




Soil degradation by water erosion at the regional scale – current and future problems in Benin (West-Africa)

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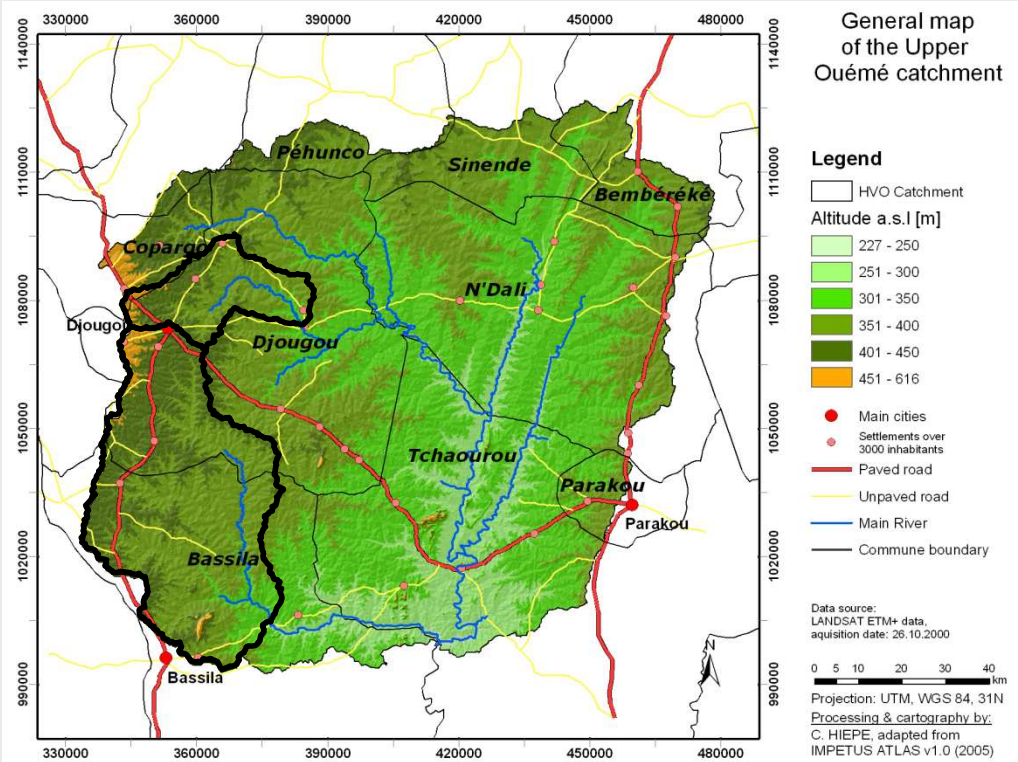
Structure

- Introduction
- Methods and field investigations
- Selected modelling results
  - Status quo (1998-2005)
  - Scenarios
- Conclusions

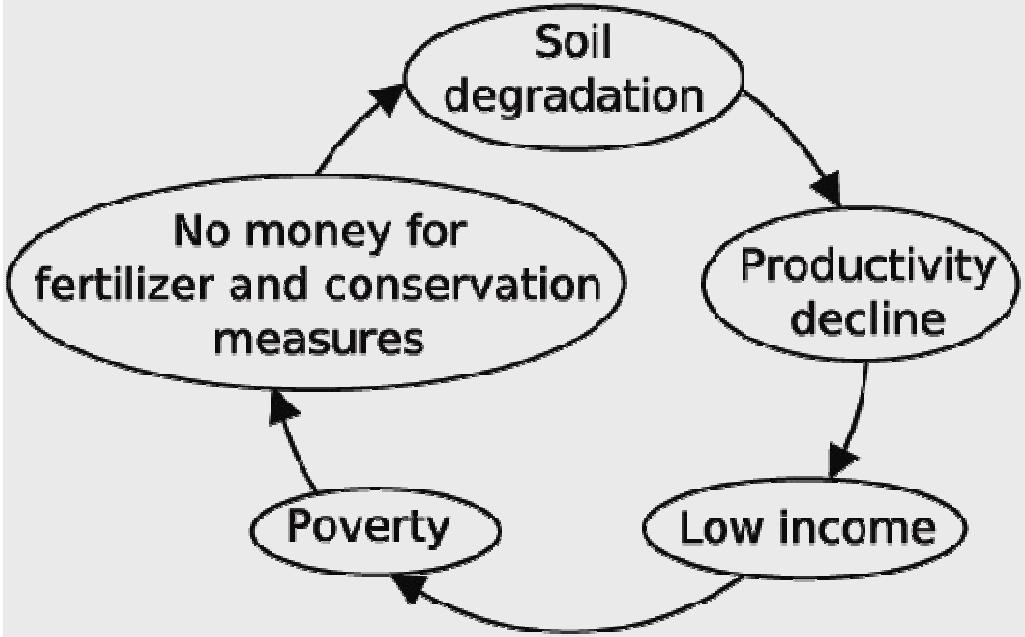
Objectives of this study

Part of IMPETUS project: An integrated approach to the efficient management of scarce water resources in West Africa

- Quantify recent and future soil erosion by water in the Upper Ouémé catchment
- Conclusions about soil degradation and options for soil conservation



Soil degradation - Upper Ouémé



- 38% of farmers report soil degradation on their fields
- Topsoil erosion by water
- Nutrient depletion - C_{org}
  Forest:fallows:exhausted fields
  2.6% : 1.1% : 0.9%


Sheet and rill erosion


Surface crusts and gravel

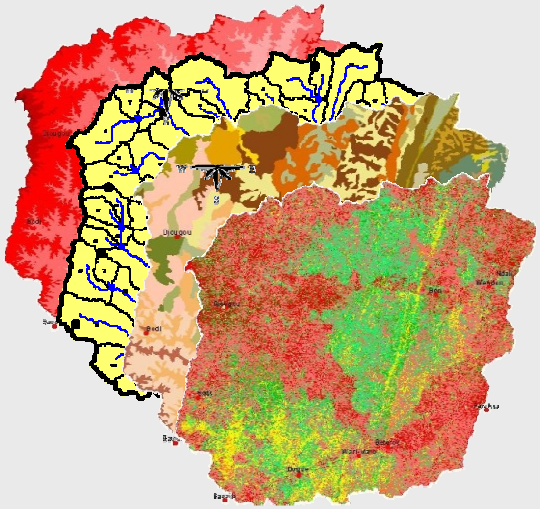

During heavy rainfall

One day after ….

