Innovation Lab for Small-Scale Irrigation: Tanzania

Discussion Paper

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Promising small-scale irrigation and fodder interventions in Tanzania

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EXECUTIVE SUMMARY

Tanzania has vast underdeveloped land and water resources. It is estimated that the country has irrigation potential of 1 million ha, of which only 20% is under irrigation. There is a strong need to exploit that potential due to the inherent threats associated with increased population, climate variability and change in the country. Smallholder farming system dominates the agricultural sector in Tanzania (82%), with most of the smallholder irrigation schemes (SSI) performing poorly due to both management and technical challenges. However, there is a huge potential for smallholder irrigation technologies to address some of these inherent challenges and hence the need to identify and suggest promising technologies that can increase the performance of SSI - in both technical and socio-economic fronts.

The Innovation Lab on Small-Scale Irrigation (ILSSI) project is being implemented in Ethiopia, Ghana and Tanzania with several aims, including increasing food production of smallholder farmers and improving nutrition. This study was commissioned by the project to review previous experiences and lessons from research projects with the view to identify key research issues in small-scale irrigation, and to suggest promising small-scale irrigation interventions in Tanzania. This desk-top study entailed mainly the review of relevant national policies and programmes related to irrigation together with the general development trends in irrigation including research. Also, this study highlighted and proposed potential research themes in small-scale irrigation (SSI). This paper also includes a section on lessons and research opportunities in irrigated fodder.

The policy review identifies three areas for further studies including (1) traditional water rights, water pricing and catchment conservation; (2) review of conflicting policies such as the National Water Policy and the National Land Policy; and (3) institutional arrangements due to transformation following initiatives and programmes such as *Kilimo Kwanza* (Agriculture First), Big Results Now (BRN), and the Southern Agricultural Growth Corridor of Tanzania (SAGCOT).

The review of irrigation development in Tanzania highlighted various processes and challenges including the privatization of large scale farms, introduction of value chain approach in rice, maize and sugar-cane and introduction of agricultural clusters especially in the SAGCOT zone, and limited efforts by the government in addressing irrigation technologies for vegetables and fruit production. These changes and the upcoming cash crops such as vegetable production require substantial studies to be undertaken in order to direct future policies and programmes.

Various irrigation researches have been conducted in Tanzania in the past 15 years. However, most of them were uncoordinated, though they focused on increasing water use efficiency. Recently, there have been efforts towards establishing coordinated irrigation research under the Ministry of Agriculture, Food Security and Cooperatives. The Ministry has now developed a 15-year irrigation research plan and is also in the process of establishing National Irrigation Research and Training Centre.

After the review of policies and programmes, past irrigation developments, and past and current irrigation research, this study recommends two main themes for research. These include: (1) technologies for improved productivity and sustainable water management, and (2) strengthened policies and institutional framework. Under the technologies for improved productivity and sustainable water management, it proposes seven sub-themes:(a) evaluation and improvement in water productivity of irrigation water, (b) mechanical and drip irrigation systems for high value crops, (c) evaluation and improvement of utilization and efficiency of irrigation water, (d) water application technologies, (e) land management practices for controlling rainfall runoff and soil erosion, (f) managing rainwater for plant growth and environmental conservation, and (g) assessment on the use of groundwater for irrigation. The sub-themes on policies and institutional framework include: (a) tools for sustainable management and utilization of water resources, (b) assessment of policies and institutional dynamics in irrigation and water resources management, and (c) research in irrigation value chain development.

1. INTRODUCTION

1.1.Background

Agriculture in Tanzania continues to be the largest sector in the economy and hence its performance has a significant effect on the people's income and poverty levels. Agricultural production accounts for more than 50% of GDP, with its output largely dependent on smallholder production. Sale of agricultural produce accounts for about 70 percent of rural household incomes (URT, 2001). In Tanzania, about 17 million people live below the poverty line of US$ 0.65 per day. Approximately 80% of the poor live in rural areas where about 70% of the population live and earn their living (URT, 2001).

Tanzania covers an area of 94.5 million ha of which 44 million ha are classified as suitable for agriculture and 23% (10.1 million ha) is cultivated. It has substantial water resources and an irrigation potential of 1 million ha, of which 20% (200,000 ha) is under irrigation (URT, 2004). The main goal of irrigation development in Tanzania is to ensure that the nation attains reliable and sustainable agricultural production in order to ensure food security and poverty reduction (URT, 2009a).

The Innovation Lab on Small- Scale Irrigation (ILSSI) is a cooperative research project being implemented through the United States Agency for International Development (USAID) through the Feed the Future (FtF) program. The project is being implemented in Ethiopia, Ghana, and Tanzania. The project aims to increase food production, improve nutrition, accelerate economic development and contribute to the protection of the environment through a partnership and engagement approach to ensure continual learning; responsiveness to local needs, demands, and realities; complementarities with national goals and initiatives; and the uptake of outputs and recommendations by farmers, researchers, policy makers and investors. The project seeks the desired development and environmental objectives by identifying, testing and demonstrating technological options and promoting dialogue among stakeholder communities and policy makers.

The research consortium led by Texas A&M University comprises of the International Water Management Institute (IWMI), the International Livestock Research Institute (ILRI), the

International Food Policy Research Institute (IFPRI), North Carolina A & T State University, and is collaborating with national partners in each of the three countries.

1.2. Problem statement and justification

Tanzania has vast undeveloped land resources. Various estimates have indicated that the country has a potential total arable area of about 44 million hectares. Of this total figure, only some 6.3 million hectares are currently under crop production, and the remaining 3.8 million is under other uses such as grazing. Out of the 6.3 million hectares, 82% (5.2 million hectares) is being cultivated by smallholder farmers. The balance (18%) is farmed by parastatals and private sector concerns.

Irrigation in Tanzania has been taking place through traditional irrigation schemes, some of which are many hundreds of years old. Although such schemes have worked well for countless generations, they are now inadequate due to: (i) increase in population, (ii) continual deterioration, and (iii) catchment degradation and other environmental problems such as waterlogging and salinity. The traditional schemes have therefore become increasingly inadequate in recent decades. The response to the increasing shortcomings of the irrigation schemes from the colonial times until recently has largely been to construct expensive new schemes for the smallholder, parastatal and private sectors. The great majority of these schemes have failed with the exception of those serving the private sector. This approach has also resulted in gross distortion in the financing of the sector.

Regardless, irrigation in Tanzania is still very important as it helps in achieving the following primary objectives: (i) satisfying subsistence requirements in many parts of the country - increased food security at household level; (ii) generating local surpluses of main staples, particularly rice in order to achieve food security in the country; and (iii) ensuring production of much need dietary supplements such as vegetables, fruits and pulses.

Other challenges were identified in the National Irrigation Master Plan (NIMP) (URT, 2002b) and the NIMP proposed an irrigation development programme that included smallholder schemes that were to be implemented by 2017.According to URT (2002b), the problems identified by the NIMP included the following:

Lack of appropriate participatory approaches

Unsound logical structure of projects and weak linkage between purpose and output of projects

Misunderstanding of the concept of “simple and low-cost technology”, taken to mean “easy and no concern of technical know-how and understanding”

While efforts have been made towards addressing the problems and issues noted above, challenges still exist.

1.3. Objectives

The main objective of the ILSSI project is to identify, test and demonstrate technological options in small-scale irrigation and promote dialogue among stakeholders. Specifically, the project aims to:

- Identify promising small-scale irrigation technologies,
- Demonstrate and assess feasibility of solutions,
- Develop context specific technological and strategic recommendations, and
- Train agricultural development students and professionals.

The project builds on knowledge and experiences gained from earlier interventions, including the recent Agricultural Water Management Solutions project. For details, the link below can be followed: [*http://awm-solutions.iwmi.org/the-ag-water-solutions-project.aspx*]. Therefore, the main objective of this paper is to review previous experiences and lessons from research, identify key research issues in small-scale irrigation, and suggest promising small-scale irrigation interventions in Tanzania.

1.4. USAID Feed the Future in Tanzania

Low-yields, inadequate storage processes and facilities, limited transportation infrastructure, and difficulty accessing credit and markets are among problems that

smallholder farmers experience across much of Tanzania. These contribute to persistently high poverty across the majority of peasant farmers.

Feed The Future (FtF) is the U.S. Government's global hunger and food security initiative, which focuses on specific countries in Africa, Asia and Latin America. The FtF Initiative aims at lifting 18 million vulnerable women, children and family members – mostly smallholder farmers – out of hunger and poverty. In Tanzania, through the USAID, FtF assistance supports national strategies to reduce poverty and accelerate progress in achieving the Millennium Development Goals (MDGs) by increasing agricultural productivity and profitability, and enhancing national and regional food security. The Feed the Future targets related to smallholder farming for Tanzania include the following:

Improve food security to over 200,000 households, thus directly benefiting 1 million vulnerable populations including women and children,

Reduce the poverty rate from 38% to 32% in the target area by 2015,

Increase yields of target crops by at least 50% (rice from 2 to 4tons/ha, maize from 1.5 to 2.5 tons/ha),

Increase area under irrigation in Tanzania by 15.5%, which will add 306,000 ha to 353,000 ha through development of seven smallholder irrigation schemes in Morogoro and Zanzibar.

2. REVIEW OF RELEVANT NATIONAL POLICIES AND PROGRAMMES

2.1. Policies

This section reviews policies, legal, and institutional frameworks related to smallholder irrigation. Irrigation water management plays a major role in ensuring that government implements plans and programmes of actions on smallholder irrigation for the well-being of smallholder farmers and the nation as a whole.

The main questions that this review addresses include: What are the macro-policies that influence smallholder irrigation in the country? What are the micro-irrigation water

management related policy objectives, delivery mechanisms and enforcements affecting the performance and sustainability of irrigation for smallholder farmers?

2.1.1. The National Agricultural Policy (1983)

The National Agricultural Policy of 1983 emphasized attainment of economic development through improved performance of the agriculture sector. The general macro-economic environment was that of state-led economy. The policy underscored the need for increased public investment in agriculture that was declining over years following the economic downturn of the 1970s. In this policy irrigation was addressed in a narrow sense (URT, 1983). Moreover, where traditional irrigation was considered it was still envisaged in the utilization of water flows in rivers and streams (IMAWESA, 2007). One of the policy objectives was '*to systematically develop irrigation to relieve the sector of great dependency on an unreliable rain-fed system and increase the utility of the rural population by working smoothly throughout the year*' (p. 97 section 2.4.278).

The policy statements that appeared to be biased towards public investment and technology transfer towards conventional irrigation include: *'...production should be enhanced through research, extension and irrigation*' (pp. 116, section 2.5.299-a); *'... irrigation infrastructure is costly and its usefulness must be permanent. In order to ensure that permanent source of water, courses and river catchment areas maintain continuous flow of water required for irrigation, a programme of protection and erosion control for river catchment areas should be instituted and maintained*' (pp. 129, section 2.5.319-d).

2.1.2. The National Land Policy (1995)

The 1995 Land Policy is aimed at promoting and ensuring a secure land tenure system, and encouraging optimal use of land resources for economic development without affecting the environment. Water and land are critical inputs in agricultural production. The land policy of 1995 formed the basis for two new land laws that were enacted in 1999 (URT, 1997a). The Land Act number 4 of 1999 covers land in general and the Land Act number 5 of 1999 addresses land that falls within village boundaries.

The land policy recognizes the dual tenure system crafted on customary and statutory rights of occupancy, which are regarded equal in law. As a result, traditional water rights can only persist when land is held under customary tenure. In registered land, however, the water policy overrules the land policy, and emphasizes that "…*water allocation system shall distinguish and separate water use permit from land title'* (Water Policy, pp. 22, section 3.3). With regard to agricultural land, the policy states that *'Agricultural land will be identified, set aside for agricultural use and protected against encroachment by pastoralists'* (pp. 35, section 7.2.1-iii).

2.1.3. Agricultural and Livestock Policy (1997)

The policy was developed to merge and consolidate into one document the Agricultural and Livestock policies of 1983. The main goal was to improve the wellbeing of smallholder and livestock keepers, who do not produce surplus. Specific objectives related to irrigation were to promote integrated and sustainable use and management of natural resources such as land, soil, water and vegetation in order to conserve the environment; to develop and introduce new technologies which increase the productivity of labour and land; and to develop and introduce new technologies which increase the productivity of labour and land.

The policy's drive to advance irrigation is evident in the following statements: *'...the government will focus its support on the development of smallholder irrigation schemes in areas of high potential and sufficient demand for irrigation facilities and will encourage the private sector to provide the necessary services in respect to pre-investment studies, scheme design, construction and management of 'large scale' schemes using their own resources'* (pp. 23, section 3.3.1-E 1-i).

