Scaling Land and Water Technologies in Tanzania: Opportunities, Challenges and Policy Implications

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Executive summary

The scaling of land and water technologies has widely increased across different parts of the world; and is recognized as important for ecological systems. These technologies contribute to sustainable management of watersheds on which agriculture, food production and rural livelihoods for most developing communities depend upon. There are ongoing efforts designed to halt land degradation in the Western Usambara which have arisen from pressure on land resources mainly caused by demographic growth, deforestation and the abandoning of the traditional regenerative land use and farming systems.

Socio-cultural and economic factors such as education level, age, gender, and land tenure, marital status and income earnings of smallholder farmers are factors considered important in the adoption of land and water management practices. Environmental factors were also identified as limiting factors to smallholder farmers in soil-water management practices. Such factors involved physical distance, slope, type of crops grown and farm sizes. Insecure land tenure especially among women limits their adoption of the technologies. Technological complexity of the technology (farmers prefer technology that are less complex and easier to use), preference for less labor intensive technology, required capital, land ownership (less adoption in new technology on hired/leased land), approach of introducing the technology (preference of participatory bottom up approach), and motivation and the involvement of farmers from conceptualization to implementation are factors that impact adoption of technologies between farmers.

Unsustainable cultivation in catchments and destruction of water sources in Tanzania is limiting the flow of water on which some of water use technologies directly depend. In some areas where farmers and pastoralists co-exist, conflicts always arise from grazing on farmland, with destruction to water infrastructure. In recognition of the need for sustainable management of land and water, and the increasing conflicts over use of resources by different sectors, Tanzania has enacted several policies. The irrigation policy calls for the improvement of irrigation water use efficiency and effectiveness by promoting closed conduit systems and high efficiency methods such as drip irrigation and promotion of efficient water utilization technologies such as the System of Rice Intensification. There is need for harmonization and linkage of land and water management and the policies to avoid conflicts. Whereas for example the customary land law recognizes the right to land entailing some resources therewith, the water law does not recognize such customary right by granting the ownership right to water by the owner of land on which the water resource is found. There is need for adequate mechanisms for enforcing policies, regulations and by-laws.

Local water governance institutions such as water user associations are important for sustainable scaling of land and water technologies. Horizontal and vertical scaling of the land and water technologies depends on factors such as facilitation of registration of water user associations and empowering them; implementing projects based on actual ground conditions for ease of adoption by communities; and involvement of the local government. Strengthening linkages between relevant institutions and their respective roles and responsibilities also require to be clearly defined. Promotion of land and water technologies should not be gender-blind but rather ensure participation of women and youth in the training and implementation. An integrated systems approach is needed to address the multi-faceted

challenges in sustainable land and water management, and a focus on the entire value chain activities; from input supply to output market.

1.0 Introduction

Climate change will continue to put pressure on Tanzanian farmers and the ecosystems as a whole – hitting harder on climate-sensitive sectors such as agriculture and water resources (Kulkarni, 2011). Tanzania has substantial water resources and an irrigation potential, which is not fully, exploited (URT, 2004). The promotion of sustainable management of water will ensure sustainable agricultural production, food security and poverty reduction (URT, 2009a). In addition, there exists inefficient management of water resources, for example, traditional irrigation systems in the Southern Agricultural Growth Corridor of Tanzania (SAGCOT), which divert surface water onto cropland, have only about 20-60% of the water remaining in the field (URT, 2007, 2012, 2013, 2014).

Thea Agriculture Climate Resilience Plan, 2014-2019, has emphasized the need to increase water use efficiency and water storage through investing in the acceleration of the uptake of sustainable irrigation among smallholders farmers. This can be achieved through affordable and climate smart pump technologies such as the treadle, wind and solar power pumps (Action 1A, ACRP, 2014). Other key investments emphasized include the need to Conduct a stocktaking on water use efficiency for different technologies, water lifting technologies, rainwater harvesting and water storage techniques (Action 1A Implementation Factsheet, ACRP, 2014).

