Exploring the Jordanian rangeland status transition merging the restoration experiment with modeling

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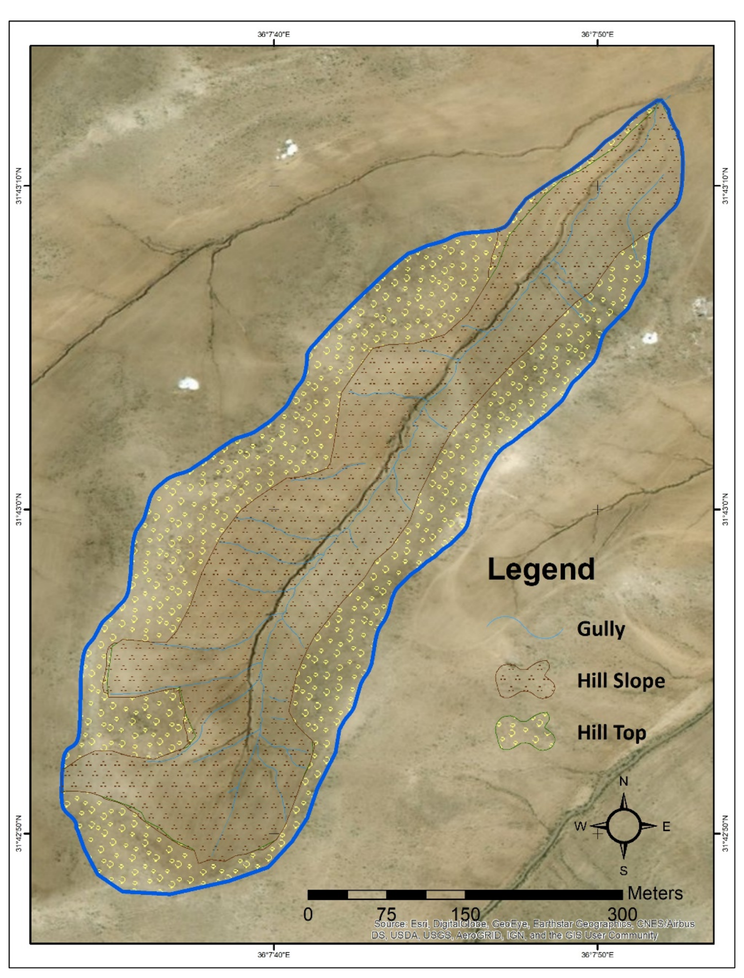
Introduction

A combination of overstocking and recurring droughts threaten the rangelands throughout the Middle East. On top of this, in Jordan, barley agriculture speed up the removal of the native range vegetation increasing the landscape's vulnerability to soil erosion. Depleted and crusted soils accelerate surface runoff and inhibit the infiltration of rainwater. The degradation of natural resources and quick drainage of water impede the re-establishment of native grasses and shrubs. Recently, huge restoration campaigns have been launched to preserve the fragile Jordanian ecosystem.

Methods & Materials

Experimental Site

Al Majidyya experimental site was established approximately 10 km south-east of Amman. The site hosts several soil, water and vegetation related experiments. The climate is semi-arid; average annual rainfall ranges between 100 and 200 mm occurring during the rainy season from October to May. The local soils is a silt-loam and vegetation cover is sparse; only few percentage of the rangelands are covered with shrubs, while large areas, are plowed for barley agriculture. In 2016, ICARDA restored around 47 ha large area through an US Forest Service funded project. Around 15 ha of a 29 ha large upland watershed were treated by mechanized micro Water Harvesting.



Mechanized micro-Water Harvesting

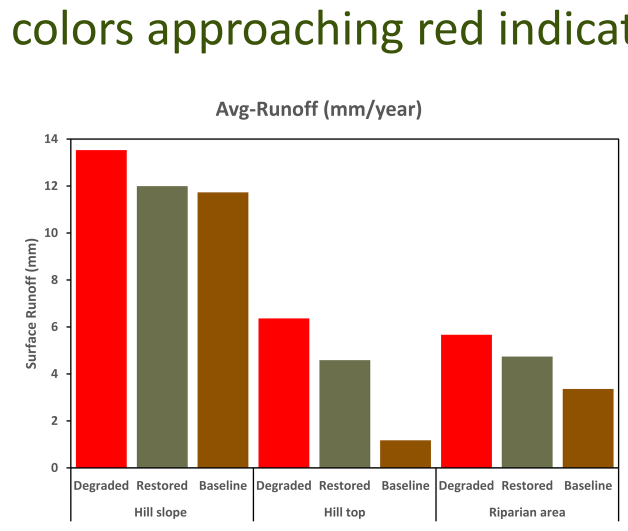
Mechanized micro-WH was performed by 'Vallerani Delfino-Plow' system, which is a hydraulically operating single ridge moldboard plow with deep-ripping sub-soiler. The Vallerani system deep fractures the soil and creates intermitted semi-circular WH structures along the contour. The Vallerani WH structure has approximately 0.5m wide ridge and a 0.5m wide pit. In the Badia research site, in each of the WH pits two native shrub seedlings (Atriplex and Retama) were out-planted to develop vegetation islands, which spread-out over time and eventually restore degraded areas.

