Effects of Land Use and Climate Change on Groundwater and Ecosystems at Yingibazar by using the MIKE SHE Integrated Hydrological Model

Final Sino-German Conference of SuMaRiO

10th to 12th of December 2015, Munich

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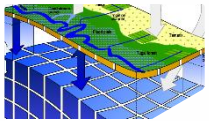
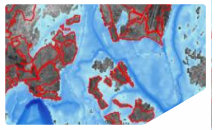
Agenda

1) Research questions and Project area

2) Generation of input data



3) Setup and calibration of a coupled MIKE SHE – MIKE 11 model



4) Results

5) Conclusion

1) Research questions and Project area

Research questions

Groundwater recharge

Is it possible to quantify the single water components (floodplains, irrigation areas and Tarim River leakage) which contribute to the groundwater recharge?

Influence of irrigation areas to the Tugai-vegetation

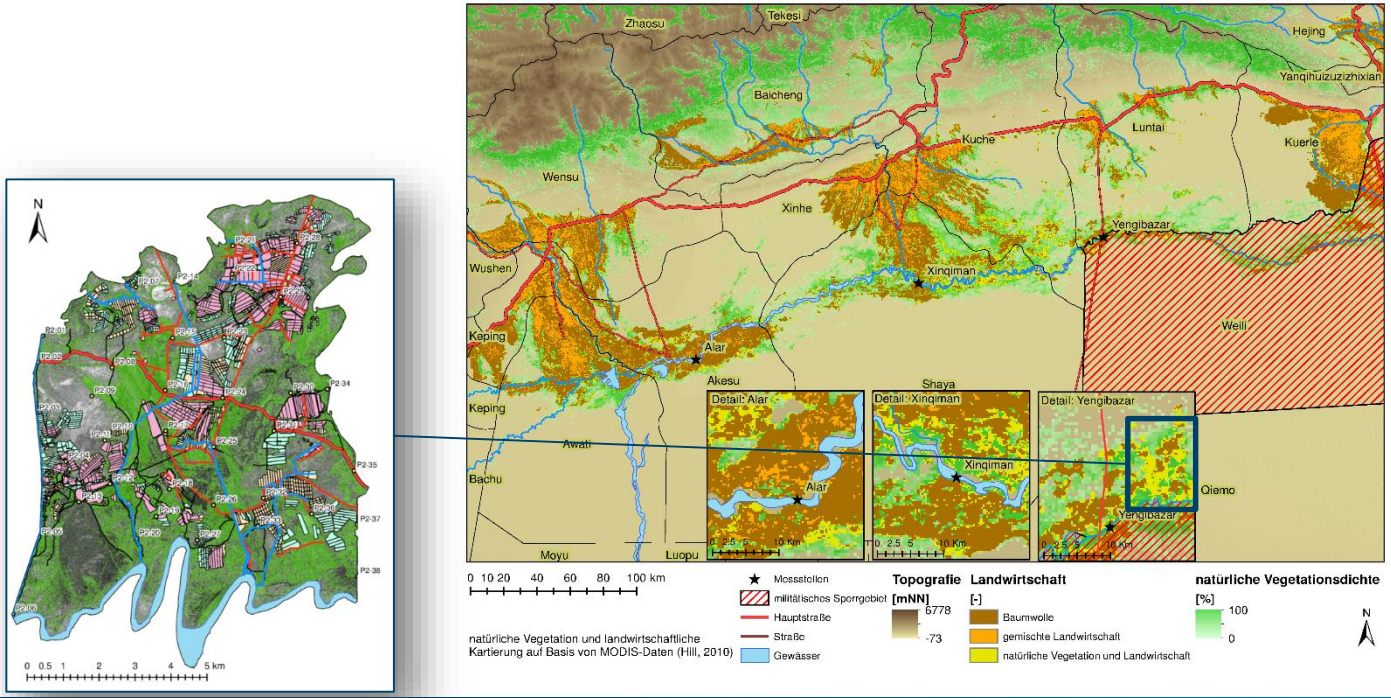
How are the irrigation areas effecting the neighborhood natural vegetation under consideration of the groundwater levels and the salt fluxes?

Climate and land use changes

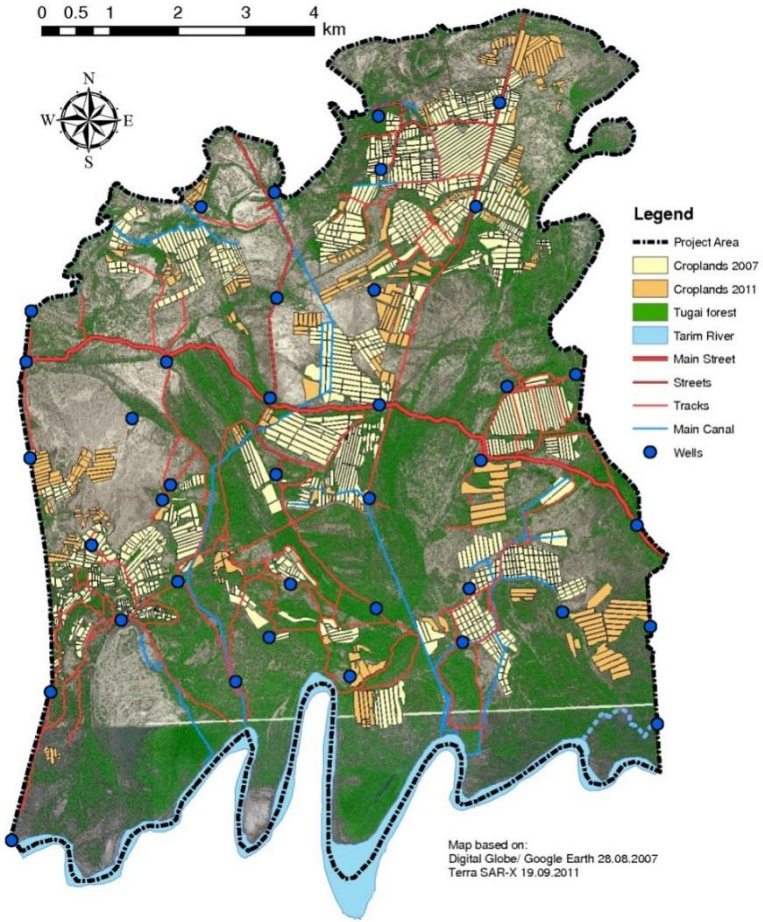
Can the effects of land use and climate changes to the agriculture and the natural vegetation estimated for the future?

