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Assessment of farmers' rainwater management technology adoption in the Blue Nile basin

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Abstract: Agricultural productivity in Ethiopian highlands is constrained mainly by high climate variability. Although use of soil and water conservation technologies is recognized as a key strategy to improve agricultural productivity, adoption of technologies has been very low as farmers consider a variety of factors in their adoption decision. This study assesses the adoption pattern of interrelated rainwater management technologies and investigates factors that influence farm household adoption and scaling-up of rainwater management technologies and draws recommendations for policy. Our results show that rainwater management technologies are interdependent to each other implying that technology adoption decisions need to capture the spillover effect on the adoption of other technologies and have follow a multi-dimensional approach. Moreover, our results suggest that instead of promoting blanket recommendations, it is important to understand the socio-economic, demographic characteristics and biophysical suitability of the rainwater management technologies. Although impact of gender is likely technology-specific and generalization is not possible, our result indicates that male-headed households have a comparative advantage in rainwater management technologies adoption in the Nile Basin and suggests the need to address the constraints of women farmers to give them an opportunity to actively participate in rural economic activities.

Media grab: Since rainwater management technologies do not stand alone, it is important to understand their interdependence and not to make blanket recommendations.

Introduction

Like in many sub-Saharan Africa economies, agriculture is the main sector of the Ethiopian economy. In sub-Saharan Africa, water scarcity and land degradation affect the performance of agriculture and people's livelihoods. Agricultural productivity is low, dominated by low input low output rainfed mixed crop livestock production in the Ethiopian Highlands (Merrey and Gebreselassie 2011). In the Blue Nile Ethiopian highlands, agricultural productivity is constrained by high climate variability, rather than low water availability where rainfall distribution is extremely uneven both spatially and temporally, which has negative implications for the livelihood of the population (FAO 2005). Drought frequently results in crop failure, while high rainfall intensities result in low infiltration and high runoff causing soil erosion and land degradation and contribute to low agricultural productivity and high levels of food insecurity (Lautze et al. 2003; Deressa 2007). High population growth and cultivation of marginal land coupled with lack of effective rainwater management strategies have aggravated poverty and environmental fragility (Tamene and Vlek

2008). Use of soil and water conservation (SWC) technologies, referred here as ‘rainwater management interventions’ (RWM), are widely accepted as a key strategy to improve agricultural productivity by alleviating growing water shortages and the effects of drought and worsening soil conditions (Kurukulasuriya and Rosenthal 2003). It has been demonstrated that access to RWM interventions can help farmers in the Blue Nile Basin to decrease poverty levels by approximately 22% (Awulachew et al. 2012) and provide a buffer against production risk in particular in the face of increasing variability due to climate change (Kato et al. 2009). However, even if technologies are appropriate to the biophysical setting, they are not always adopted (Guerin 1999; Amsalu and Graaff 2007) as farmers consider a variety of factors in their adoption decision (McDonald and Brown 2000; Soule et al. 2000). In fact, there is no consensus on factors that influence the adoption and scaling-up of rainwater management technologies, which this study is aiming to contribute to the existing literature in filling knowledge gap. This study has been carried out in the framework of the Nile Development Challenge (NBDC) program that aims at improving rural livelihoods and their resilience through a landscape approach to rainwater management in the Ethiopian part of the Blue Nile Basin. The study specifically assesses the adoption pattern and factors that influence farm household adoption and scaling-up of rainwater management technologies and draws recommendations and policy implications.

Methodology

Recent empirical studies (Moyo and Veeman 2004; Marenja and Barrett 2007; Nhemachena and Hassan 2007; Yu et al. 2008; Kassie et al. 2009) argue that farmers usually consider a set of possible technologies and try to select the one they assume can maximize their expected utility; hence the adoption decision is inherently multivariate. Most of previous studies on technology adoption, however, assume a single technology without considering the possible correlation/interdependence between different technologies (Yu et al. 2008) possibly masking the reality that decision-makers often faced by a set of choices. The conceptual framework of this study is based on the premises that farmers are more likely to adopt a mix of rainwater management technologies as a coping mechanism to climate change and agricultural production constraints implying that technologies can be adopted simultaneously as complements or substitutes. When technologies are correlated, a univariate model is not appropriate, because it excludes useful information contained in interdependence and simultaneous adoption decisions; hence, failure to capture such interdependence will lead to biased and inefficient estimates. To fill this gap, we used a multivariate probit (MVP) model (as specified in Cappellari and Jenkins 2003; Kassie et al. 2012) as follows:

$$Y_{it}^* = \beta_t X_{it}' + \varepsilon_{it}, \quad t = 1, \dots, m \quad \text{and}$$

$$Y_{it}^* = 1 \quad \text{if} \quad Y_{it}^* > 0 \quad \text{and} \quad 0 \quad \text{otherwise}$$

