Socioeconomic Barriers to Adoption and Scaling-out of Water-Smart Agriculture in Tanzania

Between 1980 and 2000, Africa is estimated to have spent about US$4 billion on agricultural research (Gura and Gundula, 2000), which has generated a wealth of agricultural innovations. However, only a few improved agricultural technologies have been adopted on a wider scale. This is the result of poor adoption and scaling-out processes of agricultural innovations, including water-smart agricultural technologies (Morris *et al.,* 2005; Tumbo *et al.,* 2011).

Tanzanian agriculture remains predominantly rainfed, largely facing water scarcity particularly in the semiarid areas that cover around 60% of the country. In this regard, harnessing agricultural water resources is critical for upgrading rainfed agriculture.

The concept of water-smart agriculture (WaSA) relates to previous concepts that harness agricultural water mainly in rainfed agriculture–e.g., soil-water conservation (SWC), water system innovations

(WSI), conservation agriculture (CA), and climate-smart agriculture. Such concepts are adequately expounded in literature with the exception of the WSI[1], which was prompted by UNESCO-IHE and IWMI (2003).

As most potential agricultural technologies, the adoption and scaling-out[2] of water-smart technologies have been unsatisfactory in spite of successful field tests in many places (Tumbo et al., 2011; Kahimba et al., 2014). An overarching question is why the uptake of such technologies at the farm-level and spread of the same over most of the agro-landscapes remain limited. This paper is a modest attempt to answer this question by underpinning socioeconomic barriers limiting successful adoption and scaling-out of WaSA practices.

Objective

The objective of this paper is to consolidate critical socioeconomic barriers that hinder successful adoption and scaling-out of WaSA.

Methodology

The paper draws empirical insights primarily from two published literature. The first covers adoption and scaling-out of water-system innovations based on a study conducted in Same District (Tumbo *et al.,* 2011). The second covers adoption and scaling-out of CA in Arusha and Dodoma regions (Kahimba *et al.,* 2014). Moreover, some insights were drawn on request from FAO's yet unpublished adoption study under its project called Mitigation of Climate Change in Agriculture (MICCA) in the Uluguru Mountains in Morogoro Region, Tanzania. The empirical results from these studies are blended with expert experience to consolidate evidence-based knowledge on the barriers to successful adoption and scaling-out of WaSA. The three reference studies collected data through cross-sectional surveys using a household questionnaire coupled with focus group discussions to gain communitywide insights.

Results and discussion

The successful scaling-out of WaSA technologies depends on a range of socioeconomic factors that can be grouped into three categories—farmer-related, community-related, and institutional.

Farmer-related include those factors emanating from the internal conditions of the farmers and those within his control. These include education and skills, labor, household resource base, and intrahousehold gender relations.

The community-related envisaged factors involved social capital, culture, and norms and values of the community. These actually determine the diffusion of innovations at the community scale. The institutional factors are those related to governance, political participation, delivery of socioeconomic services, influences and roles of external change agents, input and output markets, and microfinance.

The three categories interact in a dynamic way through complex feedback mechanisms that determine outcomes at different decision scales—i.e., farmer, community, and government. Therefore, an attempt to draw a line of distinction is arbitrary but may be necessary to enable a systematic organization of ideas.

Farmer-and community-related factors

Land tenure insecurity

Water-smart agricultural practices are carried out on the land. Insecure land tenure could be a barrier to adoption and scaling-out of WaSA. Some investments in WaSA have lasting streams of benefits that a farmer wishes to enjoy over time. When the future of resource ownership and access rights is uncertain, the farmer will be unwilling to commit such investments. For example, benefits of double digging and terracing on the farm last beyond one season; a farmer renting land may be reluctant to undertake the practice in fear of the landlord taking back the plot next season. Any arrangement that will enable secured land tenure such as land use planning and good land governance by both institutions of state

[1] WSIs can be defined as all indigenous and novel technologies for improved agricultural water management, covering both crop and livestock production (UNESCO-IHE and IWMI, 2003)—such as deep tillage, mulching or crop covers, terraces, water storage reservoirs, water harvesting and drip irrigation (Tumbo et al., 2011).
[2] Scaling-out is the horizontal or geographical spread of innovation to more people or locations (Guendel et al., 2001).

and that of society is an incentive for successful adoption and scaling-out of WaSA.