The Research Area

- Natural floodplains and a direct connection toe the Tarim-River
- Changes from agriculture to natural vegetation
- Tarim-gauging station



Project Area Yengibazar



- 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%

Model to calculate the hydrological processes

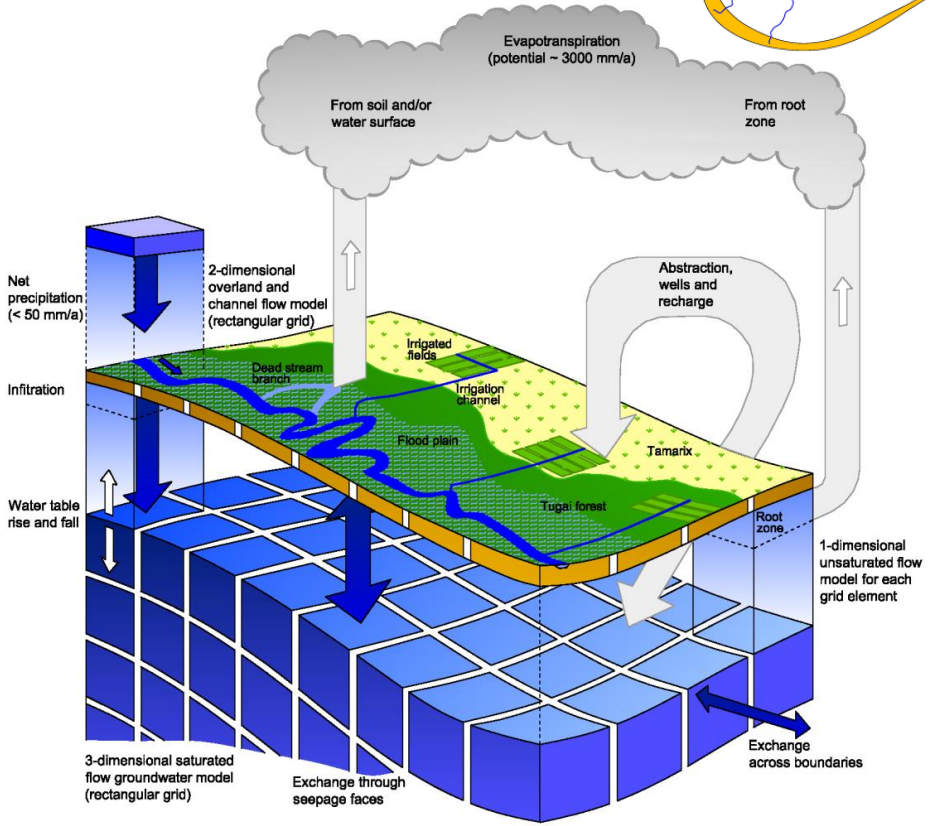
- 2-dimensional surface runoff
- Irrigation management
- Evapotranspiration
- Unsaturated and saturated soil water processes

	MODFLOW	FEFLOW	MIKE SHE	MIKE FLOOD
Groundwater Only	* * *	* * * *	* *	
Groundwater + Streams	* *	* * *	* *	
Groundwater + Streams + Unsat.	*	* * *	* * * *	
Groundwater + Streams + Unsat. + Land.			* * * *	
Salt water intrusion (SZ)	* *	* * * *		
Heat flow (SZ)		* * * *		
Geometric / Local constaints (SZ)	* *	* * * *	*	
Integrated water balance	* *	* *	* * * *	
Catchment hydrology		*	* * * *	
Regional dynamic recharge	*	* *	* * * *	
Flood hydraulics (very slow and very fast)			* *	* * * *
Flood hazard / Dam break assessment			*	* * * *
Flood water management			* * * *	* *
Rejected recharge/Groundwater flooding			* * * *	

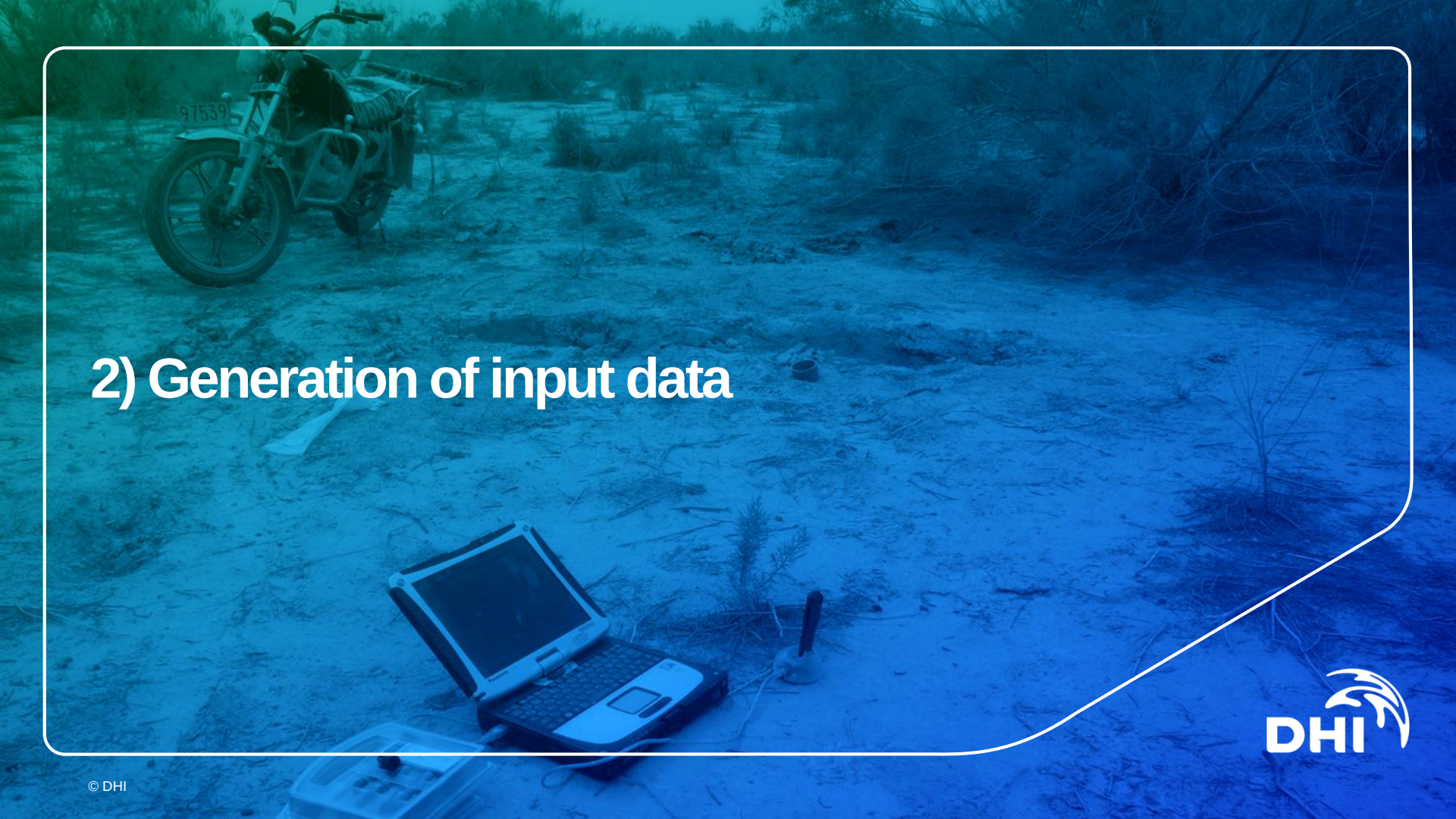
Coupled MIKE SHE – MIKE 11 model

Water quality

- ✓ Precipitation and snowmelt
- ✓ Vegetation based evapotranspiration and infiltration
- ✓ Demand driven irrigation
- ✓ Overland surface flow and flooding
- ✓ Channel flow with control structures in rivers and lakes (MIKE 11)
- ✓ Unsaturated groundwater flow
- ✓ Saturated groundwater flow



