Paper number:
337

3RD EURO-MEDITERRANEAN CONFERENCE FOR ENVIRONMENTAL INTEGRATION
ONLINE | 10–13 JUNE 2021
www.emcei.net

User-friendly and Integrated Simulation Tool for Support Sustainable Land Management Planning in Tunisian Landscape

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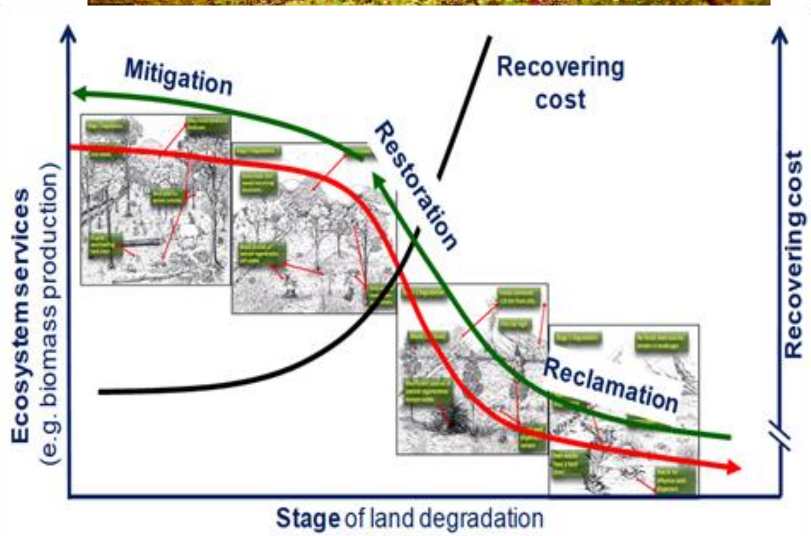
1. Background and Motivation

Problem: Land Degradation & Cost of in-action



Principal solution: Sustainble Land Management (SLM)

- In watershed context, soil and water conservation (SWC) practices are keys for soil erosion control, protecting agricultural production and ecosystems

Methodological challenges

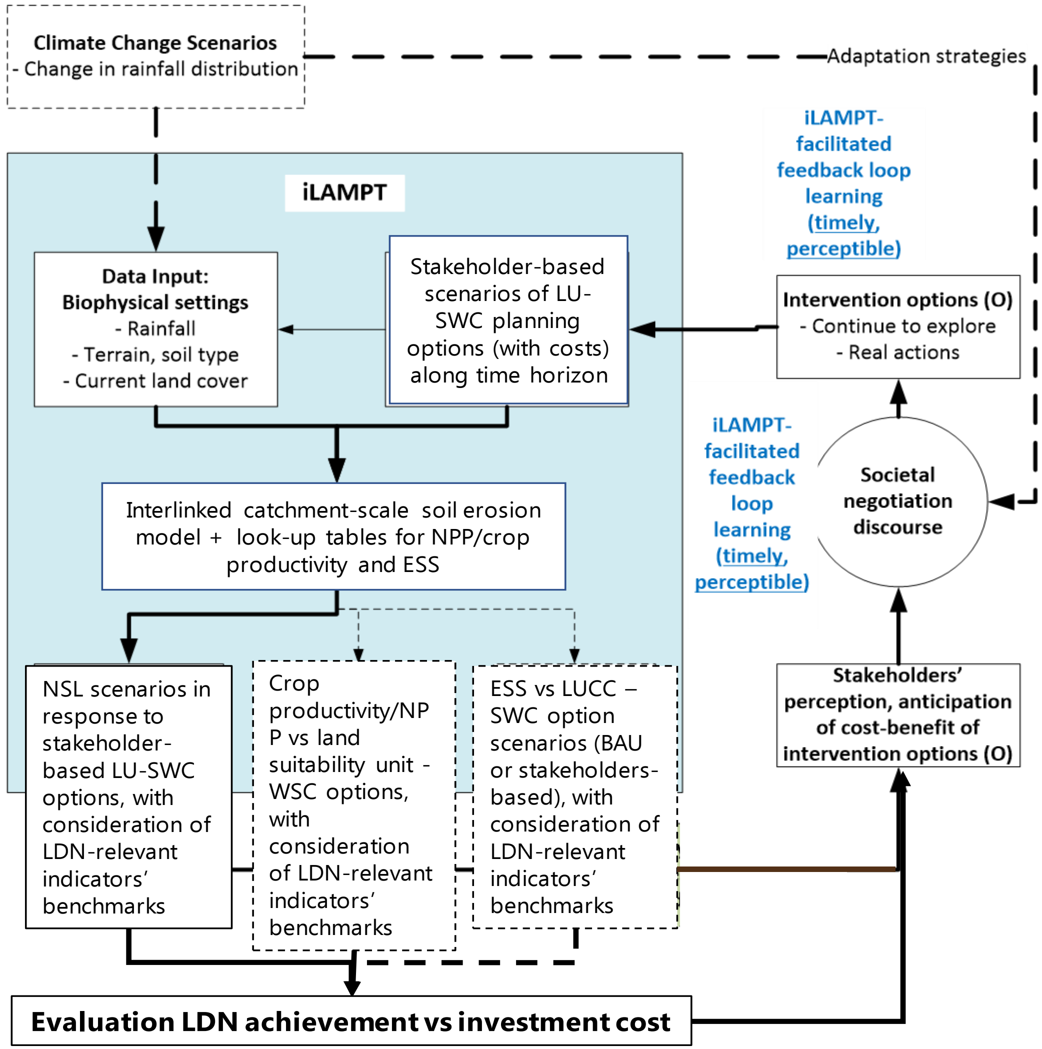
- Diversities of spatial planning options and preferences
- Uncertainty in anticipations of potential outcomes of SWC planning options
- Given existing spatial models (e.g. soil erosion model), how to put the model at hand of land users/planners for interactively answering various *WHAT-IF* questions in spatial SWC planning?