Scarcity of land resource

Land is a vital resource to resource-poor smallholder farmers. However, the land resource is not plenty to many smallholders. Land is becoming increasingly scarce over time due to increasing population, coupled with poor productivity. In the face of scarcity, resource-poor farmers tend to be risk-averse—i.e, reluctant to commit their land on new technologies. A farmer with ample farmland may be ready to try a new technology on one part of the land and spare the remaining while learning the outcome of the new technology before scaling it up on a larger land. Despite the fact that land is a finite resource and some pockets of extreme land scarcity exist in the country, still majority of the farmers, especially in the dryland, have enough land. However, the most pressing situation is low productivity mainly due to agricultural water stress.

High investment and operational costs

A range of costs is associated with adoption of WaSA. These include costs on investment in on-farm structures such as terraces and recurrent costs on inputs such as improved seeds, management, and maintenance costs. Other important typologies of costs include opportunity and transaction costs. For example, the crop residue to be incorporated in the farm under conservation farming may have alternative uses as feed for livestock and as fuel (Giller *et al.,* 2009; Bishop-Sambrook *et al.,* 2004). Transaction costs involved in searching for information about the technology and time spent in meetings and collective action can be a hindrance to adoption and scaling-out of WaSA technologies. The cost barrier can be counteracted through functioning pro-poor micro-finance schemes that can extend credit to smallholder farmers to solve the liquidity constraint.

Labor constraint

Family labor is the major input in the implementation of WaSA technologies. A household that has inadequate labor force and has no means of hiring labor would find it difficult to adopt the practice and vice versa. Improving human health through better health services and nutrition will increase labor productivity. Introduction of labor-saving technologies such as draft animals and specialized implements to carry out WaSA practices are among incentives for adoption and scaling-out of WaSA technologies.

Lack of access to input and output markets

Access to input and output markets plays a big role in the uptake of agricultural technologies. However, majority of smallholder farmers have limited access to input markets (that deliver affordable inputs timely) and to profitable output markets. The efforts committed at adopting the technology in the field is rewarded through access to affordable input and profitable output markets. Improved market access that ensures higher returns to land and labor is therefore a critical factor for the adoption of WaSA practices.

Lack of access to credit

Majority of smallholder farmers are income-poor—hence highly constrained of both investment and operating capital. The rural micro-finance institutions are underdeveloped and majority cannot access credit. This may limit the uptake of water-smart practices that are relatively capital-intensive such as terraces. Initial costs can prohibit adoption of bench terraces in spite of their potential returns on investment compared with less costly practices such as grass strip farming. Tenge *et al.,* (2005) estimated investment costs per hectare of bench terraces and grass strip to be US$215 and US$84, respectively. However, respective rates of return per shilling invested were 19% and 6%, but adoption rates were 26% and 55%. Arguably, unless poor farmers have access to credit, adoption of bench terraces will be curtailed. Change agents and development practitioners who have been promoting costly and labor-intensive innovations such as terraces have tried to have different incentive packages. Most of them—such as FAO in its MICCA project in the Uluguru mountains, Traditional Irrigation Project (TIP) and Same Agriculture Improvement Project (SAIPRO) in the south-Pare mountains—have been encouraging collective action through farmer groups as a means of mobilizing labor. Some of the NGOs, particularly TIP and SAIPRO, have had conditional incentives such as food for work and urging farmers to have installed terraces first before they get supported in the rehabilitation of traditional water reservoirs (locally called *ndiva*).