Key policy statements related to irrigation include: improvement of traditional irrigation; development of irrigation systems; introduction of mechanisms to improve water use efficiency in irrigation; strengthening of research, extension and small scale irrigation; and the Government to provide assistance at the planning and designing of smallholder irrigation schemes and supervision of construction (URT, 1997b).

2.1.4. The National Environmental Policy (1997)

The National Environmental Policy was driven, among other things, by the Rio Declaration and the need for mainstreaming environmental issues in decision-making. Prior to this policy, environmental issues were incoherently addressed under different sectoral policies (IMAWESA, 2007).

The policy does not specify issues related to smallholder irrigation. However, policy statements related to agriculture in general include: to ensure food security and eradication of rural poverty through the promotion of production systems, technologies and practices that are environmentally sound (URT, 1997c). Specifically, the policy emphasizes "*Improvement in water use efficiency in irrigation, including control of water logging and salinization*" (pp. 19, section 46-g).

2.1.5. The National Water Policy (NAWAPO, 2002)

The National Water Policy (NAWAPO) was enacted to guide water management and governance. Access to water for agriculture and food security through increased agricultural production is underscored in the policy. The policy states that *'... water for food security, energy production and other economic activities is readily available'* (pp. 20, section 3.1-e).

The policy cuts across a wide range of ecosystem services that need water. In some cases, the policy views dry season irrigation as a threat to ecosystems and wildlife due to drying up the rivers during the dry season. Smallholder surface irrigation schemes in particular are viewed to have low irrigation efficiency, with water losses of up to 15%. In 2002, about 150,000 hectares of land was under irrigation; 80% percent of the irrigated area was under traditional irrigation schemes with low irrigation efficiencies.

The water policy views irrigation as a higher consumer of water and the main competitor of water use with other users, hence irrigation development has great impact on availability of water for other sectors since it competes for the same source of water with other sectors. Agricultural activities are also viewed to contribute to pollution of water sources from the use of agrochemicals.

Nevertheless, the policy emphasizes sustainable groundwater resources development for irrigation among other uses, and to have sustainable plans and development of water resources for large irrigation schemes (URT, 2002a).

The policy also underpins water use permits and pricing, and formulation of water users associations (WUAs) as water governance instruments for efficient management of the water sources. This however, may affect the traditional water access rights. The policy states the need for all water abstractions and effluent discharges into water bodies to be subjected to a "water use permit" or "discharge permit", which will be issued for a specific duration (URT, 2002a). The policy however, did not have direct special emphasis on smallholder farmers and promotion of small-scale irrigation.

2.1.6. The National Irrigation Policy (URT, 2009)

The National Irrigation Policy (NIP) was formulated in 2009 to direct development in the irrigation sector, whereby prior to the enactment of this policy, irrigation matters were being directed through other sector policies that constrained growth. The main goal of the policy is to ensure 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 in Tanzania (URT, 2009a).

Specific goals related to smallholder irrigation include: accelerate investment in the irrigation sector by both public and private sector players; promote efficient water use in irrigation systems; ensure that irrigation development is technically feasible, economically viable, socially desirable and environmentally sustainable; ensure reliable water for irrigation so as to facilitate optimisation, intensification and diversification of irrigated crop production to supplement rainfed crop production effectively; and empower beneficiaries for effective participation at all levels in irrigation planning, implementation, operation and management. The policy recognises the presence of traditional schemes, rehabilitated or upgraded schemes, and new smallholder investment schemes.

The Policy also defines smallholder farmers as farmers owning/allocated a plot of up to 5 ha for irrigation of crops within an irrigation scheme. Small Scale Irrigation Schemes are

defined as schemes with an area of up to 500 ha; Medium Scale Irrigation Schemes are schemes having area between 500 ha and 2000 ha; and Large Scale Irrigation Schemes are schemes with areas of over 2000 ha (URT, 2009a).

The policy outlines that since the 1950's there have been several government efforts to support smallholder traditional irrigators. For example, Regional Agricultural Development Officers (RADOs) were sent to the regions to support smallholder traditional irrigators in 1968. In the 1980's there was a program for full rehabilitation of smallholder traditional irrigation schemes (URT, 2009a).

The policy also emphasises improving irrigation schemes that originally were initiated and operated by smallholder farmers through interventions such as construction of new diversion structures, lining main canals, gated canal intake, water division boxes, and other farm related structures (URT, 2009a).

Key policy statements related to smallholder irrigation are: "*continue to support the improvement of traditional irrigation schemes infrastructures and software; train farmers on irrigation techniques covering water management and support district staff to ensure improved agronomic practices; to support a mechanism to identify potential irrigation investments, especially those that could attract private sector investors and/or progressive smallholder farmers; provide technical facilitation for farmers to form Irrigators organisations (IOs) for management of their irrigation schemes; continue to encourage nucleus estate/out-grower or contract farming modalities; and assist in the mobilisation, training and organisation of smallholder farmers for new irrigation schemes*".

2.2. Legal and institutional frameworks

2.2.1. Irrigation activities

The National Irrigation Act was enacted in 2013 and resulted in the establishment of the National Irrigation Commission to provide for the development, operation and maintenance of irrigation and drainage systems; to provide for effective implementation of the National Irrigation Policy, the National Irrigation Development Strategy, and other related matters

(URT, 2013). The Act is expected to pave way for the country to use the available land resources for the sustainable development of irrigation.

With regard to small-scale irrigation, the Act recognises small scale irrigation schemes as one of the categories of irrigation schemes. With regard to responsibility of operation and maintenance of schemes, the Act states that "*for small scale irrigation schemes, the owners of the lands benefited by the irrigation system shall be solely responsible for the operation and maintenance unless otherwise specified*" (Cap 41.1(a))

Institutional frameworks are the policy and regulatory elements consisting of different organisational structures that are in place to develop and manage irrigation systems in a sustainable manner. In the National Irrigation Act (2013), all irrigation development matters will be handled by the National Irrigation Commission. The commission is mandated by law to spearhead the development, operation and maintenance of irrigation and drainage systems; and to provide for effective implementation the National Irrigation Policy, and the National Irrigation Development Strategy.

The National Irrigation Commission will be the regulatory authority responsible for all matters related to irrigation development. While this Commission will be responsible for promoting irrigation development in the country, it still needs to collaborate with other regulatory authorities to ensure that its mission is accomplished. Key authorities are the National Water Board and Basin Water Boards that are mandated to regulate all water users and provide permits for water uses and effluent discharges within each basin.

Under the Commission, the country is distributed into Zonal Irrigation and Technical Services Units (ZITSU), led by the Zonal Irrigation Engineer (ZIE). Currently, the zones follow administrative regional zones. However, owing to the overlap of watersheds among different regions there is a plan to reclassify the ZITSU to follow basins similar to the Basin Water Offices. When implementing irrigation projects, the ZITSU works directly with local-government at district level through District Agricultural, Irrigation and Community Development Officers. The ZITSU is responsible for promotion of both small-scale and large-

scale irrigation schemes and also assists smallholder farmers in the formulation of Irrigators Organizations (IOs).

According to the Policy, Irrigators Organisations (IOs) accommodate the joint interests and activities of all the farmers on an irrigation scheme primarily for ensuring increased crop productivity through optimal management of irrigation water and the operation and maintenance of their scheme (URT 2009a). On the other hand, Water Users Associations (WUAs) are defined as organisations joining water users in the use of a common source of water. They can be comprised of different water users such as irrigators, miners, livestock keepers, fisheries, hydropower producers, wildlife institutions, domestic and industries (URT 2009a).

2.2.2. Water Resources Management

The Water Resources Management Act (2009) was enacted to provide an institutional and legal framework for sustainable management and development of water sources. It resulted in the establishment of the National Water Board and the Basin Water Board responsible for managing the water resources in the country. The Act also aimed to outline principles for water resources management, pollution controls, and outlined the participatory approach in implementing the National Water Policy.

With regard to small-scale irrigation, the Act outlines the need for the community to form water users associations (WUAs) and apply for water use permits to legalize their water use for irrigation. The Act recognises customary water rights and sets procedures for formalizing them.

Tanzania already adopted a River Basin Management Approach for water resource management and administration. The country is legislatively divided into nine basins through Act No.10 of 1981, which was an amendment of the Principal Act No. 42 of 1974. The Basin Water Office is declared to be the body responsible for water administration. The Basin Water Offices have mandates to: (a) enforce and follow-up on existing legislation, regulations and operating rules governing water use and control of pollution, (b) become the legal authority to collect the various water use charges, (c) facilitate the establishment

of lower level water management organizations which will bring together users and stakeholders of the same source, and (d) become centres for conflict resolution in water allocation, water use and pollution (IMAWESA, 2007).

At village level, each village has a village assembly of all adults, which elects 25 representatives to form the Village Council. The Village Council operates through four mandatory committees, which are vested with responsibilities for handling daily affairs of the village: the Finance, Economic & Planning Committee; the Social Services and Self-reliance Committee; the Water Resources and Environment Committee, and; the Law and Order Committee (Sokile et al., 2005). The village Water Resources and Environment Committee is responsible for supervising the establishment of IOs within the village. Once established, the IOs are normally registered by the District Cooperatives office. On the other hand, WUAs, which encompass multiple water users, are normally established under guidance of the Basin Water Office, and thereafter the WUAs are registered by the Ministry of Home Affairs.

2.2.3. Land Resources

The Land Act No. 4 (1999) was enacted to translate and implement the National Land Policy (NLP) of 1995. In the Act, the Commissioner for Land and the National Land Advisory Council are mandated to administer the land in the country. There are no specific captions in the Land Act that are directly linked to irrigation in particular. Nevertheless, the Act has considered a specified land area (up to 5 ha) necessary for a smallholder farmer to feed himself and his family (Cap 41(7)). The Land Act and its 2004 amendment Act No. 2 safeguards gender rights land transfer and mortgaging arrangements.

The Village Land Act No 5. (1999) was enacted to provide for the management and administration of land in villages, and for related matters. The Act intended to cover customary law through which security of customary tenure would be assured by issuance of a customary land certificate, thereby giving equal status to both granted and deemed rights of occupancy. However, this act also does not have any special emphasis on irrigation, though it stresses proper use of agricultural land acquired under customary laws for

farming, in accordance with the practice of good land husbandry customarily used in the area (Cap 29(2)(ii)).

The National Land Use Planning Commission Act (1985) created the National Land Use Planning Commission (NLUPC) mandated to prepare regional physical land use plans, formulate land use policies for implementation by the government and to specify standards, norms and criteria for protection of beneficial uses and maintenance of the quality of land. The Commission is responsible for all regulatory matters related to land resources development and uses.

The key aspects that tend to dominate the land legislations are basically those related to tenure and gender relations. Access to irrigation water is subject to access to land. Land tenure defines the rights a person has on land ownership. Both the land policy and the land laws sought to improve the ownership rights of women under statutory law. The same policy and laws also recognizes ownership and administration of land under customary law, which is most dominant in rural areas and in some tribes where laws do not work in favour of women; especially in as far as ownership and transfer rights are concerned (van Koppen et al., 2004; URT, 1999).

The recent land laws protect access rights to land under both customary and statutory laws, to women and other disadvantaged groups, such as youths and people with disability (section 20 subsection (2) of Village Land Act No. 5 of 1999).

2.2.4. Environmental Management

The Environmental Management Act of 2004, which came into play seven years after the Environmental Policy of 1997 for enforcement, is the main legislation. It provides the legal and institutional framework for the sustainable management of the environment in mainland Tanzania. It includes compliance and incentive mechanisms for environmental management at all levels of governance, from the national level to the local government level, involving district and village representatives in the management of environmental resources and enforcement of the law (URT, 2004d).

A few provisions apply to irrigation water management, stressing the need for irrigation projects to undergo environmental impact assessment (EIA) and ensure that development projects do not cause major changes in water use for irrigation. Small-scale activities related to smallholder farmers that may not require EIA include rainwater harvesting and urban agriculture.

The National Environmental Management Council (NEMC) is another regulatory body dealing with environmental management. The primary function of the Council as stipulated in both section 4 of the Act No.1983 and the Environmental Management Act of 2004, is to advise the Government of Tanzania on all matters relating to the environment, in particular, formulation and implementation of environmental management. Hence, all major irrigation infrastructure developments are required by the Act to undergo an EIA and get certification from NEMC. The NEMC works through the regional secretariat and the local government authorities, which ensure participation of local organs. The Village Environmental Management Committees of each village are responsible for the proper management of the environment (IMAWESA, 2007).