2) Generation of input data

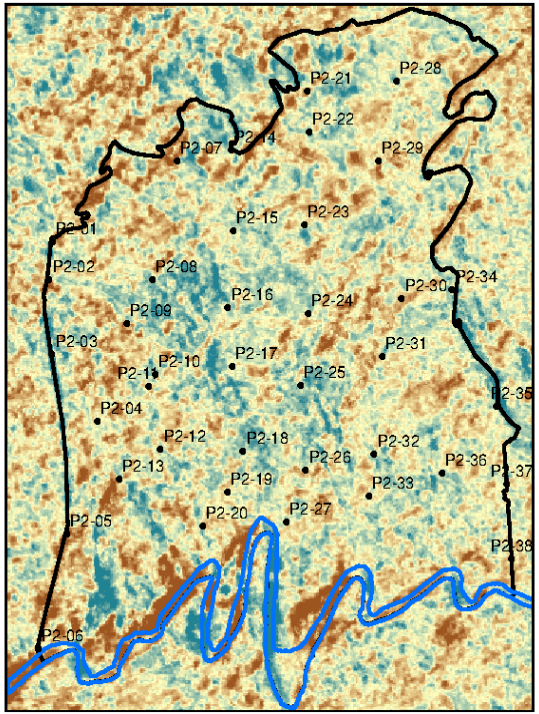


Required input data

Data set	Remote sensing	Measurements in research area
Digital elevation model (DEM)	World View 1 & 2 DigitalGlobe 8 x 8 m	In field correction points
Groundwater level		38 groundwater gauging stations with data logger (Temperature, Water level and electric conductivity)
Tarim discharge		Gauging station Yengibazar (1992-2005) and own measurements since Dec. 2011
Floodplains	TerraSAR-X Spot Mode 1x1 m	11 data logger in the floodplains
River cross sections	World View 1 Satellite image	Photogrammetric images
Soil model		38 drilling cores until the saturated zone
Climate data	Precipitation: TRMM	Climate station Yengibazar (Jun. – Nov. 2012) Climate station Kucha
Natural vegetation	- Satellite image World View 1 (NDVI/EVI) - MODIS LAI	Mapping in field
Irrigation		Interviews with farmers