Aim

- **To develop an user-friendly, spatially explicit tool for supporting stakeholders identify cost-effective soil-water conservation (SWC) planning options to reduce soil degradation**
  - The tool is as a mean to answer different WHAT-IF questions in SWC planning process

Integrated Landscape Management and Planning Tool (iLAMPT)

- Use **catchment-scale soil erosion model** being sensible to SWC practices that are planned over space by stakeholders
- A simulation model to **answer stakeholder-relevant WHAT-IF** questions in a timely fashion:
  - *WHAT would be the soil erosion pattern **y** IF SWC planning option **x** is applied?*
- To be used in a the feedback learning loop in adaptive landscape management
- Components with dotted lines are under development.



Core model

- Potential soil loss: terrain-based soil erosion assessment (LS):

$$(m+1)\left[\frac{A_s}{22.13}\right]^m\left[\frac{\sin\beta}{0.0896}\right]^n$$

where: *As*= upslope contributing area, β = slope, m and n = empirical coefficient

- Gross soil loss **RUSLE = LS*R*C*K*P**

  where: R = rainfall-runoff erosivity factor, K = soil erodibility factor, C = cover management factor, and P = management practices factor.

- Net soil loss: RUSLE adjusted by Sediment Delivering Ratio (SDR), i.e. RUSLE * SDR

$$SDR_i = \exp\left(-\beta * \frac{L_i}{R_i S_i^{1/2}}\right) \quad (6)$$

where β is a routing coefficient, a catchment-specific parameter; L_i is the length of segment i in the flow path and is equal to the length of the side or diagonal of a cell depending on the flow direction in the cell; R_i is the coefficient based on surface roughness characteristics (see Table S4, Supplementary information); and S_i is the slope gradient (m/m).