2.3.Strategies and Plans

2.3.1. Agricultural Sector Development Strategy (ASDS 2001)

The Agricultural Sector Development Strategy (ASDS) provides the framework for achieving objectives and targets of the agriculture sector in Tanzania. Its main aim is to create an enabling and conducive environment for improving sectoral profitability thereby improving farm incomes and reducing rural poverty (URT, 2001). The strategy is set to implement agricultural related policies and programmes such as the Agricultural Sector Development Programme (ASDP) of 2006. The emphasis is given to land and water resources utilization and management as an impetus to increased agricultural productivity. The strategy states the policy commitment to enhance efficiency of water utilization through promotion of better management practices with emphasis on soil water conservation, water harvesting with storage, irrigation and drainage.

Priority issues related to smallholder agriculture include strengthening the institutional framework at all levels for managing agricultural development; and involvement of the

public and private sector in improving support services such as extension, training, information and finance services (Cap 3.10 a-f). The strategy also emphasizes surveying and demarcating agricultural investment zones. Some of the key policy issues addressed by the strategy include provision of adequate extension services to smallholder farmers by the Local Government Authorities to enter into partnership and cost-sharing arrangements with out-growers and contract schemes for the benefit of smallholder farmers (Section 6.2 and 7.7)

2.3.2. The "Kilimo Kwanza"

"*Kilimo Kwanza*" (agriculture first) is a national resolve to accelerate agricultural transformation. It is comprised of policy instruments and strategic interventions aimed at addressing the various sectoral challenges and taking advantage of the numerous opportunities to modernize and commercialize agriculture in Tanzania.

The *Kilimo Kwanza* strategy was launched in 2009 to engage the private sector to participate actively in agricultural production, provision of agricultural inputs, crop marketing and the agricultural value chain. It aimed at speeding up the existing strategies and programmes regarding the modernization of agriculture. Its goal was to uplift agricultural growth from the current 4% to 10% within the timeframe of the Tanzania Development Vision or earlier, by addressing and resolving key challenges hampering agriculture development.

The public-private partnership under *Kilimo Kwanza* strategy mobilizes private-sector action to achieve Tanzania's goals for sustainable agricultural growth. This is to be achieved through developing sustainable and commercially viable growth in the Southern Agricultural Growth Corridor region (SAGCOT) in Tanzania, with a specific focus on opportunities for smallholder farmers. The created opportunities and prioritized engagement of smallholder farmers and local communities, especially women, are expected to assist in achieving sustainable economic development and poverty alleviation.

2.3.3. The Big Results Now (BRN)

Big Results Now (BRN) is a government initiative aiming at adopting new methods of working under specified timeframe for delivery of the step-change required. Agriculture is

one of the six priority areas of the economy targeted under BRN. It is a public-private partnership well-placed to achieve the objectives of *Kilimo Kwanza*. Seventy eight existing smallholder rice irrigation schemes will be impacted under the new model, with 70,000 smallholder farmers and over 60,000ha of irrigated land. The smallholder model for rice aims to increase production, productivity and marketing for smallholder rice farmers in irrigation schemes.

2.3.4. Southern Agricultural Growth Corridor of Tanzania (SAGCOT)

The Southern Agricultural Growth Corridor of Tanzania (SAGCOT) is an international public-private partnership aiming to transform agricultural productivity in Tanzania. It was launched at the World Economic Forum on Africa in May 2010 in Dar es Salaam, Tanzania.

The SAGCOT initiative was built on the *Kilimo Kwanza* Strategy. Through this initiative, it is expected that by 2030 approximately 350,000 hectares will be brought into profitable production. Most of this land is farmed by smallholder farmers, and with a significant area under irrigation.

One of SAGCOT's main objectives is to provide opportunities for smallholder producers to engage in profitable agriculture. This will be achieved through provision of incentives in creating stronger linkages between smallholders and commercial agribusinesses that allow smallholders in the vicinity of large-scale farms to access inputs, extension services, value-adding facilities and markets. SAGCOT will also support smallholder producer associations, helping them enter into equitable commercial relationships with agri-processing and marketing businesses. In many cases, irrigation will be made available through professionally-managed farm blocks.

2.3.5. National Irrigation Development Plan (NIDP)

The National Irrigation Development Plan (NIDP) comprises a management and decision-making framework based on comprehensive ranking of schemes within each sectoral management unit (river or drainage basin). The plan's main objective is to remove the remaining constraints on the sector through various programmes such as institutional reform, private sector strengthening, cost sharing and recovery, research, data,

development of operation and maintenance of schemes, undertaking detailed irrigation master planning studies, and implementation of the schemes along the major river basins.

Some of the key Policy Statements on small-scale irrigation addressed by the plan are:

a. The Government will provide information on the issuing of water rights, regulation and monitoring of natural resources exploitation.
b. Government support in the development of smallholder irrigation schemes in areas of high potential and sufficient demand for irrigation facilities.
c. Government assistance in planning and designing of smallholder irrigation schemes and supervision of construction. Actual construction work will be contracted to private entrepreneurs.
a. The Government will give consideration to land conservation and environmental aspects as well as the needs of disadvantaged groups, to gain access to good and services, land resources and credit.
b. The Government will encourage the farmers to form Water Users Associations and Irrigation Cooperatives for management of their schemes as a step towards commercialisation and participation in the market economy.

2.4.Programmes and Projects

2.4.1. River Basin Management and Smallholder Irrigation Improvement Project (1990-96/97)

The River Basin Management and Smallholder Irrigation Improvement Project (RBMSIIP) aimed at: (i) strengthening the Government's capacity to manage water resources and address water related environmental concerns both at the national level, and in the Rufiji and Pangani River Basins; and (ii) improving irrigation efficiency of select smallholder traditional irrigation schemes in the two basins. The project interventions for improving traditional irrigation schemes involved improvement of management capacities and upgrading the infrastructure in the two basins (IMAWESA, 2007).

While the project succeeded at training farmers and water user associations on water management, farmers had a general institutional concern. Some farmers perceived that basin management was meant to deprive them of exercising their customary rights of using

water for irrigation. They also viewed themselves as losers in the trade-off of their traditional water right for hydropower since electricity is primarily provided for urban domestic and industrial use (IMAWESA, 2007).

2.4.2. Traditional Irrigation and Environmental Development Organization (1997/98-2005)

The Traditional Irrigation Improvement and Development Organization (TIP), provides services to farmers through water user groups to achieve improvement of traditional and smallholder irrigation based on sustainable use of land and water resources. Its main focus is to improve agricultural productivity through improved traditional irrigation, land use management and irrigation efficiency with a gender perspective to contribute to poverty alleviation and food security (TIP, 2005).

2.4.3. Participatory Agricultural Development and Empowerment Project (1997/98-2005)

The Participatory Agricultural Development and Empowerment Project (PADEP) was a five-year intervention (2003/2004 – 2007/2008) for enhancing agricultural development through promotion and adoption of improved technologies, and fostering active participation of the private sector in input and output marketing. It was a country-wide project that targeted about 840 villages with 30 villages per district covering half a million farming households. The project adopted a decentralised approach forging partnerships between the district councils, rural communities and private sector in planning and execution of demand-driven agricultural development activities.

Expected key achievements related to smallholder farmers were empowering self-selected rural communities and farmers' groups to make decisions regarding choice of sustainable and remunerative productive technology, partially financing maintenance and/or construction of roads bridges and other small subprojects to improve access to markets, and sharing of costs by the public sector and participants thus sharing the risk of adoption of improved technologies.

2.4.4. National Irrigation Master Plan (NIMP, 2002)

The National Irrigation Master Plan (NIMP) of 2002 is a development strategy tool for identifying, itemising and initiating irrigation sub-sector development, with special emphasis on promoting an integrated and sustainable planning approach for irrigated agricultural needs of the country.

The main objective of the NIMP is to promote a sustainable approach to irrigated agricultural development through policy revision, irrigation development strategies, prioritizing irrigation projects to the year 2015, increasing farmer participation in irrigation, and making the National Irrigation Commission more self-sustainable.

Through the Master Plan, over 125 projects including small-scale irrigation projects have been identified and evaluated. It is anticipated that implementation of the NIDP by 2015 should increase irrigated area by about 37,500 ha and directly benefit about 6,900 farm families.

2.4.5. Agricultural Sector Development Programme (ASDP), (2006-2015)

The Agricultural Sector Development Programme provided a framework and processes that were needed to implement the Agricultural Sector Development Strategy (ASDS). Key objectives of the ASDP were to: i) enable farmers to have better access to and use of agricultural knowledge, technologies, marketing systems and infrastructure to ensure higher productivity, profitability, and farm incomes; and ii) to promote private investment based on an improved regulatory and policy environment. The ASDP funding programme targeted multidisciplinary issues in the agriculture sector (URT, 2003a).

With regard to smallholder irrigation in Tanzania, the programme aimed at investing in small-scale irrigation where individual farmers or small groups irrigate homestead vegetable gardens of small to medium size (0.2 to 1.0 ha), using small-scale technologies, such as treadle pumps. Other irrigation investments that the programme targeted included: i) traditional irrigation schemes initiated and operated by farmers themselves using local skills and materials, with no intervention from external agencies, ii) water harvesting and flood recession schemes, on which subsistence farmers have introduced simple techniques to

artificially control the availability of water to crops, iii) formally planned and designed modern smallholder schemes, iv) improved traditional irrigation schemes, and v) new irrigation schemes.

Key recommendations from the ASDP final report were: i) the performance of farmer-managed irrigation schemes can be improved at field level through capacity building and empowerment of the farmers to enable them secure full ownership of the schemes, and ii) low-cost technologies that are appropriate, affordable and geared towards poor farmers' needs should be developed through research, development and adaptations (URT, 2004b).

2.4.6. Participatory Irrigation Development Programme (PIDP, 2007)

The PIDP was a six-year operation in Tanzania funded mainly by IFAD and other donors from 2000 to 2007. It was aimed at: (i) increasing the availability and reliability of water through improved low-cost systems of water control; (ii) raising agricultural productivity through better extension services; and (iii) building institutional capacity with the long-term vision of realizing the potential of smallholder irrigation development. The program was initiated as a follow-up of the Smallholder Development Project for Marginal Areas (SDPMA), which promoted spate irrigation for paddy production, particularly in the semi-arid central Tanzania (IFAD, 2007).

The PIDP outlines one of the key hindrances in identifying and improving smallholder irrigation schemes as lack of data (especially hydrological data); some of the schemes could not meet the community needs. Constructing small irrigation schemes in remote areas was also outlined as one of the challenges as private contractors were less interested in small projects located in remotely-located areas.

The purpose of the programme was to contribute to the delivery of ASDS in relation to improved smallholder irrigation schemes and water management systems. The programme had moderately successful impact in reducing rural poverty in the country through improving extension services, improving market access roads, and strengthening institutional capacity. Among the outcomes of the program were rehabilitation of irrigation schemes, improvement of agronomic practices, and increased water access by resource

poor farmers. As a result, the average production of paddy under spate irrigation increased from 1-2 tons per hectare to 3-4 tons per hectare (IMAWESA, 2007).

The programme recommended provision of institutional support to water users' associations and irrigation projects that target the rural poor while at the same time considering economic efficiency of the schemes.

2.5.Lessons from policies and programmes

The reviewed policies, policy instruments and programmes address irrigation and smallholder irrigation development in particular. Whereas NIP and its subsequent Act are all supportive of irrigation development in the country, NAWAPO has no direct emphasis on smallholder farmers or the promotion of small-scale irrigation. The introduction of 'water user permit' or 'discharge permit' by NAWAPO affected the traditional water access rights of smallholder farmers. Many smallholder farmers believe that water is a gift from God and they do not see any reason why they should pay for it. The effects of water pricing vis-a- vis catchment conservation by smallholder users is not well understood in many river basins. This is an area that warrants further studies in view of water scarcity and competition.

The review has also identified areas where some policies have conflicting statements. For example: the National Land Policy recognises the dual tenure system crafted on customary and statutory rights of occupancy. The clause allows for traditional water rights to persist when land is held under customary tenure. This contradicts with NAWAPO, which has a clause stating: *'water allocation shall distinguish and separate water use permit from land title'.* There is a need for policy harmonisation amongst all the sectoral policies and policy instruments. A study to identify and come up with a recommendation is required.

It is important to note that Tanzania's agriculture sector is under huge transformation with programmes such as *KILIMO KWANZA*, BRN, and SAGCOT. The sector has created linkages between small holder farmers and private investors, for example, Kilombero Plantation Limited (a PPP model) now has outgrowers. The institutional arrangements between the emerging production systems need to be investigated. Conflict management mechanisms also need to be designed and put in place. It is not yet well established if studies on the

emerging conflicts have been undertaken. However, research has been conducted on conflicts in the Pangani River Basin. (http://www.wilsoncenter.org/sites/default/files/Mbonile12.pdf), and in the Rufiji River Basin (Sokile et al.,2005). Recent more general conflicts in Tanzania have been highlighted by William **(**2011).

