International Conference on
Land and Water Degradation Processes and Management

Magdeburg, Germany, 07/09-10/09/2009

Estimation of critical source areas and spatial distributed SDR for quantifying sediment discharge of surface waters in mesoscale

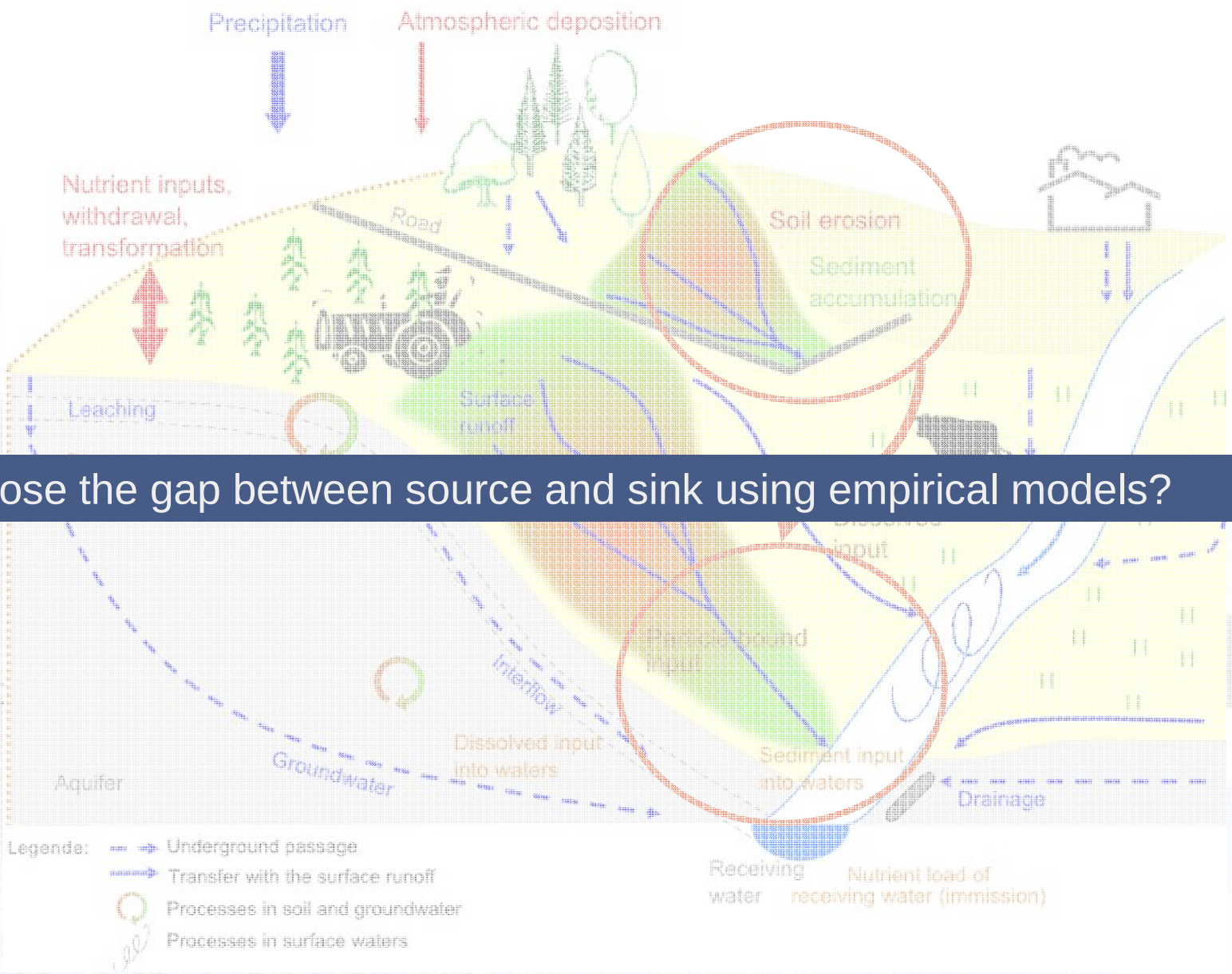
Stefan Halbfaß

GALF
GESELLSCHAFT FÜR ANGEWANDTE
LANDSCHAFTSFORSCHUNG bR

Sources
Critical Sources Areas (CSA)

Pathways
Riverine or Hydrological Connectivity

Sinks
Accumulation, Sediment Input into Rivers

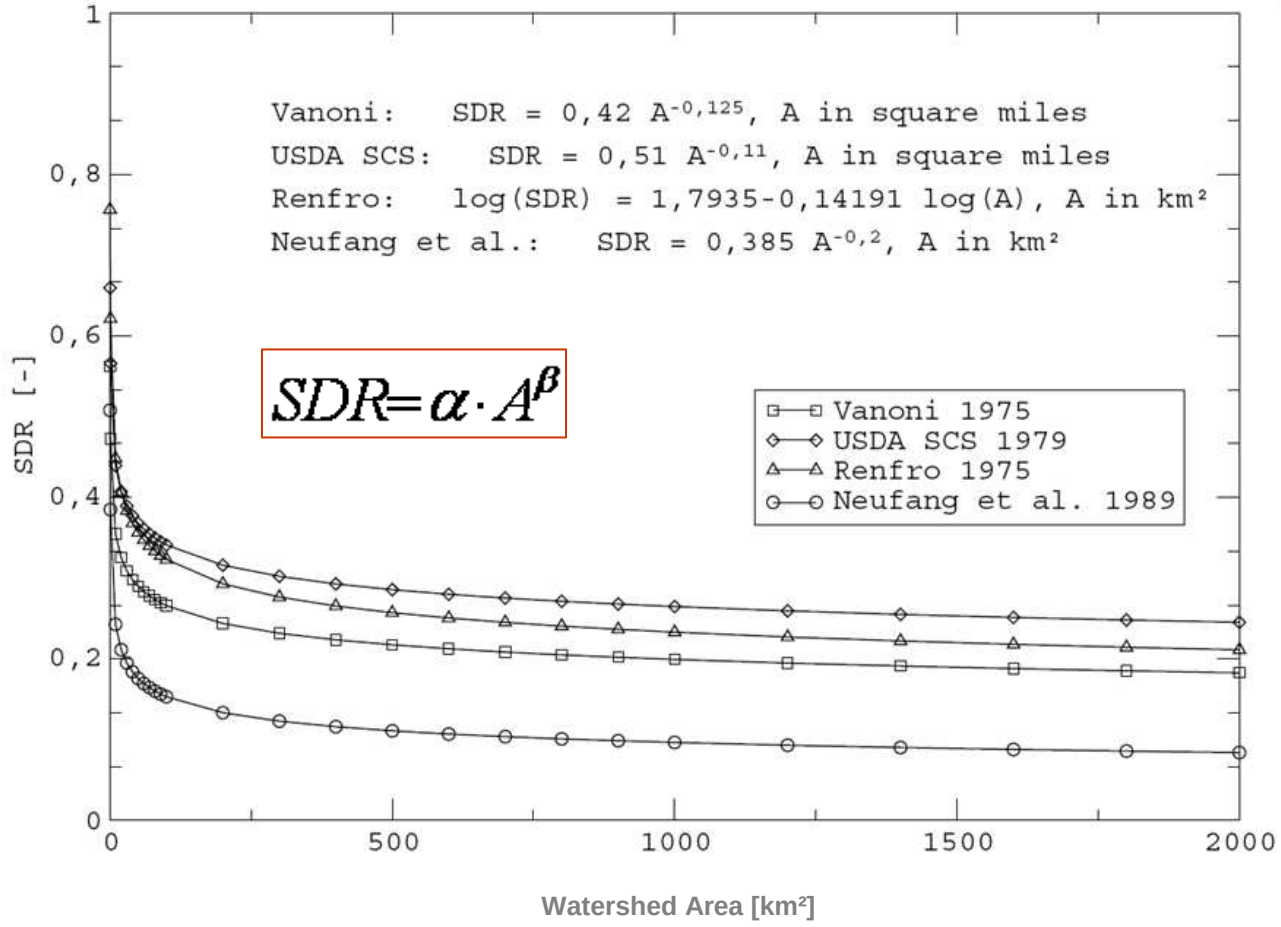


How to close the gap between source and sink using empirical models?

