Combining hydrological models with optimization for optimal placement of water-sensitive solutions

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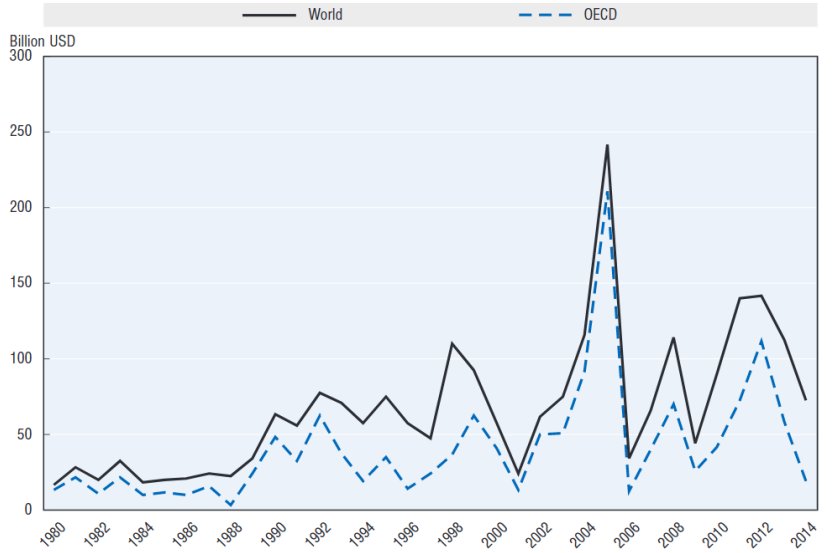
Water related risks- too much, too little, too polluted

- A rise in population, and water demand.
- Urbanization had removed vegetation and added impervious surfaces.
- Increased risk of storm damage due to climate change.
- degradation of surface and groundwater quality due to agriculture and NPS pollution

Figure 1.1. **Economic losses from climatological, meteorological and hydrological disasters, 1980-2014**

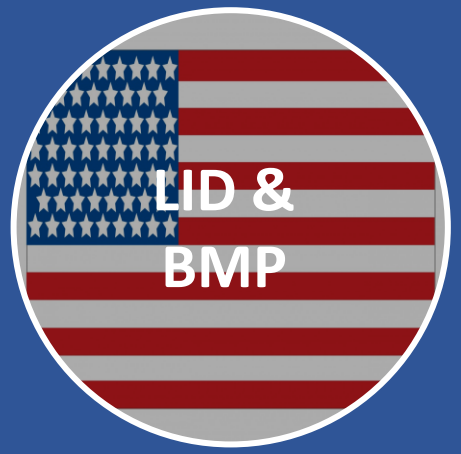


Source: EM-DAT (*Emergency Event Database*) (n.d.), "The International Disaster Database", Centre for Research on the Epidemiology of Disasters, *www.emdat.be/* (accessed 27 February 2015).

Conventional water infrastructure

- Comprised of treatment facilities, pipelines, pumps, and storage tanks.
- Climate change + urbanization = more runoff
- Conventional facilities have limited capacity
- Aging systems have become less sustainable.

Sustainable runoff management methods



LID- on-site practices to restore natural hydrological processes

BMP- structural and non-structural practices to reduce pollution from stormwater

Minimize the hydrological impacts of urban development on the environment

Technologies and techniques to drain runoff in a more sustainable way

reducing the negative impacts of stormwater and treating runoff as a valuable resource

Water Sensitive Planning (WSP)