3. IRRIGATION DEVELOPMENT IN TANZANIA

3.1.Introduction

The use of irrigation in Tanzania dates back from the Iron Age. Traditional irrigation systems have long been of considerable importance in various parts of the country. Evidence of irrigation activities in Tanzania reported to have occurred several thousand years ago was found at the foot of the Rift Valley Escarpment in the northern part of the country. Some indigenous irrigation systems that are still operational in the mountainous areas in the northeast of the country are known to date back more than two hundred years. Other traditional irrigation systems from pre-colonial times are found in the central and southern highlands, but most schemes are comparatively recent and date back to the post-war colonial period. In 1930, modern irrigation was introduced in Tanganyika through the establishment of the Tanganyika Planting Company Ltd (TPC) at Arusha Chini, Kilimanjaro Region (URT, 2003c).

An inventory survey conducted by the River Basin Management and Smallholder Irrigation Improvement Project (RBMSIIP) in 1995 and completed under the National Irrigation Master Plan (NIMP), identified a total of 1,428 existing and potential irrigation schemes covering an area of 854,300 ha (Table 3.1) and Figure 3.1 (URT, 2003b). The inventory identified the following types of irrigation schemes: i) traditional irrigation, ii) water harvesting, iii) modern irrigation, and iv) improved traditional irrigation.

Table 3.1 Inventory of schemes by type of irrigation

Type of Irrigation	No. of Schemes	Existing Area (ha)	Estimated Total Area (ha)
Existing Schemes	1,189	191,900	670,400
Traditional Irrigation	982	122,600	518,700
Water Harvesting	42	7,900	27,600
Modern Irrigation	52	35,900	73,800
Improved Traditional Irrigation	113	25,500	50,300
Newly Proposed Schemes	239	-	183,900
Water Harvesting	163	-	123,100
Modern Irrigation	76	-	60,800
Total	1,428	191,900	854,300

Source: URT, 2002b

In spite of the past investments in irrigation there is still a great deal to be done to improve the sector. When the history of irrigation in Tanzania is examined, it can be seen that it has been characterised by good intentions and underinvestment. Compared with rainfed agriculture, the requirements seem to be very high. This is because irrigation investment is regarded to be expensive especially where head-works have to be constructed and the canals are lined. This ignores not only the scale of the direct benefits, but the significant indirect benefits that can be achieved in the surrounding communities where irrigation is practiced and the wider economy of the country.

3.2.Classification of Irrigation Schemes

In Tanzania, there is no formal classification of irrigation schemes, but the informal and accepted categorization that is currently used divides schemes into 3 categories: (i) small-scale irrigation (0–200 ha), (ii) medium-scale irrigation (200–500 ha), and (iii) large-scale irrigation (>500 ha).

According to Hatibu et al.,(2002), the terms 'large scale', 'medium scale' and 'small scale' are used without any agreement on what makes an irrigation scheme or activity large or small. They pointed out that different countries and international organisations use different scale sizes in determining whether the scheme is large or small. For example in Ethiopia, large scale schemes have areas >3000 ha, while medium have areas between 200–3000ha and small scale is <200ha. In Mozambique on the other hand, large scale is >200ha, medium is 30– 200ha, and small is <30ha. According to FAO, large is >500ha, medium is 50–500ha and small is <50ha (Hatibu et al., 2002). The concept of size (at global level) cannot be used in classifying irrigation at local scale. What is large in one region may be micro-scale in another (FAO, 1996). This fact must be taken into consideration when attempting to develop programmes and guidelines for a certain scale of irrigation, especially when it involves smallholder irrigation systems.

Small-scale irrigation schemes are schemes with irrigated area less than 200ha. The description "small-scale" refers not so much to the physical size of the farm plot or the irrigation scheme or system (although these are usually small), but rather to the fact that the plots and the irrigation schemes (where a scheme is present) are managed and owned by the farmers themselves. This distinguishes small-scale irrigation schemes from medium- and large-scale irrigation, in which a public or private entity is responsible for the management of the irrigation scheme, even if smallholder farmers are the irrigators and producers.

In Tanzania, the most successful small-scale irrigation schemes are those which developed from farmers' initiatives. Examples of such schemes can be found in Kilimanjaro, Arusha and Mbeya Regions. This is in contrast to government initiated, large-scale smallholder schemes, which have been rife with problems. The spirit of "small-scale" irrigation is in the fact that it

is managed and controlled by farmers who are the users. Small-scale irrigation is easiest where a farmer has independent access to a water source. It becomes increasingly difficult as the flexibility and independence of farmers' decision-making decreases. This flexibility and independence, in turn, can be related to the number of participants on a scheme, the management requirements of the water supply infrastructure (in-scheme) and the nature of the irrigation technology (in-field).

3.2.1. Traditional Irrigation schemes

These are schemes that have been initiated and operated by farmers themselves using local skills and materials, with no intervention from external agencies. They include schemes based on traditional furrows for the production of fruits and vegetables in the highland areas, and simple diversion on the lowlands for paddies. At present, these schemes account for over 60% of the total irrigated area, and are commonly found in Arusha and Kilimanjaro regions.

Traditional irrigation schemes are characterised by poor infrastructure, poor water management and low yields. Crop yields are typically in the range of 0.8 - 1.0 t/ha and 1.8 - 2.0 t/ha for maize and paddy respectively. The existing infrastructures, starting from the head-works up to the fields, are all temporal, poorly constructed and pose difficulties in overall water management resulting to low irrigation efficiencies. This contributes to substantial water losses and overall poor performance of these schemes. Due to poor water management and absence of drainage infrastructure, salinity and water logging problems are common in some traditional irrigation schemes.

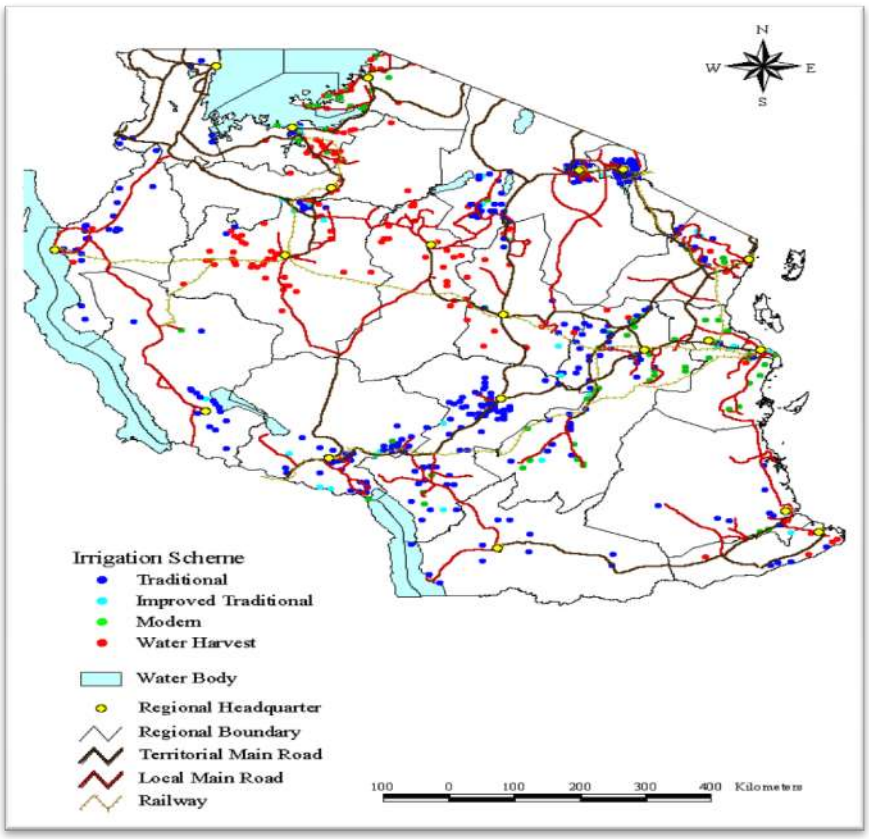

Figure 3.1. Irrigation schemes in Tanzania (Source: MAFC, 2002).

3.2.2. Water harvesting-based irrigation schemes

Water harvesting schemes and flood recession schemes are simple techniques to artificially control the availability of runoff water to crops. These schemes involve a process whereby rainfall is concentrated or is captured as runoff from a large area and is diverted or directed for use in a smaller targeted area. Water application to the scheme is essentially uncontrolled under prevailing farmer-managed practices. The objective is simply to capture as much water as possible and store it within reach of plant(s) in the soil profile of cultivated area or into a storage reservoir.

Most rainwater harvesting (RWH) based irrigation schemes are found in the arid and semi-arid areas of central and western part of Tanzania (mainly in Dodoma, Mara, Mwanza, Shinyanga, Singida, and Tabora). Such schemes involve either direct diversion of rainwater in bunded fields or diversion of rainwater run-offs from seasonal and ephemeral rivers. Farmers who are irrigating using RWH techniques tend to suffer from poor infrastructure for

diverting harvested water and lack control of water in the bunds. They also suffer from unreliable rainfall. As a result these farms are characterised by poor water management and low yields or complete crop failure.

The Government through financial support from IFAD, World Bank and Irish Aid, implemented several RWH irrigation projects in the semiarid areas of the country in Mwanza, Shinyanga, Tabora, Singida, Dodoma and Manyara Regions. The programme interventions included improving overall water availability and agricultural productivity, institutional capacity development, as well as promoting participatory approaches and intensive training and provided opportunities for the traditionally landless (especially women and youth) to get land. For example, the Participatory Irrigation Development Project (PIDP) was an IFAD-initiated programme based on the lessons of an earlier IFAD-funded project titled 'Smallholder Development Project for Marginal Areas' (SDPMA). The target group consisted of smallholder farm families who rely on paddy rice as their major source of income, particularly resource-poor farmers, women and households headed by women. The programme focused on women and their important role in agriculture. There were several challenges facing PIDP implementation and these included: the low institutional capacity at district level, the limited range of water-harvesting technologies used, the under estimated level of construction costs for individual schemes, the lengthy tendering process and the low capacity of local contractors to implement construction works.

3.2.3. Modern irrigation schemes

Modern large-scale irrigation schemes

All of the large-scale irrigation schemes were government-owned and operated either as parastatal farms under the National Food and Agricultural Corporation (NAFCO). They included schemes such as Dakawa, Kapunga, Mbarali and Ruvu or as centrally managed smallholder schemes (Madibira). They relied upon medium/high input packages (fully mechanised operations, imported modern varieties, high levels of fertilizer) and although they started well, they later fell into disarray due to inadequate management capability. Yields actually achieved fell well below expectations and even schemes with demanded industrial crops

like sugar, failed to make profits. The performance of these state farms was evaluated in 1986 and 1988 under the FAO Technical Cooperation Programme, which concluded that the farms were producing only 42 per cent of potential production. Apart from inadequate administrative and technical management, the main causes of poor performance included: insufficient machinery for land preparation and harvesting, poor seed quality (adulterated with wild rice), poor infrastructure designs, low levels of operation and maintenance by farmers, and poor weed control and cropping disciplines.

As part of its privatisation programme, the Tanzanian Government has already privatised some of these schemes, which include Dakawa, Kapunga and Mbarali. Ruvu has already been distributed to small-scale farmers who will own their own plots. Madibira Irrigation Scheme falls into a different category; at present, it is being run by Government as a smallholder scheme. The farmers' groups manage some aspects, but the Government has retained a team of professional staff who coordinates and backstop the farmers. This has helped the scheme sustain reasonable levels of agricultural production. Other schemes such as Kilombero Sugar Estate were privatised several years ago and have already been turned around from making losses to contributing well to the regional and national economies.

Modern small-scale irrigation schemes

These schemes have permanent structures and facilities for irrigation, drainage and flood protection and have been designed with full water control and measurement to assist in water delivery and management. Investments are higher than improved traditional schemes with provisions such as concrete canal lining to facilitate maintenance and reduce conveyance losses.

These schemes are formally planned and designed (fully developed) smallholder schemes, on which full irrigation facilities have been provided by external agencies/donors (such as the World Bank, IFAD and others) with or without some contribution from the beneficiaries, and on which there is usually a strong element of management provided by Government or other external agencies. Morogoro followed by Kilimanjaro and Mbeya are the major regions where the schemes have been developed.

3.2.4. Improved traditional irrigation schemes

These schemes have been initiated and operated by semi-subsistence farmers themselves, with some intervention by an external agency/donors (such as the World Bank) in the form of construction of a new diversion structure, gated canal intakes, water diversion boxes and other farm related structures. The layout of irrigation canals and drainage system is well-defined.

In Tanzania, the traditional systems have been the focus of several irrigation improvement programmes and are termed by many as "improved" irrigation systems. In the Usangu plains of Tanzania, there have been four key improvement projects between 1985 and 2001.