Limited access to appropriate farm implements and tools

Implementation of some water-smart practices requires appropriate tools. Layout of terraces needs farmers to have tools such as pick axes, shovels, and levels. Double digging can be done with an improved hand hoe designed to penetrate easily in the soil. Ripping to enhance moisture infiltration by breaking the soil hardpan can be done easily with animal-driven rippers. Majority of smallholder farmers may be unable to access these productive farm tools. Incentives would be to enable farmers to have access to such tools. This can be achieved through organized technology hire schemes, training and supporting local manufacturers to fabricate affordable tools, and improve the micro-finance arrangements for micro-capital acquisitions. Kahimba *et al*. (2014) found that training on the use of draft animal power and affordability of oxen technology contributed to increased adoption of conservation tillage in Dodoma.

Limited social capital

Some social capital elements are important for scaling-out of agricultural technologies such as water-smart technologies. Such elements include farmer group networks, interactions with different people, and collective action (Tumbo *et al.,* 2011). For example, FAO's MICCA program has used the contact farmer-trainers as paraprofessionals in the transfer of climate-smart agricultural technologies in the Uluguru mountains. The sustainability of the farmer-trainer approach depends much on how the respective community will continue to trust and value the knowledge delivered through farmer-paraprofessionals.

Institutional factors

Limited presence of non-state change agents

Increased involvement of external change agents through programs and projects is critical for successful adoption and scaling out of WaSA. However, most of the programs are short-lived and change agents leave the target communities shortly. There are evidences that adoption of water-smart practices such as terraces requires intensive training and presence of change agents over a long time (Tumbo *et al.,* 2011; Kahimba *et al.,* 2014; FAO, 2014). The farmers also stressed that the locals usually tend to value the knowledge extended by external people (FAO, 2014). The successes seen in some areas such as terraces in the Lushoto highlands, south Pare mountains, and parts of Arusha are due to interventions by TIP and the Soil Conservation and Agroforestry Programme (SCAPA) in respective areas for more than a decade from the late 1980s. For example, most of the farmers attributed the adoption and diffusion of terraces in the Makanya catchment to NGOs that have had lasting interventions in the area. For example, Kahimba *et al.* (2014) reports that an NGO called Lay Volunteers International Association (LVIA) successfully promoted conservation tillage using ox-drawn rippers by conducting training and issuing a set of oxen and oxplow at a subsidized price to a farmer group.

Lack of effective knowledge and outreach strategies

Different change agents and the government extension use different approaches to transfer agricultural technologies—including those with and without demonstrative and interactive features. Demonstrative and interactive knowledge transfer and outreach strategies are effective for successful adoption and scaling-out of WaSA. Tumbo *et al*. (2011), Kahimba *et al*. (2014), and FAO (2014) found that field demonstrations, farmer field schools, self-help groups, study tours, and field visits were perceived by farmers to be the most effective methods of communicating knowledge on water system innovations, CA, and climate-smart agriculture. In contrast, non-interactive methods that do not provide means for physical witness and immediate feedback would be less effective.

Limited partnerships and alliances

The programs and projects promoting agricultural technologies in rural areas tend to work in isolation. Partnership between key stakeholders and institutions in the community is a prerequisite in successfully outscaling an innovation. Tumbo *et al*. (2011) reports that a strong partnership between TIP, SAIPRO, the district government, and the communities was the major reason for scaling-out of some technologies such as terraces and water harvesting in Same District. The external change agents should seek to forge a partnership with a spectrum of administrative, development practitioners (internal change agents), and community-level institutions at the innovation promotion sites.

Conclusions and recommendations

Harnessing agricultural water resources is the centerpiece of upgraded productivity of rainfed agriculture, particularly in the vast dryland areas. Therefore, addressing what limits the uptake and spread of WaSA is indeed an agricultural development topic.

The socioeconomic barriers to successful adoption and scaling-out of WaSA are not different from those that have shaped the adoption and diffusion patterns of agricultural technologies in Africa. However, such barriers vary on how to address them, depending on the contexts of the technology and the biophysical and socioeconomic settings.

The most policy-relevant barriers that limit successful adoption and scaling-out that have to be addressed include land tenure insecurity especially among

women, limited access to input and output markets, and poor access to credit.

The paper recommends that the critical barriers be addressed in order to advance WaSA in the country. By addressing the barriers, WaSA practices could be widely adopted and scaled-out at the agro-landscape level.

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