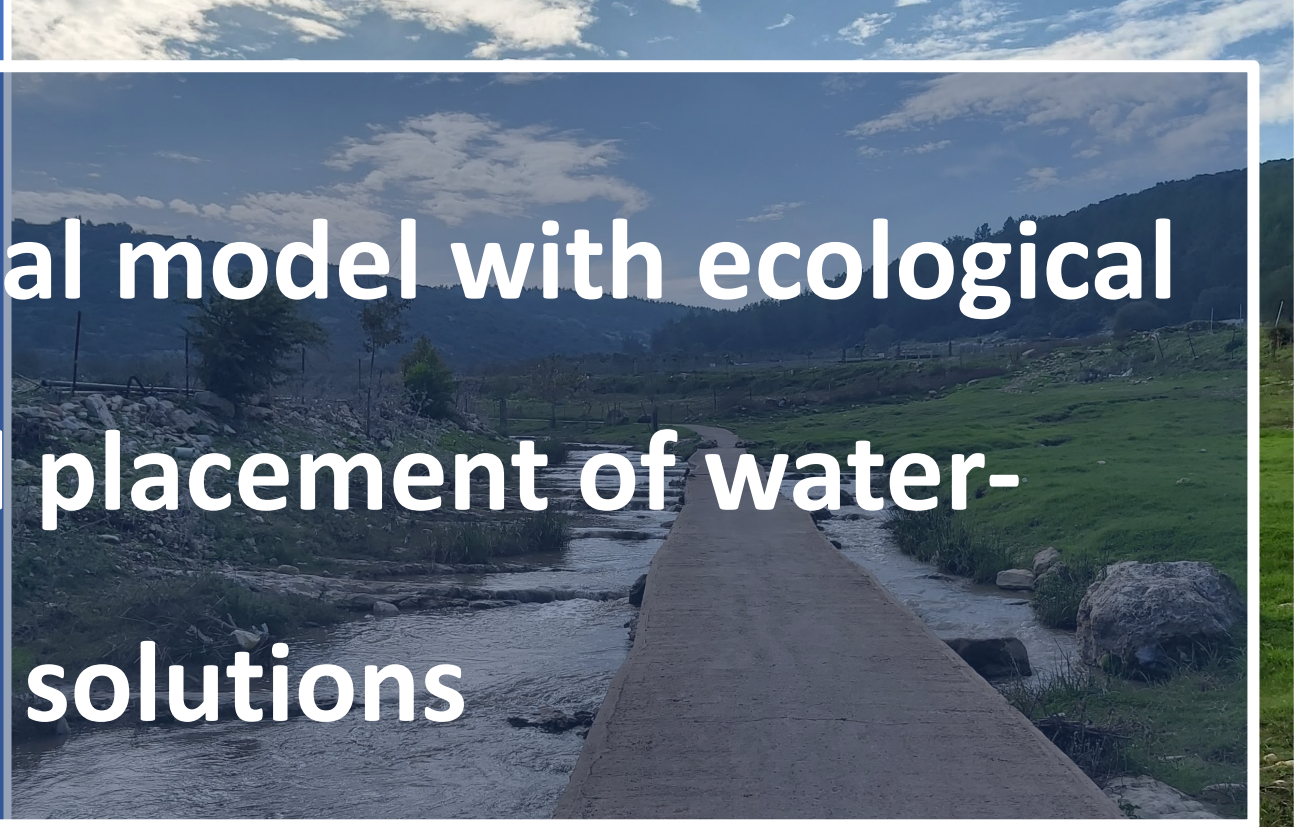
Combining a hydrological model with ecological planning for optimal placement of water-sensitive solutions



Merav Tal-maon

Advisors:

Dr. Dani Broitman, Prof. Michelle Portman and Prof. Mashor Housh

MARCOAST
Ecosystems Integration Lab

TECHNION
Israel Institute of Technology

Faculty of Architecture and Town Planning

Water Sensitive Planning (WSP)- reducing the negative impacts of stormwater and treating runoff as a valuable resource

Increase infiltration

Water detention/retention

WSP in Israel

Streams and wetlands in Israel have been neglected for many years..

A rise in pollution and damage to the biodiversity.

WSP Originally focused on conserving stormwater and groundwater recharge

Nowadays, focuses on ecological, social and economic benefits.

Drainage in Hilazon Stream

The Kishon Stream

Pictures from the Steinhardt Museum of Natural History website https://smnh.tau.ac.il/en/

WSP in Israel

The Huleh wetland

Yesud HaMa'ala

reflooding of parts of the Huleh Valley created A new ecosystem and a popular tourist destination

Hagamim park

Rishon-Lezion

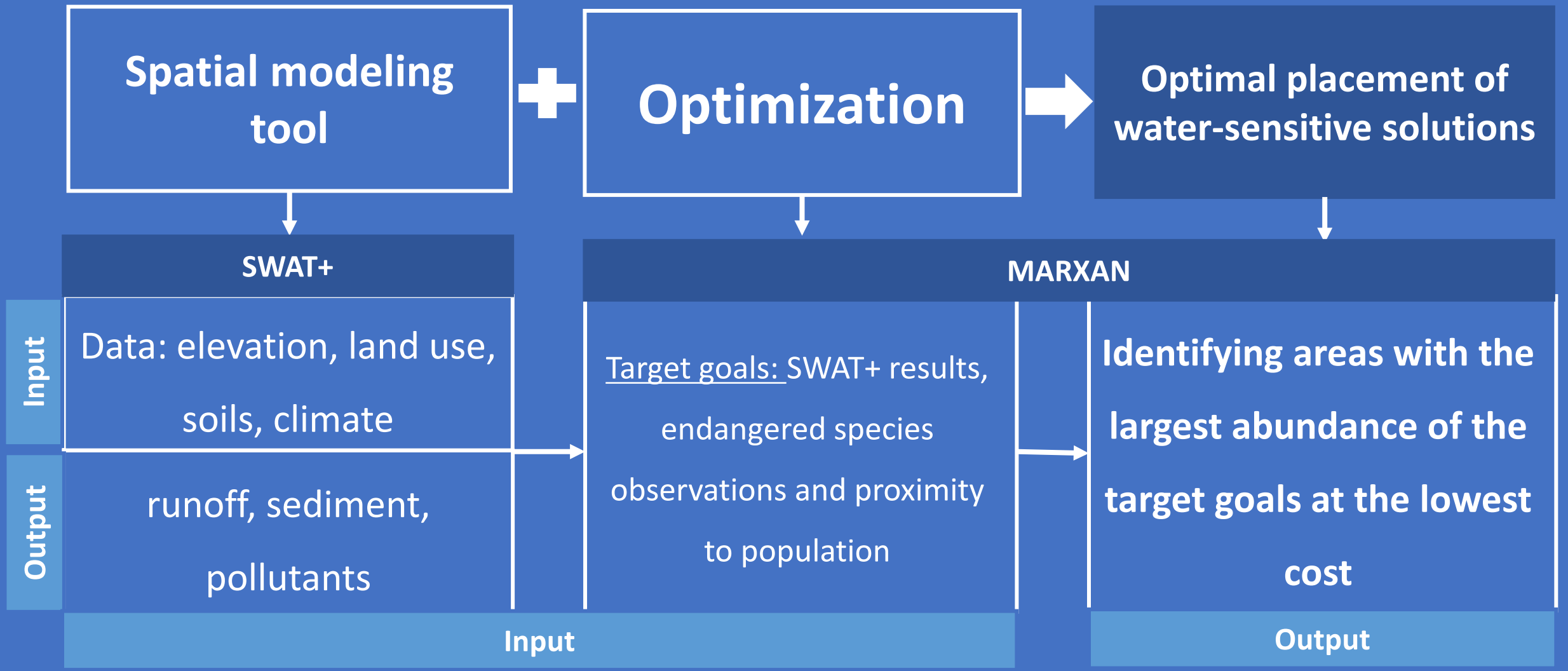
Urban runoff collected is collected and used for groundwater recharge

