

**THE UNITED REPUBLIC OF TANZANIA
MINISTRY OF WATER AND IRRIGATION
NATIONAL IRRIGATION COMMISSION**

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**Proceedings of the Workshop on
“New Directions for Irrigation Development in Tanzania: The
Context of Public Private Partnership”**

Friday, 2 September, 2016

PROTEA Hotel Courtyard Dar Es Salaam on Seaview Ocean Road,
Dar Es Salaam 1000, Tanzania

Organizers:

National Irrigation Commission,
International Food Policy Research Institute,
Manchester University,
with support from the DFID-ESRC Growth Research Programme



Research jointly supported by the ESRC and DFID

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• <i>UNFULFILLED POTENTIAL: IRRIGATION AND SMALL FARMERS- 2 CASE STUDIES FROM TANZANIA:</i> Dr Anna Mdee	

BACKGROUND AND OBJECTIVES

Background

Irrigation is important in Tanzania to deal with the erratic rainfall, especially in the context of climate change. Irrigation can minimize frequent food shortages that are attributable to dependence on rainfall, and increase yields. However, to do this effectively requires a range of infrastructure that will provide for a wide range of crops and efficient water use. Recognizing this need, the government of Tanzania has made ambitious commitments to expand the area irrigated, and set up the National Irrigation Commission (NIC) to deliver on this potential. The NIC strategy currently being developed identifies Public-Private Partnerships (PPPs) as important, but seeks advice on appropriate models of PPP. Research studies supported by DFID-ESRC Growth Research Programme have been examining different modes of irrigation development in Tanzania. This workshop provided an opportunity to bring research and policy together to advance irrigation development in Tanzania.

Workshop objectives:

- i. Review recent trends and goals for irrigation development in Tanzania.
- ii. Examine alternative paths for irrigation investment by government and private sector, including smallholder producers, and their potential for further development.
 - Research findings on public-private partnerships (PPPs) and small-scale irrigation development, and remaining information gaps and data issues.
- iii. Identify social and economic impacts of irrigation development in rural communities
 - Methodologies to assess how different paths for irrigation development generate opportunities and constraints for rural people to benefit from irrigation, and
 - How these differ for different social groups (men, women, youth).
- iv. Explore the role of irrigation policy in fostering PPP.
 - What models do we have for supporting, regulating and investing in irrigation?
 - What policy alternatives need to be considered to respond to different irrigation scenarios?

Presentations focus primarily on the Tanzanian context but also draw on experience and contemporary developments in other countries.

AGENDA

TIMING	EVENT/TOPIC	RESPONSIBLE PERSON/SPEAKER
8:30am – 9:00am	Registration	All participants
9:00am – 9:15am	Welcome and Introduction to the Workshop Objectives	Speaker: Eng. January Kayumbe
9:15am – 9:30am	Officiating Remarks	Eng. Dr. Eliakim C. Matekere, Acting Director General, National Irrigation Commission
9:30am – 10:15am	Overview of Irrigation Policy in Tanzania: Objectives and Key Questions (25 minutes presentation followed by 20 minutes discussions of key challenges to be addressed)	Presenter: Dr. Joachim Makoi Ministry of Water and Irrigation/ National Irrigation Commission Representative Facilitator: Bahati Rukiko
10:15 – 10:30am	Break	All participants
10:30am – 11:15am	Presentation: “Assessing Models of Public Private Partnership: What have we learned?” (25 minutes presentation, 20 minutes discussion)	Presenter: Dr. Ruth Meinzen-Dick, Dr. Faustin Maganga, AMPPPIDA project Facilitator: Bahati Rukiko
11:15am – 12:00pm	Presentation: “Farmer-led Irrigation: re-framing agricultural investment?” (25 minutes presentation, 20 minutes discussion)	Presenter: Dr. Hans Komakech, SAFI research project Facilitator: Dr. Mosses Mnzava
12:00pm – 13:00pm	Lunch Break	All participants
13:00pm – 13:45pm	Presentation: “Competing demands for irrigation water: challenges for PPPs” (25 minutes presentation, 20 minutes discussion)	Presenter: Dr. Anna Mdee, ODI Facilitator: Eng. Jaivi Lukuta
13:45pm – 14:30pm	Working groups to discuss implications for Irrigation Policy in Tanzania (Guiding questions)	All participants Facilitator: Steve Wiggins
14:30pm – 15:00pm	Break	All participants
15:00pm – 16:00pm	Working groups to discuss implications for Irrigation Policy in Tanzania (Guiding questions)	All participants Facilitator: Steve Wiggins
16:00pm – 16:45pm	Presentation of working group outcomes and discussion	Working groups Facilitator: Steve Wiggins
16:45pm – 17:00pm	Next steps and closing	Facilitator: Bahati Rukiko
17:00pm – 18:00pm	Reception	All participants Facilitator: Eng. Jaivi Lukuta