SDR – Models based on different Parameters

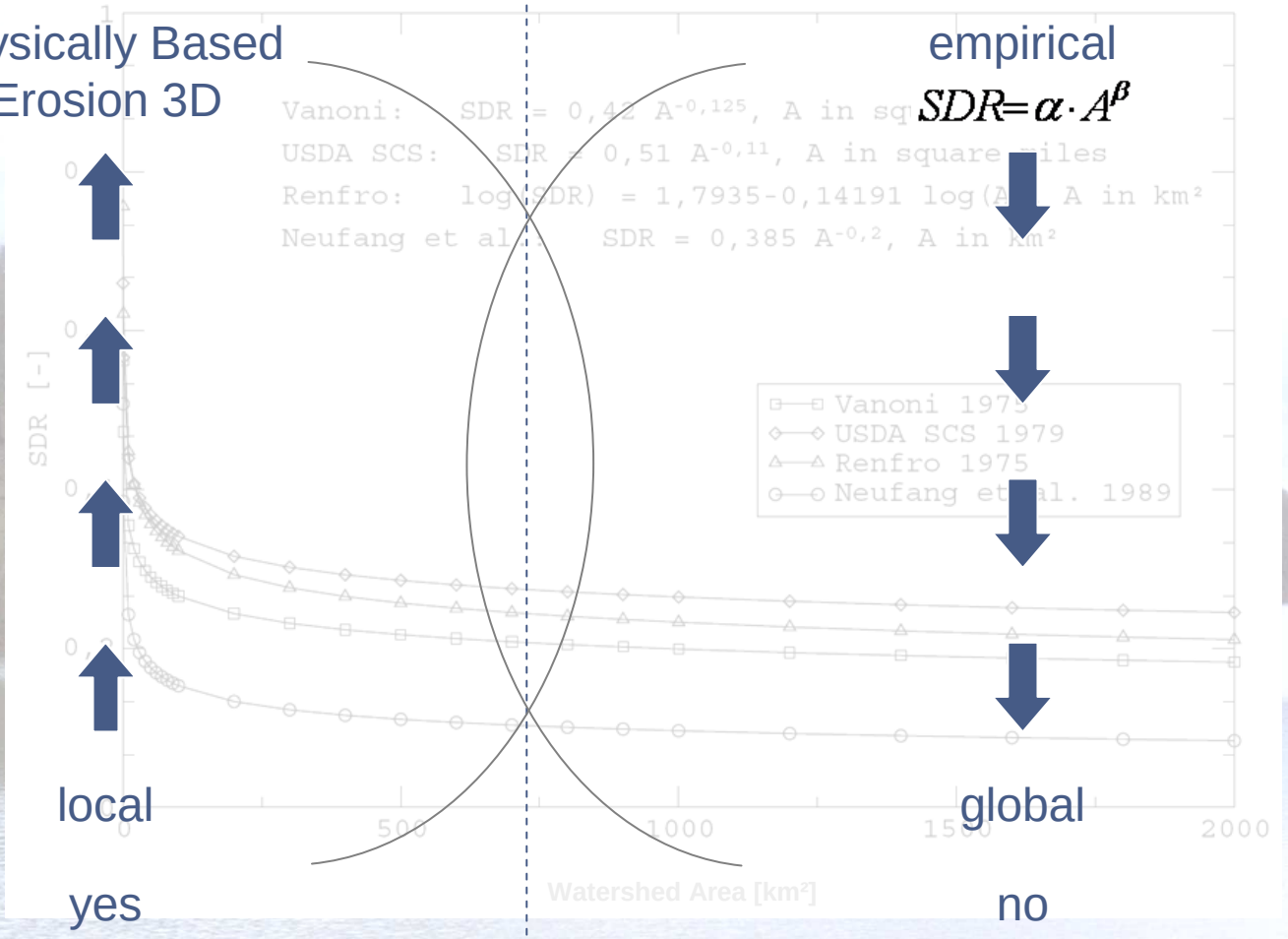
e.g. Soil erosion,
Soil texture,
Watershed area,
Slope,
Land use,
Grain size

An example based on watershed area



Problems & Questions

	Small scale	Mesoscale	Large scale
Example	Physically Based Erosion 3D		empirical $SDR = \alpha \cdot A^{\beta}$
Parameter Requirement	↑		↓
Model			
├ **Complexity**	↑		↓
├ **Accuracy**	↑		↓
└ **Costs**	↑		↓
SDR Localization	local		global
Derivation CSA	yes		no



Goal of model development

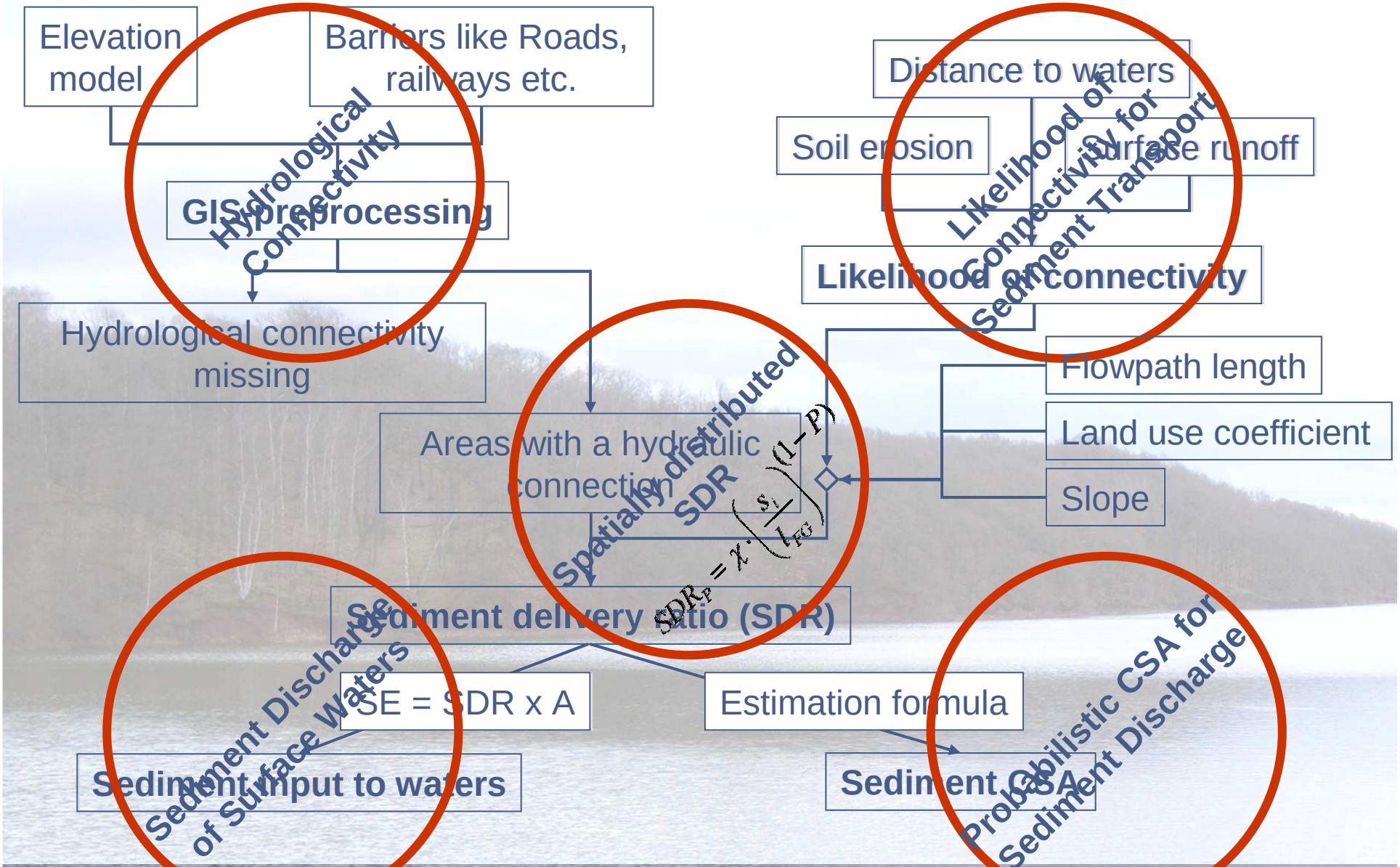
Results
- Spatially distributed SDR
- Delineation of Critical Source Areas