Beer-sheva stream park

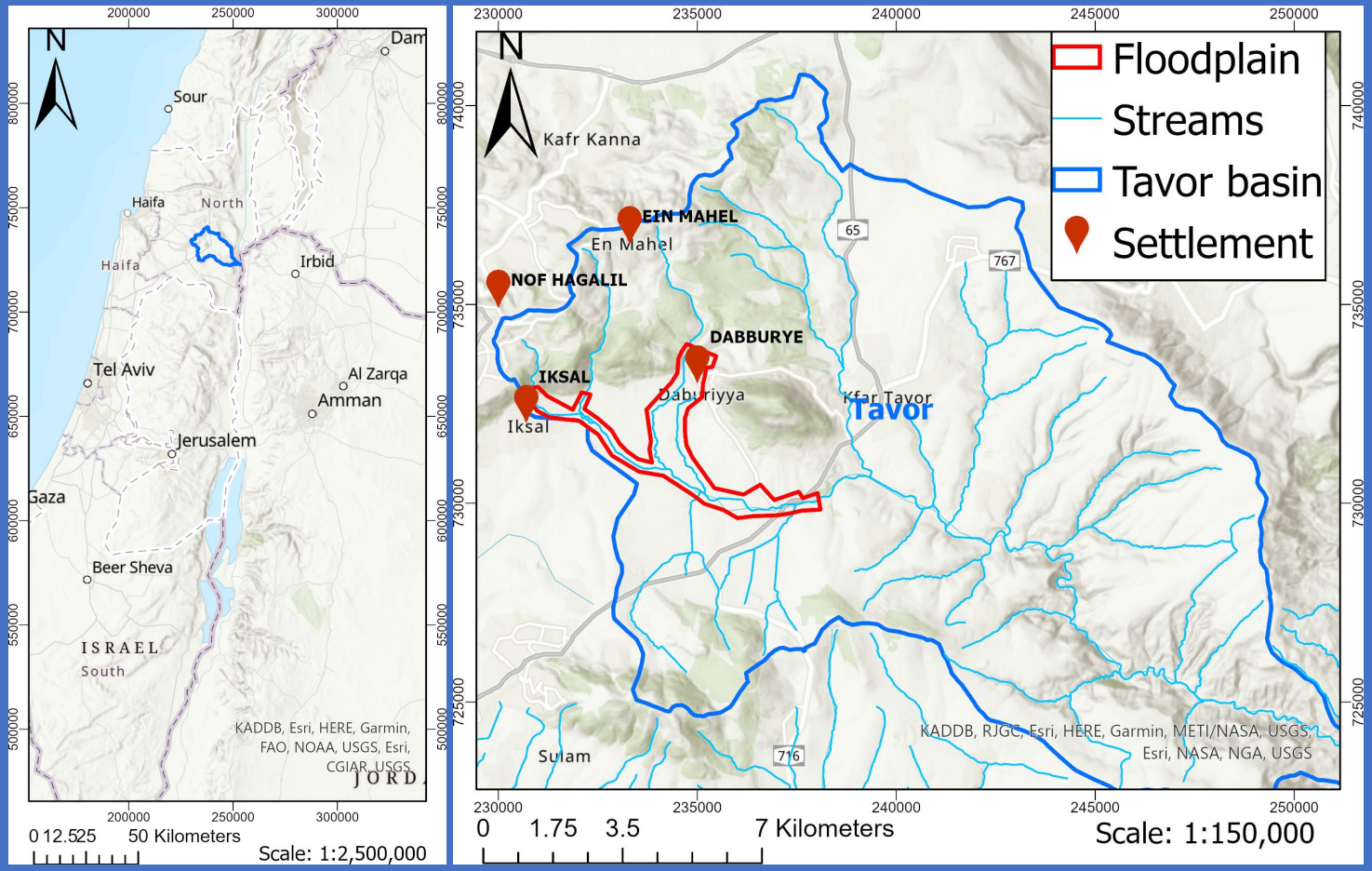
Beer-sheva

Included rehabilitation of the stream and conservation of the floodplain

Objective and Methodology



Case study: the Tavor basin

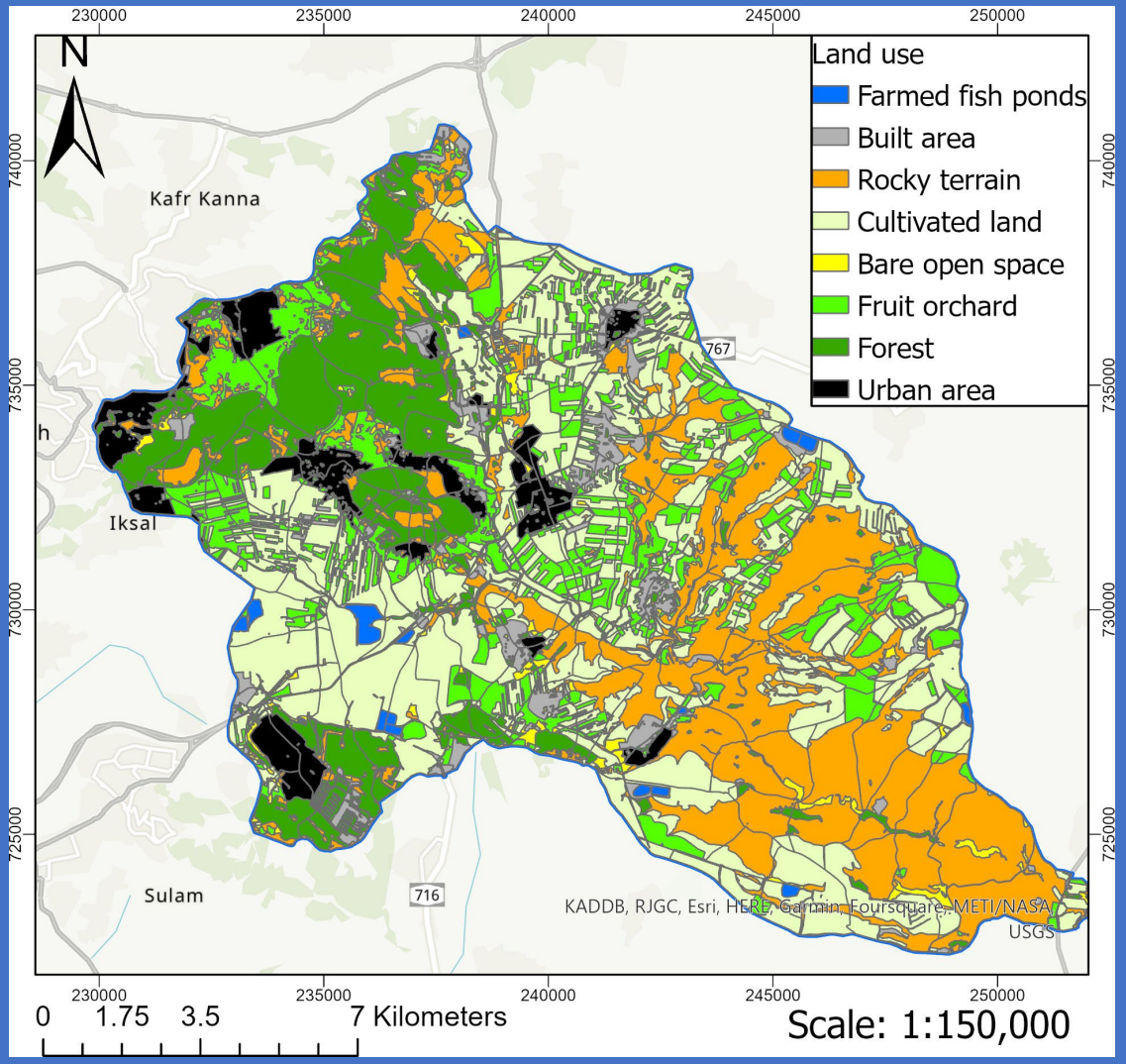


- North-east Israel
- 208 Km²
- Heavy rain in limited areas and erodible soils
- Low population density, mainly agriculture type settlements
- Extensive cultivated areas, forested areas, rocky terrain

Jordan South Drainage Authority. (2018). Drainage Masterplan.

