Linking soil biodiversity, irrigation and agricultural production: a conceptual framework

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Abstract

Soil biodiversity provides several potential ecosystem services favorable to agricultural systems especially the regulation of soil moisture. In ecology, the insurance value of soil biodiversity is as presented as an argument of its conservation. In this paper we test under which conditions this argument would be valid in a ecological-economic context. In a climate change context, water availability would be different than what we have been used to. Frequency of rainfall would be more extreme, droughts more frequent and water might therefore not be available when it is the most needed (IPCC 2007). Farmers will thence face larger risks and will have to decide on adaptation strategies. A conventional adaptation strategy would rely on the use of irrigation as a substitute to precipitation to deliver water in dry periods. But the promotion of irrigation may result in adverse effects in the face of an increased drought risk. Another strategy is an on-farm strategy that would consist in conserving soil biodiversity and to use its water storage regulation functions to stabilize the water availability in the soil. The ecological and economic synergies and tradeoffs of such adaptation strategies need to be better understood in order to design efficient adaptation policies in the agricultural sector. The present paper focuses on the role of soil biodiversity and irrigation strategies.

Water availability is the single most important limiting factor to plant growth. However, the link between soil biota, hydrological processes and the economic value of agricultural production is poorly understood although each component taken separately has been extensively studied.

We tackle the conceptualisation of this link with a bioeconomic model based on a stochastic production function in order to account for uncertainty in water availability. This enables to account more accurately for both the biophysical water related processes (including threshold effect) and the economic drivers of natural resource exploitation/conservation like prices, costs, resources substitution or risk preferences. In this model, we determine the optimal soil conservation strategy for a risk averse farmer in case of climatic uncertainty when this farmer can choose irrigation and soil biodiversity investment to regulate water in soil.

The research questions that guide the deliverable are (i) how does soil biodiversity under risk and uncertainty affect the distribution of farm profits via its ecological functions and water regulation service in agro-ecosystems? and (ii) under which bio-economic circumstances...
would an economically rational farmer decide to invest in irrigation or in soil biodiversity in a changing environment?
The results show the different values of soil biodiversity. Moreover, they show that biodiversity should be increased to face increases in drought frequency up to a certain level. But beyond that level of drought frequency, the optimal strategy is to reduce biodiversity conservation efforts. This result contrasts with intuition and conventional literature that recommend continuous increase in soil biodiversity in order to face extreme events and gives new insights for biodiversity policy making.

**Keywords:** Biodiversity, Agriculture, Ecosystem Services, Modeling, Threshold