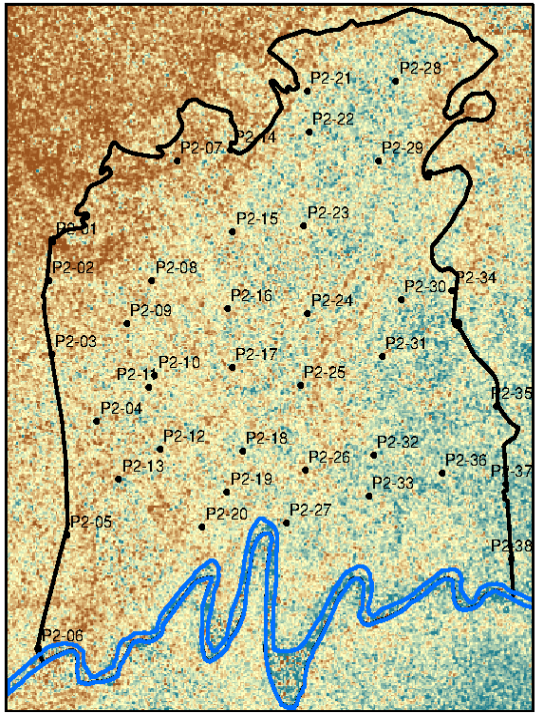
Digital elevation model

ASTER



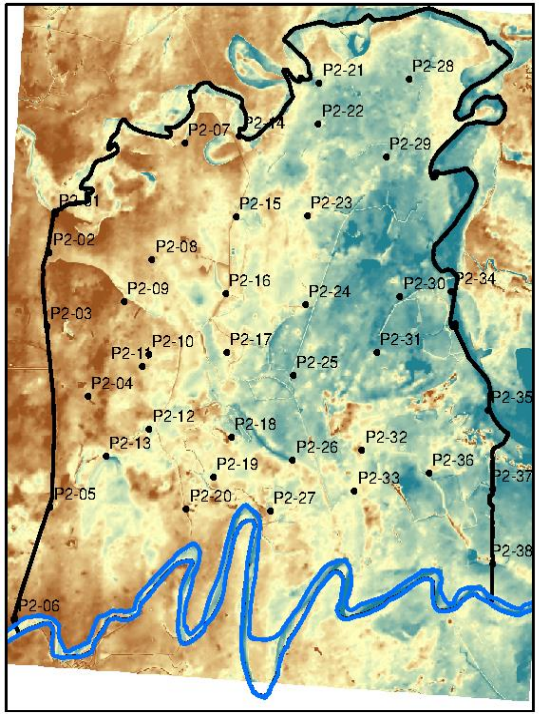
cell size: 30 x 30 m

SRTM-1



cell size: 26 x 26 m

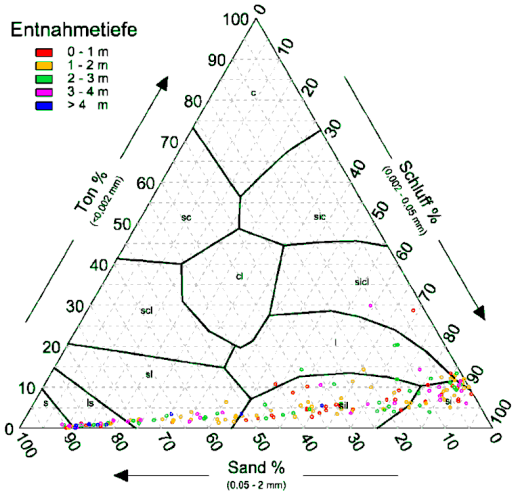
Digital Globe



cell size: 8 x 8 m

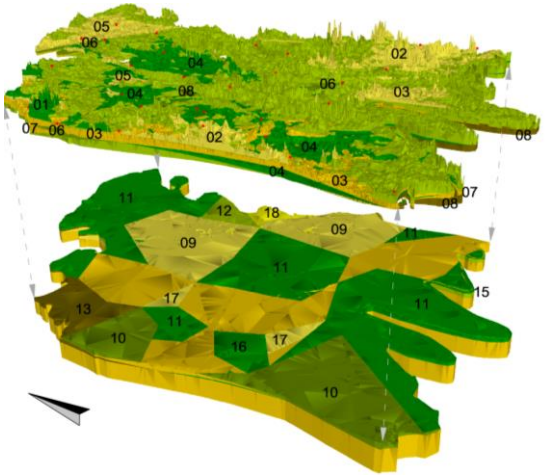
Groundwater levels & digital soil model

Drilling of 38 gauging stations with automatic data loggers



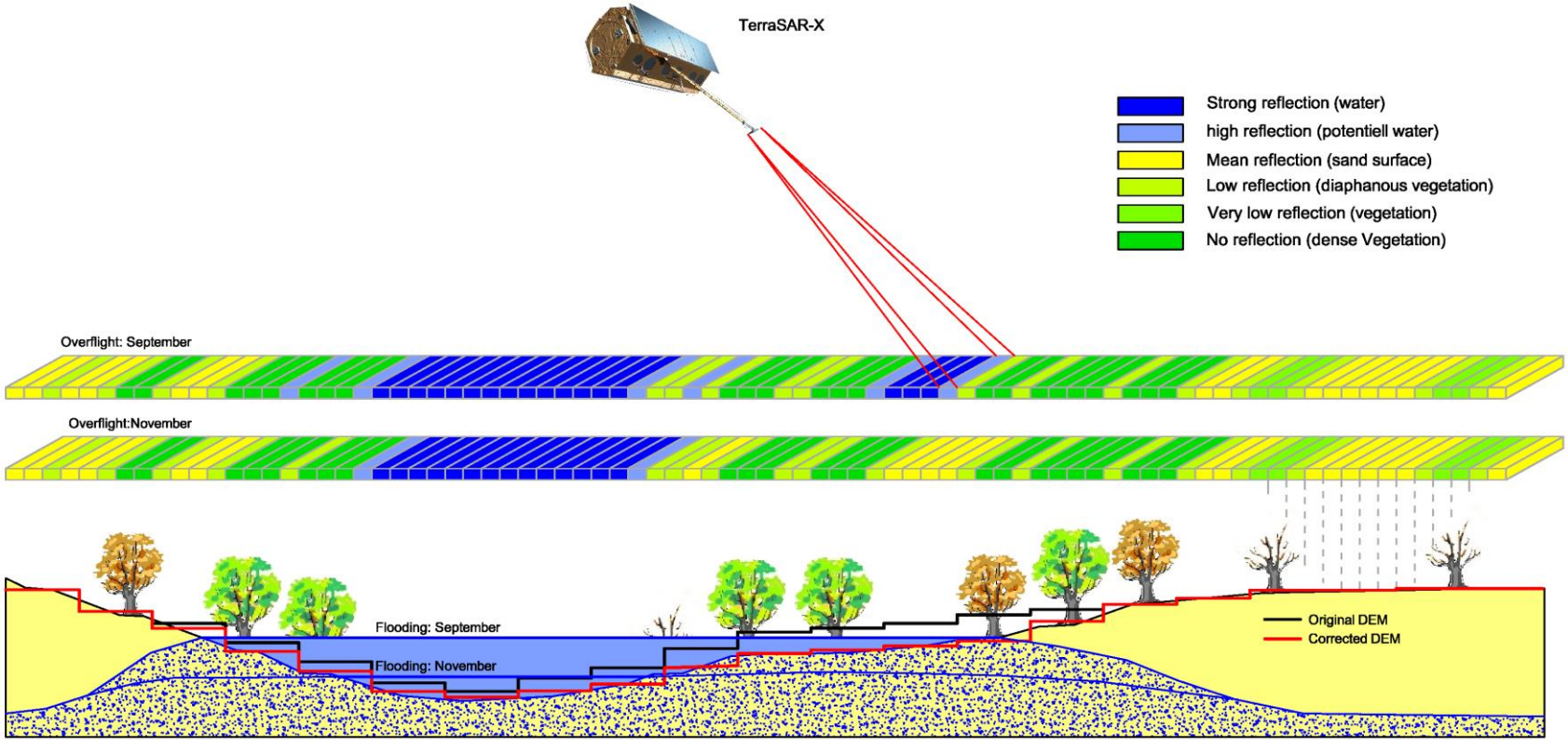
Analyzing 38 drilling cores with overall 172 soil samples

- Grain size
- Organic content
- Electrical conductivity
- Porosity



3d- soil model with 22 layers

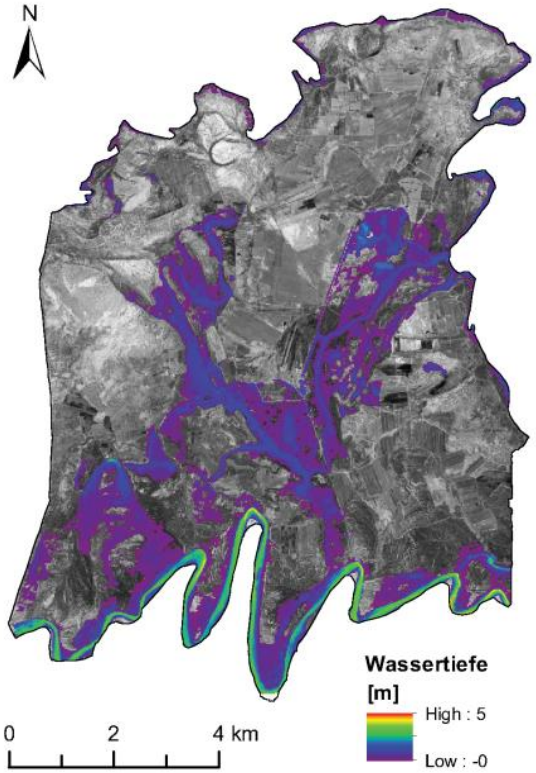
Detecting the extension of floodplains with TerraSAR-X



