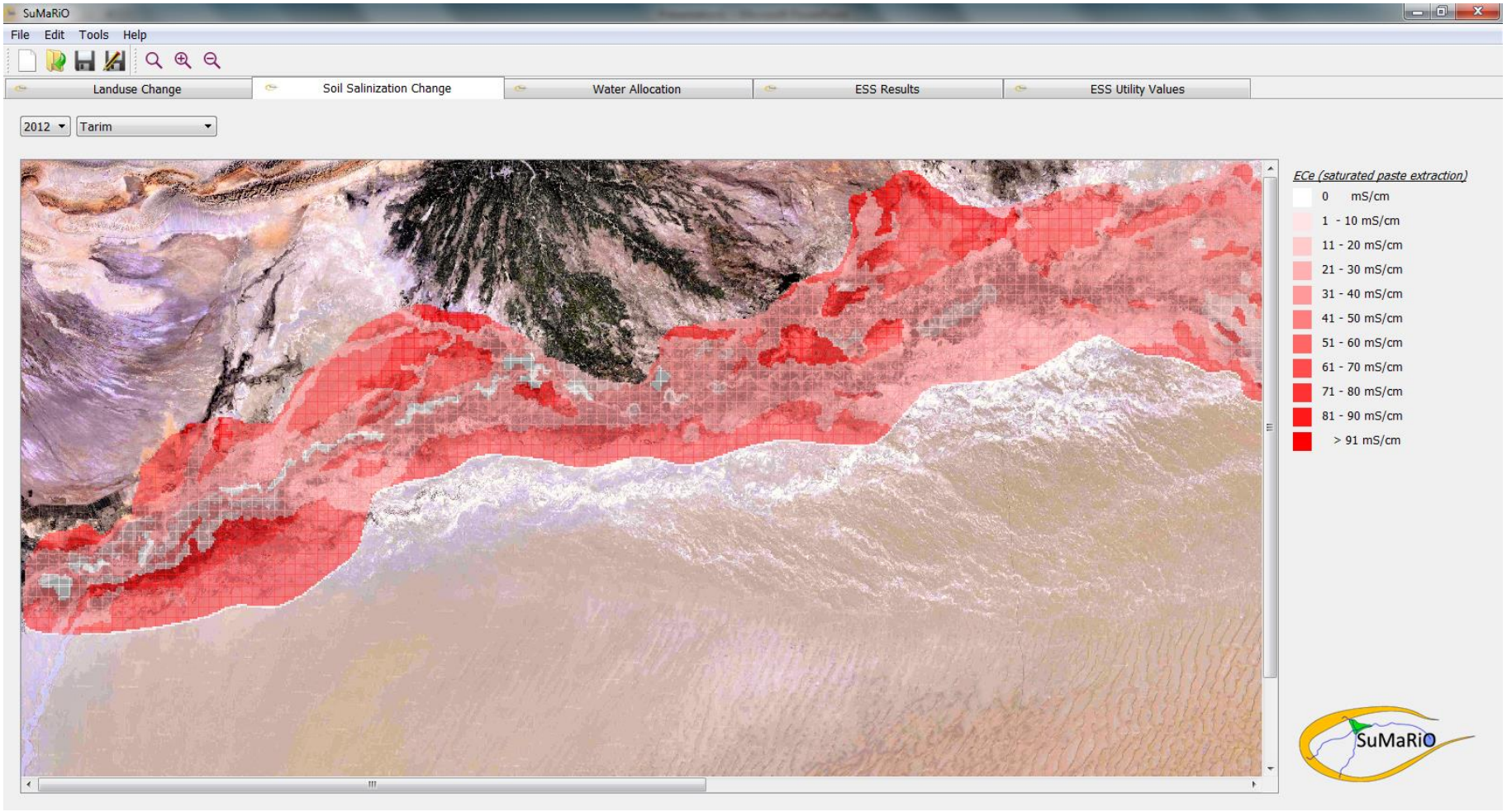
Output: Soil salinization change



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Output: Monthly discharge volume Tarim