Method
- Mesoscale approach
- General available or derivable Parameters
- Consideration of important factors controlling sediment transfer from source to sink
- Basic GIS-operations only (no cell to cell calculations)

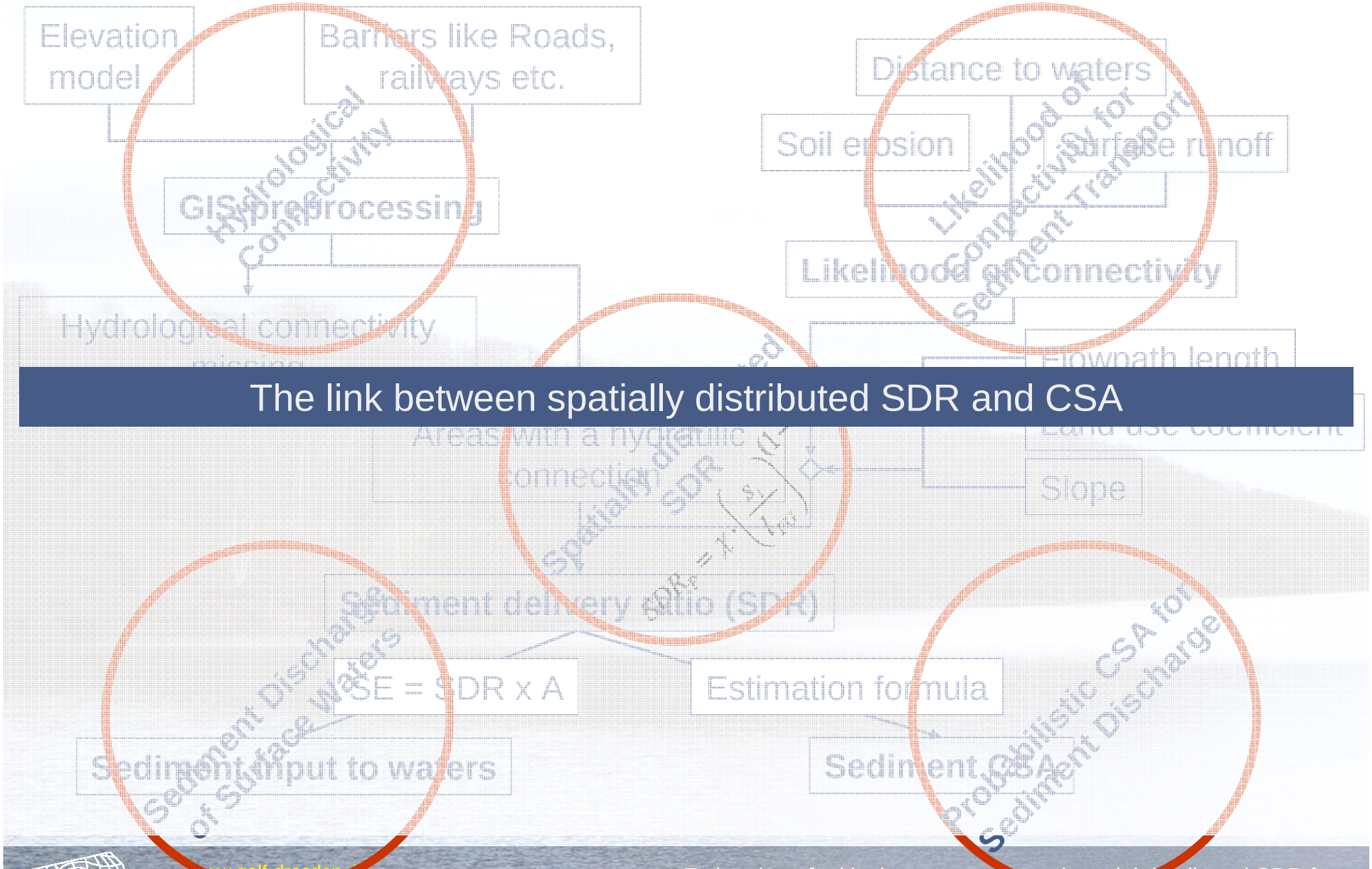
Fundamental research has been done by Voges (1999) and Veith (2002)

Voges, J.: Empirical model for the medium scale level to GIS-based destination of riverine connectivity to erosion of arable land . Diss., Univ. Hannover, 1999.

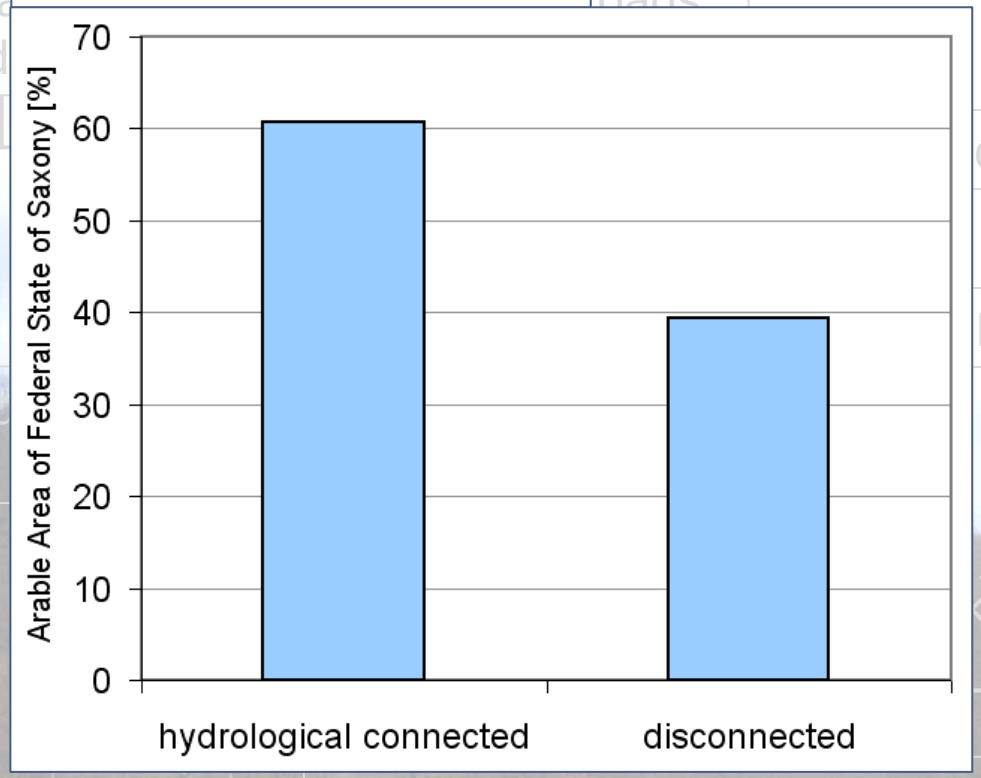
Veith, T.L.: Agricultural BMP placement for cost-effective pollution control at the watershed level. PhD Dissertation Thesis, Virginia Polytechnic Institute and State University, Virginia, 195 pp., 2002.