TerraSAR-X flood maps before and after correction

TerraSAR-X raw data

Calculated inundation areas

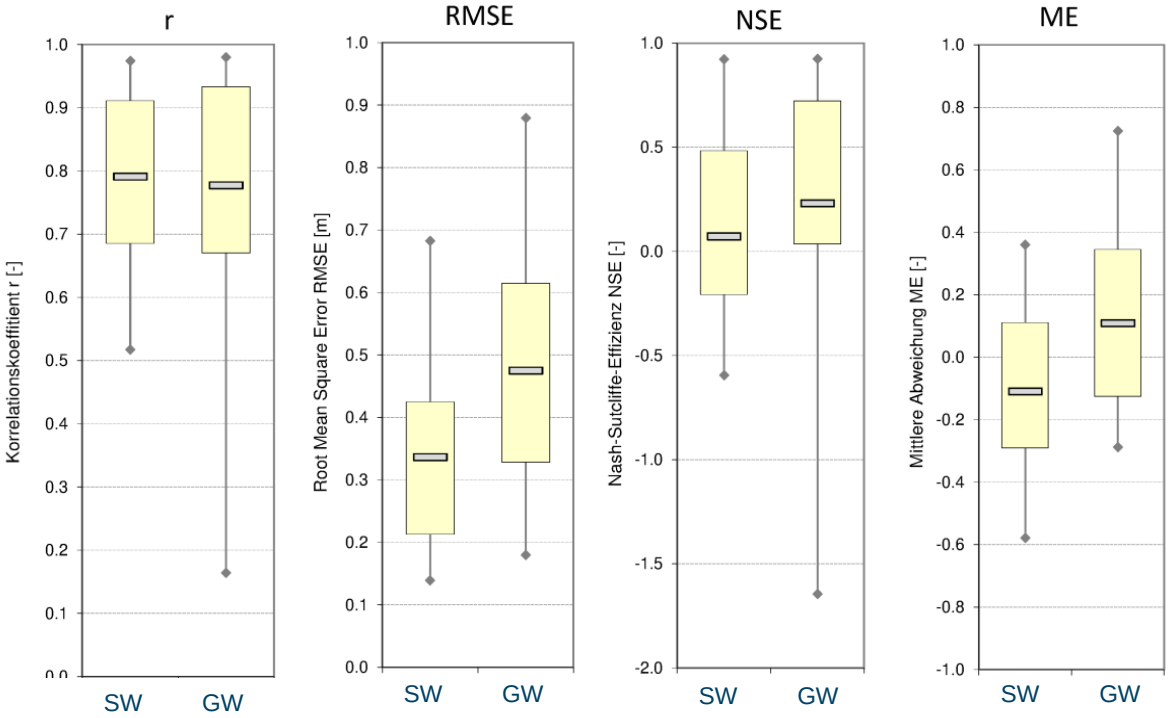


3) Setup and calibration of the model

Calibration for the year 2012

1. Surface water (SW): Changing the topography and the hydraulic resistance (kst)

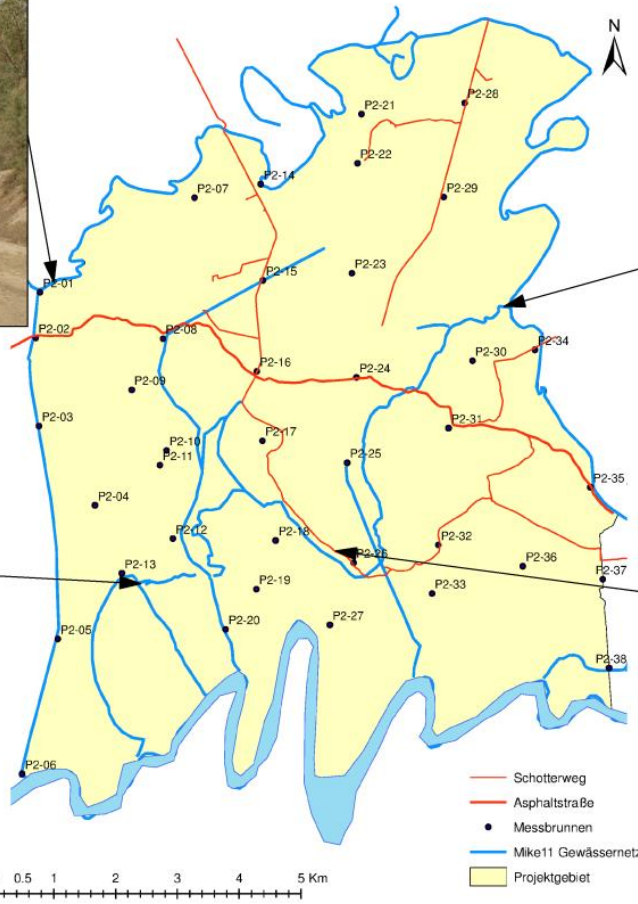
2. Ground water (GW): Choice of a fitting pedo-transfer-function and the hydraulic conductivity



Validation for the year 2013

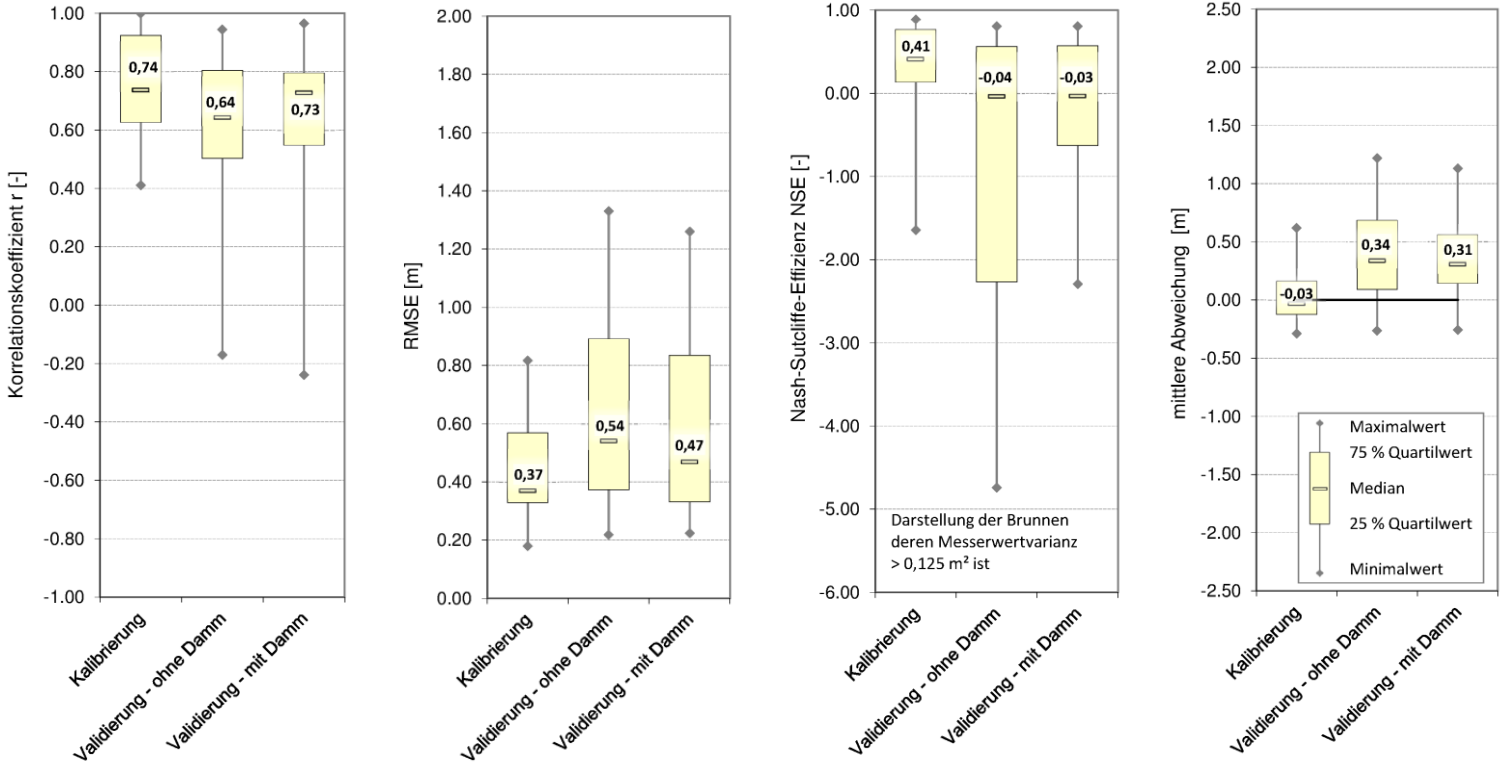
- 8 gauging stations have been destroyed by new field reclamation since 2011
- For the validation only 22 gauging wells can be used