Where (X_{it}') represents the choices of rainwater management technologies. The assumption is that farm household has a latent variable that capture the choices associated with the rainwater management technology. The estimation is based on the observed binary discrete variables that indicate whether or not farm household has adopted a particular rainwater management technology (denoted by 1 for adoption and 0 for non-adoption). The unobserved characteristics are captured by the error term denoted by, ε_{it} while β_t is a parameters to be estimated. In general, multivariate probit model is used to estimate correlated binary outcomes jointly where the source of correlation can be complementarity (positive correlation) and substitutability (negative correlation) between different technologies (Belderbos et al. 2004). A multi-stage stratified random sampling was used to draw a household survey data from 671 sample households in seven watersheds in the Blue Nile Basin.

Results and discussion

Our result shows significant joint correlation and interdependence between rainwater management technologies. Differences in the estimated coefficients across equations also support the correctness of differentiation between technology options. Household demographic characteristics, off-farm participation, migration, ownership of livestock, ownership of land, access to credit, access to market, social capital and watershed location captured by *woreda* fixed

effects are the main determinants of adoption of rainwater management technologies. The suitability of rainwater management technology is likely to be influenced by landscape, land degradation and land use patterns.

As presented in Figure 1, some technologies are more suitable in flat, gentle slope or steep slope lands. Similarly, the level of land degradation is more likely to influence where a specific rainwater management technology can be adopted, which also indicates the biophysical suitability.

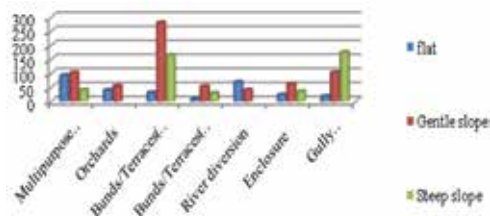


Figure 1. Adoption of rainwater management technologies by landscape

For example, Figure 2 shows that except bunds/terraces, most of the rainwater management technologies were adopted in degraded lands, probably because these technologies are used as ex-post land rehabilitation and resource conservation measures. Finally, the type of land use is likely to influence the suitability of technologies and adoption decisions of farm households (see Figure 3).

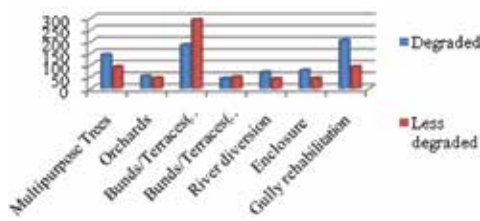


Figure 2. Land degradation and adoption of rainwater management technologies

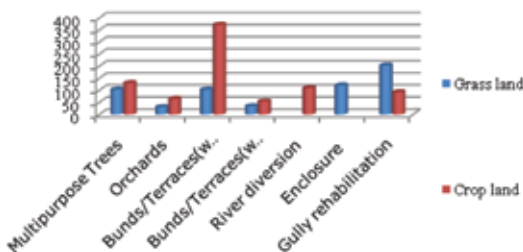


Figure 3. Adoption of rainwater management technologies by land use

Conclusion and recommendations

The main conclusion and recommendation of this study is as follows: (i) rainwater management interventions should focus not only on the engineering and biophysical performance of conservation measures, but also on the socio-economic and livelihood benefits; (ii) adoption of rainwater management technologies are interdependent, hence, any intervention towards promoting of rainwater management technologies need to consider such interdependence; otherwise failure to capture such interdependence may lead to mask the reality that farmers often faced by a set of choices and the results in poor performance of the technologies; (iii) targeting women groups to address their constraints to actively participate in rural economic activities can have positive impact on the adoption and scaling-up of rainwater management technologies leading to improved livelihoods; (iv) farmers with better experience and information are most likely to take initiatives in adopting and testing new technologies; therefore, using such models farmers can help to promote successful and proven technologies; (v) in addition to the socio-economic and demographic characteristics, it is important to understand the biophysical suitability of technologies instead of

promoting blanket recommendations for the adoption of rainwater management technologies; (vi) externally driven technical solutions are rarely sustained by farmers unless consideration is given to socio-economic, cultural and institutional, as well as biophysical and technical factors.

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