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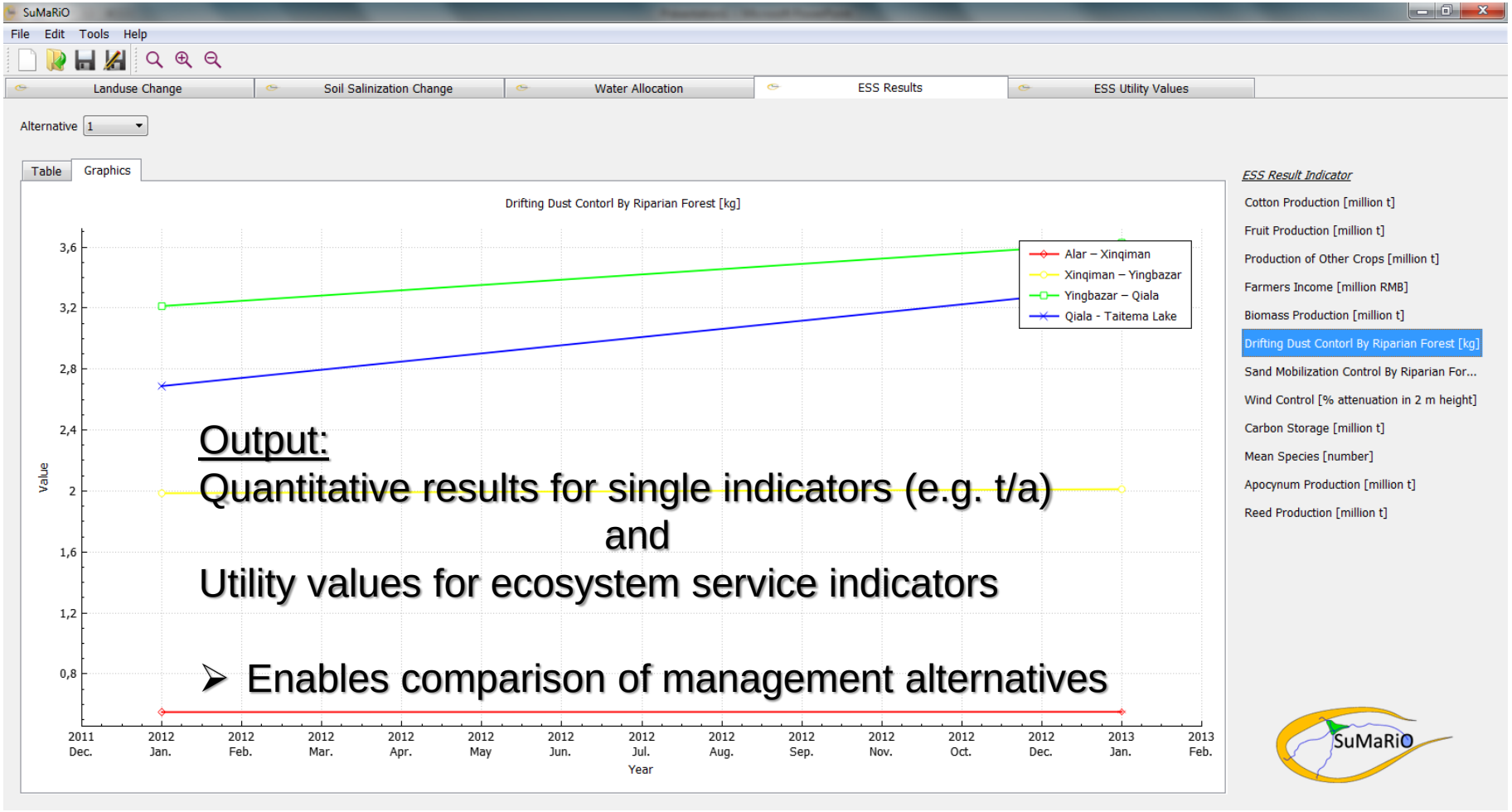
Output: Indicators for different ESS and lumped utility values