Water resources in the United Republic of Tanzania are managed according to the *2009 Water Resources Management Act* (WRMA) at five levels, from national to local: i) national water board, ii) the nine basin water boards, iii) catchment water committees, iv) district councils and v) water users associations (WUA). The latter are organized in water catchments and are responsible for managing allocation of water resources at local level, managing equitable allocation of resources during drought, and mediating local disputes (Medmu, Magayane, 2005). Community-Owned Water Supply Organizations (COWSOs) are in charge in rural areas, and Water Supply and Sanitation Authorities (WASSA) in urban areas.

Prospects for agricultural water management

The 2006 Agriculture Sector Development Strategy set a target of irrigating about one million hectares by 2016. The target of 405 400 ha equipped for irrigation by 2017, set by the 2002 National Irrigation Master Plan (NIMP), is still limited by the financial resources available. Ongoing projects such as the Rice Centre of Excellence in Eastern Africa, will have 20 000 ha equipped for irrigation, and the Kilangali Seed Farm project, with 100 000 ha. The irrigation development rate increased in the last years, through the construction of small-scale dams (MAFSC, 2014). The abundant water sources, co-existence of several agro-ecological zones and the almost unexploited 2.3 million ha irrigation potential still permits tremendous irrigation expansion and diversification in crop production that could contribute significantly to stabilizing agricultural production and increasing income. Access to both water and land for vulnerable groups may be a constraint in some cases (FAO, 2016).

 

Source: CIAT

Soil erosion is a huge challenge mainly due to deforestation, and demographic growth. Farming on the steep slopes also poses a risk for soil erosion, and that this could affect important rivers with sedimentation. However, the long-term promotion of soil conservation measures such as terraces, *fanyaju* and contour planting has helped to improve the situation. Forage grass and trees are also commonly planted along the contours and edges (Braslow et al., 2016). Soil erosion is perceived in some cases to wash fertile soil into valley bottoms and in other cases, where fertile soil has already been washed away, to wash infertile soil into valley bottoms, reducing the fertility of valley bottom soils. Soil fertility is maintained by constant manure application. Maintenance of soil fertility is an important ecosystem service as it is necessary for overall agricultural productivity.

2.0 A case study of Land and Water Management in Lushoto district

2.1 Water resources and landscapes

Water scarcity impacts communities differently depending on land use and can have economic implications on the number of cropping seasons in a year. The traditional sources of water for Lushoto district are springs and streams, which flow down the slopes of Usambara Mountains. Important rivers identified in Lushoto include: Soni (source in Mkuzi, and eventually joins river Mombo), and seasonal rivers like Mkuzu and Mnolo (Braslow et al., 2016). Due to the topographical features of the district, human settlements are located on top of ridges and water sources in many villages are found down the hills making the task of fetching water for domestic use time and labor intensive. The government in collaboration with different development partners has been constructing gravity water schemes, and shallow wells. Currently, over 50% of the population has access to safe and clean water through water pipes and shallow wells. Sedimentation is perceived to reduce water quantity in the main rivers. Increased sedimentation is attributed to run-off from roads, settlements and cultivated areas. Noted sources of pollution of the rivers also include erosion, leading to siltation of the dams and pesticides from farming the riverbanks (Braslow et al., 2016).

Forests are essential in Lushoto as they influence precipitation patterns. The Usambara Mountains were covered by natural rainforests before the first human settlement in the 18th century. The natural forests in the Usambara provide protection of the micro-environments (Rodgers and Homewood 1982). The forests recycle nutrients and act as a regulatory body in the hydrology of the area (Lundgren 1978). These two aspects mean that there is a great degree of subtle differences in the various parts of the highlands and lowlands in Lushoto district (Adolfo, 2000). The forest cover is approximately 41,701 Ha, equivalent to 12% of the total district area. The forests are divided into dense and open forests (shrub, bush, thick forest reserve). Most of the forests are natural. The district undertakes afforestation of the Usambara Mountains to prevent habitat loss. Burning to clear fields is a problem in some parts of Lushoto (around Mbuzii), this is also the case with some forests in the district. Wild vegetables used to be sourced from natural forests but have declined due to over-exploitation by increasing human populations and because of a drier climate. A reduction in available fuelwood and timber has increased tree planting on farms and the need to purchase these resources (Braslow et al., 2016). The areas between Milungui, Masanga and Mamba were characterized by thick natural forest, as well as deforested sites of pine trees, areas close to Mamba forested areas were cleared to give way to agriculture. Eucalyptus trees are dominant throughout these areas, especially near the river on the higher elevations. In general, the steeper slopes indicate less signs of erosion and higher natural land cover than the lower land sites (Benjamin et al., 2014). In addition soil organic cover is lower in cultivate land as compared to protected areas