Elevation model
Barriers like Roads, railways etc.
Hydrological Connectivity
GIS-preprocessing
Hydrological connectivity missing
Areas with a hydraulic connection
Distance to waters
Soil erosion
Surface runoff
Likelihood of Connectivity for Sediment Transport
Likelihood of connectivity
Flowpath length
Land use coefficient
Slope
Spatially distributed SDR
$SDR_P = \chi \cdot \left(\frac{s_i}{l_{FG}}\right)^{(1-P)}$
Sediment delivery ratio (SDR)
SE = SDR x A
Estimation formula
Sediment Discharge of Surface Waters
Sediment input to waters
Sediment CSA
Probabilistic CSA for Sediment Discharge

The link between spatially distributed SDR and CSA



Hydrological Connectivity



Distance to waters

oil erosion

Surface runoff

Likelihood of connectivity

Flowpath length

Land use coefficient

Slope

Sediment delivery ratio (SDR)

SE = SDR x A

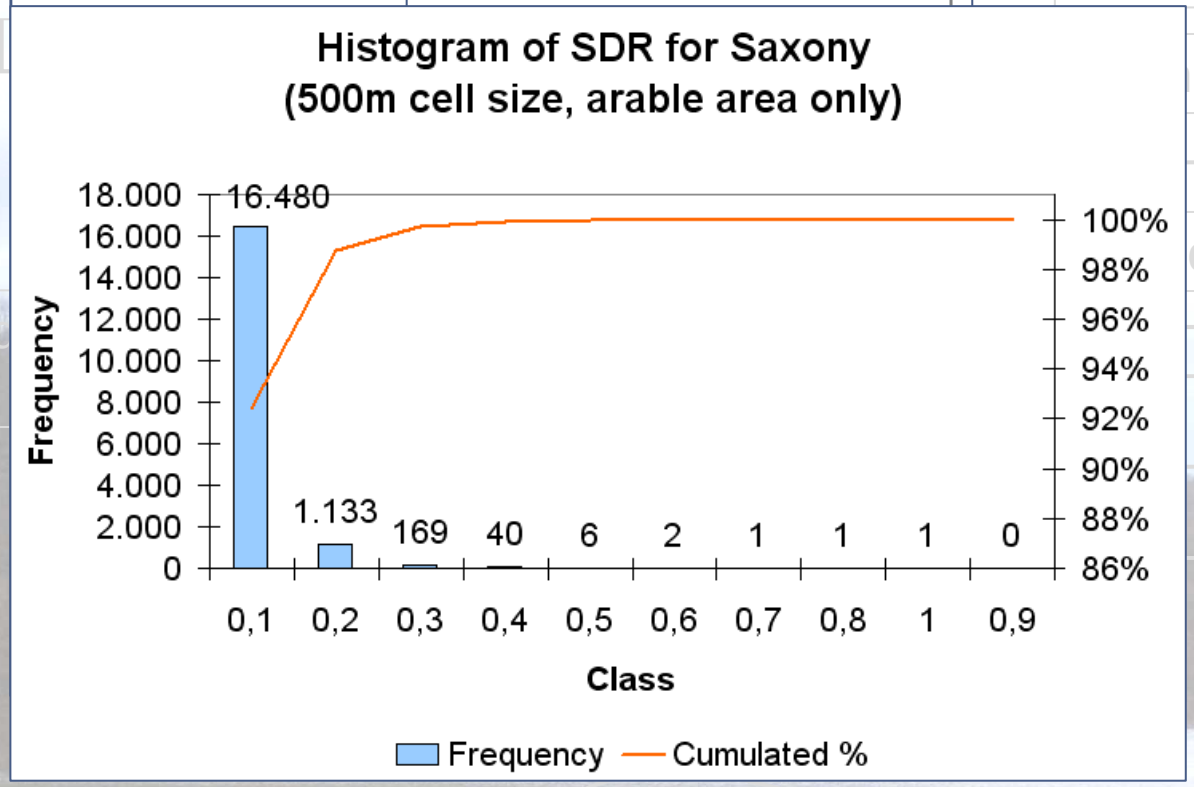
Estimation formula

Sediment input in waters

Sediment hotspot areas

Hydrological Connectivity

SDR Distribution



Distance to waters

Surface runoff

d of connectivity

Flowpath length

Land use coefficient

Slope

SE = SDR x A

Estimation formula

