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YIELD, WATER SCARCITY AND SOCIAL ATTITUDES: INSIGHTS FROM AN AGENT-BASED MODEL

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ABSTRACT

While agricultural yield demand increases, the occurrence of drought during the growing season is becoming more frequent in several regions. Multiple strategies are possible to cope with this problem, such as the choice of high-productive crops and supplemental irrigation. Nevertheless, decision-making is often driven by human perceptions and by the demand for immediate actions, which may result in inadequate or even counter-productive management choices. We addressed this issue by developing a model that simulates a social-agricultural system coupling together environmental dynamics and human responses. We use the model to explore different scenarios, varying climatic and social parameters and analyzing how they can affect the yield productivity in the short and in the medium/long term. Different scenarios are then compared, in order to identify the combinations leading to the most desirable trade-offs, for both the farmers and the environment.

1 INTRODUCTION

In many regions, the temporal distribution of rainfall does not meet crop water requirements. Such a situation may be exacerbated due to climate change (IPCC 2014). Nowadays, farmers are coping with the challenge of maintaining and possibly increasing agriculture productivity under conditions of water scarcity. High productive crop varieties, as well as supplemental irrigation, can help in mitigating the climate effects. Nevertheless the risk of failing the challenge is high, not only due to the climate hazard, but also to the human response that may be inefficient and eventually even backfire. The need of supplemental irrigation, for instance, already led to groundwater over-exploitation in many different contexts, resulting in a decline of water tables (Scanlon et al. 2012; Wada et al. 2012). More in general, human responses are usually based on risk perceptions, which do not necessarily correspond to a correct evaluation of the risk. Indeed, after dramatic events, such flooding, wildfires or droughts, people tend to overestimate the risk according to the salience theory (Bordalo et al. 2012). Also the order in which events occur can alter the risk perception and the consequent behavior (Gonzales 2017). Models can be a useful tool to deal with this issue, but to be able to provide realistic predictions they must take into account all these aspects. We developed a new agent-based model that simulates a socio-agricultural system where crops, water resources and humans interplay under conditions of unpredictable climate and drought risk. The model is focused on the farmers' choice of the irrigation source. Specifically, farmers can choose between groundwater, which they can access through a pump, and water collected into water reservoirs (on-farm ponds). Nowadays there is an increasing interest for on-farm ponds, due to their big potential to mitigate drought effects in a sustainable way (Rao 2017). Nevertheless, little work has been done to include them in socio-agricultural models.

2 MODEL OVERVIEW

Our model simulates a community of smallholder farmers in a site, who derive their income from the crop they grow in their own farm, under conditions of water scarcity. Basing on previous works (Vico 2013), the model couples together crop development and soil water, with the latter depending on the rainfall, represented in the model as a stochastic process. A further input for soil water is given by irrigation, which may come from different sources depending on farmers' preferences, as specified above. On-farm ponds reduce the amount of cultivated area and require a bigger initial investment, but can be recharged every year during the non-growing season thanks to the rainfall. Pumps are generally cheaper, but groundwater is not recharged over the time – or only very slowly –with the consequence that the water table may become deeper and the pump may be not deep enough to access it any longer. A deeper pump can be built, but the cost increases with depth and eventually the pump can become less convenient than ponds. Farmers can also choose between different crop kinds (more or less water demanding). The attitudes driving farmers' decisions are risk aversion and long/short-term orientation (Hofstede 2011). Attitudes can change in response to climatic events, according to psychological mechanisms observed in empirical cases and described in the literature (Kahneman 1979; Scholer et al. 2014). The attained yield for each farmer is hence the result of a combination of factors: multiple management choices (crop kind and irrigation source), climatic events like droughts, response to climate events, human impact on water resources. Interactions with other farmers also play a crucial role, as their decisions may lead to a significant reduction of the common resource (groundwater), raising a problem of collective action (Ostrom 2000).

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