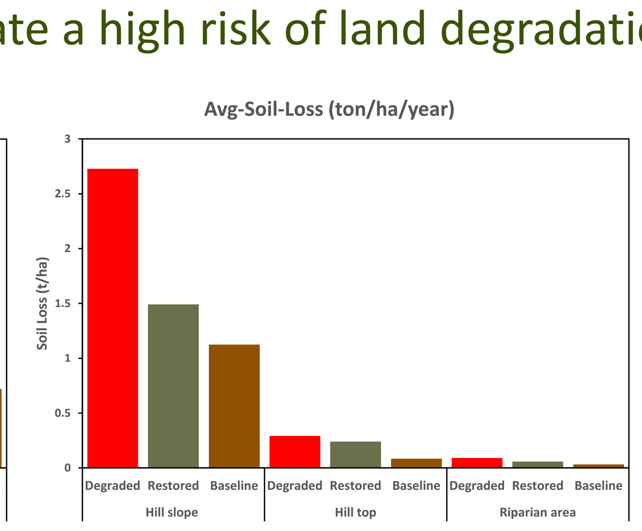
Rangeland Status Modeling

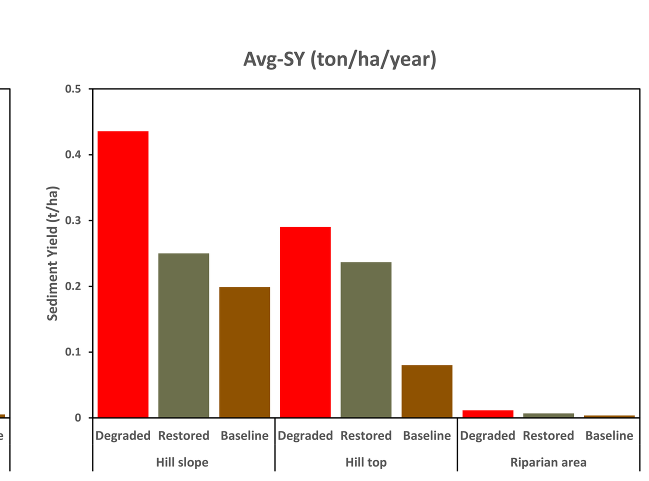
Rangeland Hydrology and Erosion Model (RHEM) was used to explore three different rangeland states' implications on water and soil fluxes: the estimated baseline (A), based on literature review and community questionnaire, the actual degraded status (B), and the micro-WH based restored equilibrium scenario (C), based on field monitoring and modeling. A 300-year climate time series was generated, using Queen Alia Airport data (Amman), to simulate rainfall, runoff and erosion. The model was run for three major zones of the local rangeland ecosystem 1) the shallow soil and rocky hill top areas, 2) the hill slope areas, which were eventually treated by Vallerani plow, and 3) the riparian area, close to the gullies. Moreover, a risk approach was carried out evaluating the impacts of heavy rainstorms most significantly contributing to surface runoff and soil erosion. In this study a 20-year return period storm event was analyzed.