SUMMARY OF PRESENTATIONS AND DISCUSSION

Welcome: Eng. January Kayumbe, Director of Big Results Now, Ministry of Agriculture Livestock and Fisheries provided the Welcome and Introduction to the Workshop Objectives

Opening: Dr. Dr. Eliakim Chitutu Matekere formally opened the workshop, noting that irrigation offers great potential for food and nutrition security, and climate resilience. Development of irrigation gives unprecedented opportunity to transform agriculture from subsistence to commercial orientation. Tanzania's irrigated area is far below the potential, and the government is committed to expanding irrigation. However, mobilizing the financial, technical, and managerial resources is a serious challenge. The government alone cannot provide all that is needed. The National Irrigation Policy and National Irrigation Act of 2013 provide for cooperation between the National Irrigation Commission (NIC) and private sector, but this is relatively new and needs careful fostering. The outcome of this workshop to contribute to furthering this ambition of irrigation development, through presentation and discussion of research on irrigation in Tanzania and elsewhere.

Objectives and Key Questions presented by Dr. Joachim HJR Makoi, National Irrigation Commission

This presentation provided a solid basis for the day's discussions, by reviewing the background of irrigation in Tanzania, providing an overview of national irrigation policy (NIP), and identifying key questions for the workshop. The National Irrigation Master Plan (NIMP) in 2002 identified a total irrigation development potential of 29.4 million ha, of which 2.3 million ha are classified as high potential; 4.8 million ha as medium potential; and 22.3 million ha as low potential. However, as of June 2014 only 1.5 percent of the potential area had been developed. The National Irrigation Policy of 2010 was developed to respond to the need from NIMP and other government policies, plans, strategies, goals etc., provide a baseline for a focused development of the irrigation sector in Tanzania, direct development of irrigation issues in the irrigation sector which was thinly addressed by other sector policies, and cover interventions required for the sector to effectively contribute towards enhancement of production and productivity in the agriculture sector. This was followed by the National Irrigation Act no 5 of 2013, Irrigation Regulations of 2013, the setting up of the National Irrigation Commission in 2014, and the National Irrigation Strategy 2015. The presentation reviews the key elements of the National Irrigation Policy, with particular reference to the roles identified for local government, the private sector, and NGOs. Key challenges are in the areas of finance for irrigation (especially large dams and infrastructure), availability of land and water for irrigation development, and capacity building, especially as many NIC staff is scheduled to retire in the next 5 years.

The discussion clarified the role of traditional furrows and other irrigation in the official statistics (as unimproved irrigation). Strategies to deliver on the ambitious targets include PPP arrangements as well as dialogue with government to invest in irrigation, including formulation of a ring-fenced National Irrigation Fund. Some basins have plenty of water, because there has not been much development of irrigation and other water uses, but there are serious water constraints in other basins. Even where there is plenty of water, dams are usually needed to have water in dry season, and there are other sectors (e.g. hydropower) that use dams, so conflict between sectors. Groundwater has not been very much exploited.

Assessing Models of Public Private Partnership: What have we learned?

Presented by Dr. Ruth Meinzen-Dick, International Food Policy Research Institute and Dr. Faustin Maganga, Institute of Resource Assessment, University of Dar Es Salaam

The presentation of the AMPPPIDA project (<https://www.ifpri.org/project/assessing-models-public-private-partnerships-irrigation-development-africa-ampppida>) in Tanzania and Ghana noted that public-private partnerships (PPPs) for irrigation are becoming a widely accepted model for financing irrigation, supported by the World Bank, IFC, ADB and directly by governments. The objectives are often to reduce government budget outlays for irrigation, bring in technical know-how on agro-processing, increase national food security, develop agricultural export sector. However there is generally little knowledge of extent to which objectives are met, who wins and loses, and how to ensure that PPPs help local populations. It is useful to think of PPPP: Public, Private, Producer Partnerships to recognize the role of (small-scale) producers who can be a potential source of investment.