2.2 Land degradation in Lushoto district, Usambara Mountains

Land degradation includes soil erosion which is a major problem in smallholder farming systems (Haile & Fetene, 2012). Sustained soil erosion and household poverty are related (Jamu, Banda, Njaya, & Hecky, 2011) and these two are now a threat to the social livelihoods of smallholder communities. In East Africa, it is the smallholder farming systems on the highlands which are the hardest hit with soil erosion (Kangalawe & Lyimo, 2010). On these highlands, many farmlands experience declining crop yields because of soil erosion (Kassie, Zikhali, Pender, & Köhlin, 2010). In Tanzania, the West Usambara highlands are among the most affected areas when soil erosion is mentioned (Tenge, Sterk, & Okoba., 2011).

There are ongoing efforts designed to halt land degradation in the Western Usambara which include soil erosion control, agroforestry, and control of overgrazing. These problems have arisen from pressure on land resources caused by demographic growth and the abandoning of the traditional regenerative land use and farming systems. It was realized that the twin causes of land degradation led to the deterioration of natural resources as is illustrated by the following effects: reduction of the water balance; loss of soil fertility; cultivation of more marginal lands such as hill tops, steep slopes and the decrease of agricultural productivity and family incomes.

2.3 Soil and water conservation technologies in Lushoto

According to the study by Mwango et al., 2014, soil fertility varied significantly between soil and water conservation technologies with the trend: bench terraces> micro ridges> *miraba*. Soil fertility also varied significantly between slope positions under all the studied technologies with the trend: lower slopes> upper slopes >mid slopes. On the other hand soil fertility varied significantly between segments of the studied technologies.

It is recommended that supportive soil and water conservation measures such as mulching should be tested and accompanied under *miraba* and micro ridges as an effort on reducing the magnitude of soil fertility and crop yields variability within the aforementioned technologies. It is further recommended that spacing of grass strip bounds that form *miraba* be reduced to minimize the speed and intensity of runoff which in turn will also reduce soil fertility and crop yield variability between segments under *miraba*.

In Tanzanian west Usambara highlands, agro-forestry, grass strips using Napier grass (*Pennisetum purpureum*) or of Guatemala grass (*Tripsacum laxum*), *fanya juu"* infiltration ditches, terracing and and cut-off drains have been reported as the main predominant soil and water management practices (Shelukindo, 1995; AHI, 2000).

Results have suggested that these practices generally reduce agricultural surface runoff and soil erosion, improve soil properties and soil organic matters as well as decrease the needs for fertilization and pesticide use (Miglierina *et al*., 2000). For instance terracing changes the landscape; they directly affect local hydrology and consequently runoff characteristics. In addition, terraces indirectly affect soil moisture and soil characteristics (Chow *et al*., 1999). Terracing has only an effect on water erosion; it does not stop or reduce the impacts of wind erosion. Another soil-water management practice is agro-forestry land use. It contributes to controlling the impacts of both wind and water erosion. In addition, the use of mulching techniques was suggested to be useful in holding soil moisture and increase in nutrient availability (Maiga, 2002).