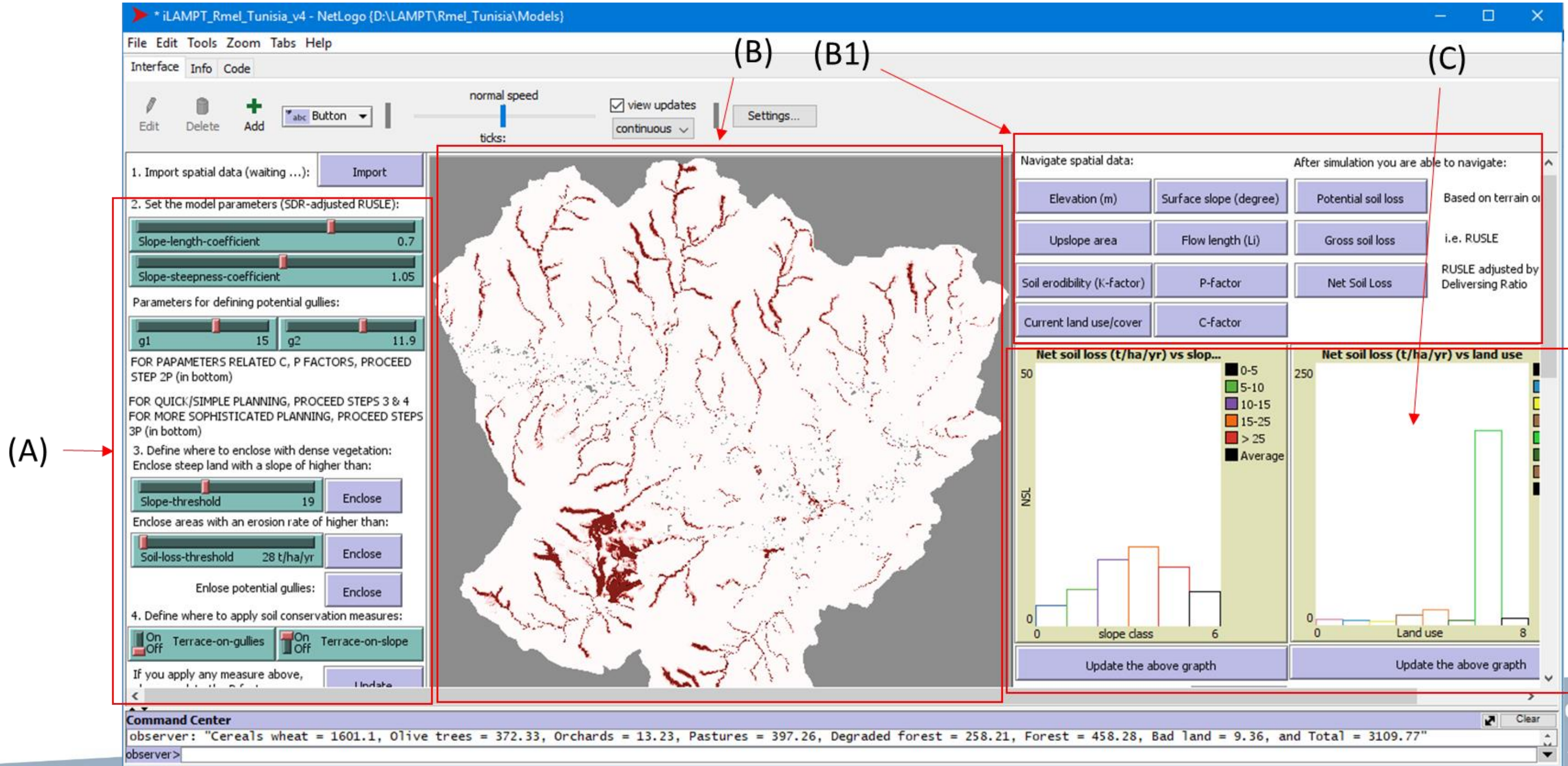
Friendly Graphic User Interface (GUI)

Graphic User Interface (GUI) links the Core Model to different visual components:

(A) SWC planning parameters easily defined by users

(B) Timely responsive map window (multi-view) (B1)

(C) Timely responsive graphs showing erosion distribution vs slope class, land use (with/without applied SWC practices, etc.)



Different options/entry-points for defining SWC planning options as inputs

- Timely explore soil erosion responses to simple rule-based SWC planning options

3. Define where to enclose with dense vegetation:
Enclose steep land with a slope of higher than:

Slope-threshold 19 | Enclose

Enclose areas with an erosion rate of higher than:

Soil-loss-threshold 28 t/ha/yr | Enclose

Enlose potential gullies: | Enclose

4. Define where to apply soil conservation measures:

On Off Terrace-on-gullies | On Off Terrace-on-slope

If you apply any measure above, please update the P-factor: | Update

- Assess impact SWC planning (prepared areal SLM transition matrix) on soil erosion and cost (needing prepared participatory processes)

3.a. Planning matrix option (you fill the bellow matrix -> the tool generates the grids of SWC over time -> update relevant C- and P- factors -> calculate LD outputs and cost):