- The Usangu Village Irrigation Project 1985–96 (UVIP, 1993). This was funded by the FAO and aimed to upgrade six indigenous furrows. Work was completed in three of these systems.

- The Kapunga Rice Project, 1988–92. This project had three components: the building of a parastatal farm, the building of a smallholder irrigation scheme and improving the existing smallholder irrigation systems abstracting from four intakes on the Chimala River.

- The Kimani Irrigation Project (KIP), 1991–94. This project, funded by the Canadian International Development Agency (CIDA), planned to upgrade 4300 ha of irrigated agriculture in the Kimani Sub-Catchment, of which only 500 ha was completed.

- Smallholder Irrigation Improvement Component (SIIC), 1997–2001. This programme was part of the World Bank-funded River Basin Management and Smallholder Irrigation Improvement Programme (RBM-SIIP). Under this programme up two indigenous furrows were upgraded (MAFC, 2002).

All of these programmes had two combined aims: to improve agricultural productivity (by increasing yields and expanding the irrigated area) and, within the indigenous smallholder systems, to increase the irrigation efficiency. Typical project physical activities included building concrete intakes, re-aligning main and secondary canals, installing concrete

diversion boxes with control gates and digging drainage channels. Some schemes (e.g. the UVIP work at Majengo Furrow) also involved land-levelling and the redistribution of land.

3.2.5. Out-growers Irrigation

The term "outgrower scheme" is sometimes used synonymously with contract farming, most commonly in Eastern and Southern Africa. Although outgrower farming must first and foremost be considered as a commercial proposition, it has also come to be viewed as an effective approach to help solve many of the market access and input supply problems faced by small farmers. Effective linkages between companies and thousands of farmers often require the involvement of formal farmer associations or cooperatives or, at least, informal farmer groups.

However, as with any contract, there are a number of risks associated with outgrower arrangements. Common problems include farmers selling to a buyer other than the one with whom they hold a contract, or using inputs supplied by the company for purposes other than intended. On the other hand, a company sometimes fails to buy products at the agreed prices or in the agreed quantities, or arbitrarily downgrades produce quality. The existence of an adequate legal framework is thus crucial for the successful implementation and long-term sustainability of outgrowers farming operations. A system of law is essential to assist farmers and their buyers in the negotiation and drafting of contracts. It is also important to protect them from risks that may occur during contractual execution, such as abuse of power by the stronger bargaining party or breach of contract. Strengthening farmer organisations to improve their contract negotiating skills can redress the potential for subsequent misunderstandings.

In Tanzania, the majority of outgrower schemes are based on plantation crops, such as sugarcane, tea, coffee and to a lesser extent, rice. In addition, most of the outgrower schemes are rainfed. For example, the Mtibwa Sugarcane Outgrowers Scheme (in the Morogoro Region) is one of the 3 fairly well-developed schemes since the early 1960s. Two other schemes are at Kilombero; two sugar producing mills run under one management (KI and K2) by the South African-based multinational company Illovo. Also two more such

schemes have been opened; one is the Kagera Sugar Company on the Western side of Lake Victoria and another is the Mahonda Sugar Company in Zanzibar.

There are a few large private irrigated schemes, which operate with outgrowers. One such example is the Kilombero Plantations Limited (KPL) with a 5,000 hectare commercial rice farm with 4,000 satellite smallholder outgrowers. KPL is located 450 km from Dar es Salaam in the Kilombero River Valley in Morogoro Region. Although KPL introduced the System for Rice Intensification (SRI) for the outgrowers, their production is rainfed. This limits the full benefits that can be realised from SRI.

4. IRRIGATION RESEARCH IN TANZANIA

4.1. Past Irrigation Related Research

4.1.1. Agricultural Water Management (AWM) Solutions project

The AgWater Solutions Project, 2010 - 2012, aimed to increase food security and income of smallholder farmers by providing reliable and sustainable access to water for irrigation. Thus, the objective of the project was to identify investment options and opportunities in agricultural water management with the greatest potential to improve incomes and food security for poor farmers, and to develop tools and recommendations for stakeholders in the sector including policymakers, investors, non-governmental organizations (NGOs) and smallholder farmers. The project strived to assess where and how agricultural water management (AWM) can improve rural livelihoods and reduce poverty in the pilot geographical areas through an initial proactive research phase followed by a dialogue process to discuss findings and distil priorities for field level. In Tanzania, the research phase entailed detailed analysis of selected agricultural water management solutions, which were identified through a consultation process with key stakeholders (Evans, et al. 2012). The AWM solutions that were identified and researched include: (i) water lifting devices, (ii) small reservoirs, (iii) community irrigation schemes, (vi) river diversion systems, and (v) conservation agriculture. This was accompanied by a dialogue process with the objective to "ground truth" the research findings and identify gaps and priorities for influencing investment in the AWM solutions through policy and links with private sector and farmer

groups. A series of workshops were organised at national and sub-national levels, where various stakeholders participated and contributed valuable input to the process. Key findings and outputs of the project included identification of possible investment pathways and recommendations on how to implement the identified AWM solutions in different agro-ecological zones. All the solutions that were identified were found to be viable for small scale irrigation in the country.

4.1.2. Integrated Water Resources Management and Development Plan for Wami-Ruvu Basin: Groundwater Resources

Japan International Cooperation Agency (JICA) undertook a study between December 2010 and June 2013 with the aim to provide a blue print of Integrated Water Resources Management and Development (IRWM&D) Plan for rationally managing and developing water resources in the Wami/Ruvu Basin for multi-sectoral needs. The study included the assessment of surface water potential, assessment of groundwater recharge and flow mechanism, estimation of groundwater potential, and assessment of extractable yield of groundwater resources. This groundwater study established that there was large amount of untapped groundwater resource in the Wami/Ruvu basin. However, the study concluded that since the occurrence of groundwater in the dominant fissure aquifers depends on the condition of fault and joint and bedding plane, further studies should be carried out such as analysis of lineament and geophysical investigation.

4.1.3. Smallholder System Innovations (SSI) research project

The Smallholder System Innovations in Integrated Watershed Management (SSI) programme was an applied research initiative studying smallholder system innovations in integrated watershed management (SSI, 2009; Sally, 2010).The project, which started in late 2003 and ended early 2009, had the objective to contribute to the development of strategies for water for food and environmental security in drought-prone tropical and subtropical agro-ecosystems. The SSI programme studied the potential of indigenous and exogenous water system innovations in smallholder farms for improved land and water productivity. These innovations ranged from in situ practices, such as deep tillage and zero tillage, to infrastructural interventions, such as underground storage tanks and small storage structures. The scope of the project included: (i) analysis of the hydrological, environmental

and socio-economic consequences of upscaling water system innovations in smallholder predominantly rainfed agriculture at watershed scale, (ii) development of methodologies and decision support tools for improved rainwater management and equitable sharing of water between upstream and downstream users in nature and society, (iii) translation of knowledge on the links between intensification of agriculture through water system innovations, and its impacts on water, food and ecosystems at watershed and river basin scale, into useable tools for planning and policy, and (iv) contribution to human capacity building on integrated resources management with specific focus on balancing water for food and nature, in Southern Africa through PhD and MSc training.

The key conclusion of this research project was that there existed immense opportunities to improve water productivity in smallholder farming systems through adoption of water system innovations. Scientific evidence indicated the huge potential of rainwater harvesting systems in safeguarding food security with multiple environmental and socio-economic benefits.

4.1.4. Raising Irrigation Productivity and Releasing Water for Inter-sectoral Needs (RIPARWIN)

The Raising Irrigation Productivity and Releasing Water for Inter-sectoral Needs (RIPARWIN) research project was implemented in the Great Ruaha Sub-basin in Tanzania. The primary objective of the project was to assess the possibility of basin managers and other stakeholders raising the irrigation efficiency and productivity in order to find water savings that can then be released downstream and for other sector needs (Franks, 2003; DFID, 2006). This project typically stemmed from the prevailing debate on how water can be shared in river basins where little spare water exists and irrigation is the major user. In this regard, the RIPARWIN project aimed at efficiently utilising water for irrigation so that savings can be found to deliver water to other equally important sectors in the basin. Hence, the RIPARWIN researched the science of river basin management (RBM) with the aim of assisting river basin stakeholders by providing analysis, tools, strategy and policy advice, mainly in Tanzania, but also to a wider audience (McCartney et al., 2007). The project also contributed to human capacity building on integrated water resources management with focus on water allocation and irrigation efficiencies in Tanzania through PhD training.

McCartney et al. (2007) highlighted several key conclusions, including: (i) under certain circumstances, improving local irrigation efficiency is important because, by reducing non-beneficial losses, water can be liberated for other uses; ii) care is needed in the development of irrigation infrastructure intended to increase catchment level water productivity since, if inappropriately designed and managed, it can have the opposite effect; iii) economic efficiency is a necessary, but not sufficient, criteria for determining water allocation; iv) in situations where withdrawals are vital for livelihoods and poverty alleviation, it is not reasonable to plan to fully implement environmental flows and it may be necessary to manage trade-offs between different ecosystems; v) although care is necessary not to perpetuate past inequities, the effectiveness of contemporary approaches to water management may be improved if built on traditional arrangements which tend to be better suited to the livelihood strategies and social norms of local people; and vi) different types of decision support systems that improve understanding of system dynamics and facilitate social learning and dialogue can contribute to better water resource management.

4.1.5. Productivity of Water in Agriculture and Interacting Systems (PWAIS) project

PWAIS project adopted strategies for improving the productivity of water in both rainfed and irrigated agriculture so as to ensure social, economic and environmental sustainability in river basins. New knowledge demanded by relevant institutions regarding alternative and best options for improving productivity of water in agriculture and interacting systems in Eastern Africa, was identified and verified by stakeholders.

Specific objectives of the project were to: (i) collate, evaluate and disseminate to stakeholders methodological tools for assessing productivity of water in agriculture (PWA) in the Case Study Basins (CSB); (ii) evaluate the benefits and consequences of options for improving PWA under different scenarios in CSB; (iii) produce a River Basin Management Decision Aide (RBMDA) with robust modules dealing with selection of options for increasing productivity of water in agricultural as well as interacting systems; and (iv) adapt and use knowledge sharing tools that link stakeholders from the community to basin to national level, to disseminate the developed knowledge on PWA.

The key findings of the project highlighted the fact that stakeholders in agriculture and water related issues have different perceptions about the productivity of water. This was evident by the different definitions of productivity of water, though most of the definitions hinge around the benefits accrued from water use. The viewpoint of smallholder farmers' regarding the productivity of water is important in order to promote the concept of productivity of water in a country like Tanzania. This is because 95 percent of the farmers in the country are smallholders. The study presented the farmers' understanding of the productivity of water in the Mkoji sub-catchment (MSC) in the Ruaha River Basin in Tanzania. It also presents their practices aimed at increasing the productivity of water in the area.

4.2. Current irrigation research

4.2.1. Integrated salt affected soils (SAS) management options for sustainable rice production in selected irrigation schemes in North and Eastern Tanzania.

The SAS research project started in 2013 with funding from the Innovative Agricultural Research Initiative (iAGRI) in Tanzania. The iAGRI initiative is aligned with the themes and road map of the USAID Feed the Future (FtF) initiative. The SAS project is scheduled to end in 2015/16. The main project partners include Kilombero Agriculture Training and Research Institute (KATRIN), Mlingano Agricultural Research Institutes in the Ministry of Agriculture, Sokoine University of Agriculture, and Florida University (Indiana River Research and Education Centre) in the USA.

The overall goal of this project is to contribute to increase rice productivity by developing and promoting the adoption of technologies that will lead to sustainable production of rice grown under salt affected soils of Tanzania. The project strives to contribute to the development of strategies for salinity and sodicity management for improvement and sustainable irrigated rice production in the country. The project is mainly working in two irrigations schemes, Dakawa and Ndungu in Morogoro and Tanga regions respectively. The specific objectives include:

- Evaluating the distribution and severity of salt affected soils of selected irrigation schemes in Tanzania.

- Conducting surveys of farmers to assess community knowledge on salt affected soils management and its economic effects before the project takes off.
- Documenting the performance and salt tolerance of promising rice varieties in different environments.
- Developing and promoting appropriate management options for saline, sodic and saline - sodic soils.
- Disseminating best water and soil management options for salt affected soil and use of salt tolerant rice varieties to farmers and extension staff.

4.2.2. Innovative drip emission devices for resource poor farmers under changing climate

This two year research project (2013 - 2014) is aimed at developing an on-line emission device for a low-cost drip irrigation system that is both robust and cheap and yet hydraulically efficient for use on any locally available tubing material. The research is trying to address the issue of dwindling fresh water resources, which are threatening global food production. Micro-irrigation technologies are seen as a means of addressing the growing competition for scarce water resources. These technologies are not readily accessed by the majority of small-scale farmers because of the cost constraint. This project is funded by the Innovative Agricultural Research Initiative (iAGRI) in Tanzania through Sokoine University of Agriculture (SUA) and implemented in Arusha region.