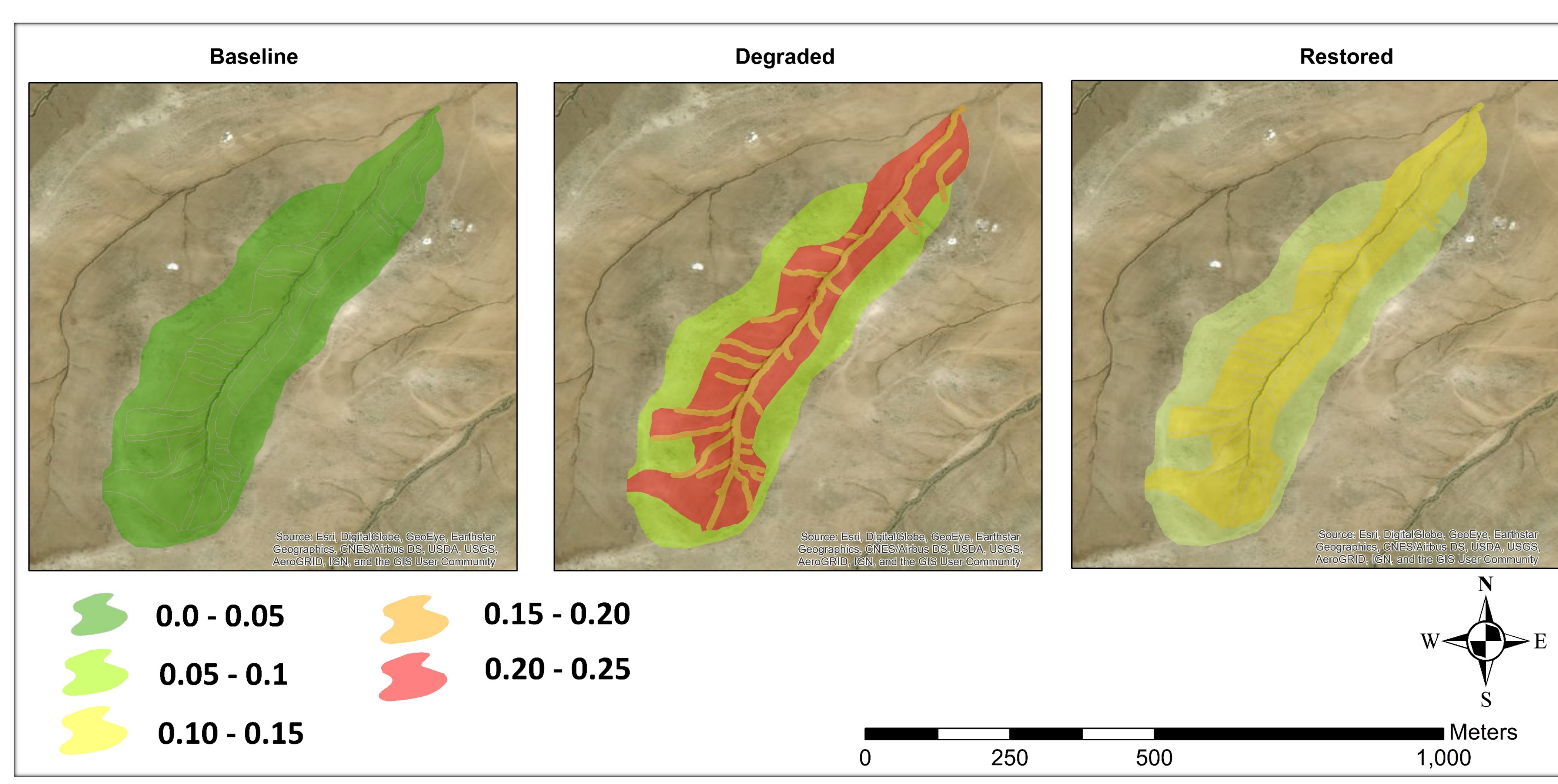
Results

RHEM was used to simulate surface runoff, erosion and sediment yield for A, B and C conditions. Average annual numbers for the three main different ecosystem components are shown in the graphs. The risk approach evaluates the sustainability of the micro-WH based watershed restoration vs. baseline and degraded scenarios. The approach compares the impact (erosion) of a 20-year return period storm considering different watershed states. Green to yellow colors indicate sediment dynamics close to the baseline conditions, whereas yellow to red colors indicate a severe erosion occurrence, significantly exceeding the sediment movement of the baseline scenario. Hence, the colors approaching red indicate a high risk of land degradation.









Conclusion

- RHEM is capable to assess the Jordanian rangeland soil and water dynamics in space and time
- Rangeland transition modeling supports the evaluation of different scenario's trade-offs (e.g. surface runoff, erosion and sediment yield).
- A risk approach helps to investigate sustainability of rangeland restoration: approaching baseline soil and water dynamics pattern (and magnitude) may indicate hydrological resilience – however, e.g. ecology and biodiversity need further investigation.
- Profound soil and water dynamics information can serve as a basis for rangeland ecosystem services evaluation (e.g. soil health, biodiversity, habitat quality)

Acknowledgements

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