SWC practice implemented	Land use type targeted	Area (% of the total LUT area) targeted in 5 yrs	in 10 yrs	in 15 yrs
SWC-A1 Conservation Agricu...	LUT-A1 Cereal/wheat	A1-5yr 20	A1-10yr 20	A1-15yr 20
SWC-A2 Cuvette individuale	LUT-A2 Olive trees	A2-5yr 30	A2-10yr 30	A2-15yr 20
SWC-A3 Mannual banquette	LUT-A3 Ochards	A3-5yr 20	A3-10yr 30	A3-15yr 30
SWC-A4 Mechanized banquette	LUT-A4 Pastures	A4-5yr 15	A4-10yr 15	A4-15yr 15
SWC-A5 Reboisement et ame...	LUT-A5 Degraded f...	A5-5yr 20	A5-10yr 20	A5-15yr 20
SWC-A6 Reboisement et ame...	LUT-A6 Forest	A6-5yr 0	A6-10yr 0	A6-15yr 0
SWC-A7 Reboisement et ame...	LUT-A7 Bad land	A7-5yr 0	A7-10yr 0	A7-15yr 0

- Assess impact SWC planning (prepared technical SLM planning maps) on soil erosion and cost (needing technically prepared SWC planning maps)

3.b. Prepared planning map option (you import your prepared SWC planning maps -> the tool generates the grids of SWC over time -> update relevant C- and P- factors -> calculate LD outputs and cost):

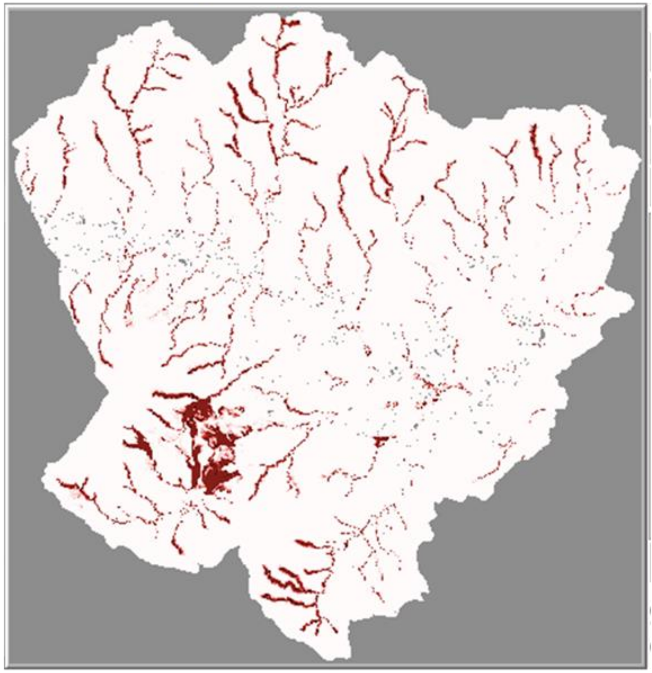
Import planned SWC map (yr 5) - parameters update

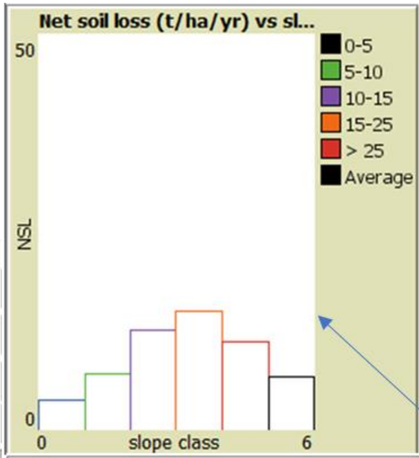
Import planned SWC map (yr 10) - parameters update

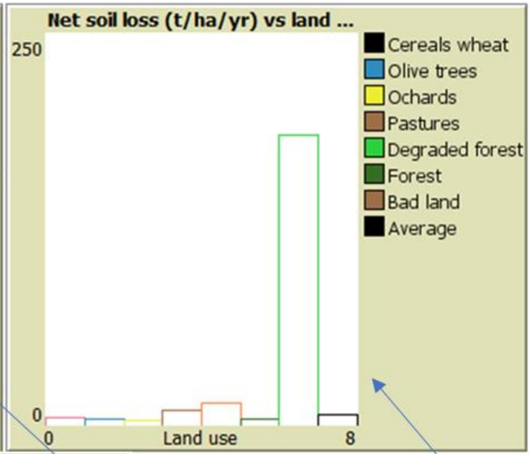
Import planned SWC map (yr 15) - parameters update

