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A spatial socio-ecosystem approach to analyse human-environment interactions on climate change adaptation for water resources management

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Global climate and socio-economic drivers determine the future patterns of the allocation and the trade of resources and commodities in all markets. The agricultural sector is an emblematic case in which natural (e.g. climate), social (e.g. demography) and economic (e.g. the market) drivers of change interact, determining the evolution of social and ecological systems (or simply socio-ecosystems; SES) over time.
In order to analyse the dynamics and possible future evolutions of SES, the combination of local complex systems and global drivers and trends require the development of multiscale approaches.
At global level, climatic general circulation models (CGM) and computable general equilibrium or partial equilibrium models have been used for many years to explore the effects of global trends and generate future climate and socio-economic scenarios.
Al local level, the inherent complexity of SESs and their spatial and temporal variabilities require different modelling approaches of physical/environmental sub-systems (e.g. field scale crop modelling, GIS-based models, etc.) and of human agency decision makers (e.g. agent based models).
Global and local models have different assumption, limitations, constrains, etc., but in some cases integration is possible and several attempts are in progress to couple different models within the so-called Integrated Assessment Models.
This work explores an innovative proposal to integrate the global and local approaches, where agent-based models (ABM) are used to simulate spatial (i.e. grid-based) and temporal dynamics of land and water resource use spatial and temporal dynamics, under the effect of global drivers. We focus in particular on how global change may affect land-use allocation at the local to regional level, under the influence of limited natural resources, land and water in particular. We specifically explore how constrains and competition for natural resources may induce non-linearities and discontinuities in socio-ecosystems behaviour.
Our general ambition is to explore the feasibility of an approach that could be implemented worldwide through the identification of representative cases described by means of spatially explicit integrated simulations in communication with global modelling.
Our specific objective is to test how ABMs can support scenario analysis at regional scale, and in particular how this can facilitate understanding of the role of human agency and its behavioural characteristics in local to global dynamics. The SES of interest is the agro-ecosystem with its relationships with other land uses.
In order to test the feasibility of application at global level, all the information about land uses, natural resources, local climate, crop potential productions, etc. were derived from freely available spatial data sets covering the whole planet, which provided the ABM model with spatial information as matrices of pixels. Input maps were extracted from the Global Agro-Ecological Zone (GAEZ) web site of the Food and Agriculture Organization of the United Nations and compiled in the local GIS from where they were then converted in a format compatible with Matlab. In this initial application, an ABM prototype was developed in three test areas around the Mediterranean Basin, in agricultural regions of Tunisia, Italy and Spain.