4.2.3. Effect of irrigation regimes on yield and quality of grapes

This four year PhD research project (2013-2016) is aimed at investigating the effect of irrigation regimes on the vines that will not lower the quantity and quality of grapes in Dodoma Region. Dodoma is a semi-arid area and grape production gives an opportunity for small holders to improve their livelihood. However, the main hindrance to grape production in Dodoma is insufficient soil moisture during the dry season (May – November). It has been observed that with irrigation, grape yield can be increased to between 8 and 15 tons per ha. Furthermore, grapes are sometimes of lower quality because of over application of water at growth stages. Therefore, the research addresses issue of insufficient moisture and over

application of water. The project is funded by the Ministry of Agriculture, Food Security and Cooperatives of Tanzanian.

4.2.4. Development of a precision irrigation control system for horticultural food crops in Tanzania

Precision irrigation offers a great opportunity to save water and energy in agriculture. This MSc. study (2012 - 2014) is aimed at developing control system to not only automate drip irrigation but also ensure that the amount applied is just sufficient to be taken up by the plant. The proposed controller is a solar-powered system that uses low cost electronic devices. The project is funded by the Innovative Agricultural Research Initiative (iAGRI) through Sokoine University of Agriculture (SUA) and is being implemented within the University grounds in Morogoro.

4.2.5. Investigation of the performance of System of Rice Intensification (SRI) and Rodent Ecology and Prevalence of Zoonotic Diseases under SRI Traditional Rice Growing Systems in Tanzania

This research aims to investigate the performance of SRI in Tanzania; and to investigate the rodent population, its relationship to rice damage, and prevalence of zoonotic diseases under SRI and traditional rice growing systems in Tanzania. Its main focus is to assist smallholder irrigators to effectively utilize the little available water resources to produce more rice, and learn means for controlling rodents in the field. This 3-year project (2012 - 2014) is funded by the Tanzania Commission for Science and Technology (COSTECH) and implemented in Mkindo, Morogoro region.

4.2.6. Enhancing Climate Change Adaptation in Agriculture and Water Resources in the Greater Horn of Africa (ECAW) Project

The ECAW project is being implemented in four countries in Eastern Africa i.e. Kenya, Ethiopia, Sudan and Tanzania (ECAW, 2014). This multi-disciplinary project is focusing on various thematic areas with the aim to enhance climate change adaptation in agriculture and water resources. The project started in 2011 and is scheduled to end in 2014 with funding from IDRC. The main project partners are the Kenya Agricultural Research Institute

(Kenya), Ethiopian Institute of Agricultural Research (Ethiopia), Agricultural Research Corporation (Sudan) and Sokoine University of Agriculture (Tanzania) - the lead institution).

In Tanzania in particular, the water resources management component of the project has the objective to evaluate the adequacy of future water resources in the Wami-Ruvu River basin in meeting future water needs for irrigation under projected changing climate. Furthermore, the study intends to identify possible future impacts of climate change in relation to the extent and severity of the water resources over space and time. It is appreciated that long-term investments in agriculture, that depend on water resources, in the Wami-Ruvu river Basin need to be guided and informed on projected future availability of water resources.

One of the main activities of this study is hydrological Modelling which entails using a physically based agro-hydrological model, the Soil and Water Assessment Tool (SWAT), to establish the adequacy of future water resources in the Wami basin in meeting future irrigation demands. The various outputs from the SWAT model, inform of distributed numeric values, are being used to produce respective maps indicating the extent and distribution of future water resources for irrigation under the changing climate in the basin. Some of the key inputs to the calibrated SWAT model is future climate data, which is obtained from GCM's that have the highest skill score for simulation of availability of future water resources in the Wami-Ruvu Basin under changing climate.

5. The potential for alleviating seasonal feed fluxes using irrigated fodder in Tanzania

5.1. Problem statement and justification

Meeting year round feed quantity and quality requirements for livestock producers in much of Tanzania is a big challenge. Tanzania has 94 million hectares of land resource which is dominated by three main production systems, (i) the extensive/agro-pastoral systems where livestock keeping dominates livelihoods, (ii) semi-intensive systems where both livestock and crops are produced; and (iii) the intensive crop livestock systems, largely committed crop and dairy productions (Figure 1). Out of the total land resource, the bulk of 50 million hectares is rangelands of systems (i) and (ii),

suitable for grazing. These are arid and semi-arid areas that experience sub-optimal rainfall and strong seasonal effects (FEAST Survey, 2013). In systems (iii) and some areas of system (ii) there is high human and livestock densities. The consequence has been increasing demand for food and feeds that have led to permanent cultivation of more land, reduction of grazing and forest lands to expand crop production, and disappearance of traditional practices that formally allowed land to fallow (Ndikumana and de Leeuw 1996; Walshe et. al., 1998). Hence, livestock producers in the intensive crop-livestock production systems rely on feeding crop residues, collected feeds such as weeds, tree leaves, banana pseudo-stem and tubers that occur seasonally, but are often of low quality. There is limited off-farm purchased and use of feed such as concentrate feeds, supplements and cereal by product ingredients. There is a need to develop solutions to meet the feed requirements in these systems.

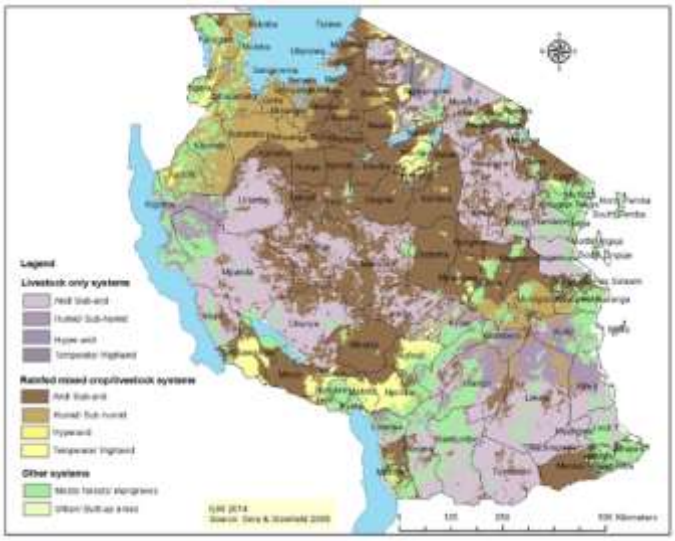

Figure 1: A map of Tanzania showing livestock only and rainfed crop-livestock production systems in Tanzania

At the same time, the livestock sector plays a critical role in Tanzania in terms of both sustainability and intensification of agricultural productivity in farming systems. Livestock contributes 13% to the Agricultural Gross Domestic Product (LSDS 2010). Tanzania is characterized by a high livestock population of 21.2 million cattle, 15 million goats and 6 million sheep (Livestock Census, 2009). Despite the large size of the livestock population, the contribution to the national economy (GDP) is only 4%, indicating very low productivity per livestock unit (Economic Survey, 2010). Further, the herd is characterized by low productivity, at least in terms of milk and meat; only 28% out of the

cattle herd is milking and yielding a mere annual average of 174 kg/year, while only 13% of the cattle is slaughtered with a very low average carcass weight of only 107 kg/animal (FAO, 2005).

Overall, livestock keepers in Tanzania meet only about 55% of their livestock feed requirements through a combination of mainly grazing, crop residues (legume and cereal residues) and some planted fodder. Inadequate quantity and quality of feeds fodder is aggravated by strong seasonal variations resulting in seasonal feed availability. Feed availability is often abundant during the wet seasons; whereas there are acute shortages of feed (just about 34% of feed needs met) during the dry season with hardly sufficient feed to maintain animals. Seasonal feed availability results in strong seasonal milk availability and this leads to fluctuations of milk price that adversely affect incomes and the nutritional diversity of smallholder farmers (FEAST Survey, 2013).

5.2. Past research

Various research works have demonstrated the importance of irrigation systems in enhancing rural agricultural production (Shibundu and Luvanga, 1998; Mkavidanda and Kaswamila, 2001; Tagseth, 2002). Mkavidanda and Kaswamila (2001) found that irrigation enabled income increases through the multiple cropping seasons and higher prices fetched in the dry season. This research mainly focused on food crops. Mowo, et al, (2002) note that irrigation has improved yields and has led to a shift by most farmers to production of high value crops. Agricultural communities in Tanzania have developed different small-scale farmer managed irrigation systems, such as the traditional irrigation systems, in which water is conveyed to the fields by traditional furrows that are managed by local farmers. There are also modern large-scale irrigation schemes. A literature review shows no current research work focused on improved irrigated forages, as such. Related research involves agroforestry and the irrigated production of fodder tree seedlings that are transplanted to grow under rainfed conditions (Oduol et al. 2005; Kimaru et al. 2012, Kingkamkono & Lyamchai 2003) and the Chagga agroforestry system that involved 100 crops integrated with trees (Tagseth 2000).

5.3. Opportunities and challenges

Potential technologies that can help alleviate seasonal feed availability include fodder conservation, fodder trading, and increasing the amount of concentrate feeds in animal diets. Fodder conservation is an important tool for improving the balance between feed demand and supply, and to level out the peaks and troughs in forage production. Excess fodder cannot only be conserved in the wet season, but it is also possible to conserve fodder in the dry season where irrigation is possible and to

supply those areas where forage production and feed supply is low (Massawe et al., 2005). A fodder markets study in northern Tanzania by Massawe et al. (2005) strongly linked small scale irrigation on the slopes of Mt. Kilimanjaro to the thriving maize stover trading in the area. Similarly, the rice straw trading observed around Morogoro town has been traced to the rice irrigation schemes in Kilombero region (FEAST Survey, 2013). A major challenge is that the adoption of these technologies has remained low primarily because of costs and poor access to inputs and services in most areas of Tanzania (FEAST Survey, 2013).

As observed earlier, most irrigation efforts Tanzania have focused on production of high value food crops, especially vegetables and rice. For example, as an alternative to rainfed agriculture, farmers in the mixed crop livestock systems of Iringa region successfully cultivate in the valley bottoms using the 'vinyungu system' to produce food and cash year around (Ravnborg, 1990; Lema, 1996, Masiga, 1993). Vinyungu is a Swahili word which is a valley bottom dry period farming practice in which farmers harness water from rivers and or springs to produce both food and cash crops at subsistence level using traditional irrigation techniques. A study by Majule & Mwalyosi (2011) examined the role of traditional irrigation 'vinyungu system' on small scale production in Iringa region. It is clear from the study that shortage of rainfall due to climate variability has forced farmers to concentrate more in valley bottoms where farming is possible due to high soil moisture availability. It also reports that although this intensive cultivation system has enabled farmers to increase the production of cash and food crops (tomatoes, vegetables, green maize or Gobo) the upland areas have been increasingly depleted of soil fertility, thus making them less productive and less dependable. Other challenges identified in this study include water-logging, labor shortage and unreliable market for vegetables. Nevertheless, there are opportunities to integrate fodder production and enhance crop residue and waste utilization in such irrigated areas to alleviate feed fluxes and bridge feed gaps. Links to fodder markets can strengthen these opportunities.

5.4.Lessons from the research and technology options

One of the factors identified by Majule & Mwalyosi (2011) for declining productivity of 'vinyungu' farming system is declining soil fertility caused by leaching of nutrients (45%), uncontrolled burning (24%), excessive use of nitrogenous fertilizers (20%), and siltation associated with soil erosion (11%). As a result, introducing fodder on soil conservation structures and other niches that are highly prone to soil erosion will help address the problem of declining soil fertility in small scale irrigation schemes. Pests and diseases are also major a problem associated with 'vinyungu' systems; there has

been excessive use of pesticides and the development of pesticide-resistant pathogen strains. Introduction of forages could be used as an integrated pest management strategy in some cases.

While there is already an emphasis on growing food crops under irrigation systems in Tanzania, there is potential for enhancing feed production. Evaluating and recommending the basic productivity components of food and feed crop varieties in these systems is needed. For example, irrigated cereal and root/tuber crop production offers an opportunity for fodder production. Due to the intensification in the smallholder crop-livestock systems, the integration of improved forages has a high potential of facilitating the intensification of mixed crop-livestock systems while mitigating climate change and reversing environmental degradation. Some of the strategies might include exploiting unused niches e.g. fodder banks, use of boundaries, intercropping and dedicated plots in crop dominated irrigation systems to produce fodder for livestock. Some of the potential regions in Tanzania include Iringa, West Usambara mountain, Lushoto, Babati, Mwanga, Same, Mbeya Morogoro, Dodoma Singida, and Iringa districts amongst others.