Modelling hydrology and sediment

- process understanding at regional scale; scenario analysis
- regional scale hydrological model: SWAT (Soil Water Assessment Tool)

Parametrisation → Calibration → Validation



DEM 90m, land use map 28.5m
Soil map, climate data
121 subbasins, 926 HRUs

+ related databases

„Adjust parameters so that model results can reproduce field data“

„Check for different time/space“

Calibration/validation data

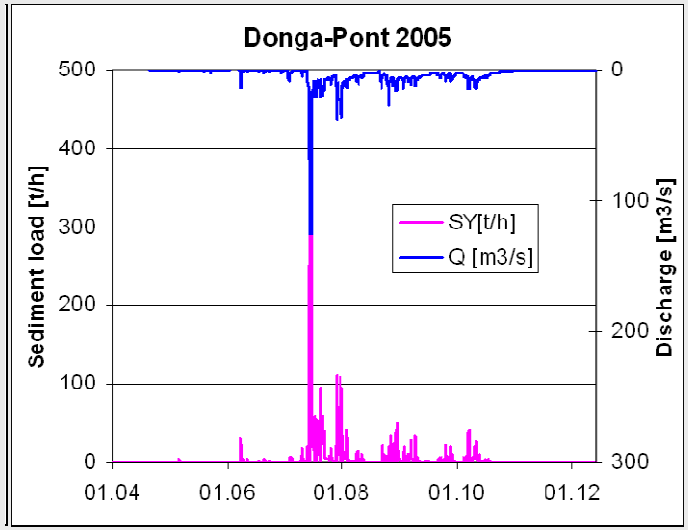
- Discharge (components)
- Suspended sediment concentrations
- Pedotransfer functions

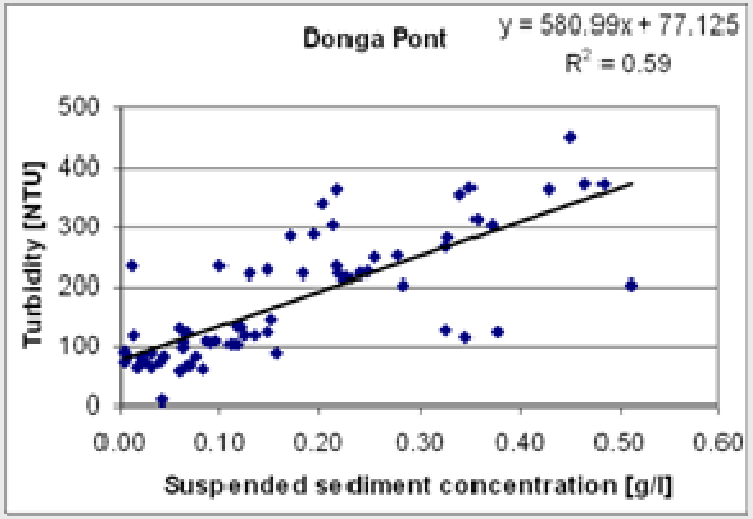
Soil data (38 representative profiles)