The research study conducted stakeholder net mapping of Kilombero Plantations Ltd, Madibira, and Kilombero Sugar Company. The case studies identified that there are many actors involved in PPPs, beyond the simple categories of government, private sector, and (smallholder) farmers. The AMPPPIDA project has developed a framework for assessing the role of many different actors—including various government agencies, private sector firms, NGOs, development partners, research organizations, and smallholder farmer cooperatives or associations (see PowerPoint presentation). This framework may be useful for planning and creating greater clarity in expectations on PPPs.

Discussion focused on the types of risks involved, how these are distributed between different parties in PPPPs, and what key risks might make investors (including smallholder farmers themselves) shy away from irrigation. While PPP arrangements are complex, there is a need for practical diagnostic tools to guide public sector action. Not all should be expected to be perfect right away. Benefits will change over time. What is important is to build in a learning process and dialogue among the key stakeholders—government, private firms, and farmers.

Farmer-led Irrigation: re-framing agricultural investment? Presented by Dr. Hans Komakech, Nelson Mandela University

The presentation reported on emerging findings of the SAFI project (www.safi-research.org). The project is investigating ‘farmer-led’ irrigation development – understood as processes whereby farmers’ drive improvement in their water-use for agriculture by changes in technology use, investment patterns, or in the governance of land and water. While farmers will commonly interact with a range of public and private sector agencies in pursuing their drive to develop irrigation, the presentation drew on case studies in Tanzania and Mozambique to highlight the role of farmers as significant investors in irrigation development, often demonstrating technical awareness and innovation in their use of technology. Farmers’ investment in irrigation was highly responsive to market conditions, producing commercial crops on areas that may total thousands of hectares in any given region. The cases indicate that farmers do not need formal land titles to invest in irrigation, but it seems likely that irrigation development will have profound social and economic consequences, which are as yet poorly understood.

Data presented on crop yield levels and water use in such systems challenged the view that farmer-led irrigation is unproductive or inefficient. The presentation further argued that neglect of this dynamic aspect of irrigation development risks ignoring a cost-effective route to achieving the rapid increase in irrigation that many African governments seek. From a PPP perspective, farmers therefore need to be considered an active element of private sector investment in irrigation. As well as generating a series of case studies of farmer-led irrigation, the SAFI project aims to understand how public and private sector agencies engage with the

phenomenon. The presentation ended with a summary of the potential responses such agencies may make, ranging from engaging to support and replicate farmers' initiatives to efforts to shut them down. The discussion addressed the variety of conditions that would determine which response would be adopted in specific contexts.

The discussion noted that this type of irrigation is currently overlooked in policy; in many cases the government does not even know where these systems are. The National Irrigation Act of 2013 gives National Irrigation Commission a mandate to register all irrigators in the country and to maintain that register, including individual irrigators. Including them will increase the acreage under irrigation. One of the major problems of irrigation in Tanzania is access to land. In the case of farmer-led irrigation the irrigators already have access to land (even if not formal titles), so this type of irrigation development may be easier to promote than large-scale systems with external investors. Government could assist these farmers, e.g. through extension, technical assistance, inputs, marketing, or transport. Policy needs to consider how such irrigation fits within catchment areas.

Competing demands for irrigation water: challenges for PPPs presented by Dr. Anna Mdee, Overseas Development Institute.

In this presentation two cases from Tanzania were used to examine the implications of scale in PPP and the need for a stronger strategic role to be taken by public agencies in the political process of resolving competing priorities in water use. The 2000ha Dakawa paddy rice irrigation scheme near Dodoma has been the object of repeated rehabilitation since its inception. Despite high levels of investment from international donors, the scheme suffers from high pumping costs and inadequate water supply from the Wami River. In contrast, farmers who use very effective small-scale irrigation to grow a profitable strawberry crop in the Uluguru Mountains have been threatened with eviction by the Morogoro Municipal Council, who sees them as a threat to the city's water supply. The cases illustrated the problems of water governance. In particular, that the Wami - Ruvu River Basin Office had an excellent understanding of the challenges but no capacity to monitor actual water use. This contributes to a situation where, in Dakawa, it has little ability to regulate upstream water use and secure the scheme's water supply. Conversely, it appears unable to provide individual permits to the many small-scale irrigators in the Ulugurus and enable them to operate legally. The presentation ended by emphasizing the diversity of irrigation contexts and the consequent challenges to a narrow model of PPP. Rather, it argued, the public sector needs to have strategic oversight of water allocation and to engage with the politics of competing water use.