Increase infiltration

Water detention/retention


Infiltration wetland


Wet pond


Bioretention cell


Green roofs


Pervious pavement


Constructed wetland

Objective and Methodology

Simulation

Multi-objective optimization

Pareto

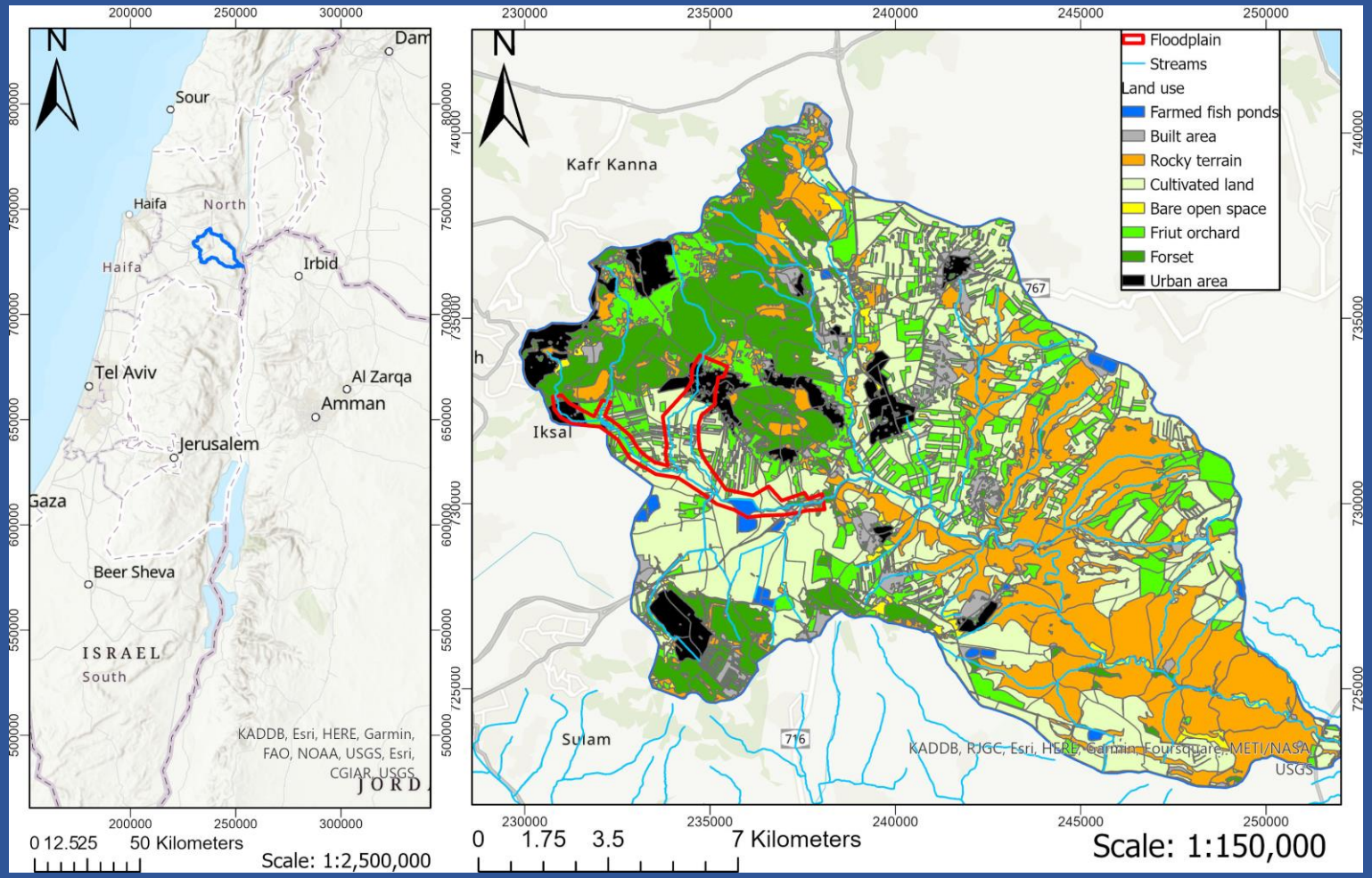
Optimal placement of WSP solutions

Cost-benefits analysis

Multi-objective optimization

Optimal type of WSP solutions

Case study- the Tavor basin



Low population density, mainly agriculture type settlements

Heavy rain in limited areas and erodible soils

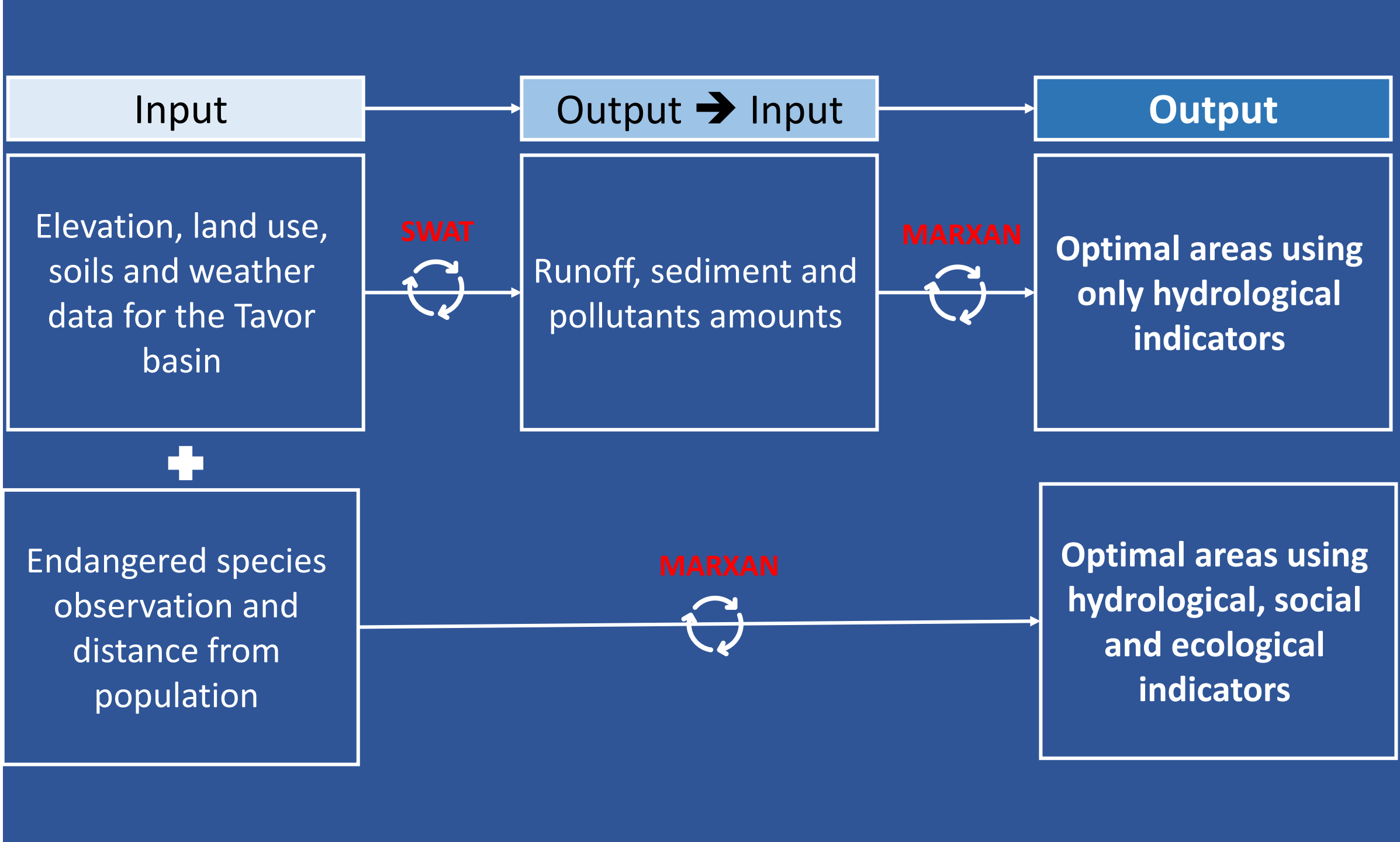
Characteristics

Climate

Extensive cultivated areas, forested areas, rocky terrain

Land use

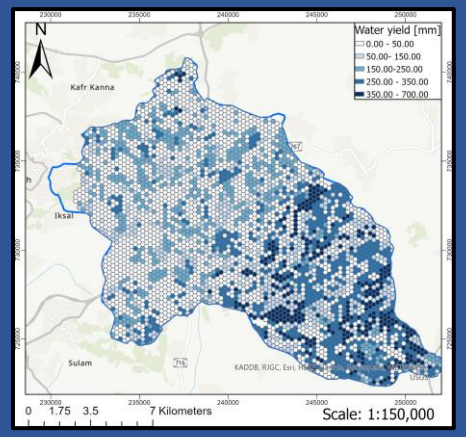
Phase 1- identify "hot spots"