Data: Suspended sediment measurements

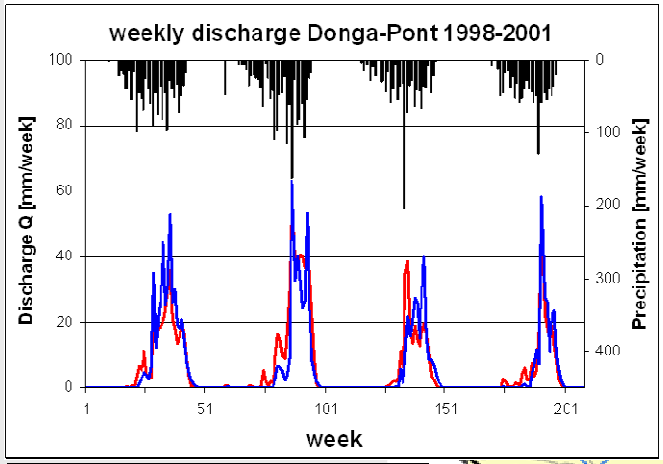
Water sampling

Filtration,
gravimetric weight

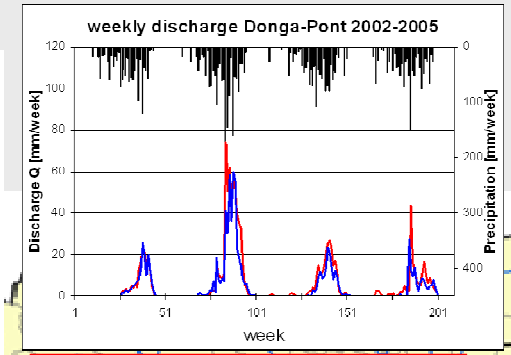




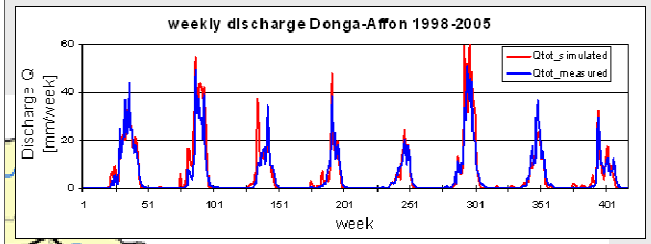
Model calibration/validation: Hydrology

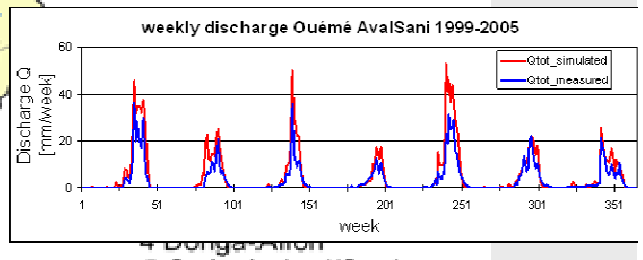


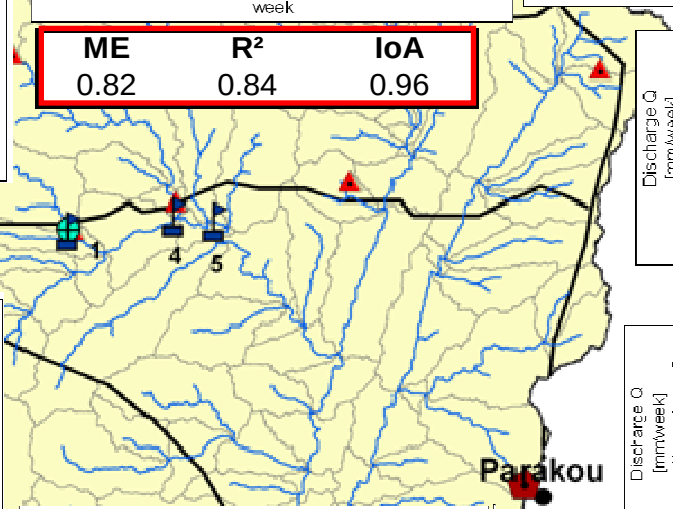
ME	R^2	IoA
0.81	0.81	0.95

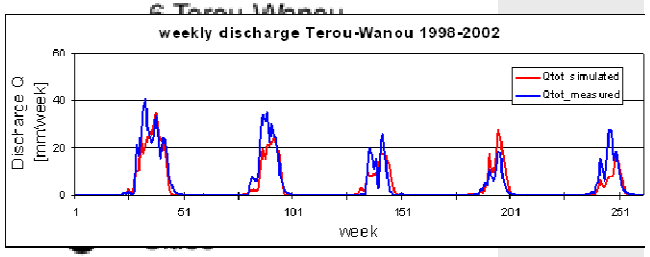


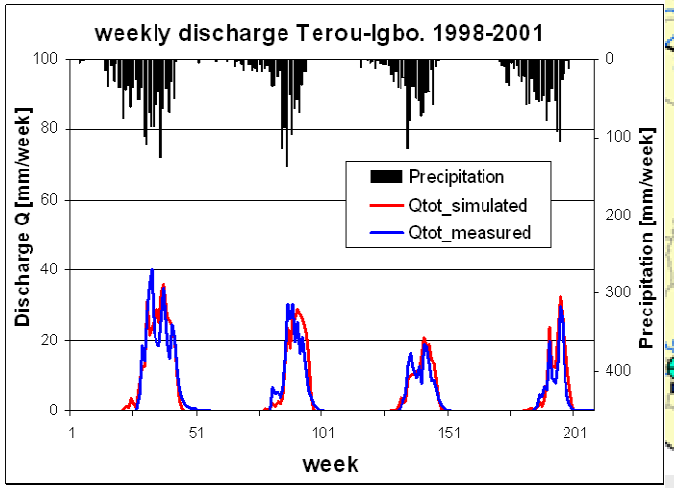
ME	R^2	IoA
0.82	0.84	0.96



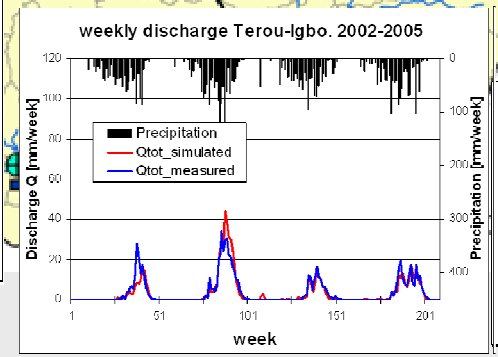