In the discussion it was noted that the Water Resources Act doesn't prohibit individual users from getting a water permit, but they have to apply for a permit and pay. The local understanding was that they had to be in water user associations (WUAs), and farmers didn't want to be in a WUA because they had been operating individually. If their contributions to ecosystem services were recognized, Uluguru irrigators might be eligible for payment for ecosystem services, rather than being evicted or asked to pay for water. Dakawa might be better if got energy-efficient pumps, but need to look at whole basin water use, evaluate tradeoffs between using water in Dakawa and elsewhere, and determine what the best for economic growth and poverty reduction is.

WORKING GROUPS

Following on from the opening presentation of key questions for irrigation policy in Tanzania, working groups addressed the issues and recommendations for:

1. Financing Irrigation Development
2. Land and Water for Irrigation Development
3. Capacity Building for Irrigation Development

Group 1: Financing Irrigation Development

Issue	Recommendation
Low government financing for irrigation	<ul style="list-style-type: none"> • Government should show political will to fund and operationalize the Irrigation Development Fund • Explore mechanisms for funding that are ring-fenced for irrigation • Work with private sector and farmers to increase investment in medium and small scale irrigation • Examine other cases for possible applicability to Tanzania, e.g. <ul style="list-style-type: none"> ○ Kenya's Water Services Trust Fund ○ Malawi distributing irrigation investment funds districts, so that district irrigation engineers identify ways to invest in particular areas, identify bottlenecks, and address particular issues
Low financing available from banks for irrigation	<ul style="list-style-type: none"> • Identify why banks are reluctant to loan for irrigation (including timing and questionable profitability of irrigation) • Explore possible credit guarantee schemes • Capacity building of financial institutions and of prospective irrigators on how to develop business plans, and irrigators on managing credit • Assist farmer's organizations to develop savings programs for irrigation through credit and savings groups • Increase farmers' access to Tanzania Development Bank (TDB) • Investigate applicability of lessons from other countries, e.g. <ul style="list-style-type: none"> ○ India's NABARD in increasing financing for agriculture and irrigation (https://www.nabard.org/english) ○ In Kenya, technology providers put up savings schemes, e.g. save up 40-60% and then get irrigation equipment on credit for balance
Low private sector interest in irrigation	<ul style="list-style-type: none"> • The government has to share risks with private investors • Reduce taxation especially on importation of irrigation equipment in order to attract private investors (small and large scale) • Give clear order for customs clearances • Provide access to land for investors • Government to provide complementary infrastructure (e.g. roads) • Concessional power tariffs/subsidies
No clear modality on how government and private sector work together	<ul style="list-style-type: none"> • NIC to prepare and implement the private sector engagement strategy. • Create transparency on the roles, responsibilities, risk and rewards of all actors/stakeholders in irrigation development (especially PPPs) • Identify financing (and technical assistance) needs of smallholders so they can invest <ul style="list-style-type: none"> ○ As outgrowers on large-scale PPPs ○ In farmer-led systems

Group 2: Land and Water for Irrigation Development

Issue	Recommendation
<p>Improve technical knowledge about the resource base - for example, USAID was planning to support 4 sites in the upstream area of Kilombero valley, but the main limitation was soil suitability, only on site had suitable soils for basin rice and passed the economic test</p>	<ul style="list-style-type: none"> • Mapping status of available land, soil and water resources • Mapping the percentage of general, village and conserved land – it is more difficult to access village and conserved land. To develop a scheme, Village Land has to be recognized with certificates of customary rights of occupancy, which requires a land use plan and village lands to be certified. • Identify suitability of land and water for irrigation • Identify the market for land and water resources
<p>Address governance issues related to land and water use</p>	<ul style="list-style-type: none"> • Clarify laws and regulations related to land and water resources • Promote women's access to land and water resources
<p>Resolve competing claims to land and water rights</p>	<ul style="list-style-type: none"> • Promote legitimacy of claims to land and water resources by harmonizing long standing claims and statutory claims • Promote negotiated approach to clarify formal/informal access to land and water resources • Identify and mediate between competing needs for land and water resources – whose needs should be prioritized, and which sector? • Promote upstream/downstream collaboration through e.g. the river basin game (see ftp://ftp.fao.org/agl/emailconf/wfe2005/Lankford_river_basin_game.pdf and https://www.youtube.com/watch?v=fjFa_NEXVlc) • Compensate upstream resource users through e.g. payment for ecosystem services. • Promote technologies to save water and to allow more use

Group 3 - Capacity Building for Irrigation Development

Capacity building is required for:

1. Ministry of Water & Irrigation and National Irrigation Commission
2. Local Government (LGAs)
3. Farmers (Irrigation organizations)
4. Financiers (Banks etc.)