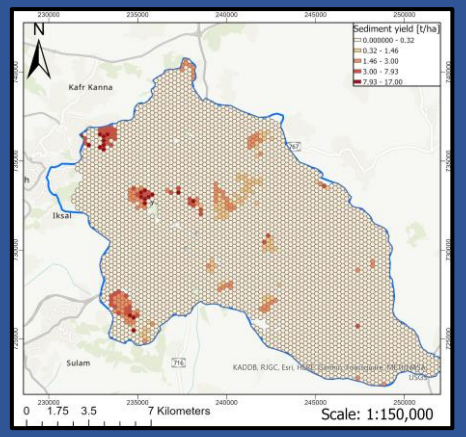


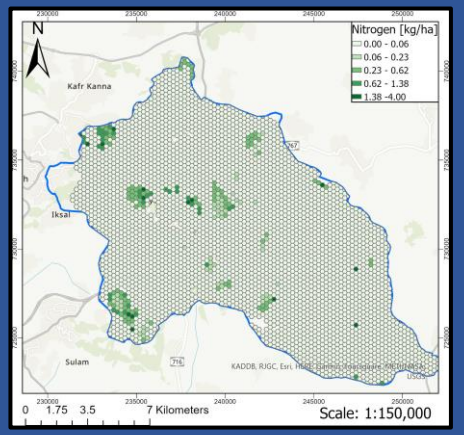
Phase 1- identify "hot spots"