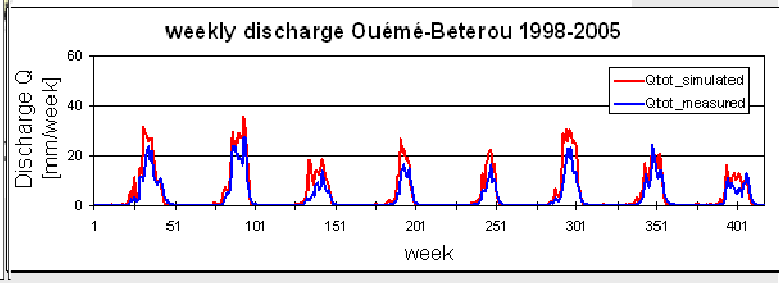




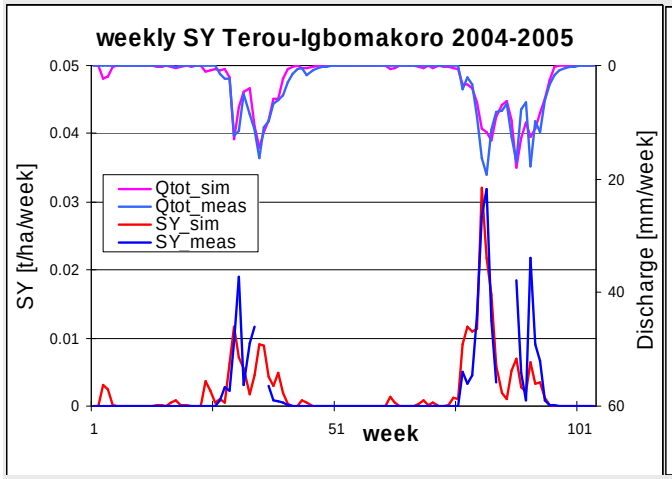
ME	R^2	IoA
0.85	0.87	0.96



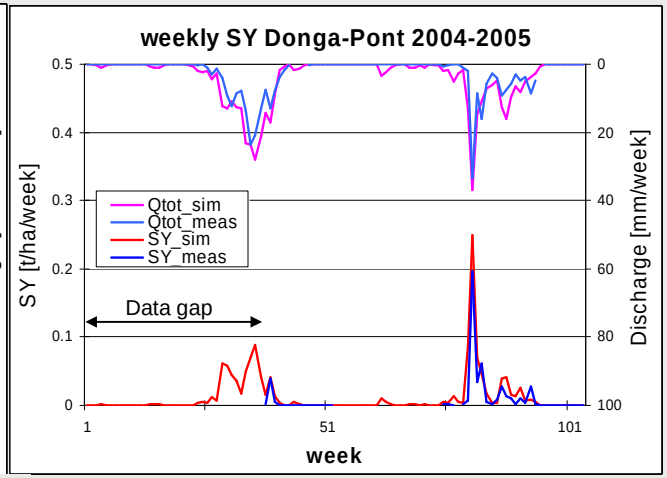
ME	R^2	IoA
0.83	0.85	0.96



Model calibration/validation: Sediment

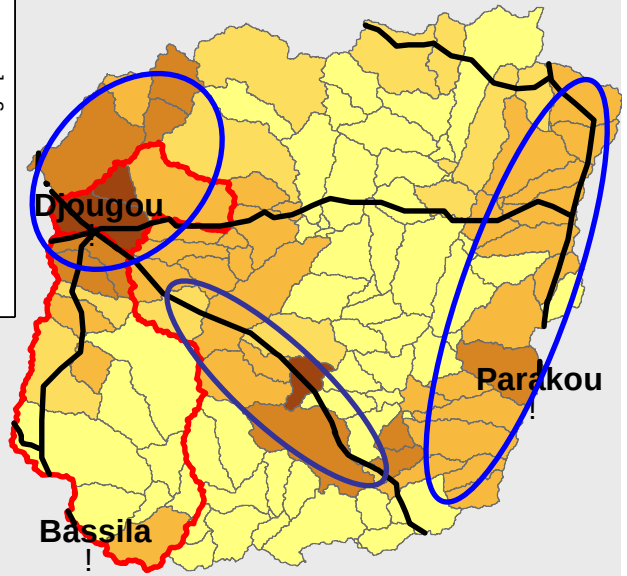


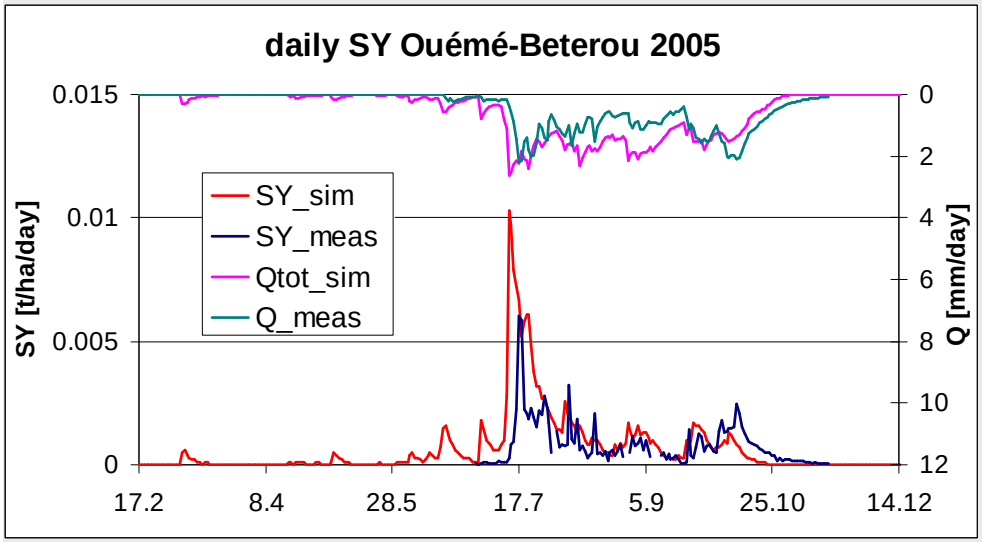
ME 0.68 R^2 0.69 IoA 0.90



ME 0.71 R^2 0.87 IoA 0.94

Interpretation of results





Sediment load:

- Cropland (97%)
- Brush and grass savannah (2.4%)
- Others <1%

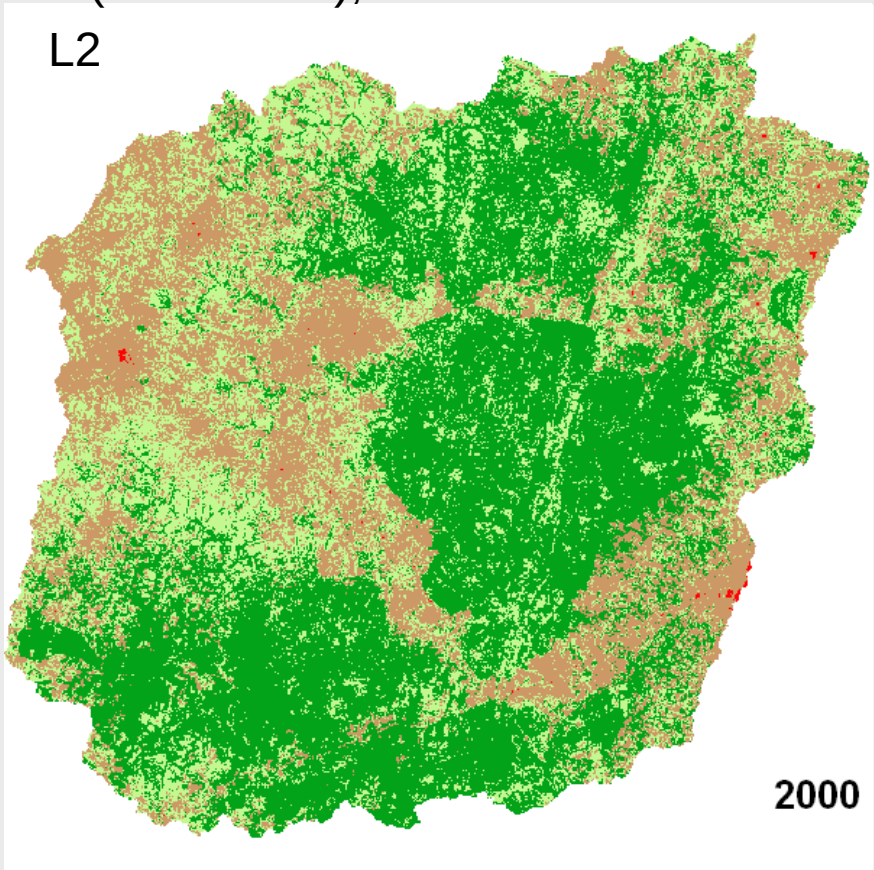
Mean SY [t/ha/yr]