Case study: the Tavor basin

- Expanding urbanization.
- Increase in NPS pollution.
- Little environmental awareness
- social alienation between the different communities.
- Lack of infrastructure
- Fragmented governance



Jordan South Drainage Authority. (2018). Drainage Masterplan.

MARXAN- A systematic conservation software

MARXAN conservation solutions

Minimum biodiversity representation for minimum cost.

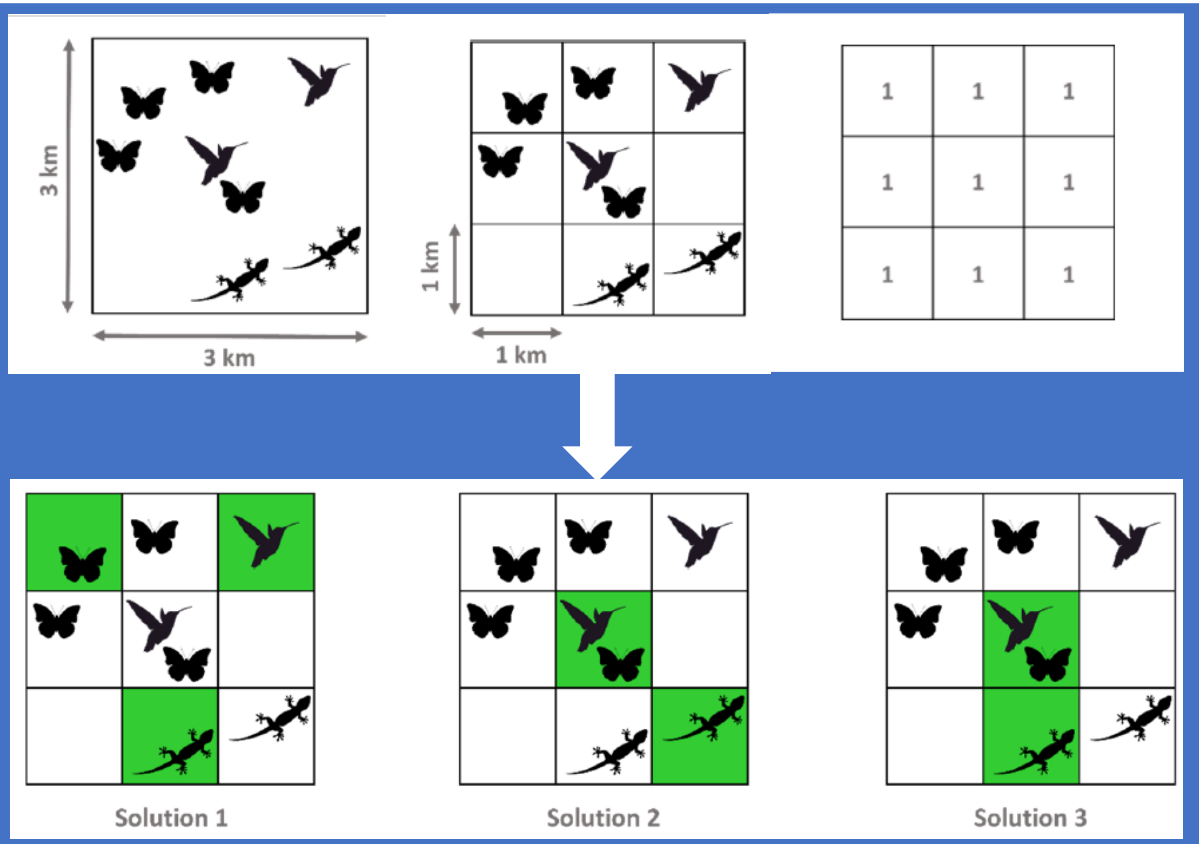
https://marxansolutions.org/

$$\min Total\ cost = \underbrace{\sum_{PUs} Cost}_{1} + \underbrace{BLM \sum_{PUs} Boundary}_{2} + \underbrace{\sum_{Target\ Value} SPF \times Penalty}_{3}$$

1 → The cost of the selected PUs

2 → The cost of Pus boundary length- creates clusters

3 → The cost of not meeting a conservation target- prioritize features

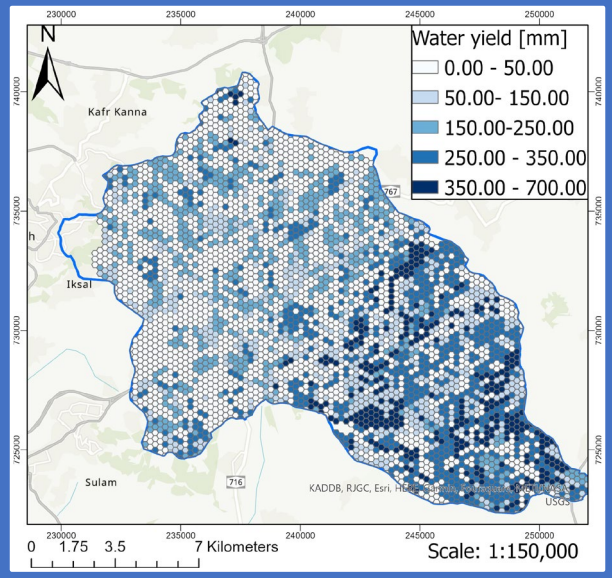


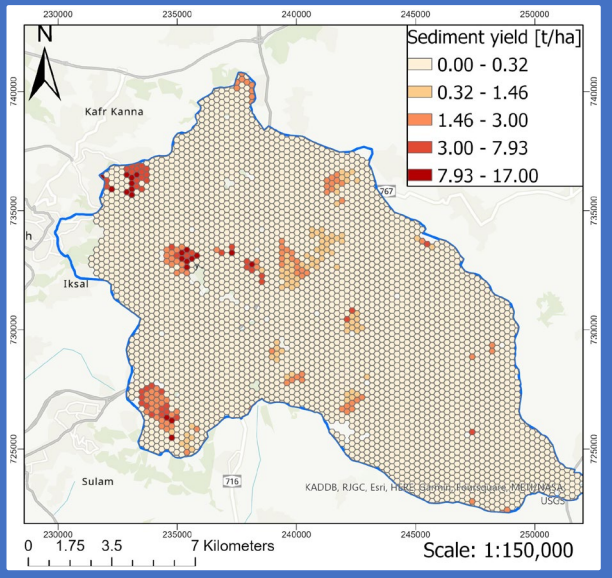
the frequency of election of each planning unit indicates its efficiency in meeting the conservation targets.