INSTITUTE	ISSUE	PROPOSAL
MoWI & NIC	NIC staff lack skills on negotiations and facilitation on PPP	Training on PPP negotiating skills
	Most experts are at retirement age	Share of knowledge and experience between graduates and those close to retirement at Ministry and District level
	Lack of experts on certain departments such as IT and Legal	HR strategy on how to recruit effectively
		Promote inter-ministerial work with farmers organizations
LGAs	Extension workers do not have the skills on irrigation	Extension workers should be trained in fundamentals of irrigation
	Irrigation engineers need communication and diagnosis skills	Irrigation engineers should be trained in and communication and social skills to enable them to be more effective when dealing with farmers
	Skills on facilitation and negotiations on PPP	There should be emphasis on district officials/engineers to use the irrigation guidelines (set by the NIC). The Irrigation Guidelines include information on water management, O&M, finance management etc.
Farmers	Farmers lack training on: <ul style="list-style-type: none"> - modern agricultural practices - finance - marketing - water management - maintenance of existing irrigation infrastructure 	Training on irrigation management, governance, financial literacy, irrigated farming practices and marketing.
Financiers	Financiers need to create products that suit farmers.	Work with financial institutions to create financial products that include: <ul style="list-style-type: none"> - Timely disbursement of funds - Realistic repayment schedules that account for irrigated production cycles

ANNEX 1: PARTICIPANTS

S/N	Name	Institution
1	Ms. Neema Ndikumwami	2030 Water Resources Group
2	Eng. January Kayumbe	Big Results Now, Ministry of Agriculture Livestock and Fisheries
3	Dr. Ruth Meinzen-Dick	International Food Policy Research Institute
4	Stephen Mooney	DFID
5	Mwombeki Baregu	Financial Sector Deepening Trust
6	Angela Manjichi	ISPM, Mozambique
7	Eng. Fares Mahuha	MALF
8	Dr. George Lugomela	Ministry of Water & Irrigation
9	Bahati J. Rukiko	National Irrigation Commission
10	Dr. Eliakim Chitutu Matekere	National Irrigation Commission
11	Dr. Mosses Mnzava	National Irrigation Commission
12	Ms. Zukheri Huddy	National Irrigation Commission
13	Eng. Amy Mchelle	National Irrigation Commission
14	Dr. Joackim Makoi	National Irrigation Commission
15	Eng. Jaivi Lukuta	National Irrigation Commission
16	Dr. Hans Komakech	Nelson Mandela University-AIST
17	Dr. Anna Mdee	Overseas Development Institute
18	Steve Wiggins	Overseas Development Institute
19	John Mboya	PMORALG
20	Justine Liberio Joseph	President's Delivery Bureau
21	Dr. Faustin Maganga	University of Dar Es Salaam
22	Philip Woodhouse	University of Manchester
23	Gert Jan Veldwisch	University of Wageningen
24	Gene Peuse	USAID
25	Caroline Chema	World Bank

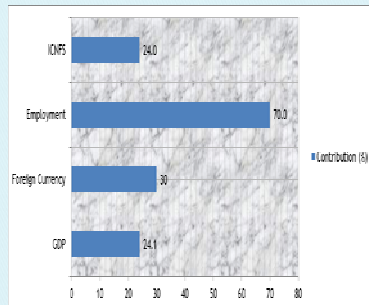
Overview of Irrigation Policy in Tanzania: Objectives and Key Questions

Workshop:
2 Sept 2016, At PROTEA Hotel Courtyard, on Sea View
Ocean Road, Dar es Salaam 1000, Tanzania

Dr. Joachim H.J.R. Makoi
Email: joachimmakoi@yahoo.com

Outline

- Background of Irrigation in Tanzania
- Overview of National Irrigation Policy (NIP) in Tanzania
- Key Questions