6. PROPOSED RESEARCH THEMES

6.1. Key lessons from past and on-going research

Good efforts have been made in irrigation research including piloting technological advancements in the country. However, adoption of such research findings into mainstream operational activities in both public and private sector has been poor. The adoption process needs equal attention similar to that given to the research phase. It is understood that the adoption process has more uncontrolled dynamics compared to the research phase and hence the need for more attention.

One of the adoption challenges is in sharing research results with key stakeholders. Effective sharing of research results is a process that needs resources, due diligence and commitment. Most often, irrigation research projects have adopted the conventional way of sharing results i.e. scientific papers, websites, posters etc. Despite the fact that these approaches are important, they are often not specifically targeted to the application and use of the research results at farm level, largely due to funding constraints and the lack of a clear pathway to share such project results.

One example of an effective project that innovatively engaged all key stakeholders across the country was the AgWater Solutions project through its dialogue component. The dialogue component was well funded with a clear implementation pathway and objective to share and ground-truth the project research results while identifying gaps and priorities. Lessons from the AgWater Solutions dialogue process are worth sharing for possible wider adoption and implementation.

Most of the research, including in irrigation, has often not engaged the private sector in the way that it deserves. For development and sustainability of irrigation in the country, there is a great need to engage the private sector for wider adoption and upscaling of research results. The private sector is always motivated to invest for return benefits. The upscaling and wider implementation of pilot research results can be done effectively by the private sector and hence the need to engage them. The business orientation found in the private sector is also needed by the smallholder farmers that practice any form of irrigation and who form the backbone of the agricultural sector in the country.

Most of the successful irrigation research projects have had a multi-disciplinary orientation given the fact that the target smallholder farmers have diversity in their livelihoods. Thus, it would be advisable, for future research projects, to incorporate and adopt a multi-disciplinary approach in both design and implantation phases.

Based on the past and present research, key researchable issues are basin scale quantification of available water resources available for irrigation and other sectors; use of water efficient and affordable technologies such as low cost drip irrigation systems, precision irrigation to minimize irrigation water loses; upstream and downstream effects of improved irrigation systems, and ways of minimizing water losses in smallholder surface irrigation systems. There is also a need to invest in research that will improve understanding of effective implementation pathways to research uptake and use for the identified and prioritized AWM solutions.

6.2. Research Gaps: Irrigation Development in Tanzania

In the traditional irrigation schemes, water losses, water logging and salinity are common due to poor irrigation and drainage infrastructure. However, most of these claims are yet to be quantified. Technical, economic, social and environmental studies need to be carried out in order to propose the most likely solutions. It might be worthwhile to even compare the performance of traditional, improved traditional and modern smallholder schemes from technical, economic, social and environmental aspects.

Modern large schemes, which used to be owned by the Government of Tanzania, were privatized to large scale investors and smallholder farmers about 10 years ago. Before being privatized, these farms were facing several challenges including administrative and technical management and low production. Studies need to be done to compare the before and after privatization and also between farms privatized to smallholder and those to large investors. Studies need to look at benefits to the Government and the public. Also, technical, economics and environmental aspects need investigation. These findings will be able to guide future investments.

The strong push on value chain approach and the SAGCOT corridor initiative have led to a new type of irrigation development whereby large private investors are linked to smallholder farmers, who in this case are considered as outgrowers. Smallholder farmers in this type of schemes are encouraged to form farmers' groups or associations. Above all, several schemes are organized around an agricultural cluster, in which the government and development partners can provide support with the provision of necessary infrastructure, such as electricity, water and roads. This initiative has existed for more than five years. This calls for studies related to irrigation and value chains, irrigation efficiency and productivity, and gender related studies in order to reconfigure the original production systems.

This review has also shown that the government efforts have not addressed irrigated vegetable and fruit production where other types of technologies such as treadle and diesel pumps are used. Essentially, this sub-sector is one with highly self-developed irrigated value chain components. However, more in-depth studies are required to investigate rents and/or entry barriers, and how these barriers can be addressed. Also, issues related to vertical and

horizontal up scaling may be of interest because there is still potential for expanding this sub-sector.

6.3. Technologies for Improved Productivity and Sustainable Water Management

Water shortage is already experienced in different major catchments, such as Kinyasungwe in the Wami-Ruvu River Basin and the Pangani River Basin. In the coming decades, water scarcity is expected to rise due to population growth, irrigation development and climate change. The agricultural sector accounts globally for around 70% of all freshwater withdrawals; however, less than 60% of all the water used for irrigation is effectively consumed by crops. There is a strong need to have studies geared towards improved irrigation water productivity and use efficiency.

There are various proven technologies available and in use that can improve water management and productivity. However, they are yet to be adopted at a wider scale. Therefore, this theme proposes that action research should be undertaken to understand adoption barriers and solutions for wider scaling up of these technologies.

6.3.1. Evaluation and improvement in water productivity and utilization efficiency of irrigation water

Systematic and regular assessment of irrigation efficiency of irrigation schemes is proposed. Currently, a significant number of irrigation schemes are being either established or improved. However, follow up studies are not embedded to monitor and assess the performance of these schemes in terms of irrigation use efficiency. More systematic studies are also needed to evaluate irrigation use efficiency and explore opportunities for improving it. In early 2000s, some studies were carried out on irrigation use efficiency but scientists and practitioners could not reach a consensus on the irrigation use efficiency of different schemes in Tanzania.

Water productivity studies are more important than irrigation use efficiency studies. A few studies were conducted in the early 2000s focusing on water productivity. Currently, there are no studies on water productivity. With irrigation in Tanzania dominated by surface

irrigation systems, water productivity studies are very important to ensure that the available water is directed towards high productive (kg/m^3) and/or high income gain systems ($/$m^3$). This is where the System of Rice Intensification (SRI) will feature most.

6.3.2. Mechanical and drip irrigation systems for high value crops

One way to increase irrigation use efficiency and improved water productivity is through the adoption of irrigation technologies that reduce losses and increase application efficiency. Surface irrigation is the most common form of irrigation used in the country. However, if we were to continue using this type of irrigation and other inefficient methods, agriculture would consume virtually all of the available fresh water by 2050. Therefore, there is a strong need to undertake research in efficient irrigation equipment and technologies, especially drip irrigation (e.g. sub-surface drip irrigation) and sprinkler irrigation systems (e.g. mechanical move irrigation). Research issues might include efficiency, water productivity, adoption pathways and hydro-economics of these technologies.

6.3.3. Water application technologies

Water application technologies in this case refer to water lifting devices such as manual pumps (e.g. Money-Maker and concrete pedal pump), motorized and electric pumps. IWMI (2012) showed that dry season vegetable production is very popular and profitable, and pumps provide a reliable method of drawing water from water sources, such as a river or a reservoir. The study estimated that more than a million smallholders in Sub-Saharan Africa are growing vegetables in dry season using irrigation and the number of farmers is growing. However, there are challenges such as access to information and finance, choosing the right product, and support services. Therefore, the proposed research calls for further investigation related to the enabling environment for participation of poorer smallholder farmers in the dry season irrigated vegetable value chains. The specific focus should be on how an enabling environment can be built to ensure water application technologies are made available to poorer farming households.

6.3.4. Land management practices for controlling rainfall runoff and soil erosion

The main mechanical technique that is used in agricultural land to control runoff and soil erosion is the use of terraces. Other techniques that can also be used include use of cover crops and crop residuals. In non-agricultural land, the main technique that can be used is planting of trees. Even though the cause and impact of soil erosion is well known to most farmers, they continue to use flat cultivation. Labour has been mentioned as one of the reasons for lack of adoption. More participatory action researches, as well as studies on legislation and institutional arrangements for accelerated uptake of these technologies, are required.

6.3.5. Managing rainwater for plant growth and environmental conservation

Agricultural productivity in semi-arid areas is challenged by inadequate and erratic rainfall. Therefore, agricultural practices in these environments require better management of rainwater for proper plant growth and environmental conservation. Adoption of technologies that promote soil conservation and better utilization of rainwater is going to become necessary. IWMI (2012) identified technologies such as conservation tillage, pit and trench farming, and in-situ water harvesting as possible candidates for improving management of rainwater and soil conservation. The study identified locations in Tanzania where there are opportunities for scaling-out. Various researches have been done to identify adoption barriers and several solutions have been proposed, but still there has been limited adoption. We propose further studies be done to identify the factors that affect adoption of these technologies.

6.3.6. Groundwater use assessment

There has been very limited research related groundwater mostly because of cost involved in undertaking such studies but also because there is a feeling that the country has plenty of surface water resources to exploit. However, most of the arid and semi-arid regions they highly depend on groundwater for domestic as well as for agriculture. Moving forward, even areas with substantial surface water resources may likely need to explore groundwater resources because of population increase, GDP growth and climate change. It is therefore

recommended that more studies be done in groundwater availability, mapping and groundwater technologies.

6.4.Policies and Institutional Framework

6.4.1. Develop tools for sustainable management and utilization of water resources

Development and practical use of decision support tools to assist planners and practitioners in various sectors has been an on-going struggle. The challenge has been more on the uptake/adoption even though there is still a need for developing other decision support tools. Already, there are several decision support tools that have ended up on the shelves, for example, the Lake Victoria Decision Support System (LVDSS) and Rufiji Basin Decision Aid (RUBDA). This does not mean the development of such tools should stop. There is still need to develop new tools for water resources management however, innovation is needed in identification of the entry point of involving end-users in the development process to ensure uptake. Therefore, this research component calls for continuous development of computer-based decision support systems, which are user-friendly, and identification of the entry points and strategies that will ensure uptake of developed technologies.

6.4.2. Assess policies and institution dynamics in irrigation and water resources management

Irrigation and water are dealt with in Tanzania by two different institutions. The water sector is under the Ministry of Water while irrigation is under the Ministry of Agriculture, Food Security and Cooperatives. However, the configuration of the two ministries have been changing their . Most recently, the irrigation department was shifted to the Ministry of Water, but later returned to the Ministry of Agriculture, Food Security and Cooperatives. Therefore, there is a continuous need to assess policies, regulatory and institutional frameworks, both formal and informal.

6.4.3. Irrigation Value Chain Development Research

Agricultural value chain development is a new development phrase aimed at enhanced income for smallholder farmers and chain actors through increased and sustained markets. Through the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) initiative, the

Government of Tanzania introduced out-growers scheme formats especially in irrigated rice to ensure sustained inputs and markets for smallholder farmers through large-scale farmers. This calls for multidisciplinary integrated research in water management, agronomy, economics and institutions in the new mode of production in order to assess effectiveness, identify areas for improvement, and ultimately form policies and strategies.

7. RESEARCH SITES

7.1.SUA Research Sites

7.1.1. Same District - Kilimanjaro Region

Most studies carried out on soil-water management and rain water harvesting (RWH) in the semi-arid areas by SWMRG-SUA included those in the Western Pare Lowlands (WPLL) in Same District (4.80 to 4.30 S, and 37.50 to 37.50 East), Kilimanjaro Region (Figure 6.1). The area is characterized by three agro-ecological zones, namely, the highlands (elevations above 1350m), midlands and lowlands (elevations below 650 m). The western side of the Pare Mountains receives low amounts of rainfall and is characterized by semi-arid conditions. Annual mean rainfall is in the range of 400 to 600 mm with a bimodal pattern. This area is characterized by two distinct seasons, the short rainy season locally called ***Vuli*** and the long rainy season locally called ***Masika***. ***Vuli*** is characterized by short rains and runs from November to January, while ***Masika*** is characterized by long rains and runs from March to May. ***Masika*** rains average 180mm in the lowland, 260mm in the middle land and 600mm in highland zone. The evaporation in this area varies in the range of 3.0 to 5.4 mm per day with an annual long term average of 1,575mm (Barron *et al*., 2003). The western Pare lowlands are considered to have low agricultural potential. The average population density is 42 persons/km^2 (Tumbo et al., 2011).