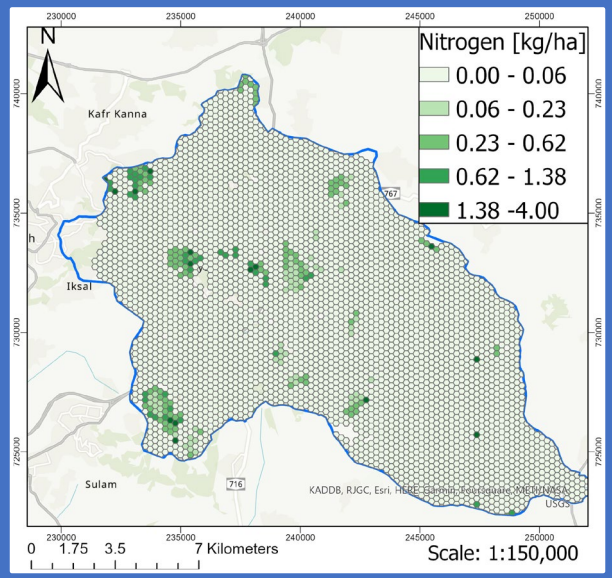
Serra, N., Kockel, A., Game, E. T., Grantham H., Possingham H.P., & McGowan, J. (2020). Marxan User Manual: For Marxan version 2.43 and above. The Nature Conservancy

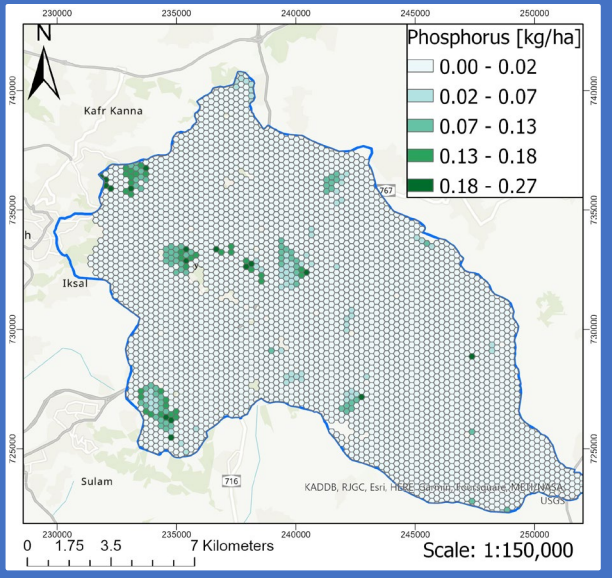
MARXAN inputs- SWAT+

- **SWAT+ results** represent the hydrological features (water quantity and quality objectives).
- **Annual averages of HRU-** water yield, sediment yield, and organic Nitrogen and Phosphorus
- **SWAT+ Toolbox-** Sensitivity analysis (Sobol method), calibration, and validation of the model for streamflow ($NSE = 0.56$). 2011-2012- calibration period and 2013-2014 validation period.







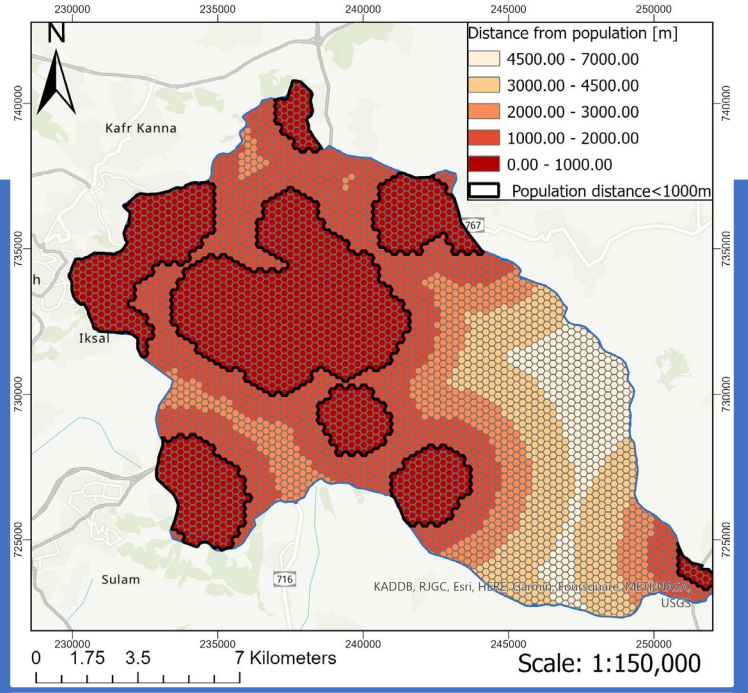


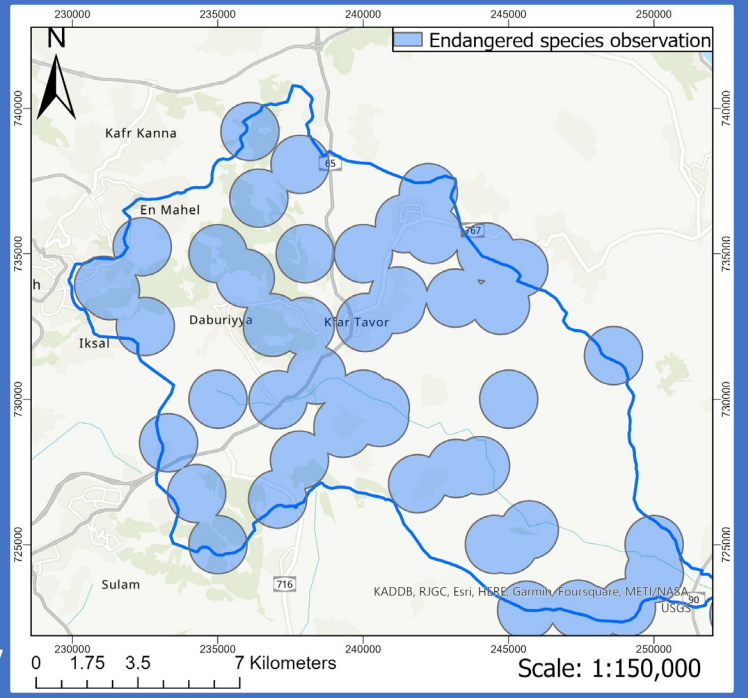
MARXAN inputs- Ecological and Social

WSP seeks synergy between various hydrological, ecological, Social, and economic goals.

We are searching for “hot spots” where WSP solutions could contribute to ecological and social objectives.

- **Ecological indicator-** endangered species observations (from BioGIS 1990-2021)
- **Social indicator-** distance from human populations





https://biogis.huji.ac.il/

MARXAN additional inputs

Land use limitations-

- unavailable for conservation- urban areas and archaeological sites
- already conserved- Churchill Forest reservation