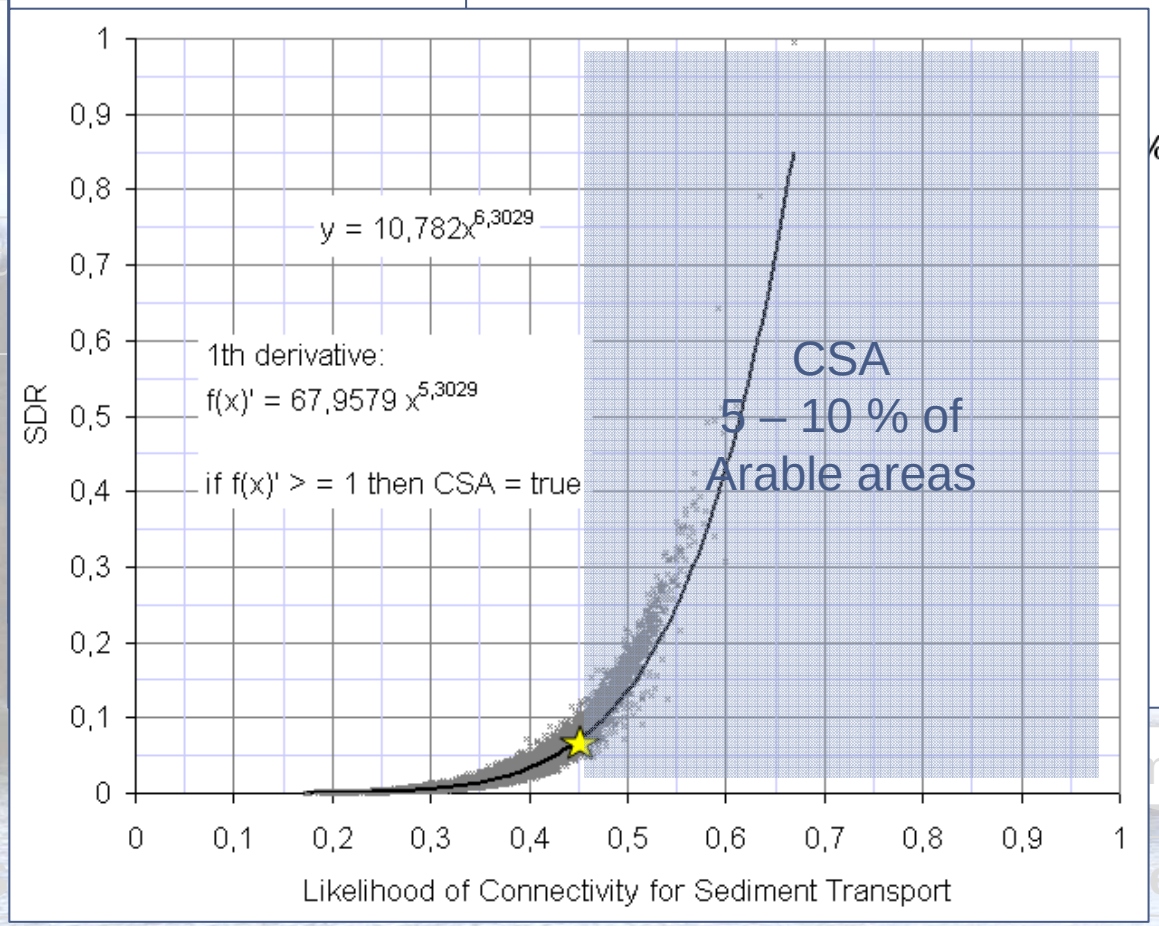
Sediment input in waters

Sediment hotspot areas

Hydrological Connectivity

SDR Distribution

Correlation function



Distance to waters

Surface runoff

d of connectivity

Flowpath length

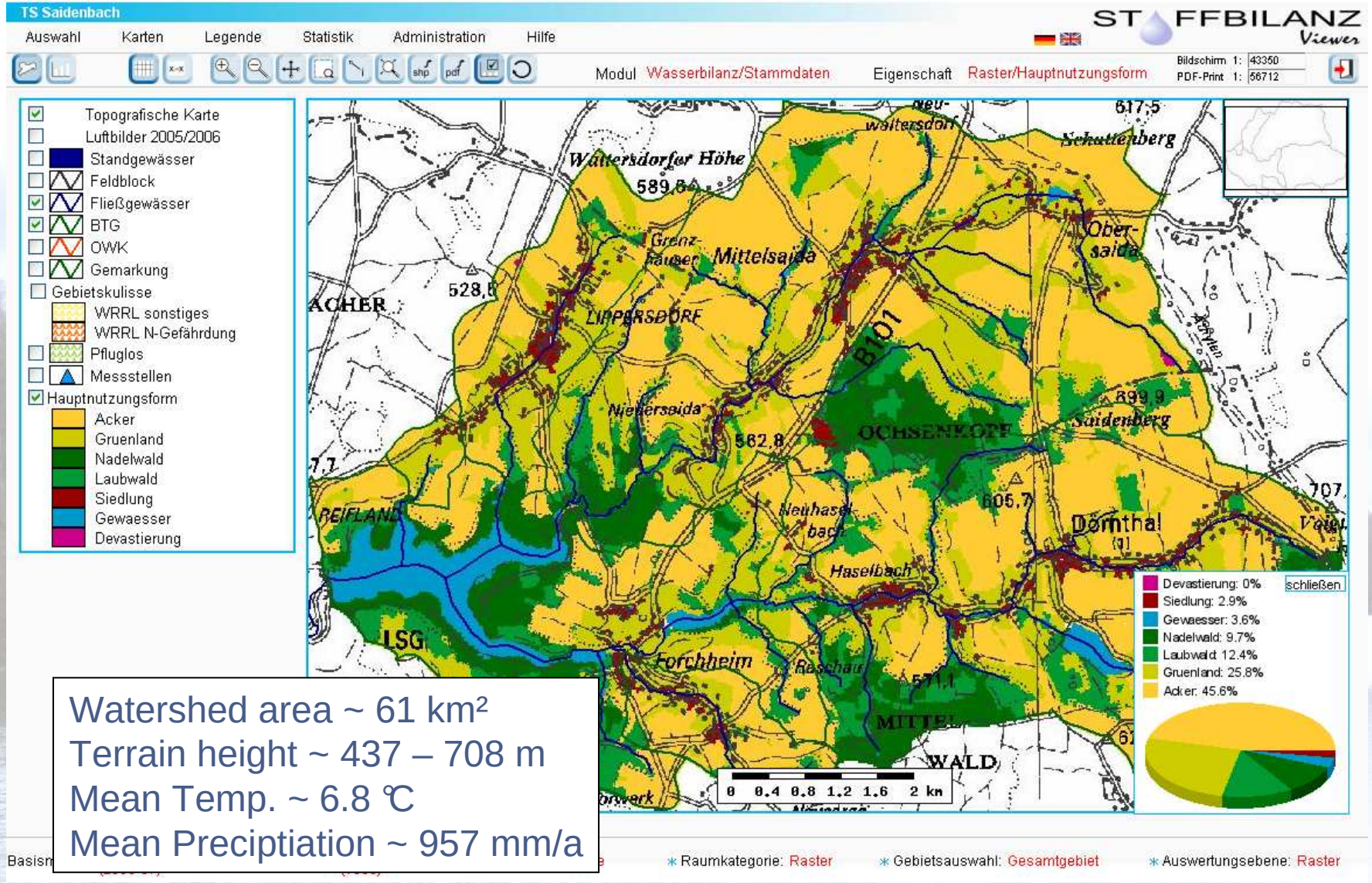
Land use coefficient

Slope

nula

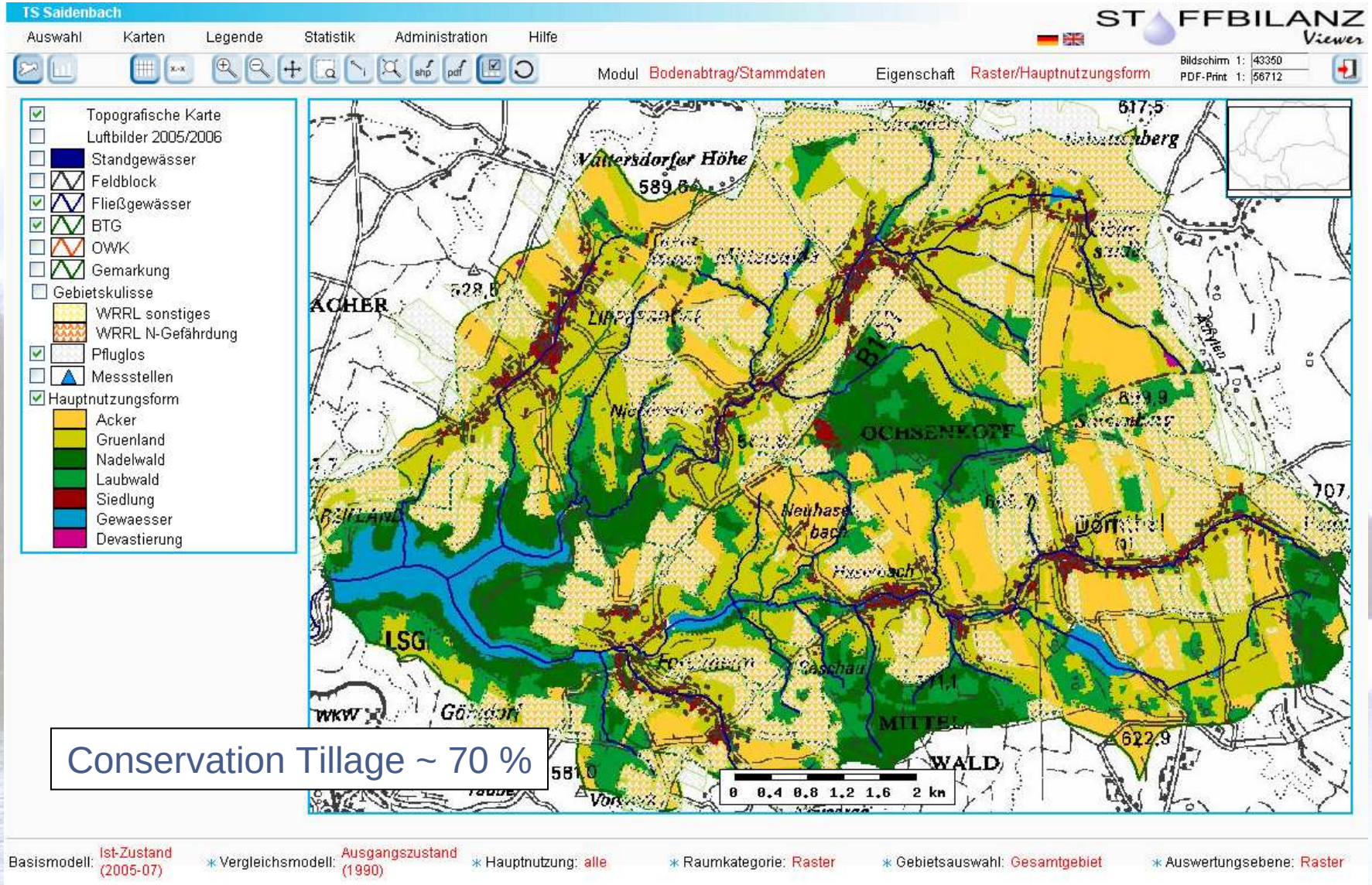
ent hotspot areas

Reservoir Saidenbach / Ore Mountains / Saxony



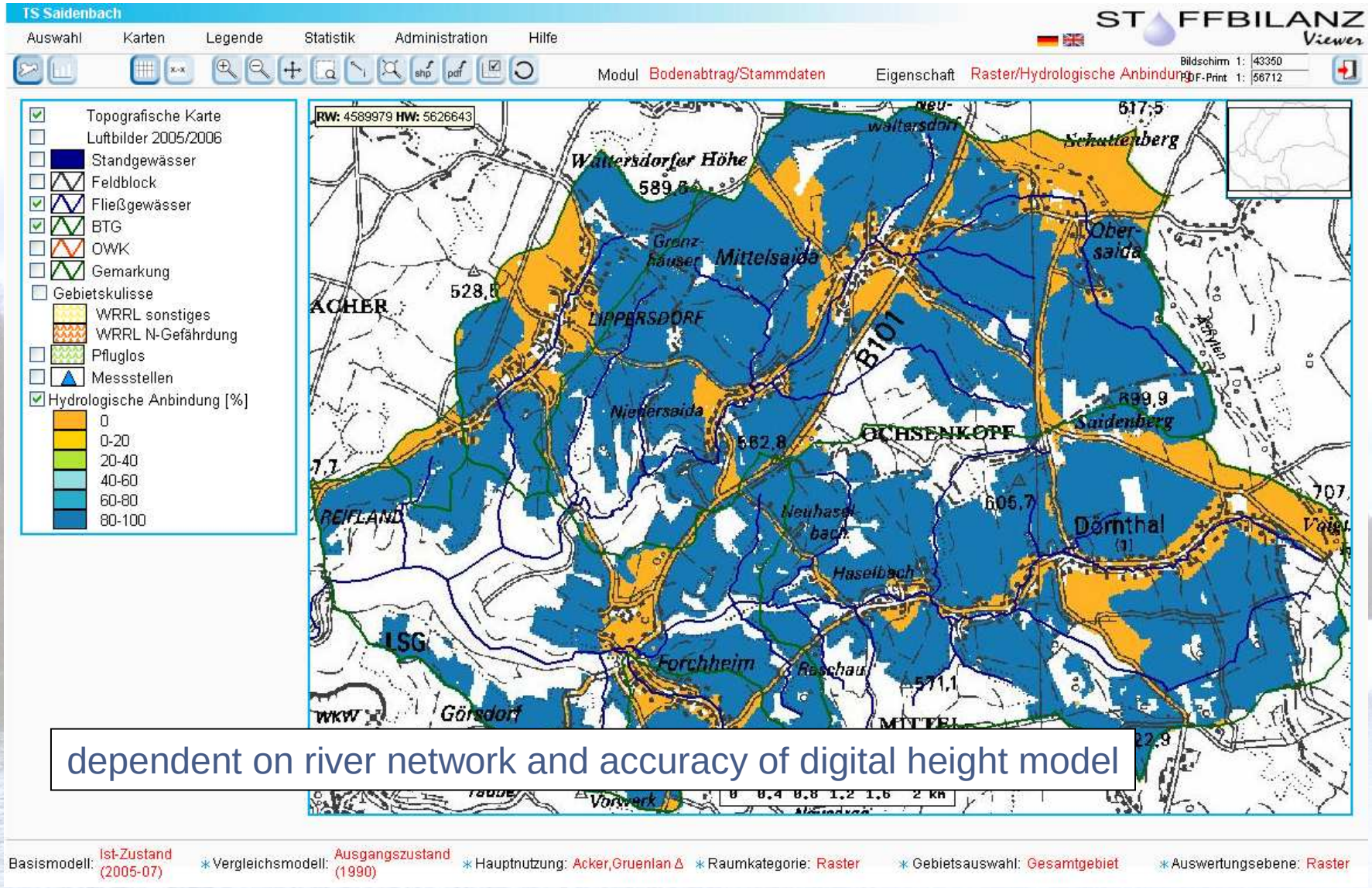
Watershed area ~ 61 km²
Terrain height ~ 437 – 708 m
Mean Temp. ~ 6.8 ℃
Mean Preciptiation ~ 957 mm/a