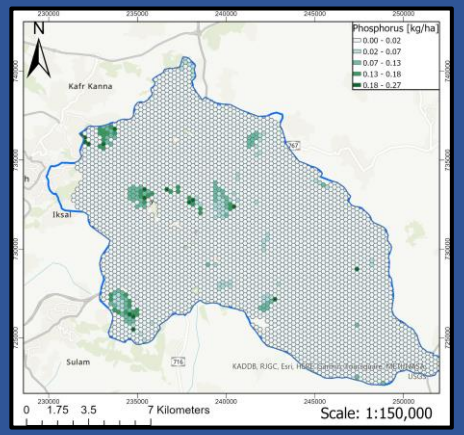
Simulation

SWAT Soil & Water Assessment Tool



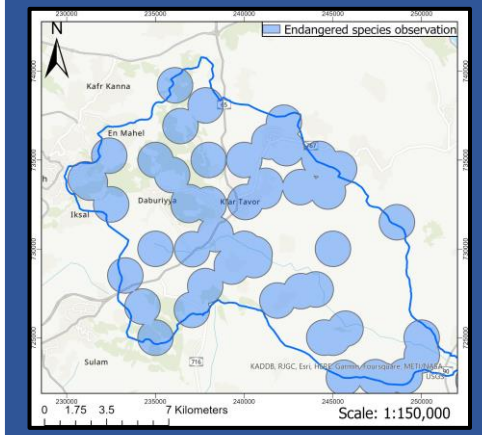


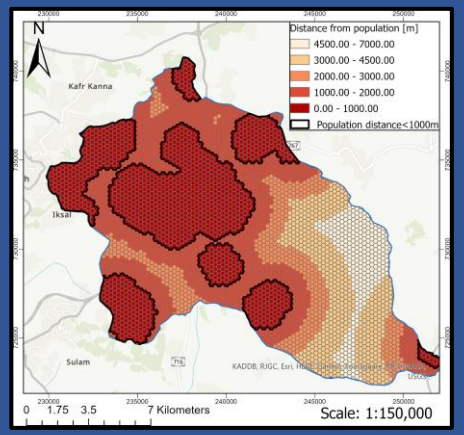




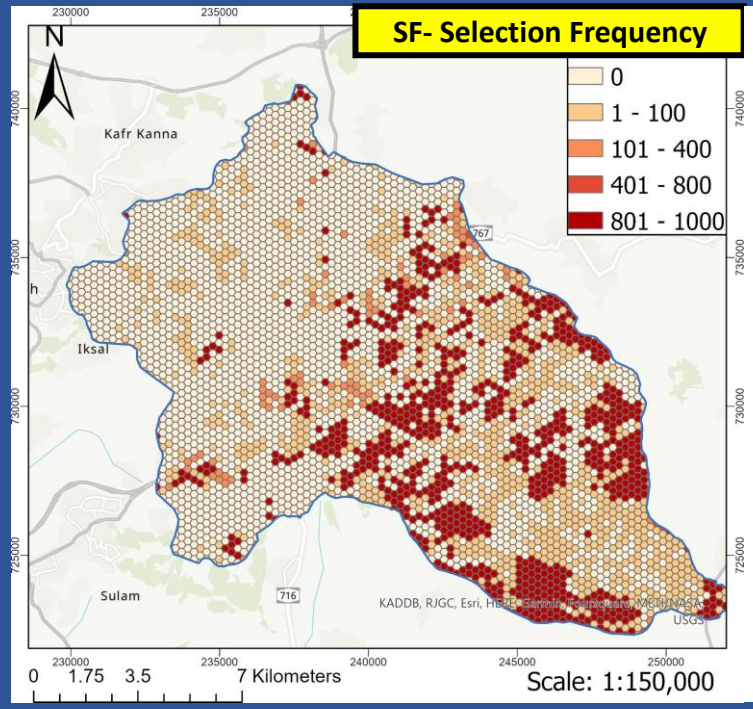
Optimization

MARXAN conservation solutions

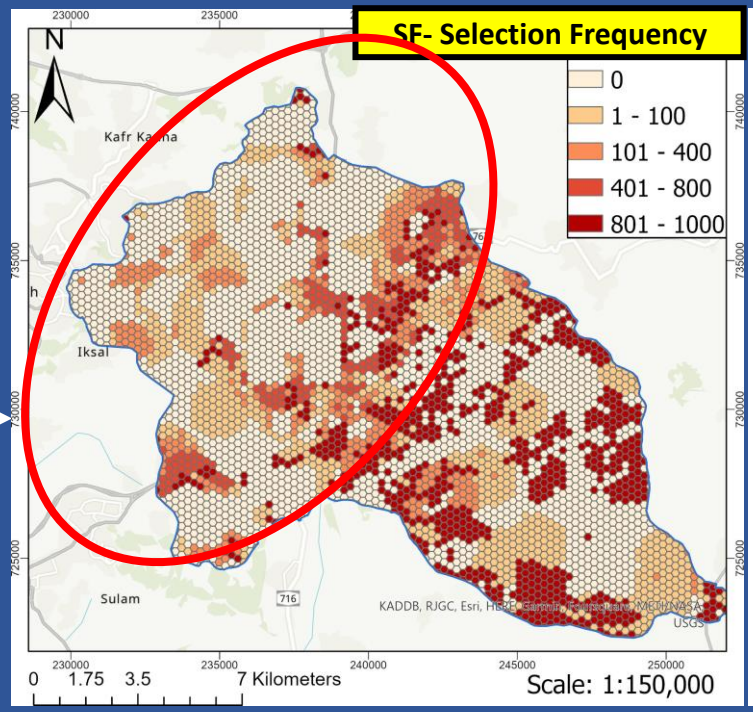




Hydrological indicators Only



Adding ecological and social indicators



Phase 2- maximum effectiveness

Stage 1: Multiple land use scenarios

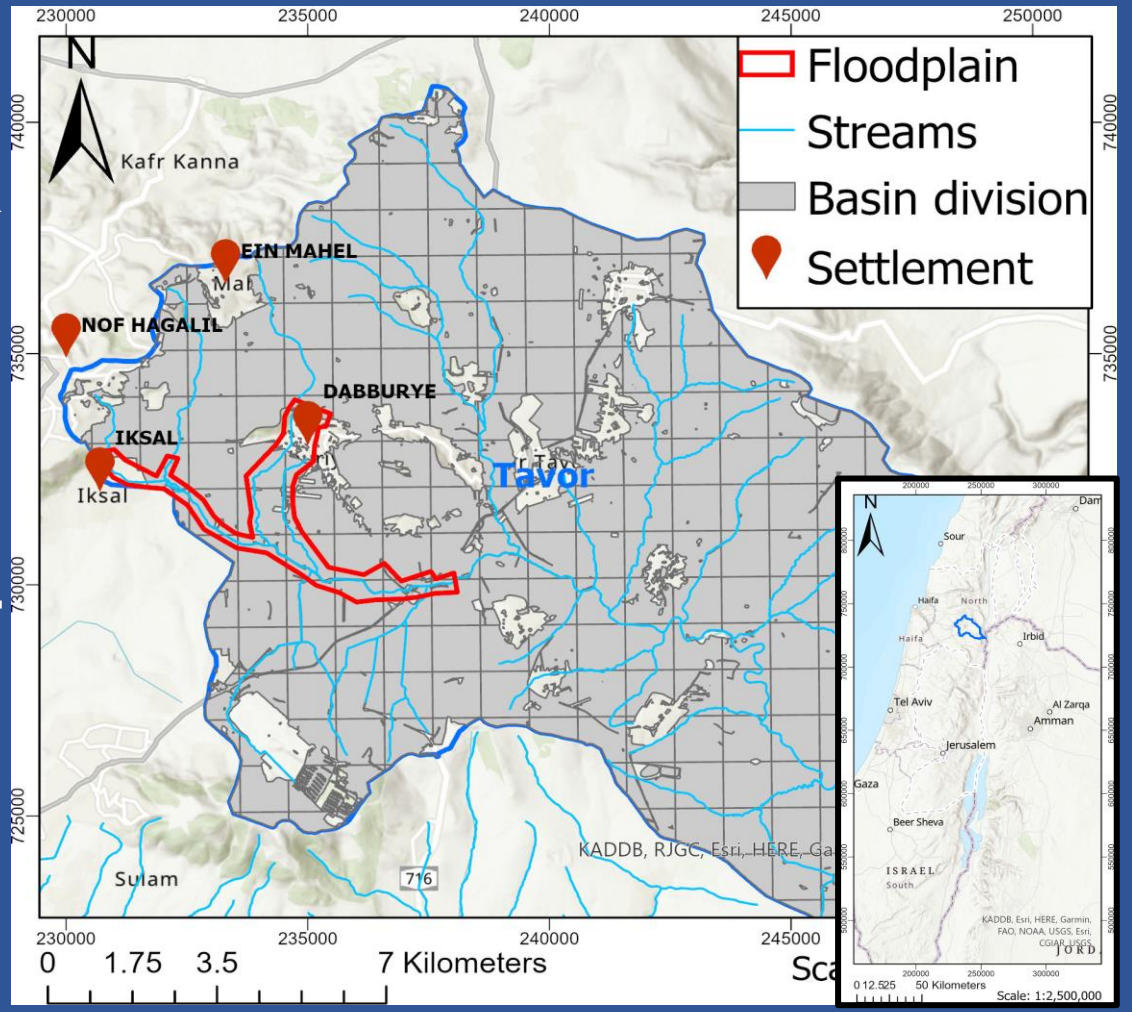
- Building a baseline scenario in OpenNSPECT
- Dividing the basin into land parcels
- Creating multiple scenarios by changing the land use of each parcel into a wetland.