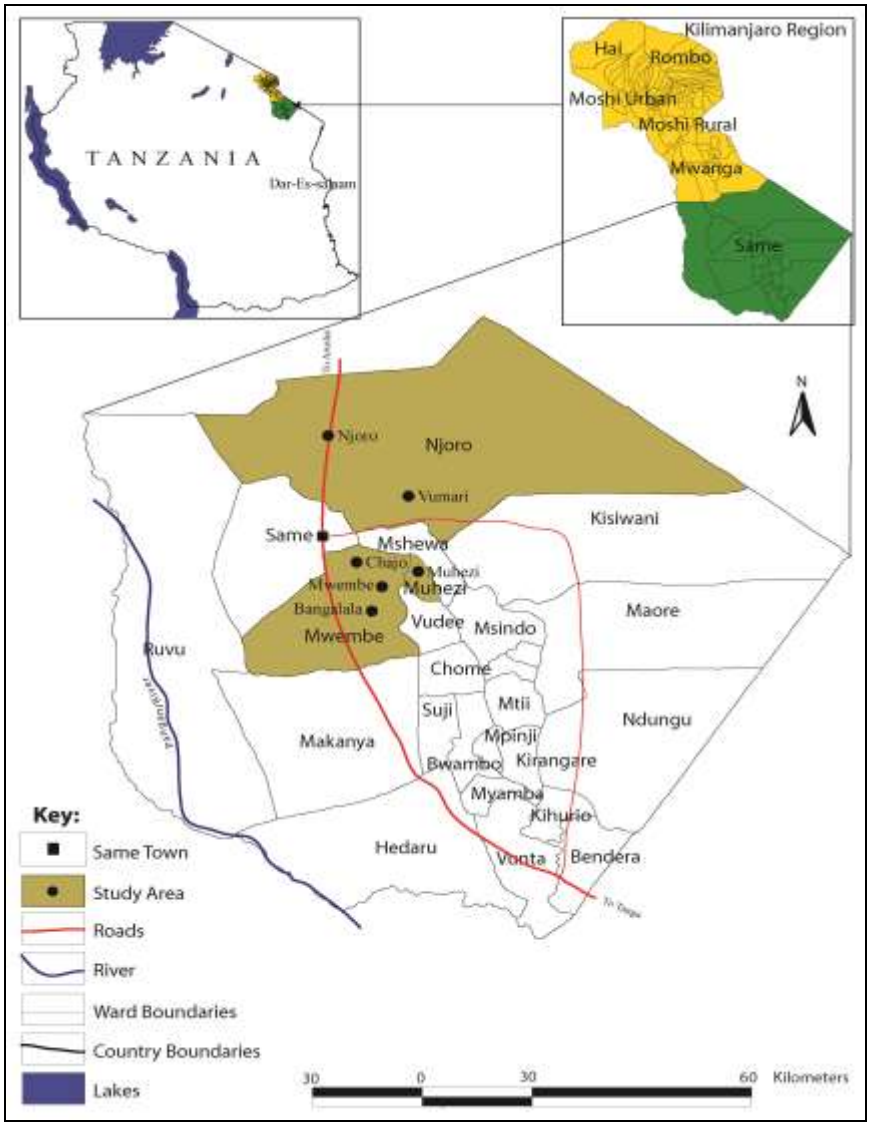

Figure 6.1. Same District showing past research study sites in highlands, midlands and the Western Pare lowlands

Currently, SWMRG-SUA is finalising the implementation of the Water Harvesting Technologies Revisited (WHaTeR) project in Bangalala and Makanya villages. However, in collaboration with SWMRG-SUA, CARE International is implementing another project titled 'Global Water Initiative East Africa (GWIEA): Water for Agriculture and the Community Based Adaptation in Same District, Kilimanjaro Region, Masasi District in Mtwara Region and Morogoro. The GWIEA is a regional program being implemented also in Uganda and Ethiopia. A core focus is on improving information flow at different levels and using this

information to influence policymakers (both insiders and outsiders) to invest more in water for smallholder farmers.

Other study sites where SWMRG-SUA worked included the Lake Victoria Zone, specifically Mwanza and Shinyanga Regions. The studies included soil-water management and rainwater harvesting. Various themes were covered including economics and social aspects.

7.1.2. Wami-Ruvu River Basin, Morogoro Region

The Wami - Ruvu river basin is one of four basins in Tanzania that drain into the Indian Ocean. The total area of the Wami – Ruvu River basin is about 72,930 km^2. Of this total area, the Wami system encompasses about 40,000 km^2 and crosses the political boundaries of four administrative Regions, namely Dodoma, Morogoro, Tanga and Coast Regions. The Wami River originates in the catchment of the Ukaguru, Rubeho, and Nguru mountain ranges, which are all part of the Eastern Arc chain of mountains in Kenya and Tanzania. The Eastern Arc Mountains are recognized as one of 25 globally important “hot spots” for forest biodiversity in need of immediate conservation action. The Eastern Arc Mountains are directly linked to the Indian Ocean. Predominantly Easterly Trade Winds from the ocean are forced to rise, cool and are converted to precipitation on the mountains. The main source of water for the lowlands, which are the main population centres, is therefore the Eastern Arc Mountains.

The Enhancing Climate Change Adaptation in Agriculture and Water Resources in the Greater Horn of Africa (**ECAW)** project is being implemented by SWMRG-SUA in this river basin.

7.2.Feed the Future zones or priority sites

Feed the Future is the US government's global hunger and food security initiative that supports country-driven approaches to address the root causes of hunger and poverty. In Tanzania, FtF has initiated several programs including the Tanzania Agriculture Productivity Program (TAPP), Tanzania Staples Value Chain (NAFAKA) and Africa Research in Sustainable Intensification for the Next Generation (AfricaRISING).

7.2.1. Tanzania Agriculture Productivity Program

Tanzania Agriculture Productivity Program (TAPP) aims at increasing smallholder incomes, improving nutrition, and expanding markets through agricultural innovation and commercialization. The regional focus is the Southern Agricultural Corridor of Tanzania (SAGCOT), which the Tanzanian government identified as the most conducive for agricultural growth. Specifically, TAPP is targeting fresh and processed fruit, vegetables, and spices in Arusha, Kilimanjaro, Lushoto, Morogoro, the Coastal Strip, and Zanzibar. The primary goal of USAID-TAPP is to increase incomes of smallholder farmers through enhanced productivity, increased investment, and improved market systems. Specific objectives include:

- Raising the sales, incomes, and food security of 19,000 smallholder farmers
- Increasing yields of targeted products by 40 percent
- Providing training in agricultural productivity to over 40,000 individuals
- Leveraging $8 million in new client and counterpart investments
- Generating over $16 million in new incremental agricultural sales

7.2.2. Tanzania Staples Value Chain (NAFAKA)

The NAFAKA Staples Value Chain Activity is a $30 million project funded by USAID under the Tanzania Feed the Future (FtF) Initiative implemented by ACDI-VOCA. It integrates agricultural, gender, environment and nutritional development efforts to improve smallholder farmer productivity and profitability within the maize and rice value chains in Morogoro (Kilombero and Mvomero Districts), Dodoma (Kongwa District) and Manyara (Kiteto District). NAFAKA's goal is to sustainably reduce poverty and food insecurity by increasing incomes for smallholder farmers, including men, women and youth. Overall, the objectives of NAFAKA include:

- Improving the competitiveness and productivity of maize and rice value chains
- Facilitating improved domestic and regional trade

- Expanding the depth and breadth of benefits from the growth of the maize and rice subsectors, including increased benefits to women and youth

- Enhancing rural household nutrition by promoting women-focused value chain development and improved consumption of a quality diet

7.2.3. Africa RISING

As part of the US government's Feed the Future initiative to address global hunger and food security issues in sub-Saharan Africa, the US Agency for International Development (USAID) is supporting three multi-stakeholder agricultural research projects to sustainably intensify key African farming systems. The overall aim of Africa RISING is to transform agricultural systems through sustainable intensification projects in three regions of Africa (West Africa, Ethiopian Highlands, and East and Southern Africa). The research is being led by CGIAR centres and implemented with partners. The specific objectives include:

- Sustainable Intensification of Cereal-based Farming Systems in the Guinea Savannah Zone of West Africa – led by the International Institute of Tropical Agriculture (IITA)

- Sustainable intensification of crop-livestock systems to improve food security and farm income diversification in the Ethiopian highlands – led by the International Livestock Research Institute (ILRI)

- Sustainable Intensification of Cereal-based Farming Systems in East and Southern Africa – led by IITA

- In Tanzania, the Africa RISING project and the Babati District Council in Manyara Region have launched the Babati District Research for Development (R4D) platform to facilitate the uptake of the project's innovations in the district. Babati District in Northern Tanzania is one of the three districts the project is working. The platform will help in setting priorities for the research and ensure sustainability of the project.

7.3.SAGCOT zone

The Southern Agricultural Growth Corridor covers approximately one-third of mainland Tanzania. It extends north and south of the central rail, road and power 'backbone' that runs from Dar es Salaam to the northern areas of Zambia and Malawi (Figure 6.2).

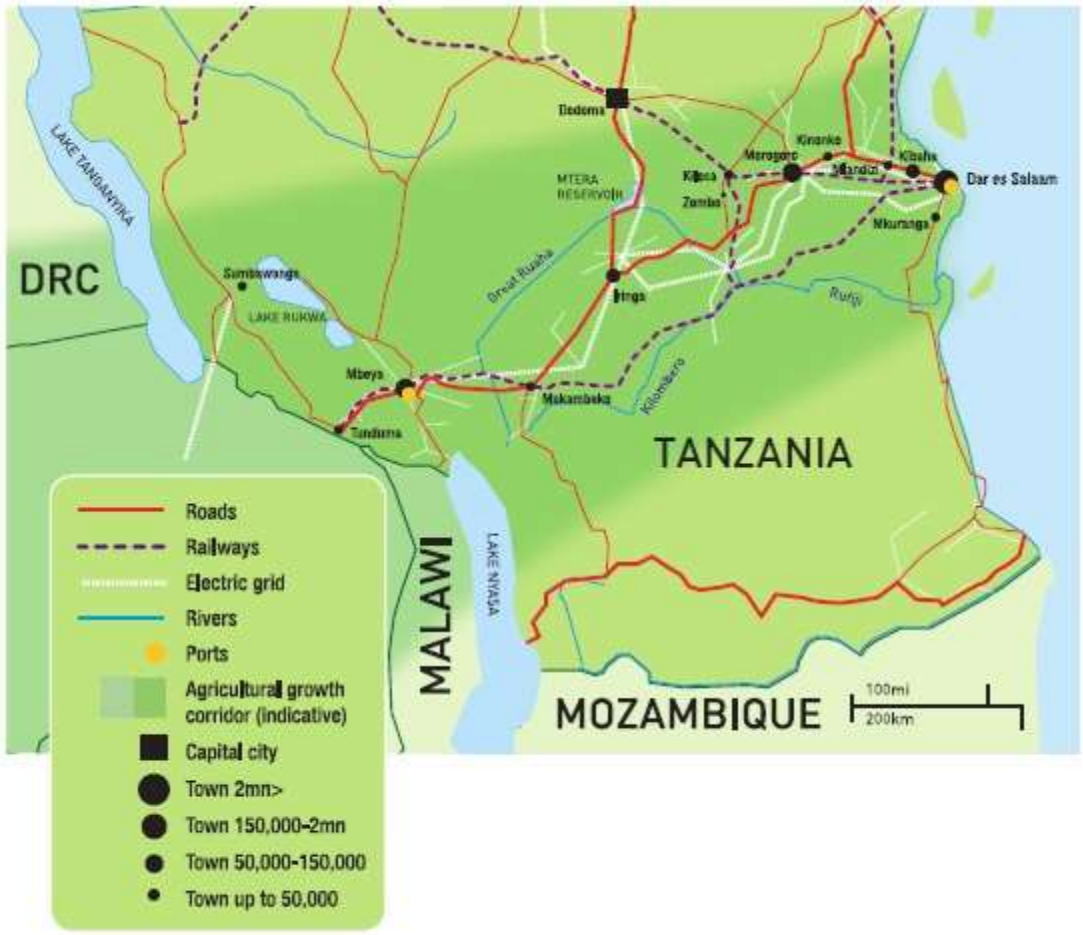

Figure 6.2. The Southern Agricultural Growth Corridor of Tanzania (SAGCOT).

The Southern Agricultural Growth Corridor of Tanzania (SAGCOT) is an agricultural partnership designed to improve agricultural productivity, food security and livelihoods in Tanzania. SAGCOT has the potential to make a serious and significant impact by bringing together government, business, donor partners and the farming community to pool resources and work together towards a common goal.

8. NEXT STEPS FOR THE PROJECT

This discussion paper is intended to provide the basis for consultation with stakeholders comprised of the Government of Tanzania, scientists, researchers, practitioners and implementers, including farmers. This paper proposes a number of research gaps and opportunities based on past and current research and the lessons learned from past and on-going projects in small scale irrigation. The project seeks stakeholder input on identifying the most promising small scale irrigation options that require further research toward establishing research interventions at field level in Tanzania.

The project stakes a continuous dialogue approach to research interventions in regards to field-level piloting of promising small scale irrigation technologies and practices, as well as modelling of potential economic and biophysical opportunities, constraints and sustainability. The stakeholder consultation is also the basis for identifying collaboration and partnership opportunities to implement the research in Tanzania.

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