- 0.00 - 0.10
- 0.11 - 0.25
- 0.26 - 0.75
- 0.76 - 1.50
- 1.51 - 2.25
- 2.26 - 3.05

Modelling – future scenarios

.... Parametrisation of scenarios

CLUE-S model: land use maps (2001-2025), scenarios L1-L3

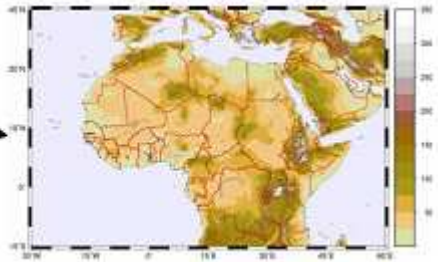


Settlement
Cropland
Forest and dense savannah
Shrub and grass savannah

Regional climate model REMO

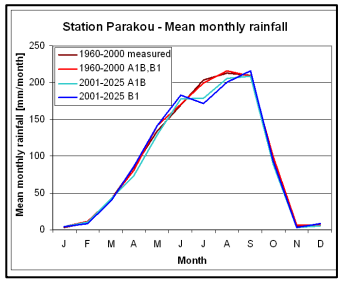
IPCC SRES scenarios A1B and B1

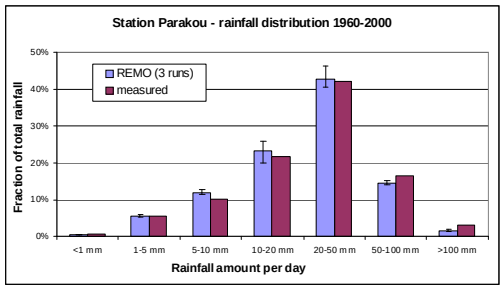
ECHAM4
300km, 200yrs



REMO
55km, 90yrs

REMO
By station





Modelling – future scenarios

.... → Scenarios analysis → Interpretation of results → ....

SWAT

Climate scenarios
(2001-2050)

Land use scenarios
(original period)

Combined scenarios
(2001-2025)

Land use scenarios
Lu2025

Cropland	+51 to +108%
Water yield	+3 to +7%
Surface runoff	+11 to +23%
Sediment yield	+42 to +95%

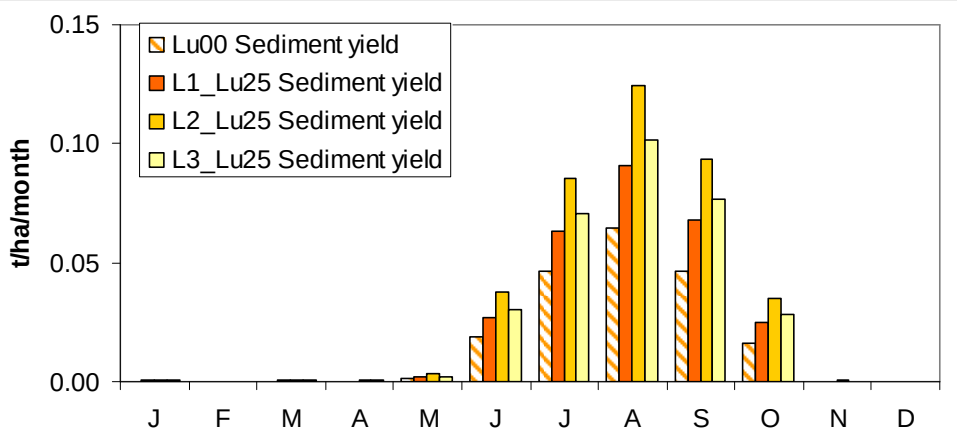
Climate scenarios
2001-25/2026-50

Rainfall	-3 to -8%
Water yield	-6 to -23%
Surface runoff	-3 to -15%
Sediment yield	-5 to -27%