Additional parameters-

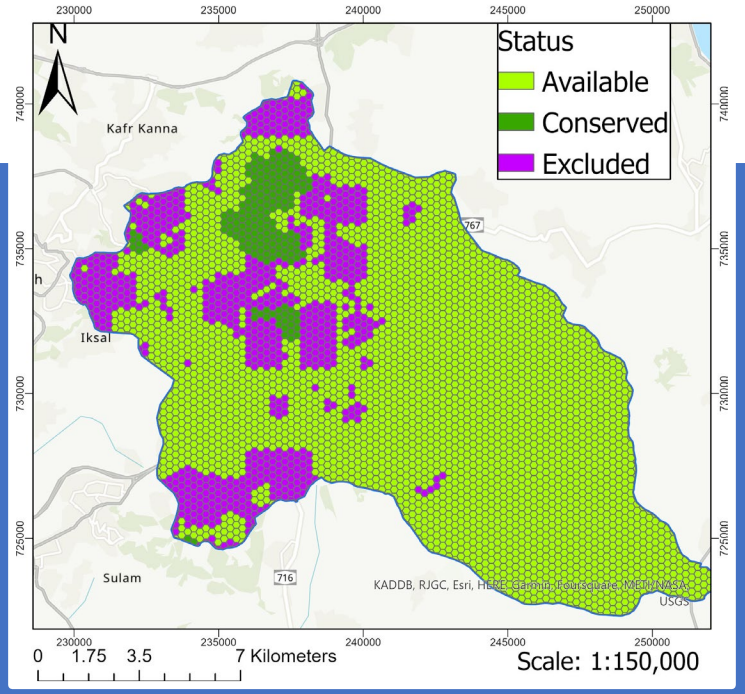
- Conservation target- 30%
- SPF-100

} Prioritize features

- BLM-0 → Length cost

Cost- equivalent to the area of the PU

PU grid- 5 ha hexagons

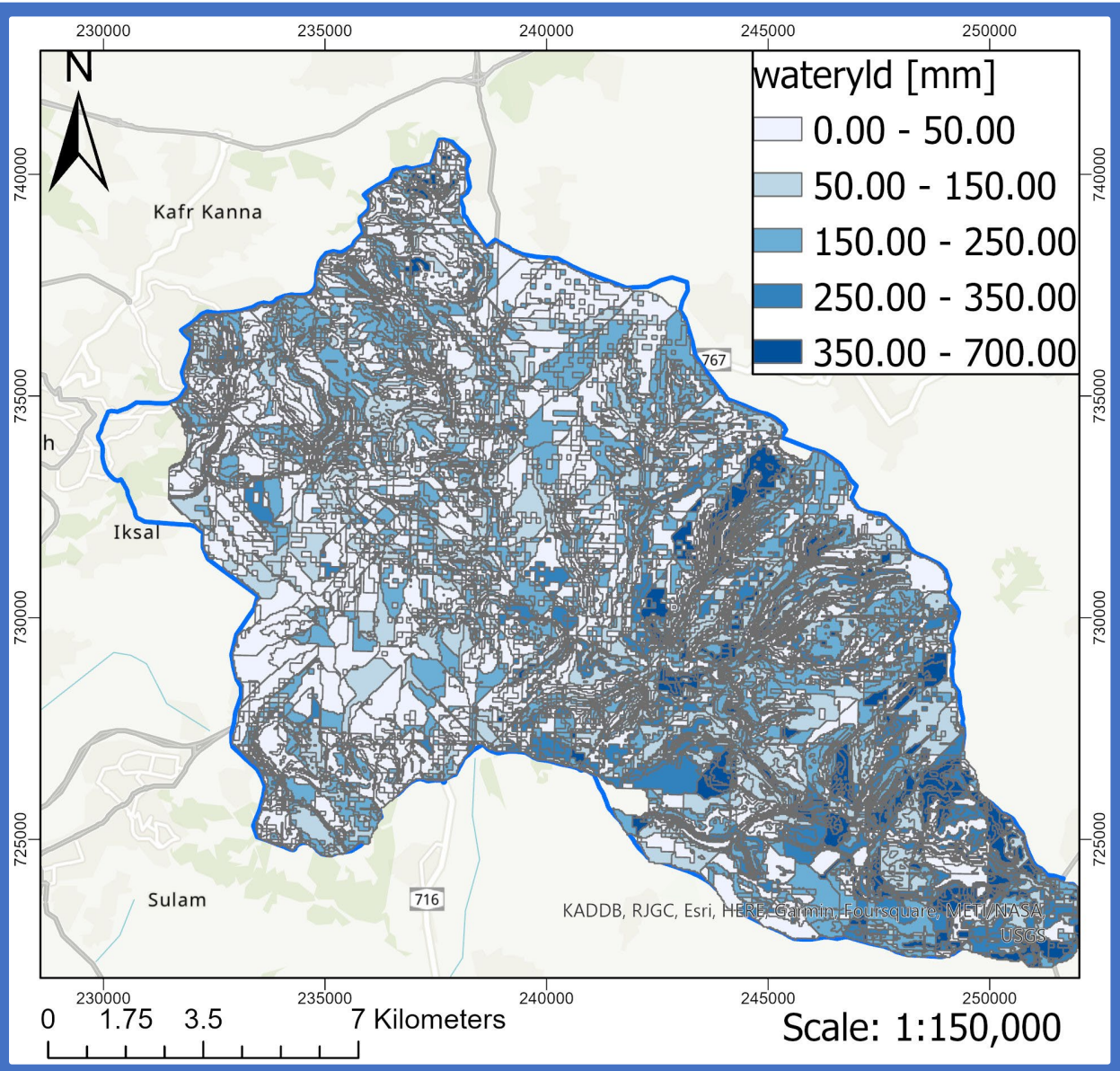


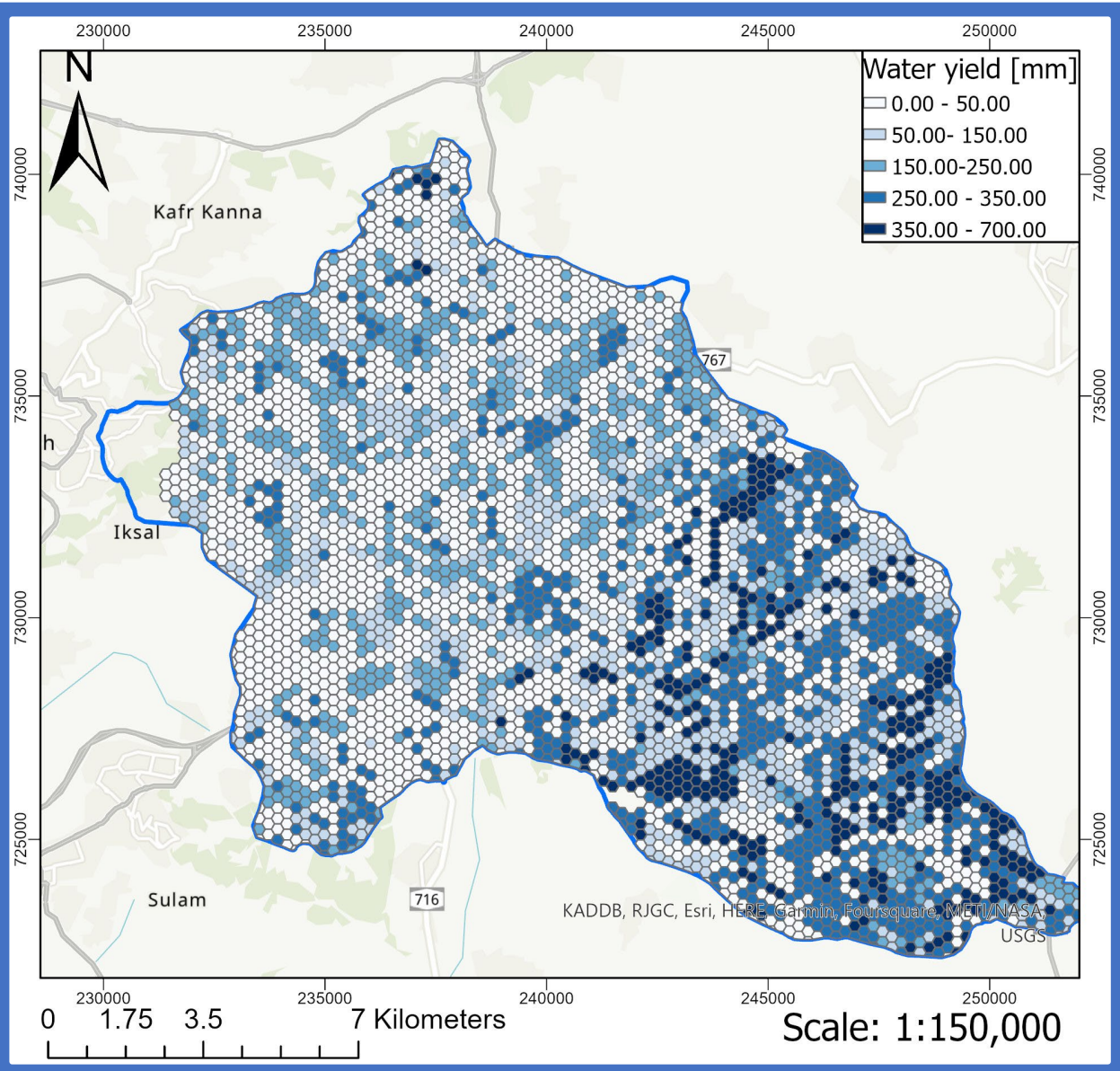
$$\min Total\ cost = \underbrace{\sum_{PUs} Cost}_{1} + \underbrace{BLM \sum_{PUs} Boundary}_{2} + \underbrace{\sum_{Target\ Value} SPF \times Penalty}_{3}$$