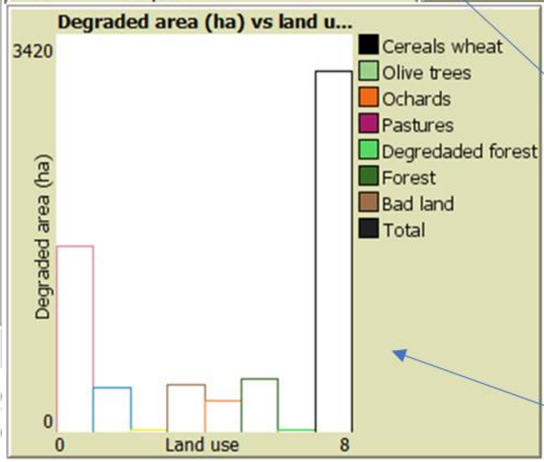
Timely responsive map and graphs of soil erosion as outputs

Responsive GIS maps of different erosion indexes (potential and gross soil losses, sedimentation delivering ratio, net soil loss)









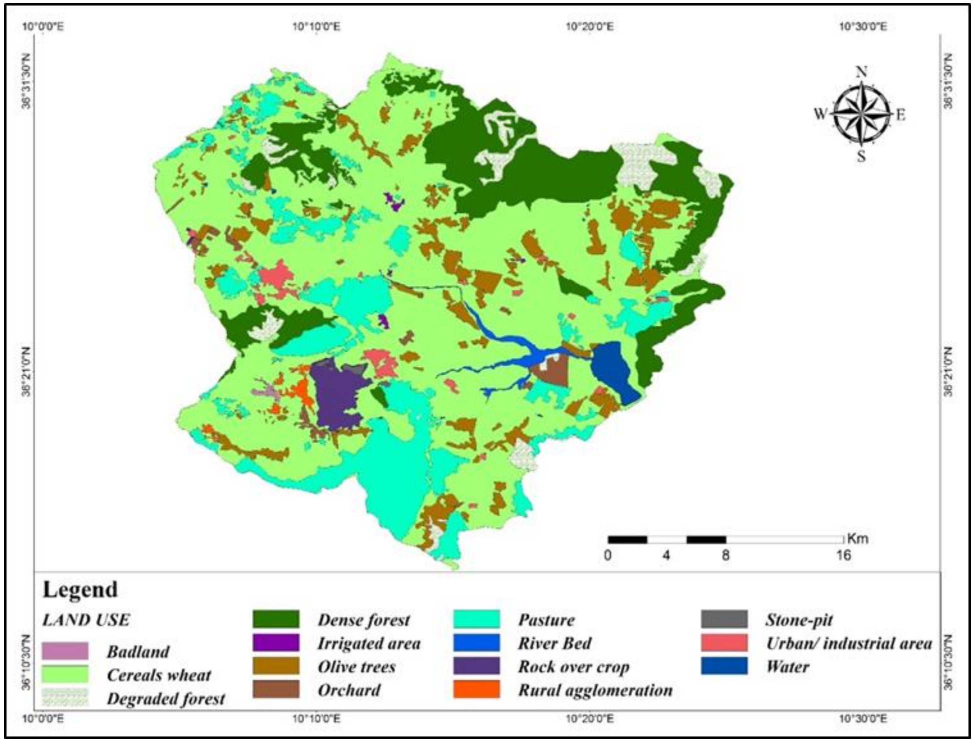
Responsive graph of net soil loss vs. Slope class and land use type (with/without SWC)

Responsive degraded area vs. land use type (with/without SWC)