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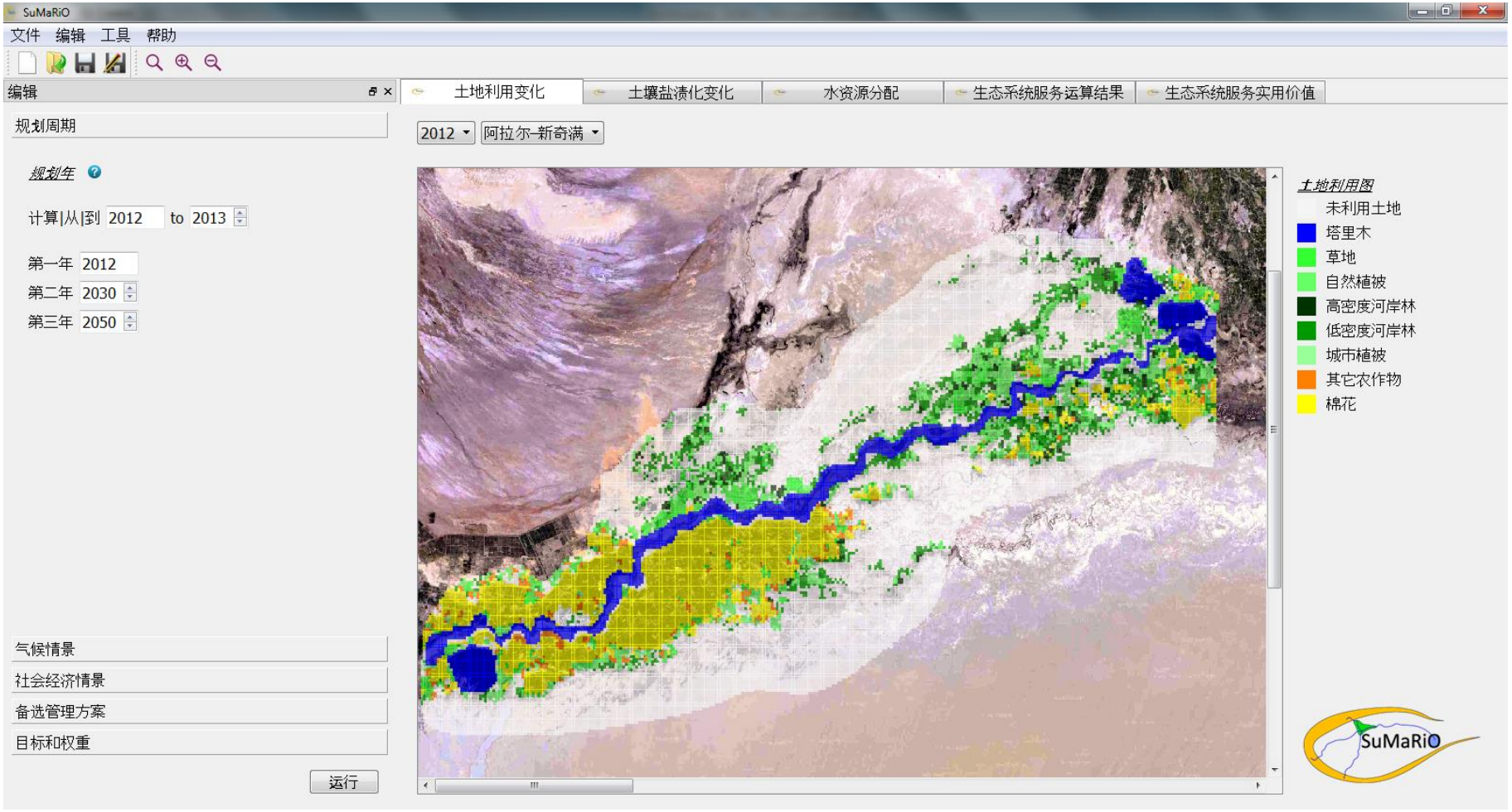
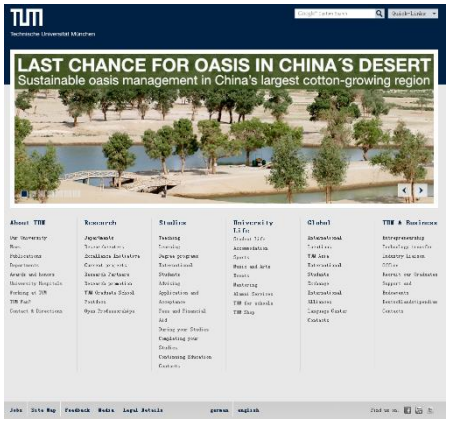
Chinese Version



Outlook:

How can we realize a sustainable land and water management (along the Tarim)?



- Reliable models / DSS of the hydrological, ecological, economic and social impacts (scientific work!)
- Management alternatives should be evaluated by suitable indicators (ESS approach!)
- Acknowledging **different** stakeholders simultaneously (e.g. water, agriculture, forest, ecology, economy)
- Provision of technical training, PhD and MSc students for education and capacity building (educational work!)
- Transfer of knowledge by workshops and conferences in a holistic way (5-year plan)

Thank you for your attention!

SuMaRiO Partner

Sponsered by the: Federal Ministry of Education and Research

FONA
Forschung für Nachhaltige Entwicklungen
BMBF

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