- Provides employment
- Contributes to Foreign Currency
- Contributes to GDP
- Irrigated Agric. contributes to National Food Requirements

Fig.1: Importance of Agriculture and Irrigation in TZA (ICNFS: Irrigation Contribution to National Food Requirements). Source: NAP (2013)

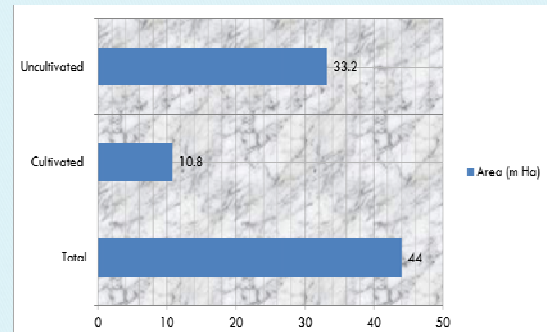


Fig.2a: Land Area (m Ha) under cultivation (NAP, 2013)

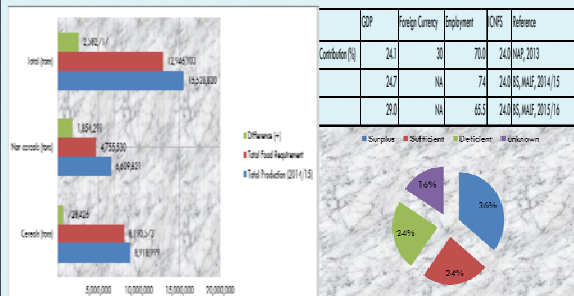


Fig 2b: Agriculture performance in TZA (Budget Speech, 2016/17)

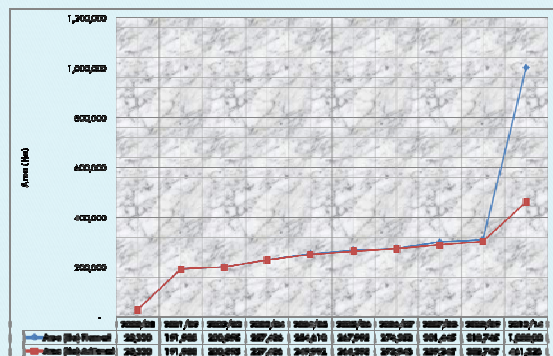
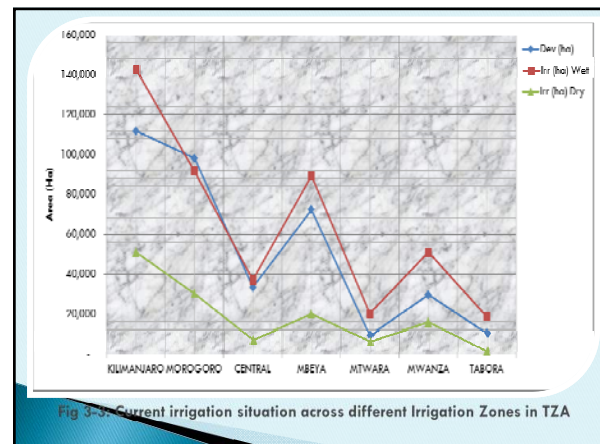
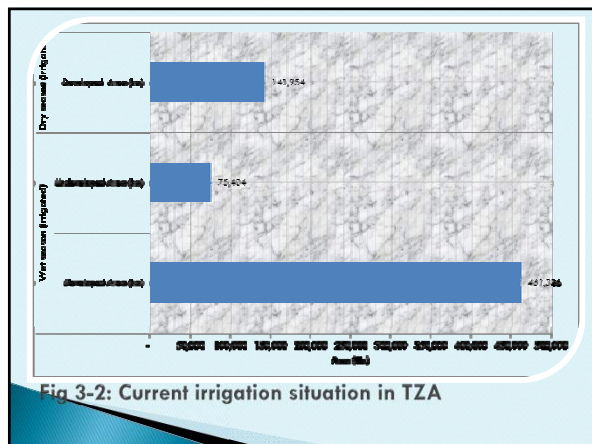


Fig.3-1: Irrigation Development in Tanzania (2000/01 – 2013/14): Source: (NIP, 2010)

