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Combining scenario workshops, quantitative approaches and land use change modeling to design plausible future land use scenarios in the Tleta catchment (Morocco)

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Mediterranean soil resources are heavily affected by water erosion. As a consequence, soil losses may lead to a decrease in soil fertility affecting agricultural production, and to an accelerated rate of siltation in water reservoirs which are of primary importance for drinking water supply and for irrigation. Climate and societal changes are expected to increase these processes. Therefore, there is a need to anticipate the potential impacts of global change at the catchment scale, in order to prepare relevant adaptation strategies. While foresight approaches are promising, their outputs generally take the form of narrative storylines which may be difficult to link to spatially distributed and quantitative biophysical models used to simulate soil and water processes.

We address this challenge by developing a systemic approach that combines the use of scenario workshops with quantitative approaches (surveys, statistics, satellite images), and land use and land cover change (LUCC) modelling. This approach is implemented to the Tleta basin (Morocco), a 180 km² rural watershed located about 10 km from Tanger and affected by important soil degradation due to water erosion. First, we identify past farming and landscape trends, based on the analysis of historic satellite pictures and the local knowledge of farmers (surveys). Second, we build three contrasted narrative storylines describing the potential evolution of farming and landscapes at the catchment scale by 2040, based on a foresight approach and interviews with institutional stakeholders. Third, we translate these narratives into quantitative land use change rules, based on observed historic changes (surveys, statistics, and satellite pictures) and on geomorphologic constraints. The fourth step consists in using a LUCC model to simulate these changes, the LUCC model being based on both constrained probabilistic rules and a cellular automaton. Lastly, we put into debate, adjust and evaluate these scenarios by organizing two half-day workshops involving 18 scientists and 13 local institutional stakeholders.

As a result, we propose three plausible future land use scenarios by 2040 for the Tleta basin. The first scenario *Urbanisation and industrial development* considers a high urbanisation rate in the plain and a decrease in agricultural areas. The second scenario *The fruit basket of Tleta* assumes an important development of the arboriculture (olive, grape, pomegranate and fig trees) mostly in the plain, with a lower urbanisation rate. The third scenario *One foot in the city, one foot in the countryside* envisions the development of farming systems with high added value and quality local products (honey, aromatic and medicinal plants, goat cheese) in the hillslopes, benefiting from the proximity of Tanger. Each scenario includes a narrative, future land use maps up to 2040, and a set of quantified socio-economic variables.

These scenarios will serve as an input to biophysical models aiming to assess the evolution of soil resources degradation in the Tleta catchment under global change. From a methodological perspective, the research highlights the interest of combining narrative storylines and quantitative approaches to develop spatially explicit scenarios at the catchment scale that account for the local knowledge of stakeholders.

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Keywords: Foresight, Global change, LUCC modeling, Soil erosion, Morocco