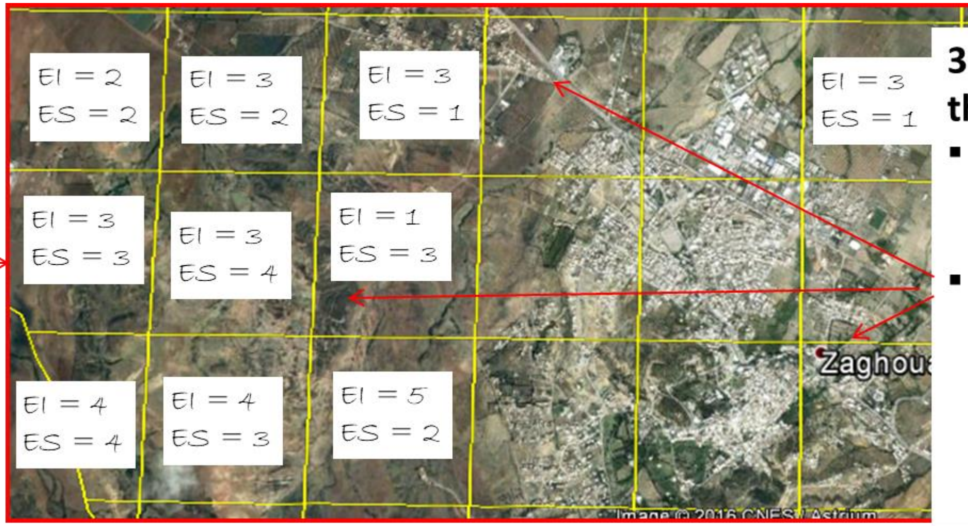
Validation 1: simulated vs. observed siltation

- Consider Rmel catchment in Zaghouan governorate, Tunisia

- Pilot runs show average NSL being close to measured siltation in local lakes (12 sites, 2014): 13.32 ± 5.80 T/ha/yr (tentative data, in revision)



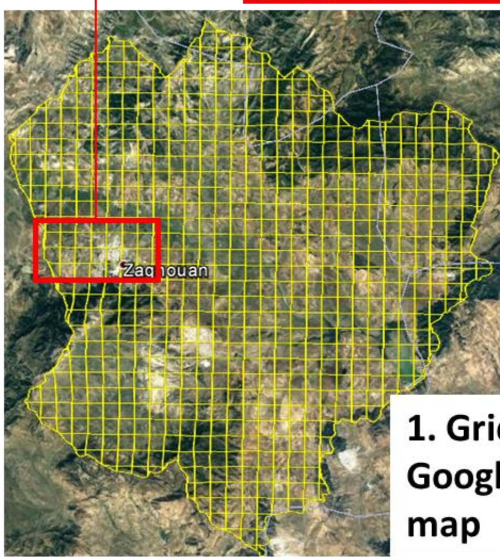
Validation 2: participatory and grid-based method



3. Getting familiar with the selected map:

- Match the map's North with the real North direction
- Check with participants: *Can you recognize at least 3-5 important features on the map (e.g. town, river, road, mountain peak, etc.)?*