Stage 2: Sensitivity analysis

- Running the model multiple times each time with a different land parcel as a wetland.
- Comparing the results of each scenario to the baseline scenario

Stage 3: Multi-objective optimization

- Using the change in runoff, sediment and pollutants to build a pareto frontier graph
- **Identifying the most efficient placement of the WSP solution**

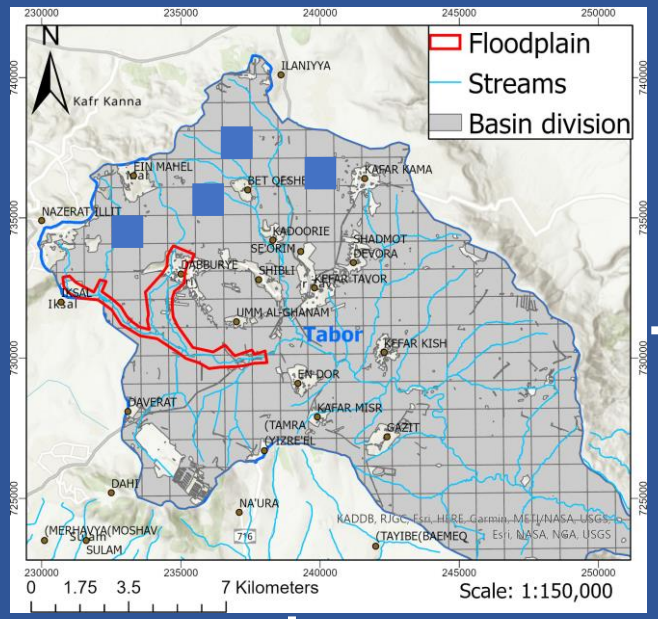


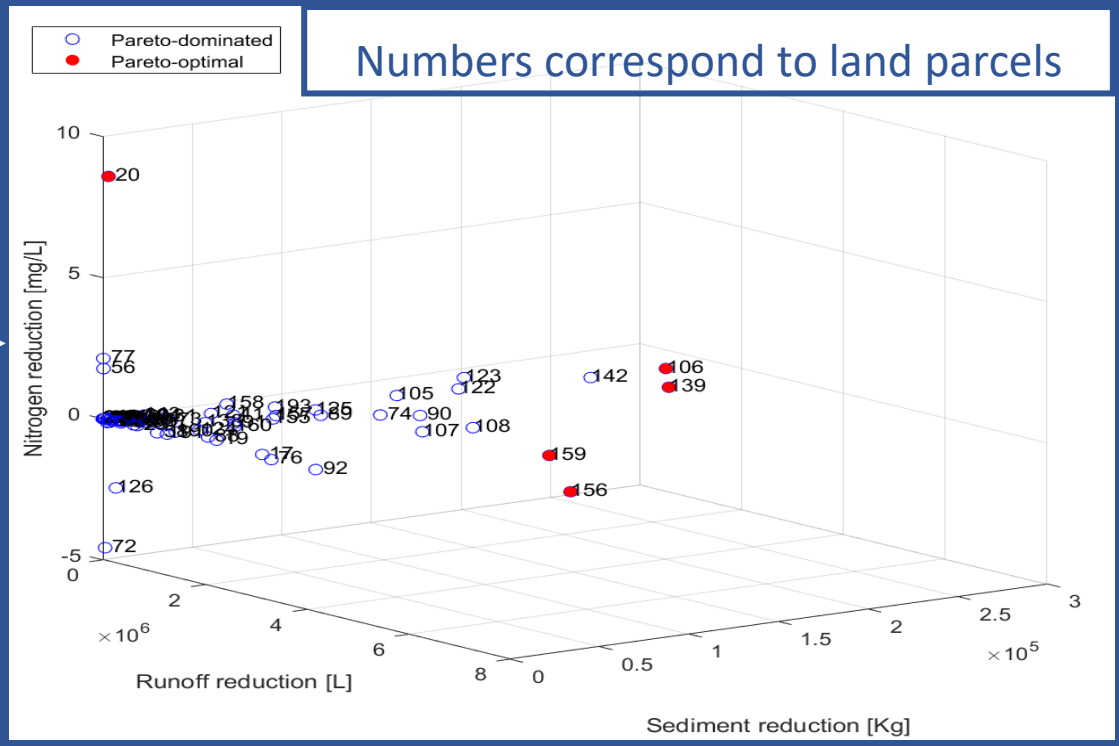
Phase 2- maximum effectiveness

Simulation

OpenNSPECT

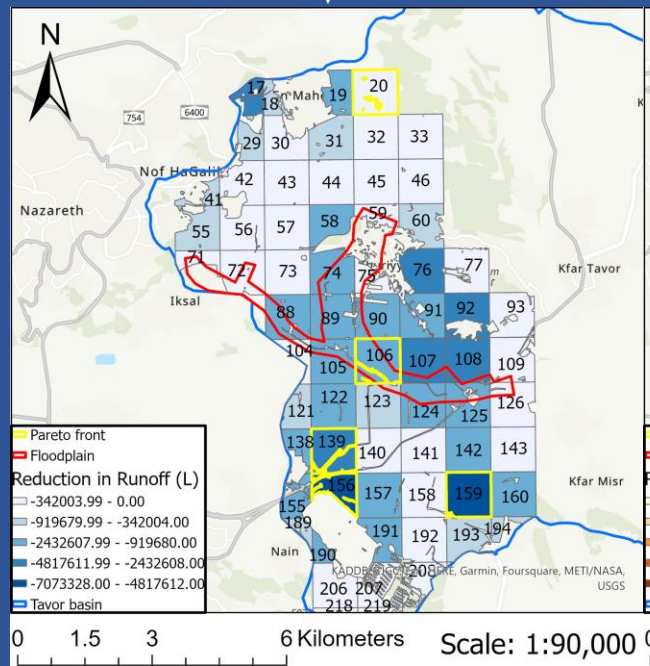
An Open-Source Version of the Nonpoint Source Pollution and Erosion Comparison Tool