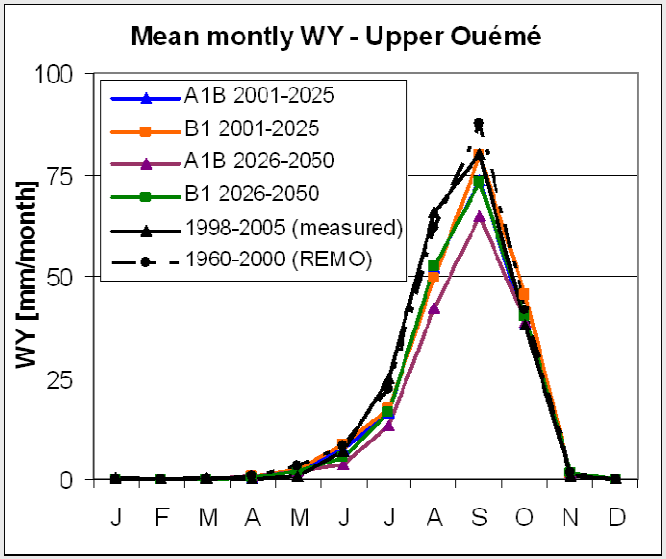
Combined scenarios 2001-25

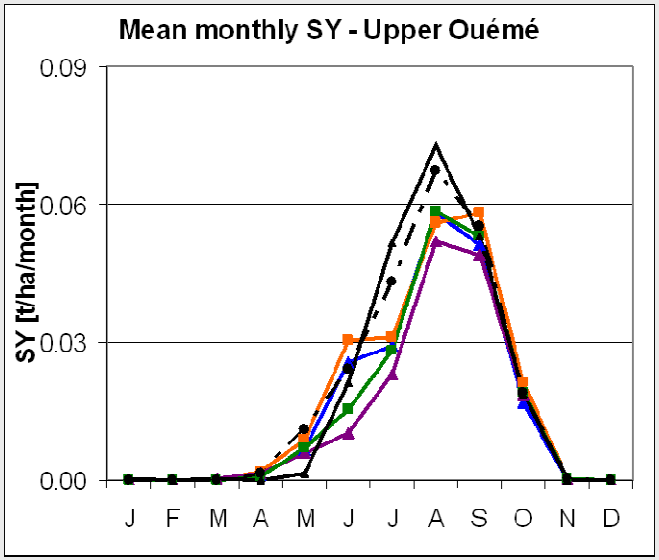
Water yield	-3 to -11%
Surface runoff	-4 to +6%
Sediment yield	-2 to +31%