Conservation tillage



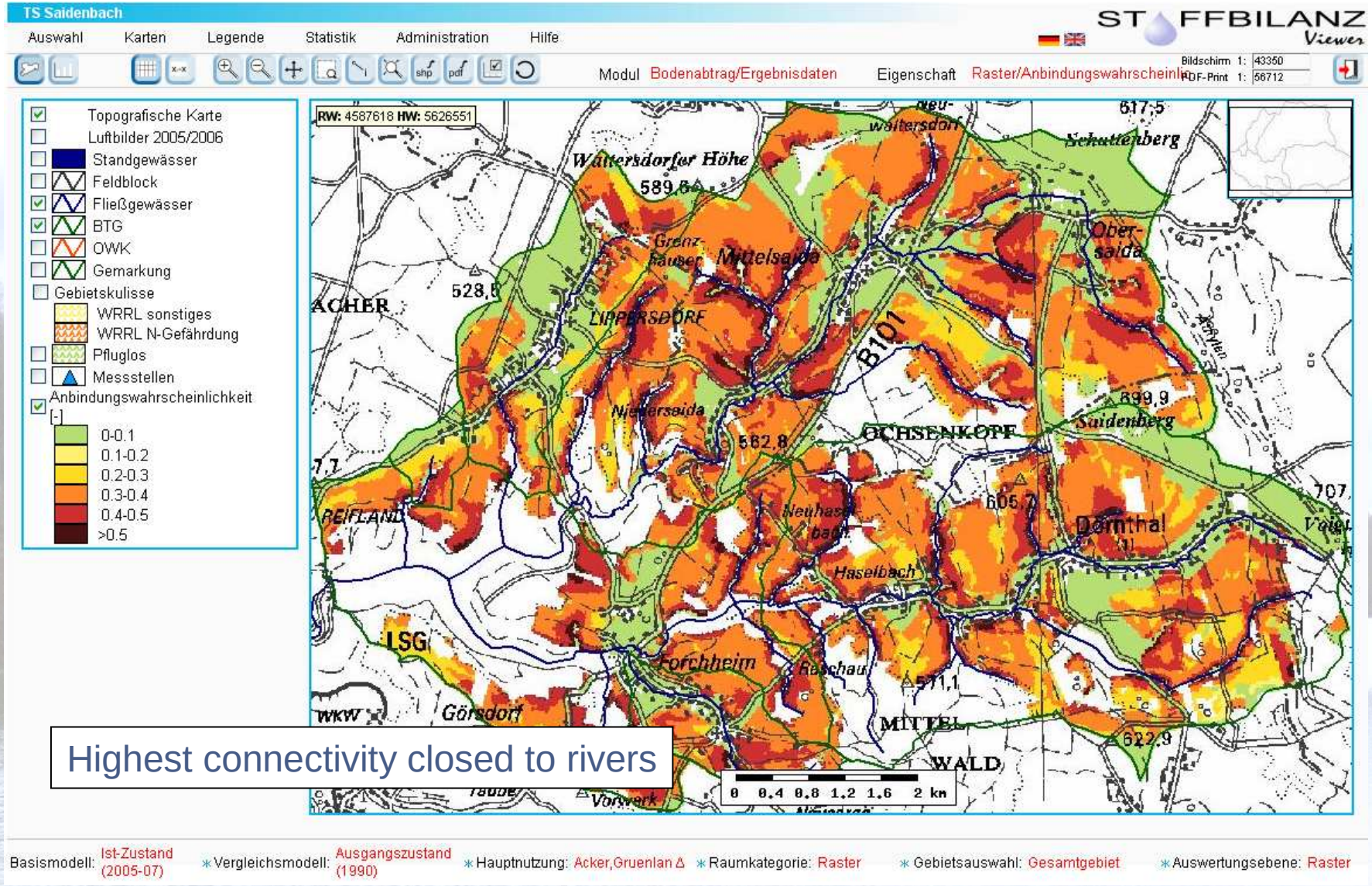
Conservation Tillage ~ 70 %

Hydrological Connectivity



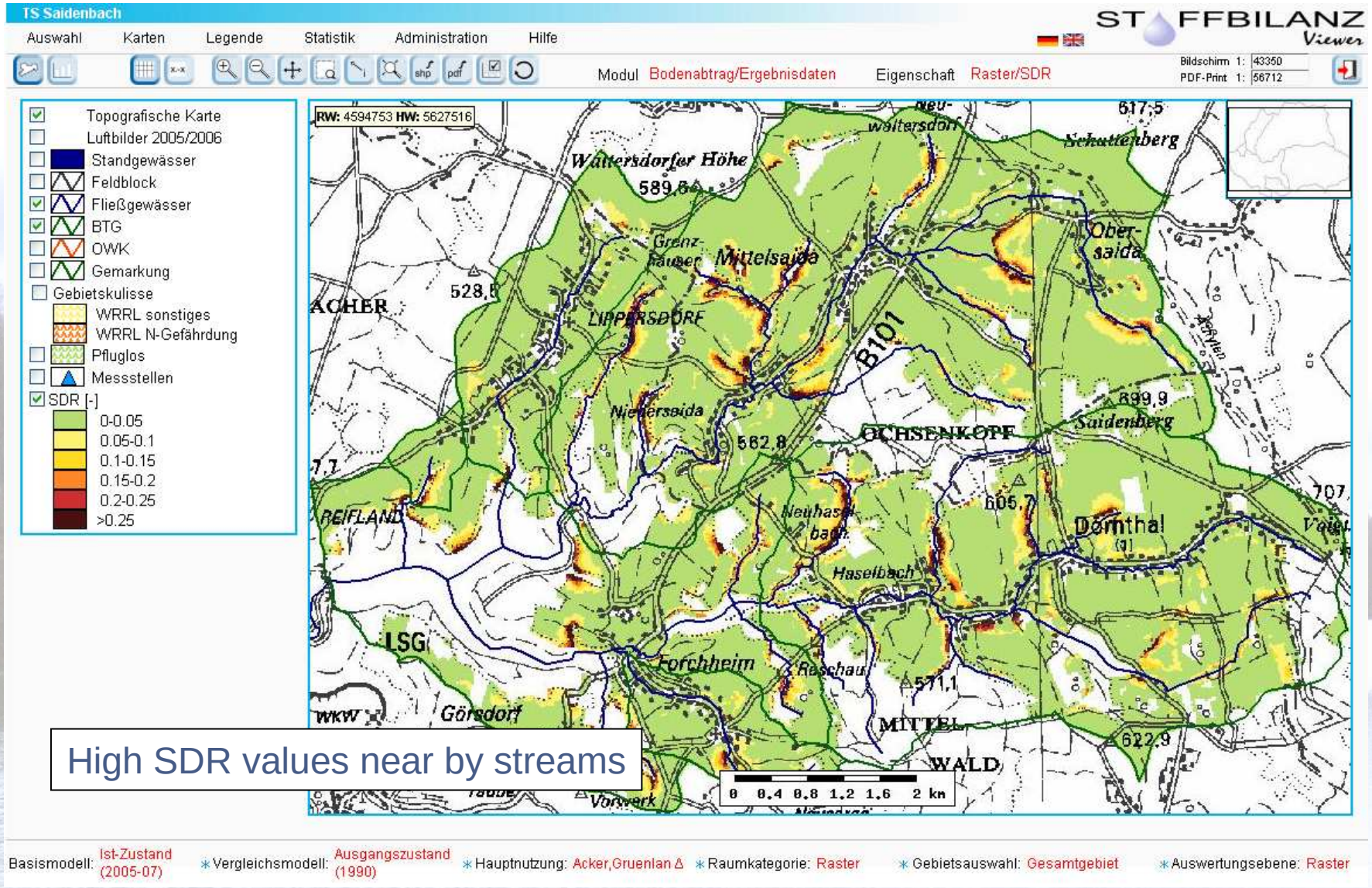
dependent on river network and accuracy of digital height model