Local changes in the irrigation system



Results of the validation

By the dynamic land use changes a validation is only limited possible.

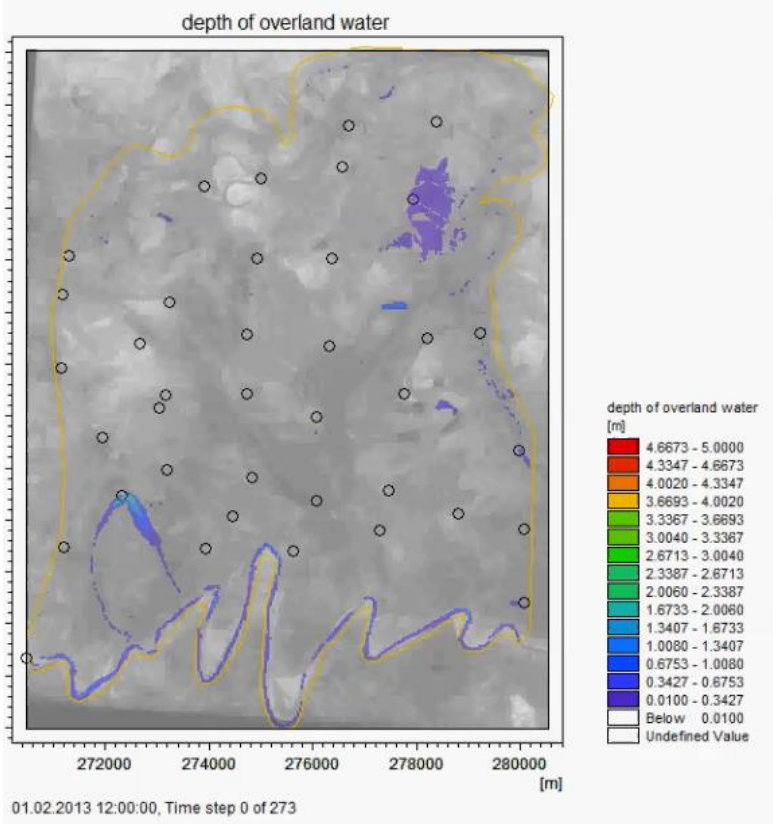


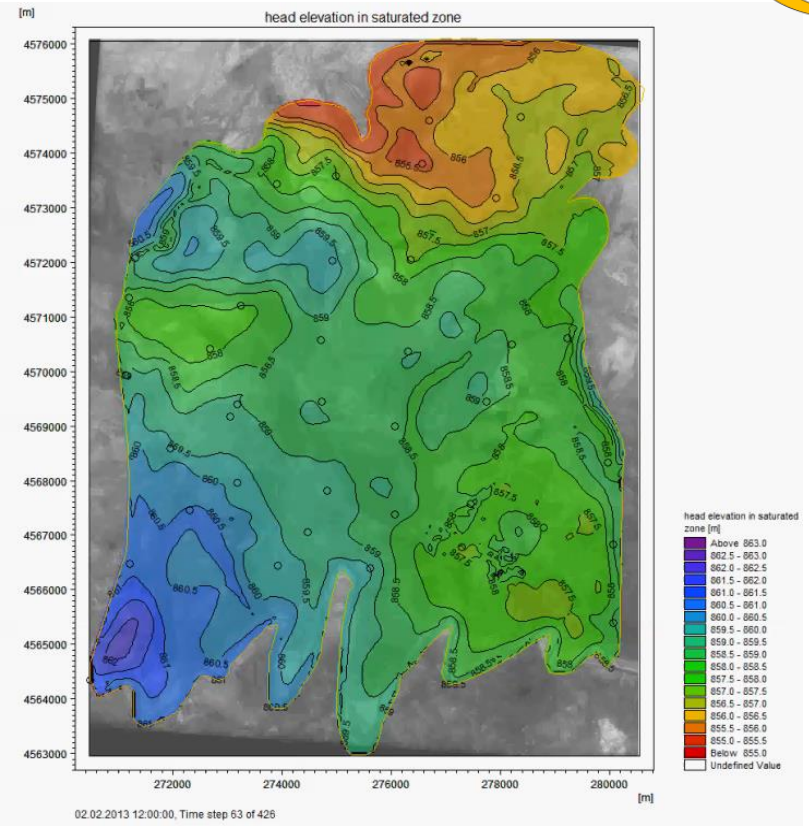
4) Results

Landuse- and climate scenarios

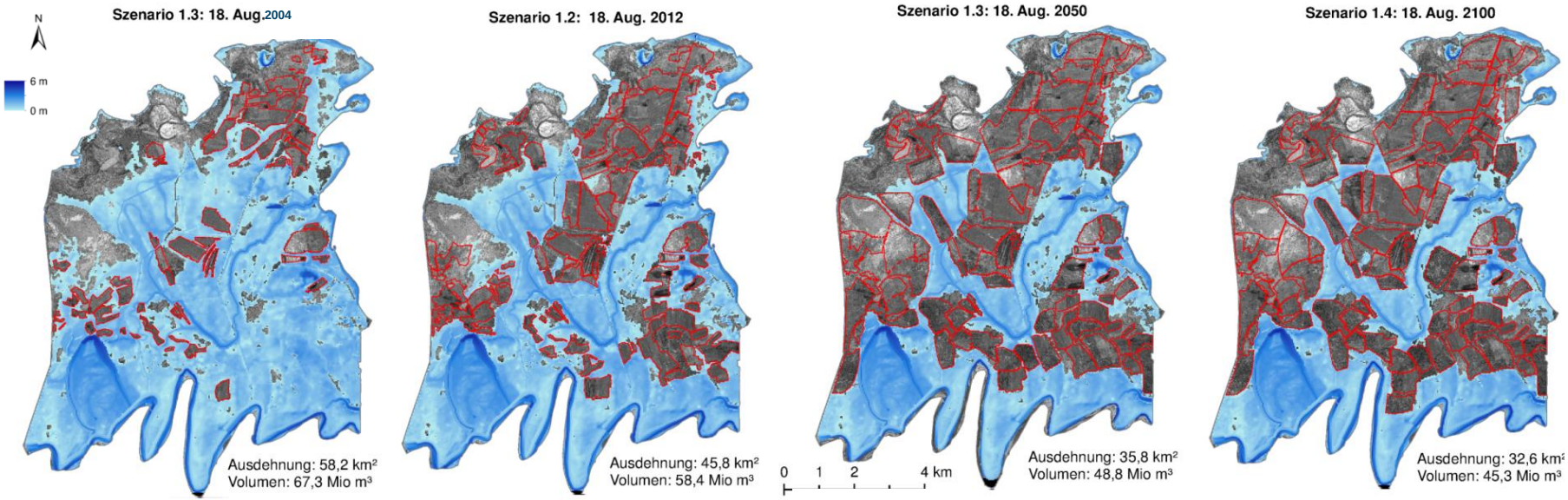
Major scenario	Scenario No.	Name	Extension of agriculture	Climate change		
				Tarim-Discharge	Temperature	Rainfall in area winter/summer
Land use	1.1	Past2004	8,1 km²	MQ	0 °C	0 %