Scenarios: Temporal results



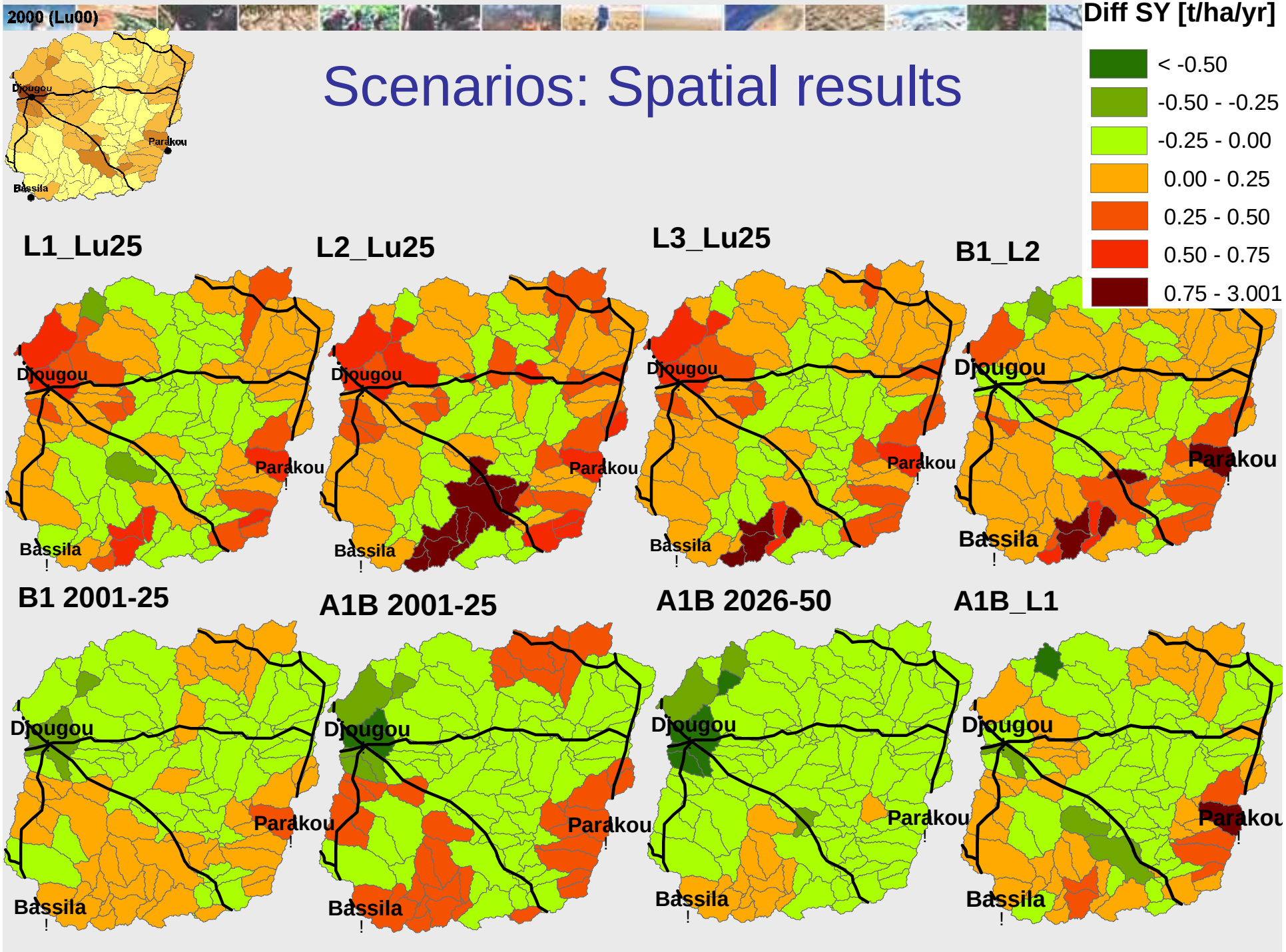
Lu scenarios:
Regularly distributed





Clim scenarios:
↑WY/SY in May,
↓WY/SY in June to Sept

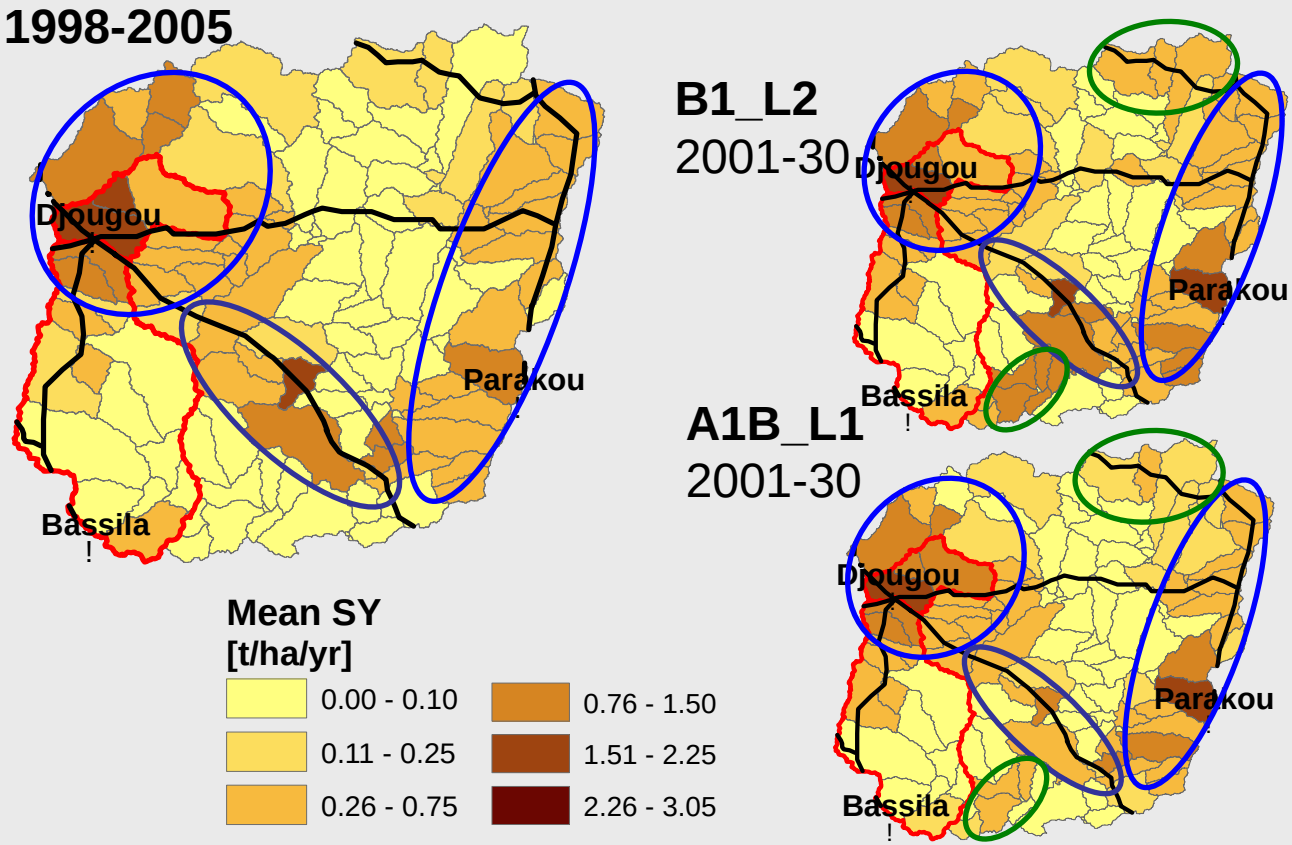
Scenarios: Spatial results



Conclusions

- SWAT successfully applied, improved understanding, regional hotspots
- Opposite effects of climate and land use change, LU change dom (SY -2 to +31% in 2001-30), aggravating soil degradation
- After 2030 CC more relevant with ↑differences among scenarios
- Further aggravation of existing hotspots of soil erosion
- New hotspots in S and NE of the catchment

Conclusions

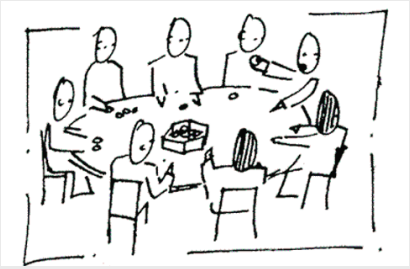


Zoom out …

- Hotspot analysis can support land use planning, SDSS
- Impact assessments crucial for climate change adaptation, need to look at climate + land use change
- Link erosion to productivity loss, management scenarios
- Soil and water conservation is a no-regret option

Main challenges in impact assessments:

- Data collection
- Robust model calibration/validation requires expertise
- Transdisciplinary work
- Limitations of climate models



Towards a sustainable land use

→ Little active soil management

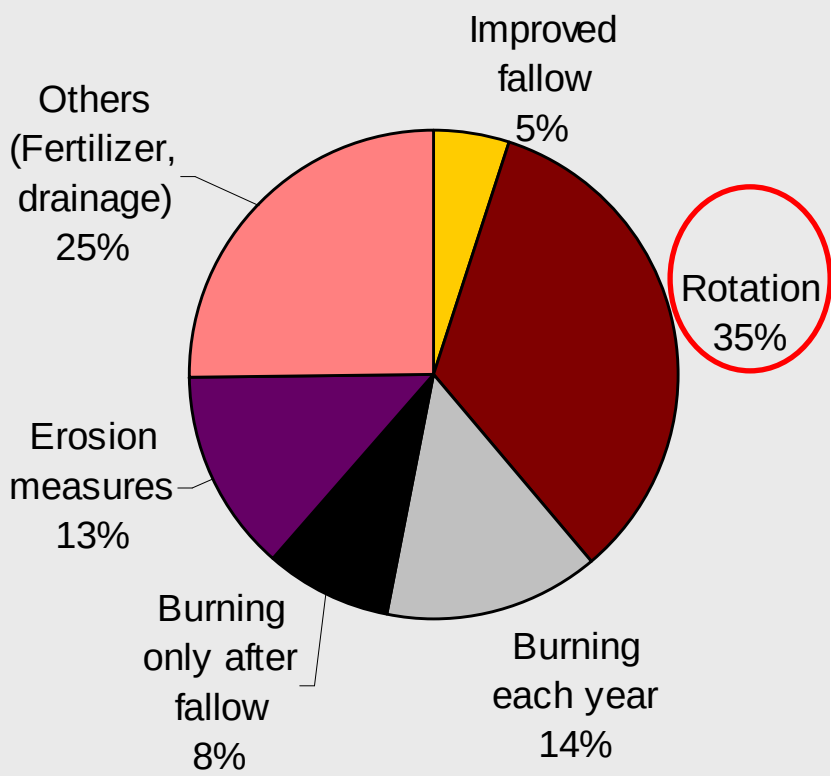
→ Solution lies in the farming system

→ Adoption is location- and livelihood specific

Wide range of soil conservation measures

- Cultural technology and soil tillage
- Plant management
- Use of organic/mineral fertilizer
- Improve framework conditions