Likelihood of Connectivity for Sediment Transport



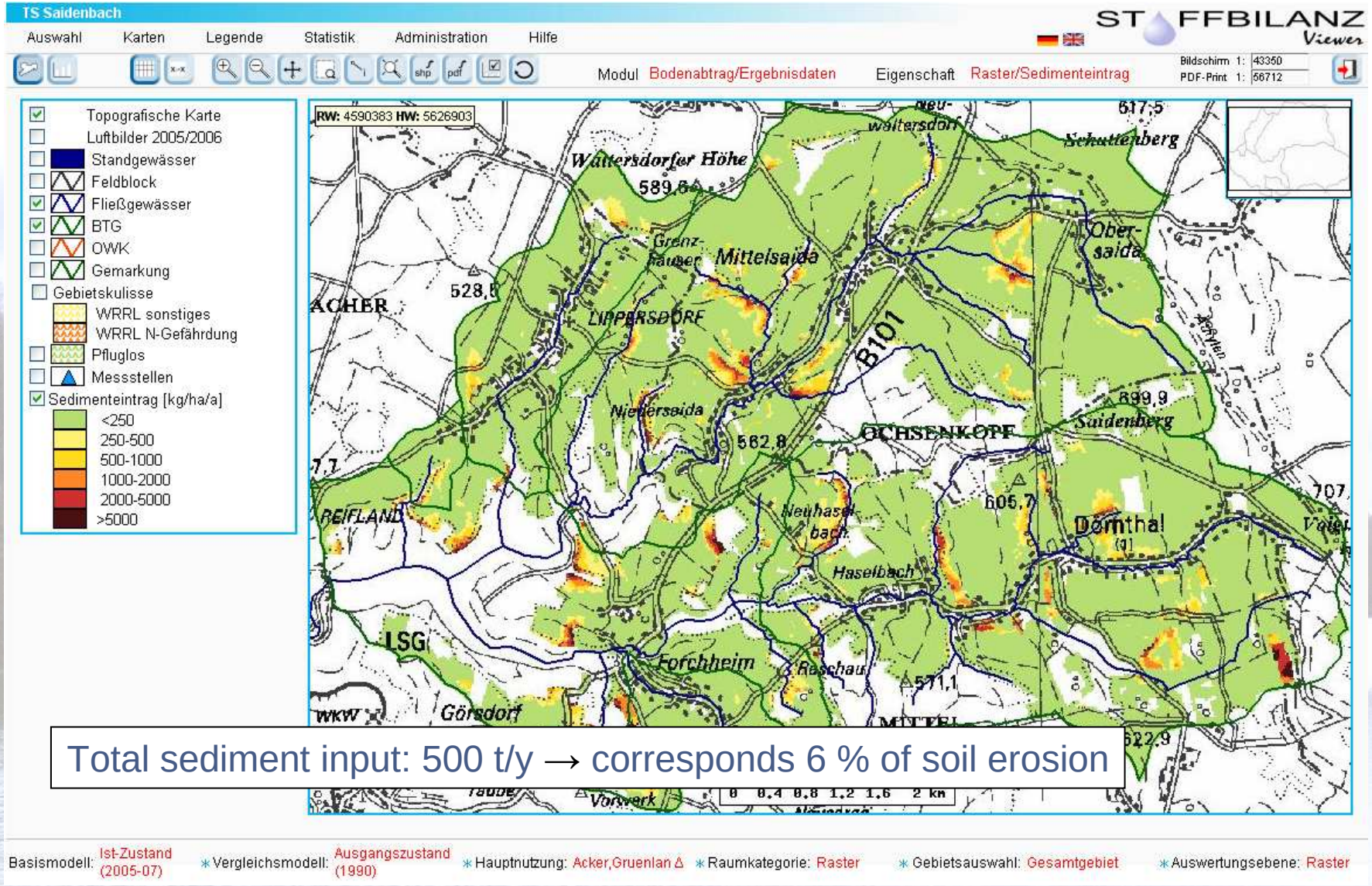
Highest connectivity closed to rivers

Sediment Delivery Ratio



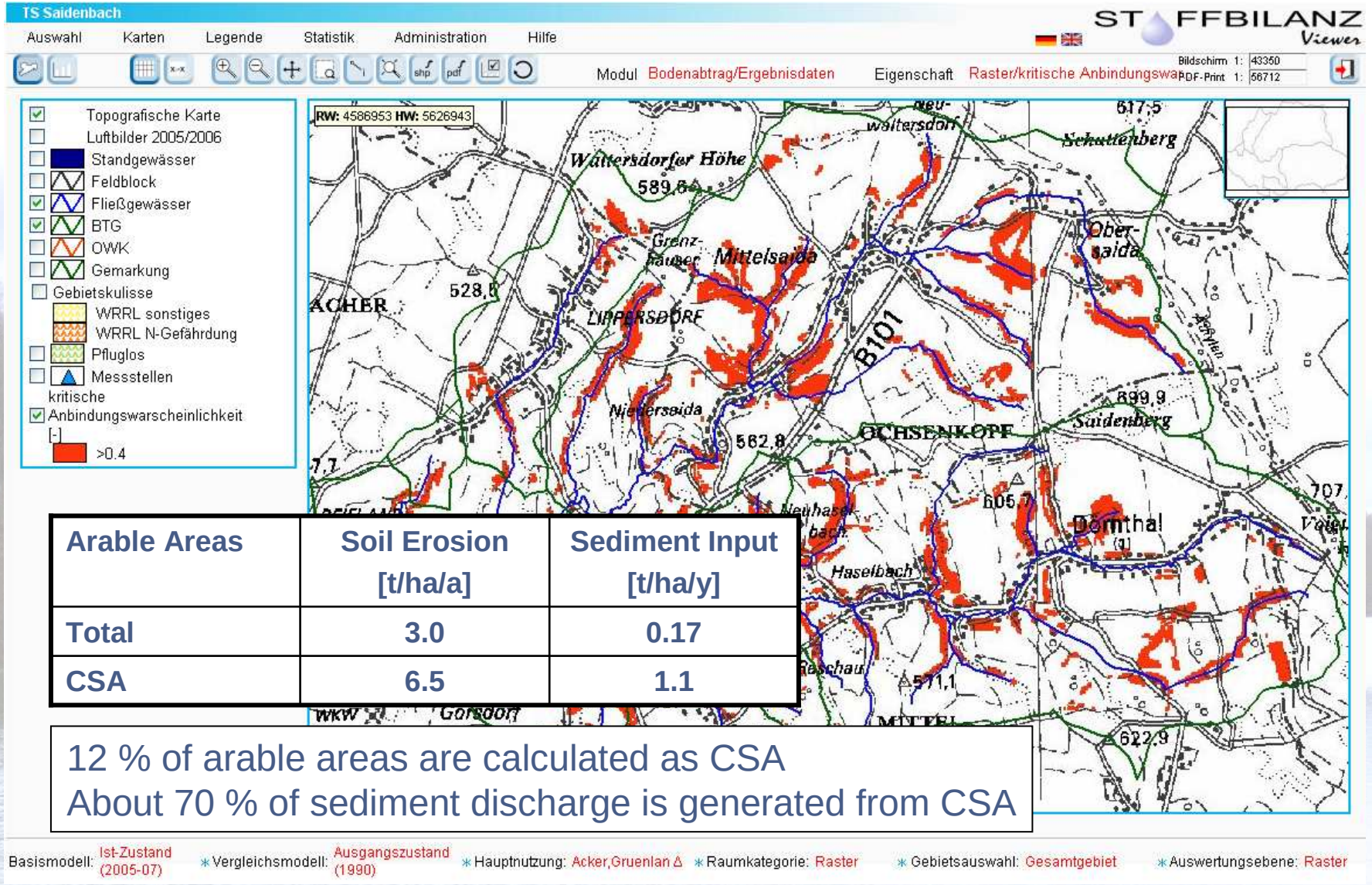
High SDR values near by streams

Sediment Discharge to Surface Waters due to Soil Erosion by Water



Total sediment input: 500 t/y → corresponds 6 % of soil erosion

Critical Source Areas for Sediment Input



Arable Areas	Soil Erosion [t/ha/a]	Sediment Input [t/ha/y]
Total	3.0	0.17
CSA	6.5	1.1

12 % of arable areas are calculated as CSA
About 70 % of sediment discharge is generated from CSA

Restrictions / Questions

- Method for Quantifying Soil Erosion → Which erosion types are considered ? (sheet erosion, rill e., gully e.)
- Sediment Sources ? → agriculture, river bed, urban areas
- Spatial resolution of model grid ?
- Type of digital river network? → spatial accuracy, generalization, completeness