	1.2	Present 2012	19,3 km²	MQ	0 °C	0 %
	1.3	Future 2050 L	32,2 km²	MQ	0 °C	0 %
	1.4	Future 2100 L	34,5 km²	MQ	0 °C	0 %
Climate	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 %

Surfacewater – groundwater interaction

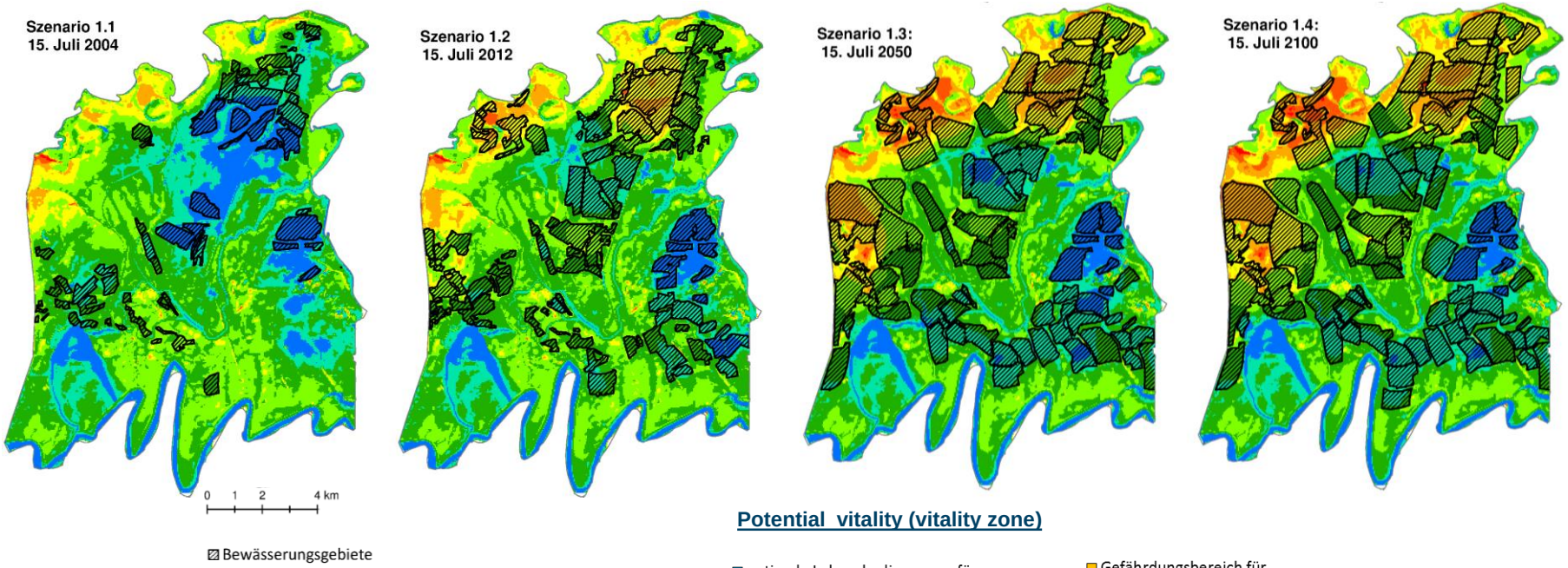




Changes in the flooding by land use changes



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

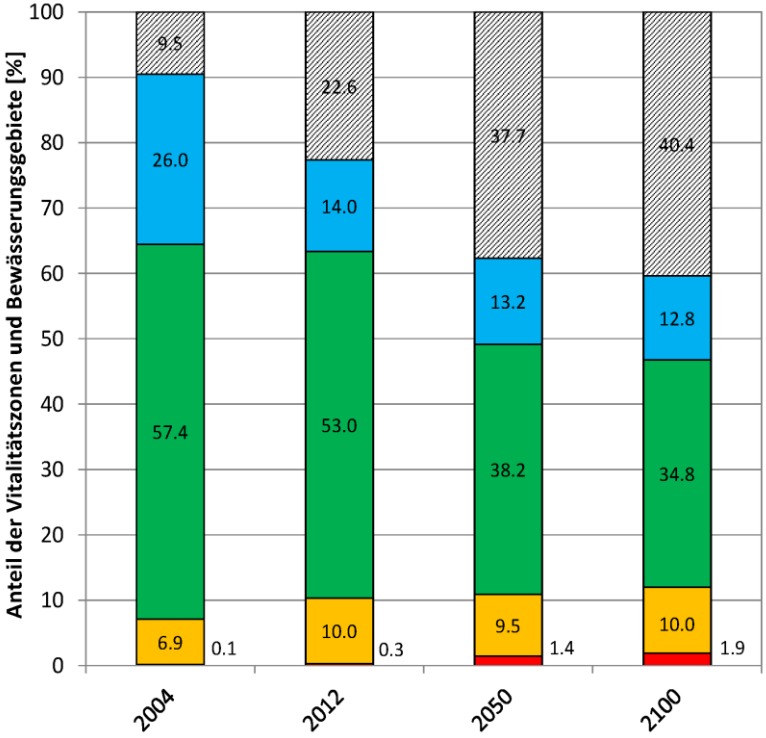


Potential vitality (vitality zone)