QGIS plugin for MARXAN (Smith, 2019)

https://anotherbobsmith.wordpress.com/software/cluz/

MARXAN results only swat+ inputs





MARXAN results only swat+ inputs

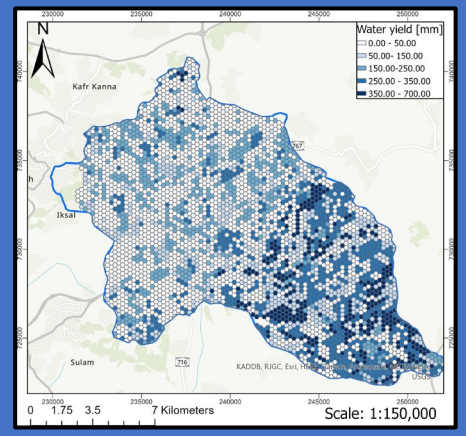
- **Swat+ outputs-**WATER

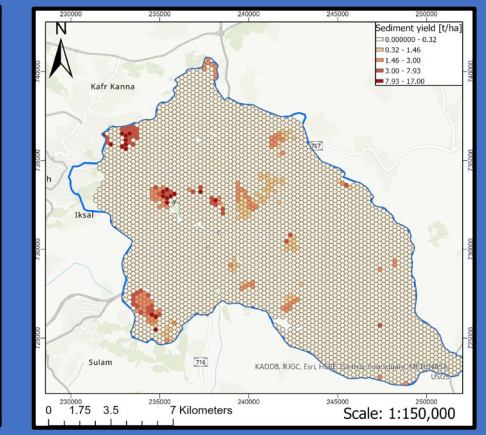
  YIELD, SED YIELD,

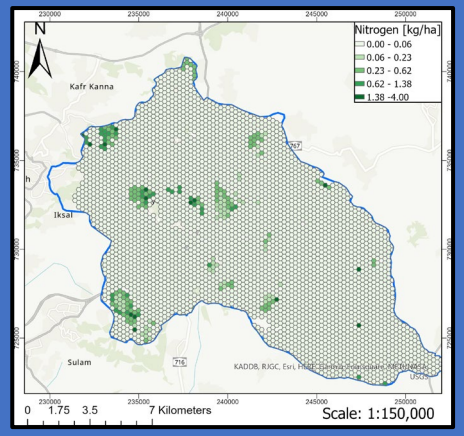
  ORGN,ORGP

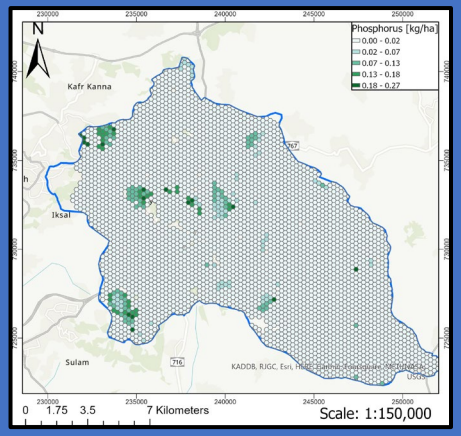
- MARXAN results- mainly

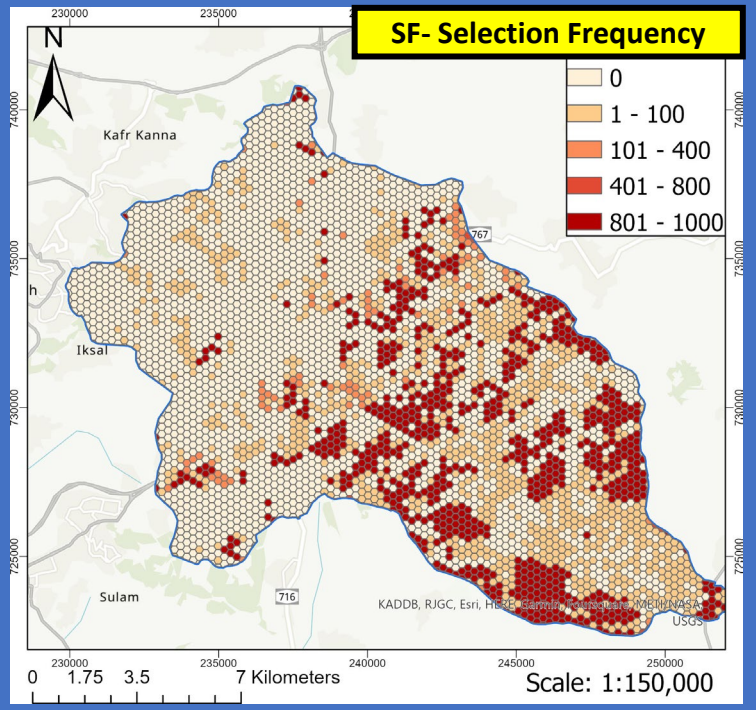
  in the down stream area.



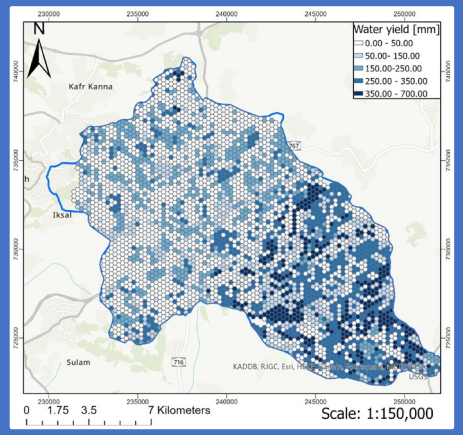


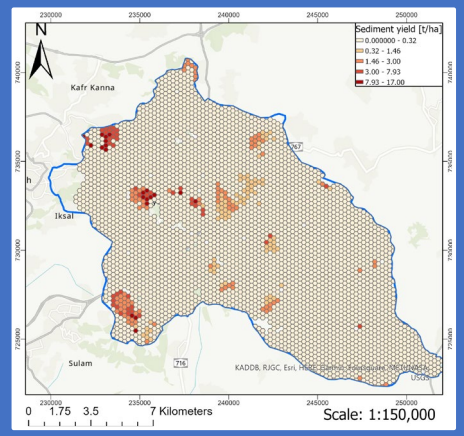


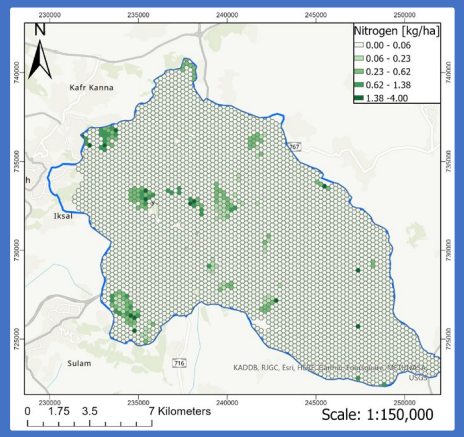


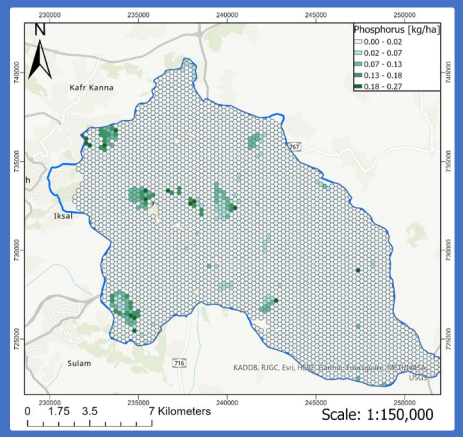


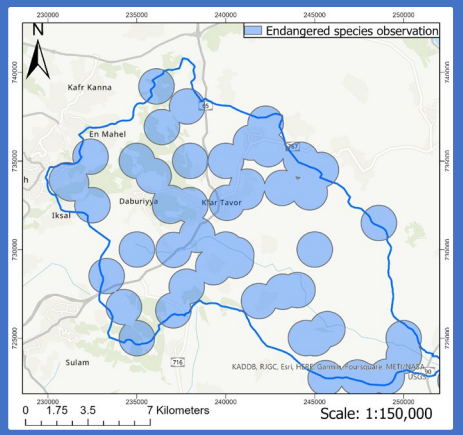
Marxan results with ecological and social indicators