Soil conservation - Upper Ouémé




Cover crops

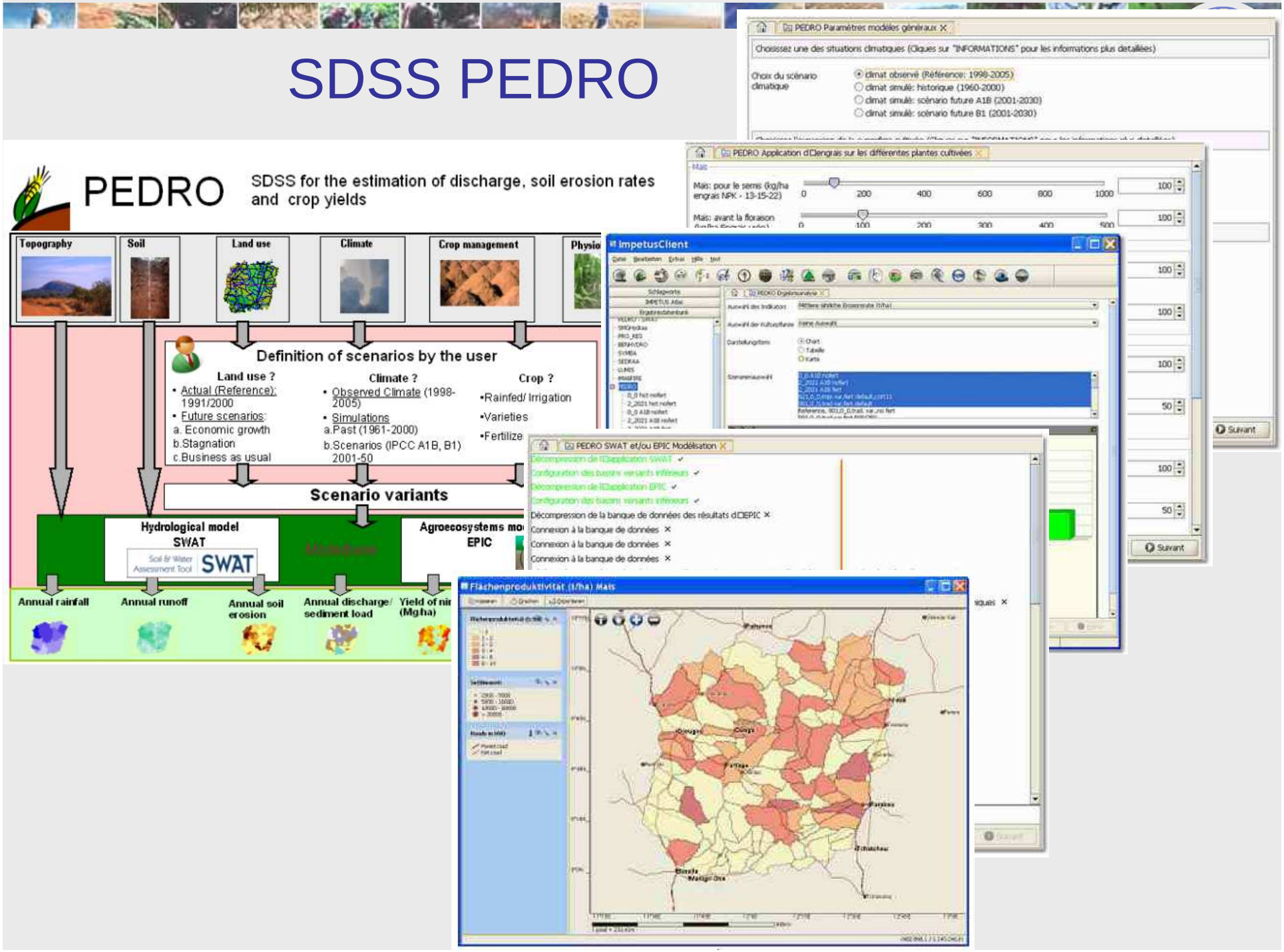

Agro-forestry

Top mulching

Vetiver hedge

Tillage

SDSS PEDRO


PEDRO
SDSS for the estimation of discharge, soil erosion rates and crop yields
Topography
Soil
Land use
Climate
Crop management
Definition of scenarios by the user
Land use ?
• Actual (Reference): 1991/2000
• Future scenarios:
a. Economic growth
b.Stagnation
c.Business as usual
Climate ?
• Observed Climate (1998-2005)
• Simulations
a.Past (1961-2000)
b.Scenarios (IPCC A1B, B1) 2001-50
Crop ?
•Rainfed/ Irrigation
•Varieties
•Fertilize
Scenario variants
Hydrological model SWAT
Soil & Water Assessment Tool SWAT
EPIC
Annual rainfall
Annual runoff
Annual soil erosion
Annual discharge/ sediment load
PEDRO Paramètres modèles généraux
Choisissez une des situations climatiques (Cliques sur "INFORMATIONS" pour les informations plus detaillées)
Choix du scénario climatique
climat observé (Référence: 1998-2005)
climat simulé: historique (1960-2000)
climat simulé: scénario future A1B (2001-2030)
climat simulé: scénario future B1 (2001-2030)
PEDRO Application d'engrais sur les différentes plantes cultivées
Maïs: pour le semis (kg/ha engrais NPK - 13-15-22)
Maïs: avant la floraison
Suivant
ImpetusClient
PEDRO SWAT et/ou EPIC Modélisation
Décompression de la banque de données des résultats d'EPIC
Connexion à la banque de données
Flächenproduktivität (t/ha) Mais

Thank you!

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Hiepe, C (2008): http://hss.ulb.uni-bonn.de/diss_online/math_nat_fak/2008/hiepe_claudia/

http://www.impetus.uni-koeln.de/en