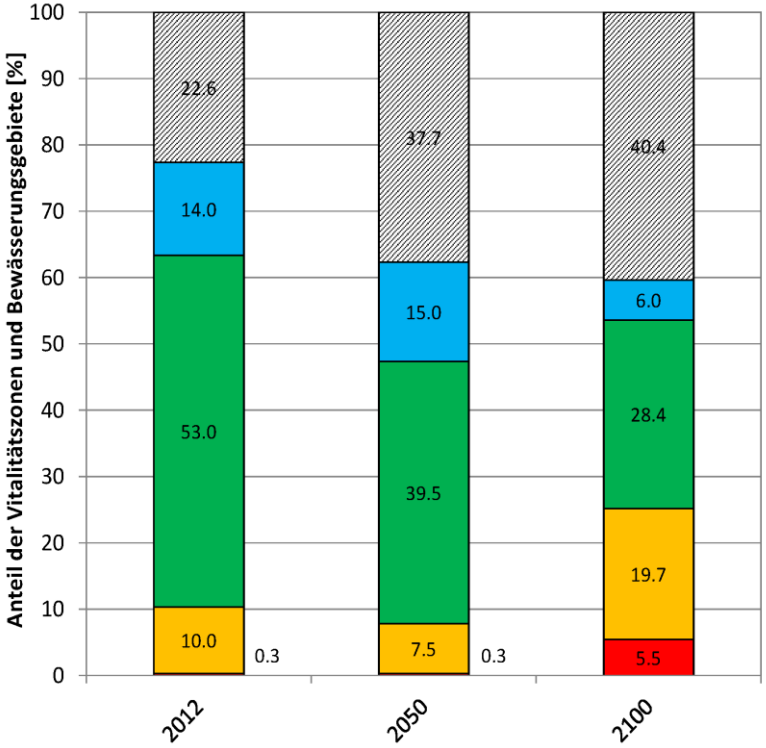
- optimale Lebensbedingungen für Feuchtgebietsvegetation (Gw-Flurabstand: 0 m bis -2 m)
- optimale Lebensbedingungen für Tugai-Vegetation (Gw-Flurabstand: -2 m bis -4 m)
- Gefährdungsbereich für Pappelvegetation (Gw-Flurabstand: -6 m bis -4 m)
- Gefährdungsbereich für Wüstenvegetation (Gw-Flurabstand: -10 m bis -6 m)

Effects to the vitality of the natural vegetation

land use change

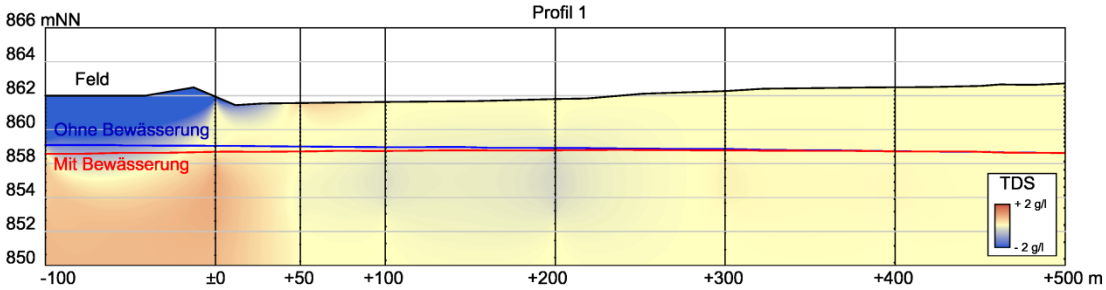


land use & climate change

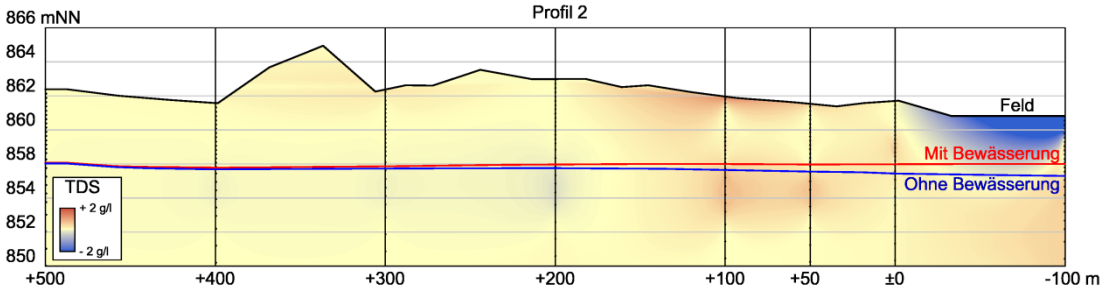


Salinization

Irrigation with local groundwater resources



Irrigation with fresh river water



TDS = Total dissolved solute

5) Conclusion

Conclusion

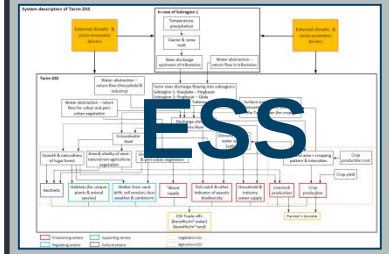
- **Groundwater recharge**
  It was possible to determinate the single components of groundwater recharge for the year 2012. The highest influence have the floodplains is with 84 %. New embankments along the River can minimize the groundwater recharge extremely.

- **Influence of irrigation areas to the Tugai-vegetation**
  There is an interaction between the irrigation areas and the natural vegetation. The Changes of groundwater levels and salt fluxes are depending by the used water (local groundwater and/or river water) for irrigation.

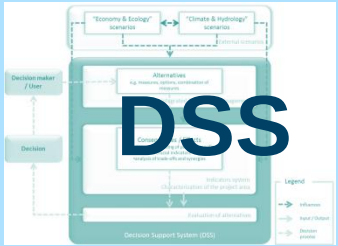
- **Climate- and Land use changes**
  By continue reclamation of new fields the natural vegetation looses space. These effects the groundwater recharge. Since now the groundwater recharge is reduced from 124 mm/a (2004) to 116 mm/a (2012). By future scenarios it can be estimated that the groundwater recharge further decline to 96 mm/a (2100). This effects a water stress for the natural vegetation.

ESS / DSS

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



- Input data for vitality analyses



- Groundwater recharge rates (river, foodplains)
- Effects of salinization
- Influence of embankments along the Tarim River
- Laterals water transfer from an into the Tarim River


Thank you
DHI
WASY