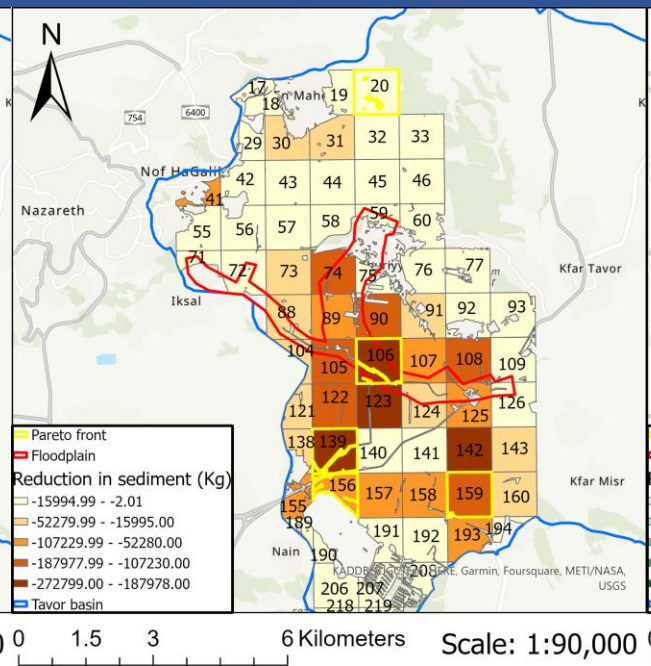


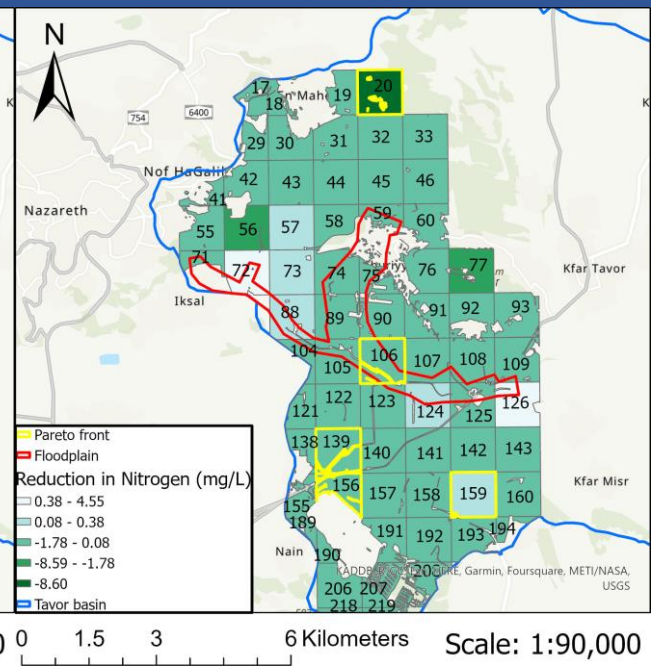


Optimization

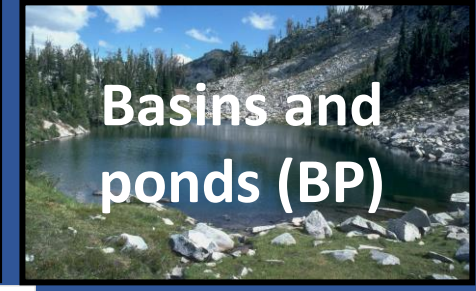
Pareto frontier

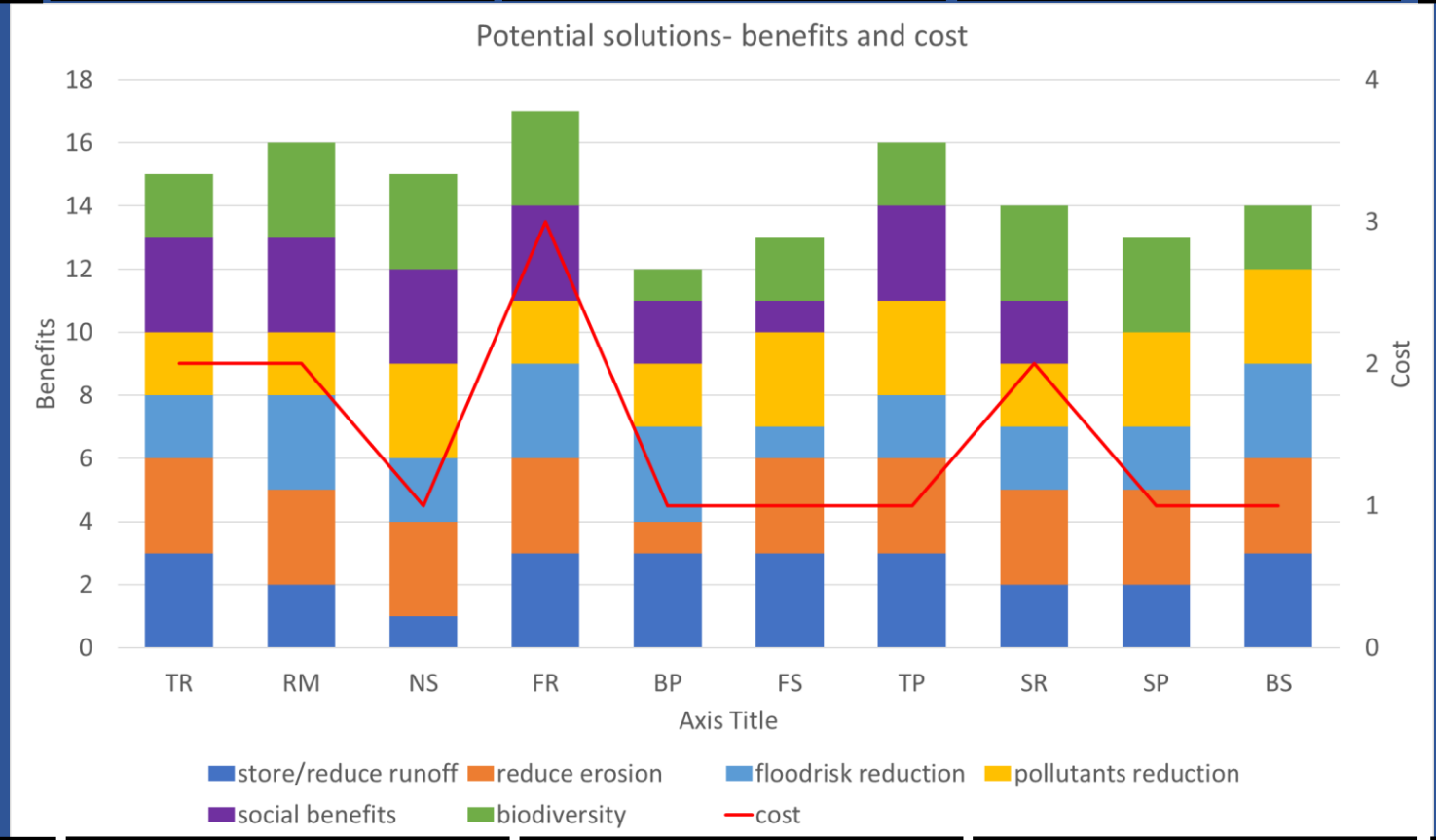






Phase 3- select solutions

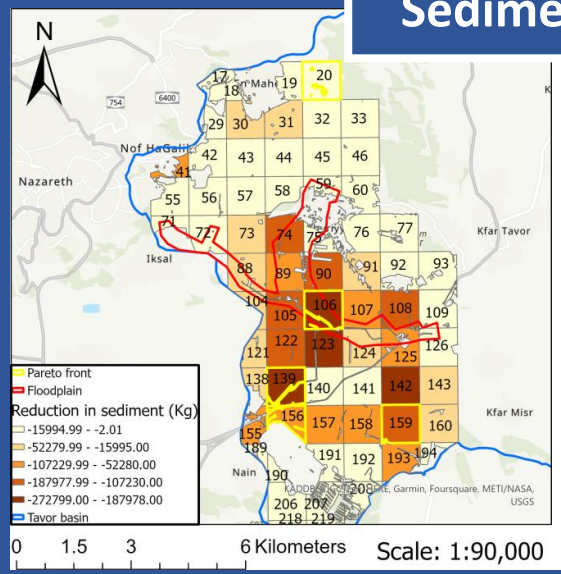


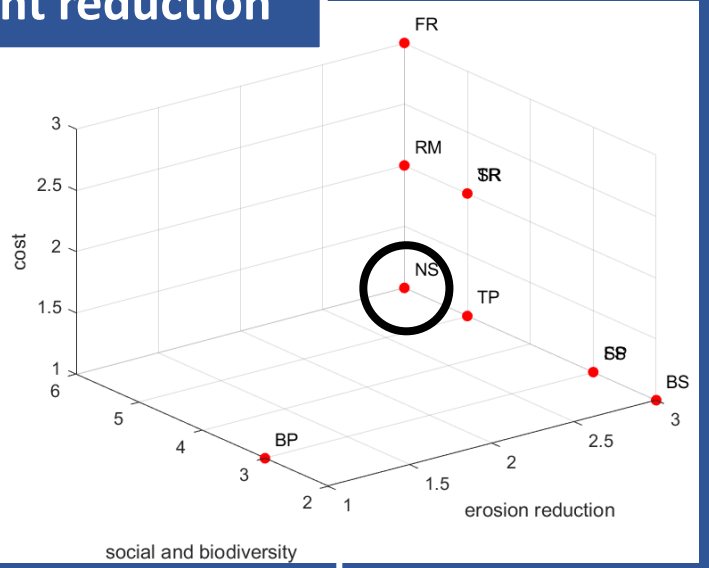