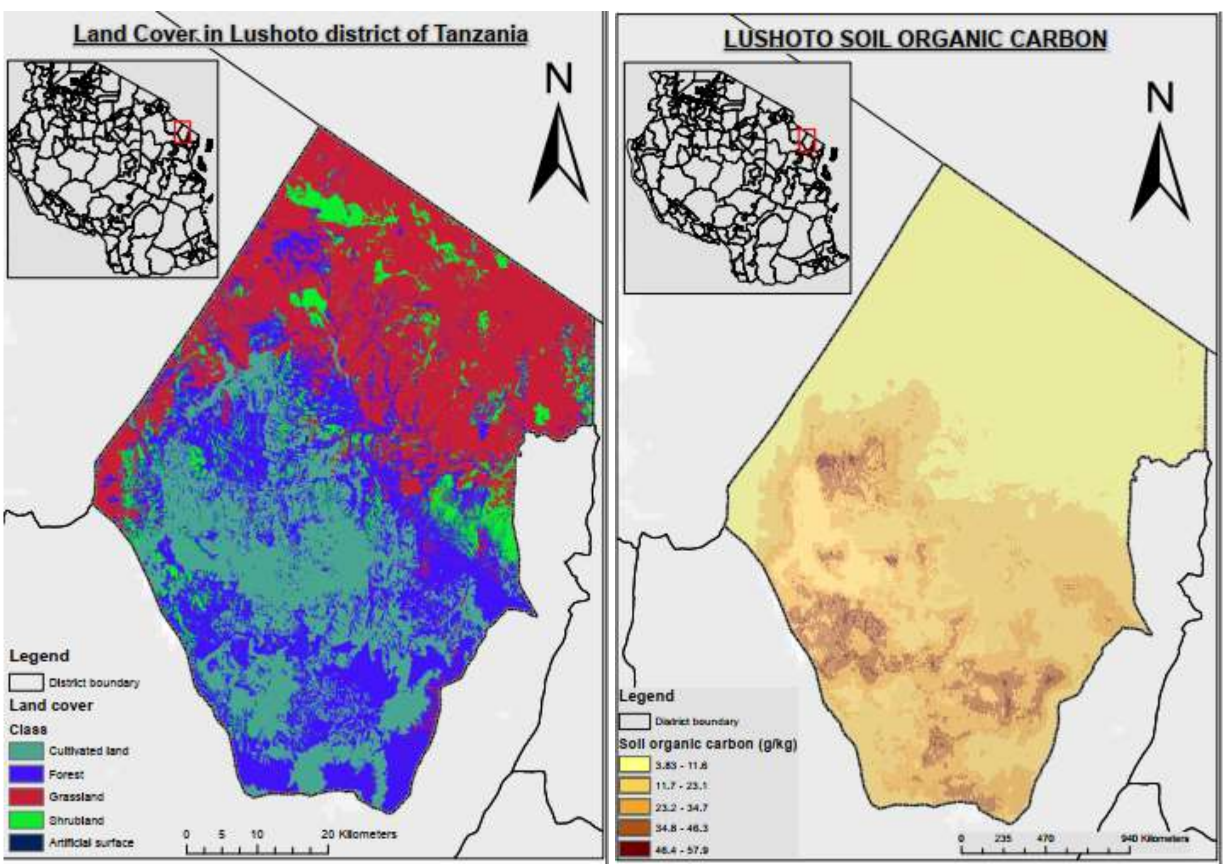

Figure 1: Land Cover and Soil Organic cover in Lushoto district, Usambara Mountains, Tanzania

2.4 Challenges to adoption of water and land management technologies for smallholders farmers in Lushoto

The participatory workshop as reported by Benjamin et al., (2014) showed that the most common challenges for smallholders are**:**

- Soil erosion: according to farmers, the erosion of soil, particularly in zones 3 and 4, has depleted the soil of its nutrients and has contributed to crop loss. As a soil erosion defense mechanism, farmers use terraces framed with Napier grass.
- Deforestation: observations showed that deforestation had occurred in some places along steep slopes.
- Land scarcity: land availability is limited, as a solution, intercropping systems are used.
- Soils in the lower lying areas appeared to have high clay contents, being red in color; in those plots where organic matter was incorporated; the soil was darker / black in color. In the higher areas, soils were darker, again potentially due to addition of organic matter.
- Unpredictability of rains.

Gender disparities:

Women, like men, are actively participating in agriculture. Male farmers are mainly involved in the production of cash crop, whilst women farmers largely focus on food crops. Unlike the highland women's group, men in the highland areas practice contour bunding and ploughing to combat soil erosion. Women stated that there was an unavailability of stones to practice contour bunding. Women in both the highland and lowland areas, in contrast to the men's group, identified water harvesting as commonly practiced.