2. Pick an area of interest

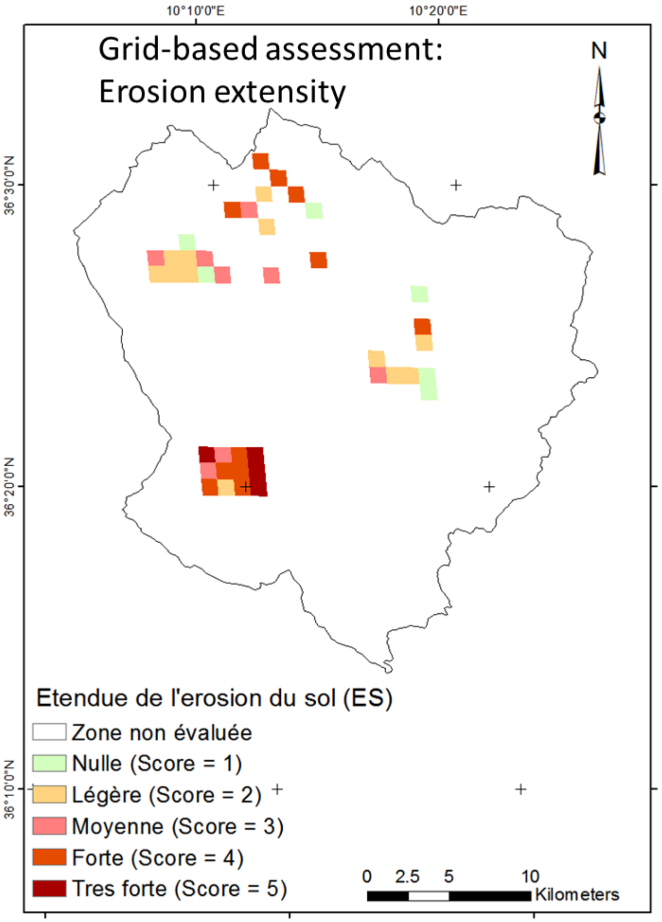


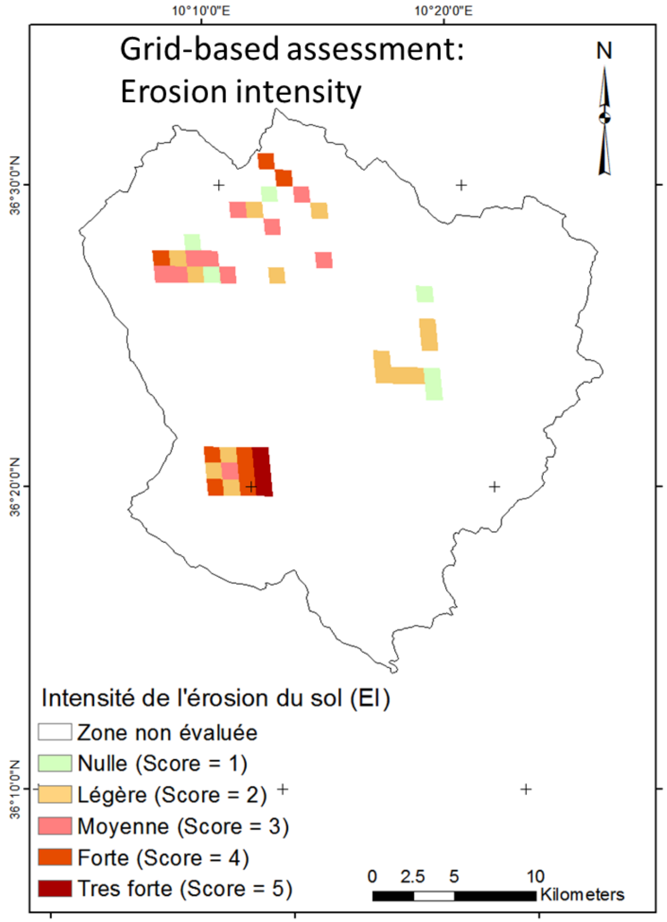
1. Gridded Google Earth map

4. FOR EVERY GIRID of the selected map:

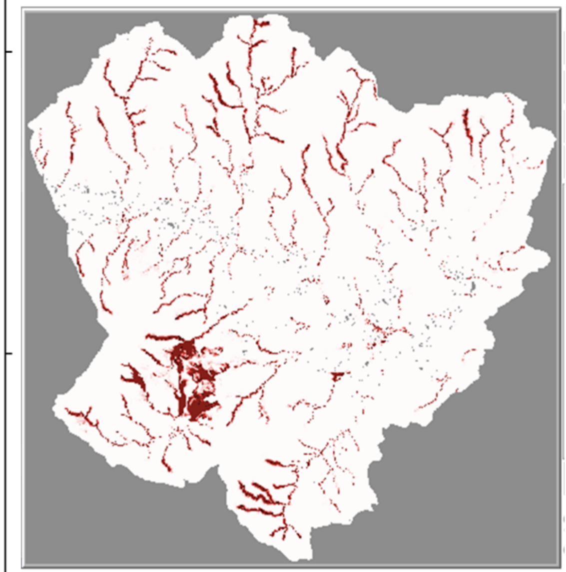
- **To score soil erosion intensity (EI)** (1 to 5)
  1- no
  2- light
  3- medium
  4- strong,
  5- very strong
- **To score soil erosion speading (ES)** (1 to 5)
  1- no
  2- 10 – 20% of the grid area
  3- 20-40%
  4- 40 – 70%,
  5- > 70%

Validation 2: participatory and grid-based result





Simulated NSL pattern



Conclusions

- We developed user-friendly, spatially explicit modelling tool for supporting stakeholders identify SWC planning options to reduce soil degradation across watershed
- The tool was validated by comparing simulated vs. observed siltation and participatory grid-based appraisal
- Being prepared for testing usages and collecting feedbacks from stakeholders (farmer org., governmental managers, researchers, educators)
- The tool will be adaptively developed version-by-version in meeting community needs.

Thank you!

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Sponsors: EC-H2020 LANDSUPPORT Project (Grant Agreement No. 774234)