Adapted from nwrm.eu

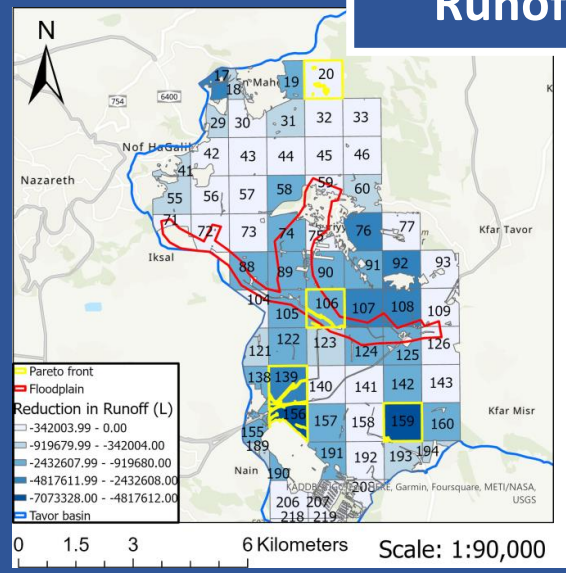
Phase 3- select solutions

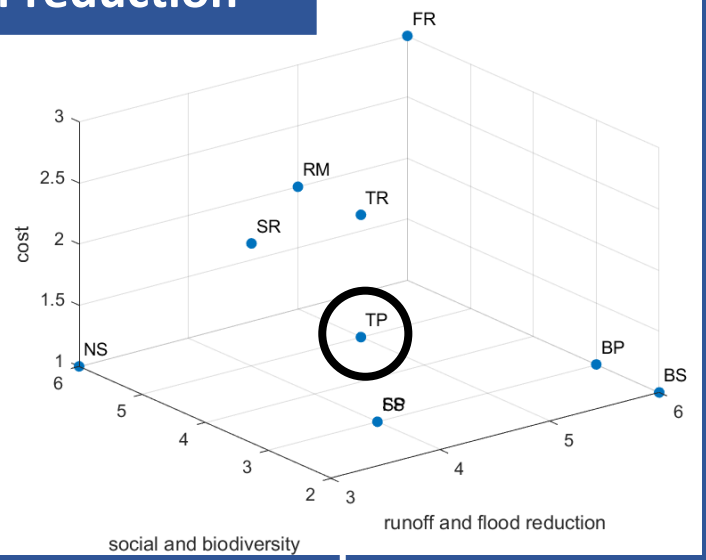
Sediment reduction



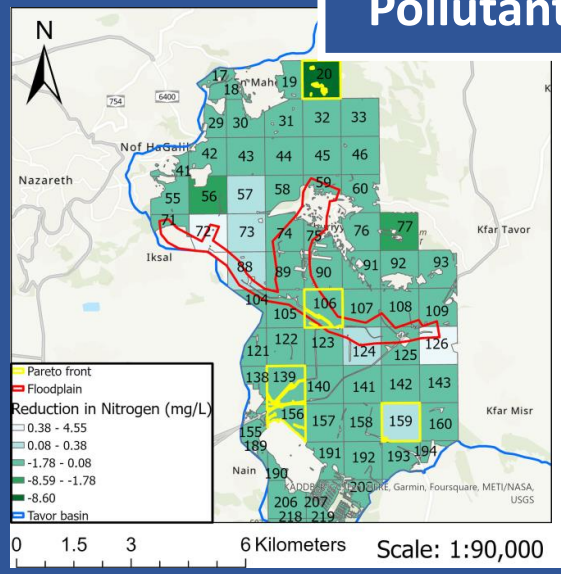


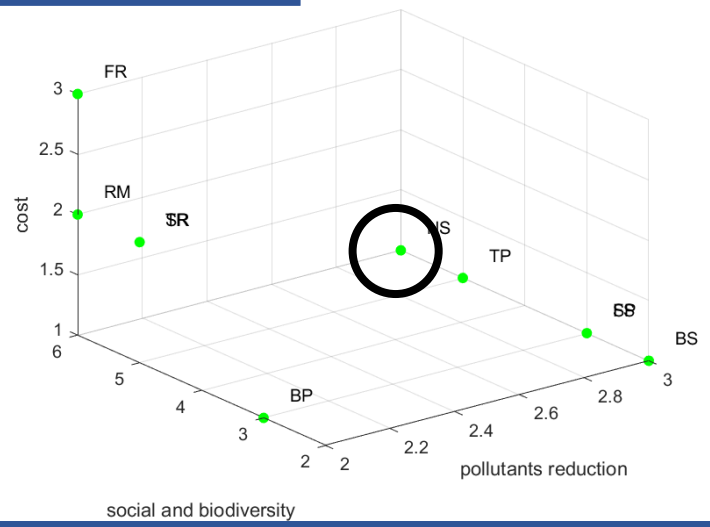
Runoff reduction





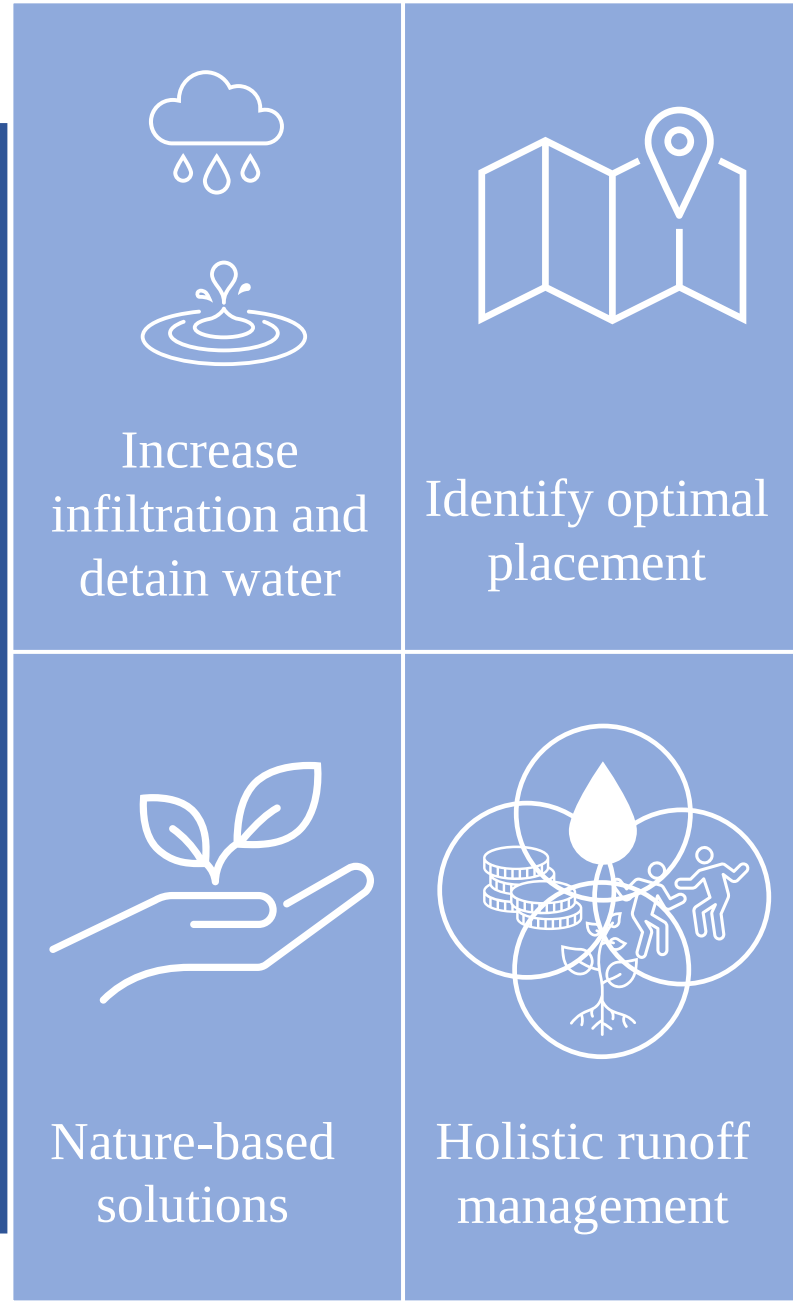
Pollutants reduction





Summary and Implications

- Consider ecological, and social goals along with hydrological goals.
- Mitigate the knowledge gap about the potential benefits of runoff.
- Help planners and stakeholders with optimal runoff management strategy.



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