3.0 Policies for water use and management

The main regulatory framework for irrigation in the United Republic of Tanzania is the *2009 WRMA No.11*, which repealed the previous *1974 Water Utilization (Control and Regulation) Act. No.42* as amended by the *1997 Water Laws (Control and Regulation) Act*. The *2009 WRMA Act* stipulates that all water in mainland Tanzania is vested in the United Republic of Tanzania and introduces more participatory management through the five levels of water management in the country. It was completed by the 2013 National Irrigation Act establishing a National Irrigation Commission. Finally, the 2009 Water Supply and Sanitation Act (WASSA) organize the water provision services and establish the National Water Investment Fund (MW, 2014). More generally, the 2004 Environmental Management Act (EMA) requires irrigated agriculture to protect the land, surface water and groundwater resources, as well as the community.

A wide range of policies further define the water and irrigation sectors:

- The 2002 National Water Policy (NAWAPO 2002), which amended the first National Water Policy of 1991, was prepared in part as a response to the growing water use conflicts, especially in the Pangani and Rufiji basins, most of which involve irrigation. It addresses the need for participatory agreements on the allocation of water use and to involve the private sector in water management.

- The 2002 National Irrigation Master Plan (NIMP) proposed an irrigation development programme for 405 421 ha to be implemented by 2017 that includes only smallholder schemes.
- The 2006 National Water Sector Development Strategy (NWSDS) aims to develop a comprehensive framework for sustainable development of the country's water resources, together with the NAWAPO 2002.
- The 2006 Water Sector Development Programme 2006-2025 (WSDP) was prepared to implement objectives of NAWAPO 2002 and NWSDS 2006 (SEI, 2007).
- The 2010 Nation Irrigation Policy provides a vision and step-wise prioritization of irrigation development in the country and research with reference to the NIMP. It leads towards the establishment of financing mechanisms for irrigation. It has the objective of ensuring sustainable availability of irrigation water and its efficient use for enhanced crop production, productivity and profitability that will contribute to food security and poverty reduction.

Finally, the Tanzania Agriculture and Food Security Investment Plan for 2011-12 to 2020-21 (TAFSIP) and the National Agricultural Policy of 2013 detail the priority for the agricultural production (FAO, Agwa & IFAD, 2014).

3.1 Policy recommendations on water use technologies

In recognition of the increasing conflicts over water use by different sectors, the recent irrigation policy calls for the improvement of irrigation water use efficiency and effectiveness by promoting closed conduit systems and high efficiency methods such as drip irrigation and promotion of efficient water utilization technologies such as the System of Rice Intensification (SRI) (URT 2013a).

- Policies on water management need to have coherent focus in promoting efficient water use technologies (WUT) among smallholders.
- The need for harmonization and linkage of water management and natural resources policies to avoid conflicts over water uses. Whereas for example the customary land law recognizes the right to land entailing some resources therewith, the water law does not recognize such customary right by granting the ownership right to water by the owner of land on which the water resource is found.
- The irrigation policy needs to be revised to put additional emphasis on markets and minimizing post-harvest losses and focusing on a value chain approach. Currently it has emphasis on increased crop production and productivity.
- There is need for adequate mechanisms for enforcing policies, regulations and by-laws. Unsustainable cultivation in catchments and destruction of water sources, is limiting the flow of water on which some of WUTs directly depend. In some areas where farmers and pastoralists co-exist, conflicts always arise from grazing on farmland, with destruction of water infrastructure.
- Crop enterprise choice is critical to ensure returns on investment from different WUTs. For increased adoption, WUTs should be bundled with other technologies such as improved seeds, fertilizer use, and appropriate crop choice to ensure that farmers realize higher productivity and profitability.
- Promotion of WUTs should not be gender-blind but rather ensure participation of women and youth in training and implementation of WUTs. Insecure land tenure especially among women limits their adoption of the technologies.

- Strengthening local water governance institutions such as Water User Associations (WUAs) are important for sustainable scaling of WUTs.