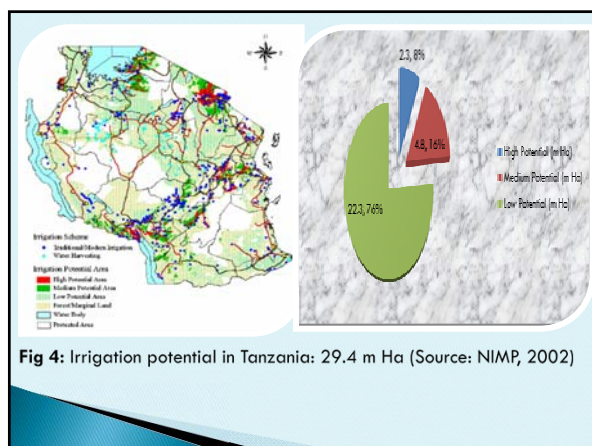


3. Why Irrigation Development?

- Agriculture in TZA has remained unpredictable and of low productivity due to erratic and unreliable rainfall as a result of increasing global warming (GW) & climate change (CC)
- To cut off R/fall dependency and minimize frequent food shortages.
- Ensure a wide coverage of irrigation infrastructure in the identified potential area for wide range of crops.
- There is a need to improve irrigation infrastructure for efficient water utilization to overcome the negative impacts of GW & CC.
- The yields are 3 to 4-fold compared with rainfed

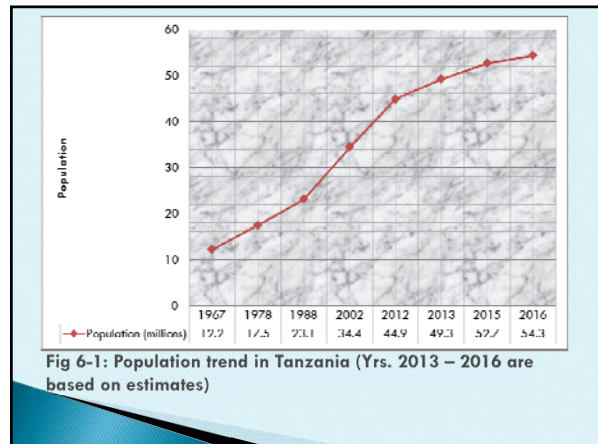
3. Opportunities for Irrigation Development in TZA

- ❑ The NIMP has identified potential area for irrigation development as 29.4 m Ha (Fig 4).
- ❑ There is high potential of surface as well as ground water resources in nine water basins namely: **Rufiji, Pangani, Ruvuma, Wami/Ruvu, Internal Drainage, Lake Rukwa, Lake Nyasa, Lake Tanganyika and Lake Victoria** (Fig 5)
- ❑ These basins hold all the surface and groundwater in the country for all uses of water including irrigation.



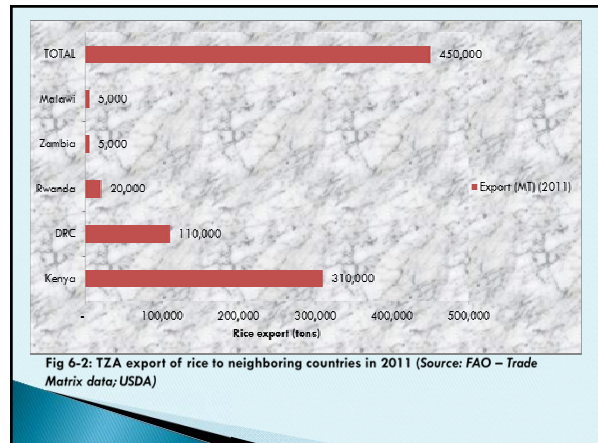
3. Opportunities for Irrigation Development in TZA cont.....

- ❑ There is a great opportunity for market of produced crops through irrigated agriculture within and outside the country.
- ❑ Population growth trend and change of eating habit towards rice consumption requires more water to grow crops (Fig. 6)



3. Opportunities for Irrigation Development in TZA cont.....

- ❑ Tanzania's is strategically located for export outlets and there is a potential demand for irrigated crops especially rice from EAC and beyond (Fig 6-2)
- ❑ Existence of the institutional set up with qualified personnel of different disciplines related to irrigation. However, the number of personnel is inadequate.
- ❑ The Government is now giving high priority to irrigation development and Water Resources Management which offers strong synergies with irrigation development.



