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Mapping the potential success of agricultural water management interventions for smallholders: Where are the best opportunities?

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From field to basin scales, there are many appropriate interventions used to manage rainfall efficiently and productively in smallholder farming systems. Yet, successful targeting and scaling-out of these approaches remains a challenge. This paper presents an innovative approach in decision support called 'Targeting Agricultural Water Management Interventions' (TAGMI) with application in Limpopo and Volta river basins (available at http://www.seimapping.org/tagmi/). The online open-access TAGMI uses country-scale Bayesian network models to assess the likelihood of success for outscaling various agricultural water management (AWM) interventions at sub-national level. The web tool integrates multiple sources of expertise on the enabling environment for outscaling based on key social, human, physical, financial, and natural factors. It estimates the relative probability of success of an AWM intervention across the Limpopo and Volta river basins. Here we present

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TAGMI as a 'proof of concept', areas of high, medium, and low probabilities of success for three AWM technologies common in Limpopo and Volta River Basins: the soil water conservation/in situ rainwater harvesting technologies in rain-fed systems, small-scale private irrigation and small reservoirs used for communal irrigation purposes. We then apply a climate change scenario and discuss the robustness in potential AWM, according to the TAGMI tool. Finally, we discuss the need for generic or specific information on 'best practices of implementation' for successful uptake of technologies in poverty-constrained smallholder farming systems.

1. Introduction

Agricultural water management (AWM) is one principal management strategy to increase production and productivity of crops in smallholder farming systems under climatic stress, such as in semiarid and sub-humid sub-Sahara Africa (SSA) (e.g., Stevenson et al. 2014; Biazin et al., 2012; Cooper et al., 2008; Rockström et al., 2003). Yet to date, water management in both rainfed and irrigated crop production continues to challenge farmers' livelihoods. Dry spells and droughts, as well as floods and water inundation, cause substantial losses in yields. These affect both income and food security at local and national scales. At a continental scale, despite yield increases in smallholder farming, crop systems in SSA on average produce less than a quarter of biophysical potential (e.g., FAO (Food and Agriculture Organization of the United Nations), 2011; Mueller et al., 2012), the lowest of any region in the world. And yet, crop production and productivity for major staples and cereals have increased in SSA (e.g., Benin et al., 2011) albeit still lagging behind population growth and dietary change. As a consequence, several SSA regions are a net importer of staple foods (e.g., Rakotoarisoa et al., 2011). In addition, data by FAO show the net staple crop production and food supply increasing above the production and productivity of the 1960s, only in the last 10 years (e.g., Grassini et al., 2013; Rakotoarisoa et al., 2011). Hence, the use and implementation of agricultural water management interventions for crop and livestock production improvements continue to be a major contributing factor towards securing food supply in the future (e.g., Tilman et al., 2011).

Here we focus on the opportunities in targeting AWM interventions for smallholder farming systems in SSA. The Volta and Limpopo basins are still subject to substantial poverty and food security challenges, especially in rural smallholder farming context. Both basins are subject to high rainfall variability, where deviation from the long-term average of ±2 standard deviations is the norm rather than exception. Dealing with such rainfall and subsequent stream flow variability is a profound challenge for the farming systems. The need for rainfall and water management strategies from field to landscape scale is fundamental to securing crop growth. Whereas there are a range of well known, well tested and widely promoted AWM interventions, there is an understanding that smallholder farmers, in particular, may benefit from broader adoption of various AWM interventions. Alongside this consensus, there is also growing evidence that AWM uptake, adoption and outscaling are complex processes combining biophysical, human and social factors. To date, decisions support tools (DSS) for policy, development agents and investors have little explicit account for these multidimensional system components. There are already various spatially explicit DSS tools available for identifying potential areas for AWM interventions for sub-Sahara Africa conditions. Some are more locally focused, whereas others are national to sub-continental (e.g., Mati et al., 2006; Mbilinyi et al., 2007; Andersson et al., 2009). However, these tools emphasise biophysical aspects (agro-ecological zone, climate, slope, soil, surface water distance, etc.) and possibly incorporating some dimensions of human (labour availability, population density), financial (poverty/income proxies) and physical capitals (typically market access). To date, the incorporation of social and human capital dimensions is not common, and factors such as institutional capacity, leadership and community cohesion are largely absent. Yet, these factors are