4.0 Institutions for water use technologies

The main institutions involved in agricultural water management are:

- The Ministry for Water (MW), created in 2008 from the former Division of Irrigation and Technical Services of the Ministry of Agriculture. The Ministry of water is responsible for the development and management of water resources, the preparation of integrated water resources management plans, the planning and designing of dams and the promotion of rational allocation of water with formal water use permits. These tasks are through the implementation of the National Irrigation Policy in collaboration with the Ministry of Agriculture. The ministry also provides technical services through the Zonal Irrigation Units (ZIUs) working with the regional administration and the local governments, as well as promotes integrated water resources management in the basins with the Basin Water Offices (BWOs). The Water Development and Management Institute (WDMI), is the MW entity responsible for research on water management.
- Ministry for Agriculture, Food Security and Cooperatives (MAFSC) implements the National Irrigation Policy from crop production and productivity perspective, in particular through its:
    - Ministry of Agriculture Training Institutes (MATIs) and
    - Ministry of Agriculture Research Institutes (MARIs).
- The National Environmental Management Council (NEMC) is the advisory body to the Government on environmental matters.
- The National Water Board, established in 2012, advises MW on multi-sectoral coordination, integrated water resources planning and management as well as resolution of national and international water conflicts.

Linkages between relevant institutions are weak and their respective roles and responsibilities are not clearly defined. Other constraints to irrigation development include the lack of staff and limited data on the sector (MWI, 2009).

In relation to water and sanitation, two public sector institutions are officially responsible in Dar es Salaam: the Dar es Salaam Water and Sewerage Authority (DAWASA) owns the water supply infrastructure and the Dar es Salaam Water and Sewerage Corporation (DAWASCO) manages the water supply practically (UNDP, 2011). The Energy and Water Utilities Regulatory Authority (EWURA) is in charge of the technical and economic regulation of the water sectors, as well as the electricity, petroleum and natural gas sectors.

5.0 Financing water use technologies

Irrigation development is constrained by low level of government funding for both irrigation and water storage infrastructure and low rate of private investments due to insecure land ownership rights (MWI, 2009). As a result, irrigation development, together with sustainable water resources and land use management, was set as priority investment in the Tanzania Agriculture and Food Security Investment

Plan for 2011 to 2021 (TAFSIP 2011) and two funds–the District Irrigation Development Fund (DIDF) and the National Irrigation Development Fund (NIDF)–were established (MAFSC, 2014).

The cost of irrigation infrastructure varies across the irrigation schemes and can be as high as US$18 500/ha for example for a 10 ha new Igingilanyi irrigation scheme in Iringa, which uses groundwater. Unit cost of investment of new irrigation scheme and rehabilitation in Tanzania is lower than the equivalent cost in Sub-Saharan Africa (MAFSC, 2013)

6.0 Conclusion and recommendations

Literature by Kahimba et al., (2015) identified the lack of emphasis on the use of efficient WUTs, calling for the need to review the policy to include objectives to promote efficient water use technologies, and harmonization of policy statements related to natural resources use and management to avoid land and water resources conflicts. In addition, environmental related policies are not specific on issues related to water use technologies. The National irrigation policy was also observed to put more emphasis on increased crop production and productivity.

Factors influencing adoption of land and water technologies by smallholder farmers are influenced by the type of technology and demographic characteristics of the farmers themselves e.g. family wealthy status, gender, land ownership, level of education (URT, 2013b). They also depend on to what extent a smallholder farmer is able to take risks. Key factors identified in this review include: technological complexity of the technology (farmers prefer technology that are less complex and easier to use), preference for less labor intensive technology, required capital, land ownership (less adoption in new technology on hired/leased land), approach of introducing the technology (preference of participatory bottom up approach), and motivation and the involvement of farmers from conceptualization to implementation.

Horizontal and vertical scaling of the WUTs depends on factors such as facilitation of registration of WUAs and empowering them; implementing projects based on actual ground conditions for ease of adoption by communities; and involvement of the local government.

Measures to improve land and water productivity may include:

- Making more rainwater available to crops when most needed (capture water -rainwater harvesting, soil and water conservation-, and using it -deficit irrigation; supplementary irrigation etc.);
- on-farm water management to minimize water losses by evaporation;
- use of improved crop varieties;
- use of improved cropping systems and agronomics, such as conservation tillage;
- development of financial frameworks to provide incentives for the adoption of best practices and new technology;
- use of low quality water in non-conventional (not for direct human consumption) applications such as forestry;

- Evaluation of rainfall patterns to determine quantity and quality available for agriculture use and rethinking crop scheduling.

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