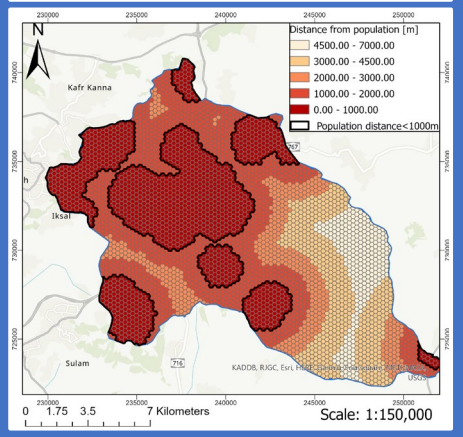


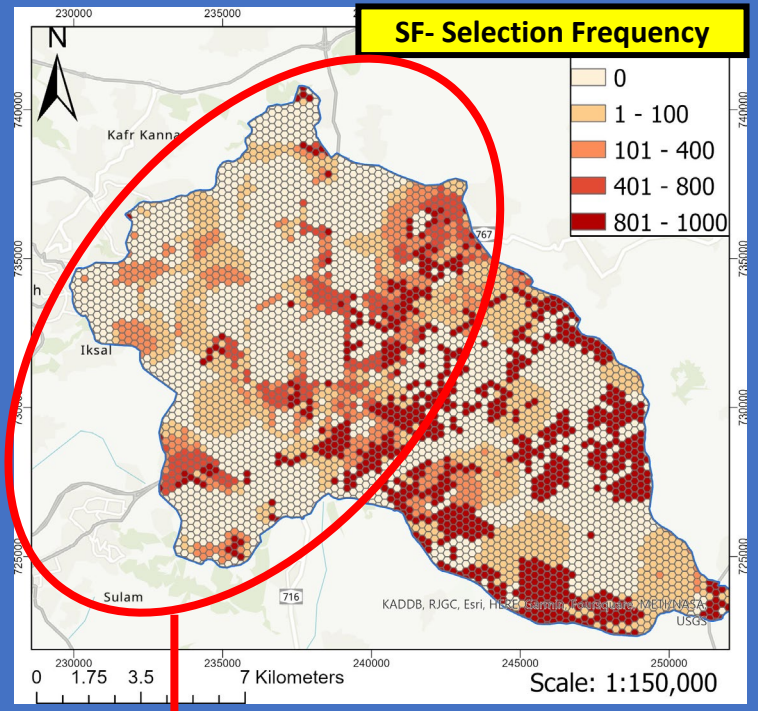








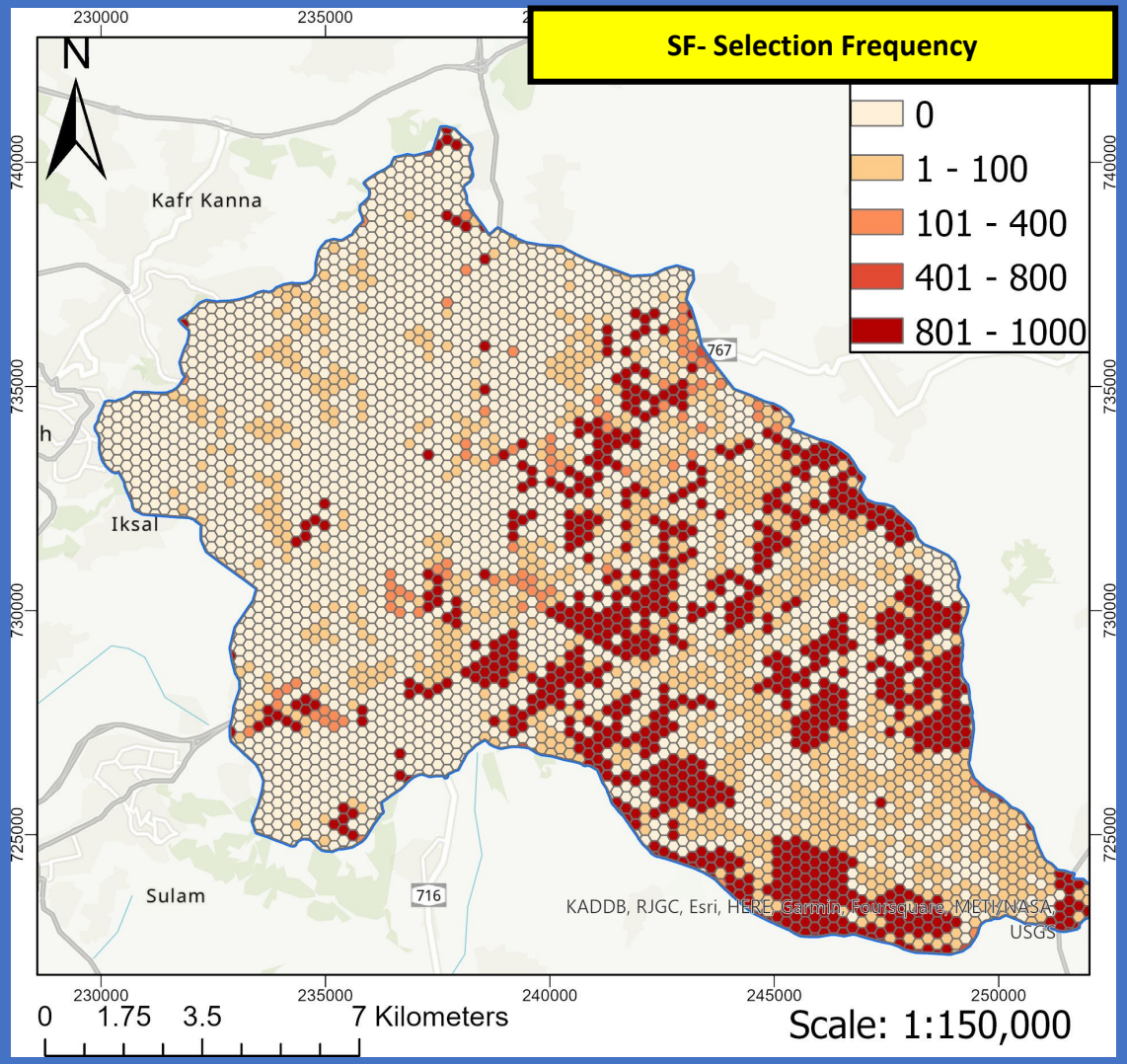




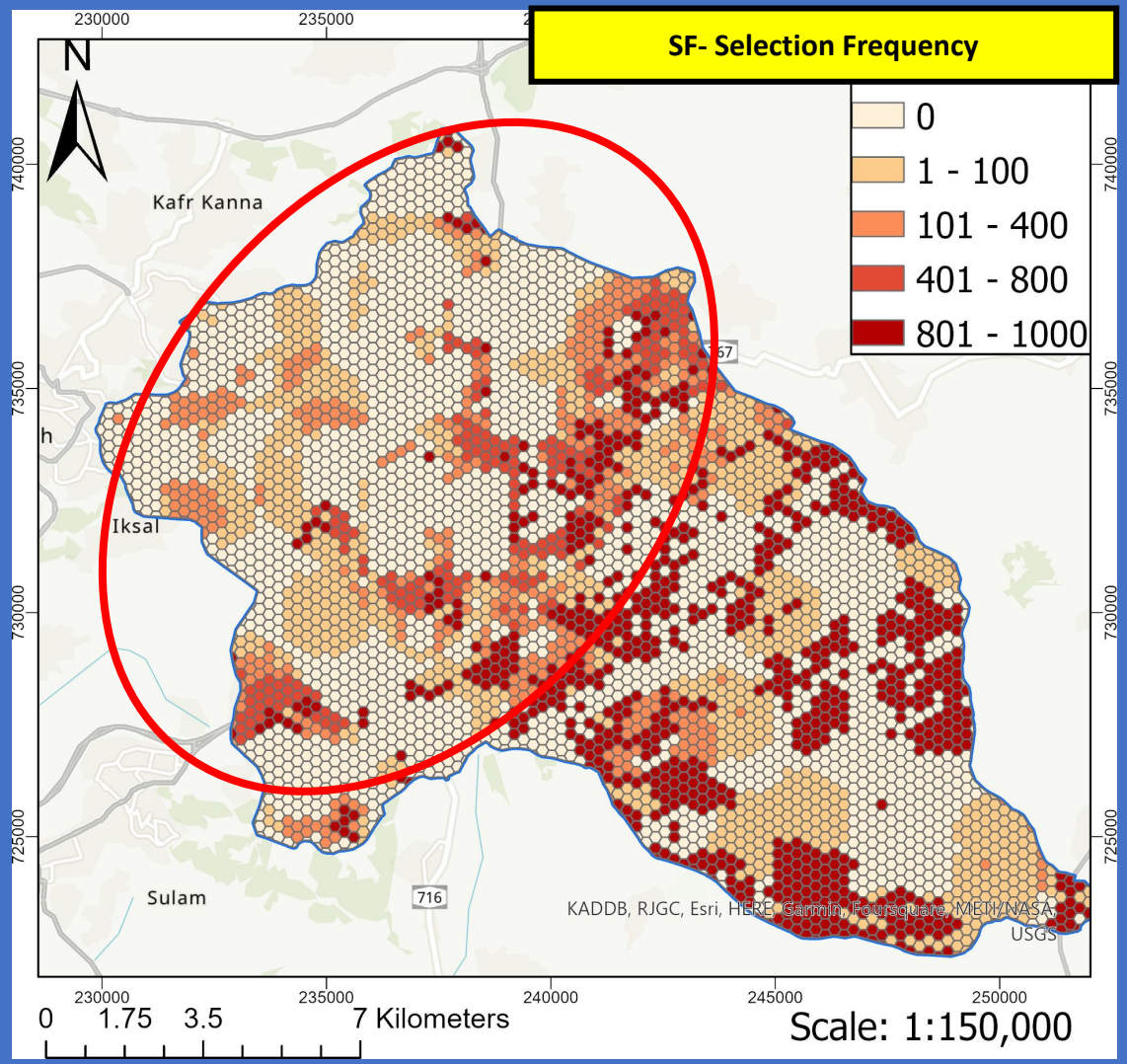
Higher selection frequency in the Tavor upstream area

Comparing the results of MARXAN optimization

Hydrological indicators Only

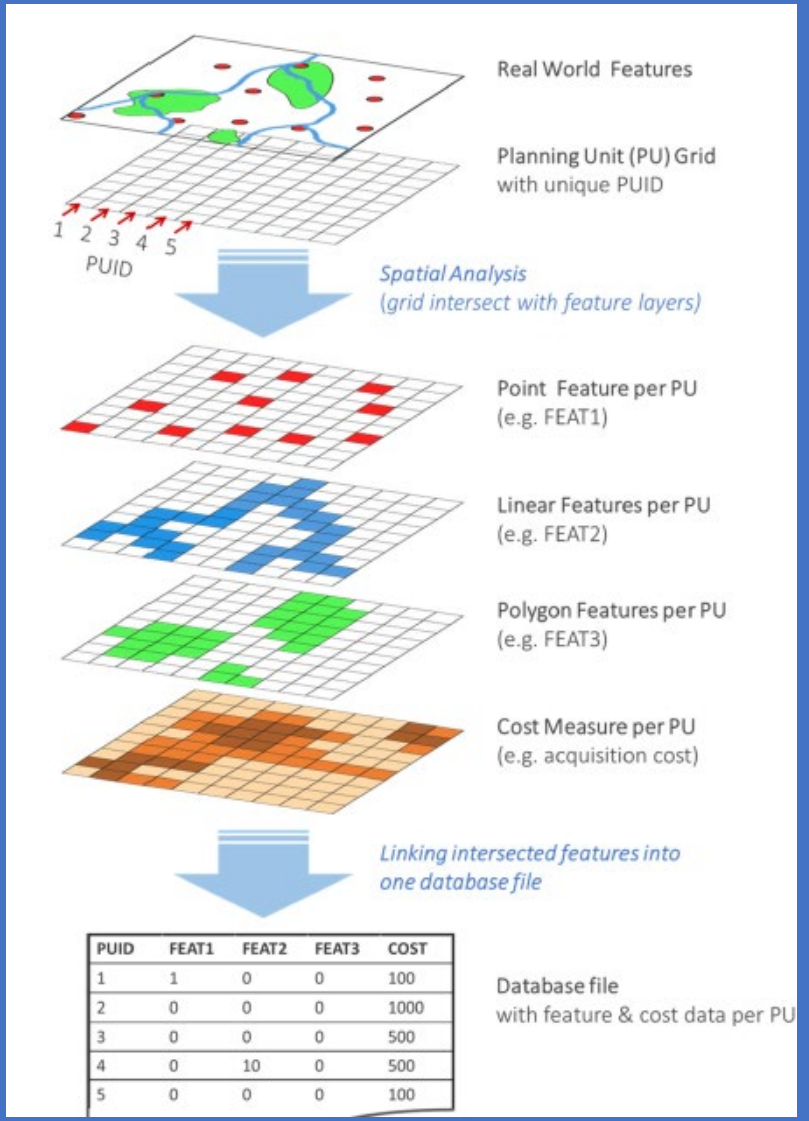


Adding ecological and social indicators



The advantage of using SWAT+ and MARXAN

- SWAT+ can simulate various hydrological representative values
- SWAT+ is easier to use- definition of the watershed and visualization of the outputs.
- Both QSWAT+ and MARXAN+ use QGIS
- MARXAN can combine data from different contexts.
- MARXAN simplifies the optimization process



PUID	FEAT1	FEAT2	FEAT3	COST
1	1	0	0	100
2	0	0	0	1000
3	0	0	0	500
4	0	10	0	500
5	0	0	0	100

From the Marxan version 2.43 (Game and Grantham. 2020)

Limitation and future research

- High water yield does not necessarily indicate a problem. sediment and nutrients have a high dependence on runoff.
- SWAT+ can simulate other parameters like groundwater recharge could also be incorporated as potential features.
- Little monitoring data to use for calibration.
- More social metrics - socio-economic status, accessibility, potential damage due to floods, and alternative land use costs.
- This research only address the location to implement WSP solution and not the type of solutions.

Summary and Conclusions

- This study presents a watershed-wide methodology considering hydrological, ecological, and social aspects
- This methodology is applicable to all watersheds, especially those primarily rural.
- We used SWAT+ results with ecological and social indicators as input for MARXAN to identify areas to implement WSP measures.
- Combining SWAT+ and MARXAN offers opportunity to combine stormwater management and environmental planning.
- This combination can benefit planners and stakeholders understand the existing conditions in the watershed and identify opportunities for sustainable runoff management.

Thank you!

- **Revised manuscript in preparation:**

Tal-maon, M., Broitman, D., Portman, M., and Housh, M. (2023). Combining a hydrological model with ecological planning for optimal placement of water-sensitive solutions. Manuscript submitted for publication.

- **Manuscript In preparation:**

Tal-maon, M., Broitman, D., Portman, M., and Housh, M. (2023). Identifying optimal type and locations of natural water retention measures using spatial modeling and cost-benefit analysis. Manuscript in preparation.

We thank the Israel Drainage and Valleys South of the Jordan Valley Authority (www.yardend.org.il) for providing data and input and the Israel Ministry of Agriculture and Rural Development for supporting this research

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