2. Why National Irrigation Policy

- ❑ Respond to the need from NIMP and other Government Policies, Plans, Strategies, Goals etc.,
- ❑ Provide a baseline for a focused development of the irrigation sector in Tanzania,
- ❑ Direct development of irrigation issues in the irrigation sector which was thinly addressed by other sector policies,
- ❑ To cover interventions required for the sector to effectively contribute towards enhancement of production and productivity in the agriculture sector,
- ❑ There is evident increase in food insecurity and prices in and outside Tanzania

4. Other Government Policies, Plans, Strategies etc

- ❑ They include:
 - National Irrigation Development Plan (NIDP) (1994)
 - Agricultural and Livestock Policy (1997)
 - Tanzania Development Vision (TDV-2025) (2000),
 - Agricultural Sector Development Strategy (ASDS) (2001),
 - Rural Development Strategy (RDS) (2001)

4. Other Government Policies, Plans, Strategies etc cont...

- Millennium Development Goals (MDGs) (2002),
- National Irrigation Master Plan (NIMP) (2002),
- National Water Policy (NAWAPO) (2002),
- National Strategy for Growth and Reduction of Poverty (NSGRP-MKUKUTA) (2005)

5. How was NIP formed?

- ❑ The NIP was formulated in a participatory manner involving stakeholders' representatives including:
 - ❑ Farmers,
 - ❑ LGAs,
 - ❑ Government Ministries,
 - ❑ Government Institutions,
 - ❑ NGOs,
 - ❑ Private Sector (PS) through Stakeholders' consultative meetings and workshops.
- ❑ The Cabinet approved the NIP on 18th Feb 2010 after a thorough review and consideration.



Fig. 7: The genesis and outcomes of NIP

6. Policy Coverage

- ❑ Background of irrigation development,
- ❑ Challenges facing irrigation development,
- ❑ Opportunities available for Irrigation development for agriculture and rationale for having the NIP,
- ❑ The Vision, Mission and Objectives,
- ❑ Key issues impairing irrigation development in the country,
- ❑ The Institutional Arrangement for Policy Implementation,
- ❑ The Legal and Regulatory Framework,
- ❑ Coordination, Monitoring and Evaluation.

7. Tools for guidance and enforcement in the implementation of the NIP

- ❑ National Irrigation Development Strategy (NIDS)
- ❑ National Irrigation Strategy (2015)
- ❑ Legal and Regulatory Frameworks for Irrigation
- ❑ The National Irrigation Act (NIA), 2013 (which provides for the establishment of the NIC and NIF)

8. Who will implement the NIP?

- All stakeholders (as in Sect 5) with the LGAs taking the largest stake on implementation on the ground,
- Ministry Responsible for Irrigation (MoWI),
- The National Irrigation Commission (NIC),
- Private Sector (PS),
- Financial Institutions (FIs)

9. Vision

- ❑ A sustainable and dynamic irrigation sector that is a driving force in transforming agriculture into a stable, highly productive, modernised, commercial, competitive and diversified sector which generates higher incomes; increases food security and stimulates economic growth.

10. The Mission

- ❑ To facilitate a participatory demand driven irrigation development through Integrated Water Resources Management to enhance WUE for increased and sustainable agricultural production, productivity and profitability to ensure food security, poverty reduction, and national economic development.

11. Main Objective

- ❑ The main objective 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.

12. Specific Objectives

- ❑ To accelerate investment in the irrigation sector by both Public and Private Sector players,
- ❑ To ensure that Irrigation Development Funds are established with a legal status,
- ❑ To promote efficient water use in irrigation systems,
- ❑ To abide by the Integrated Water Resources Management approach in irrigation development,
- ❑ To ensure that irrigation development is technically feasible, economically viable, socially desirable and environmentally sustainable,

Specific Objectives cont.....

- ❑ To ensure reliable water for irrigation so as to facilitate optimization, intensification and diversification of irrigated crop production including pasture and aquaculture,
- ❑ To ensure demand driven, productive and profitable irrigation development models that are responsive to market opportunities,
- ❑ To strengthen institutional capacity at all levels for the planning, implementation and management of irrigation development,

Specific Objectives cont.....

- ❑ To empower beneficiaries for effective participation at all levels in irrigation planning, implementation, operation and management;
- ❑ To strengthen research undertakings, technical support services, development and dissemination of new practices, innovations and technologies on irrigation and drainage; and
- ❑ To mainstream cross cutting and cross sectoral issues such as gender, HIV/AIDS, environment, health, land and water in irrigation development.

Table 1: NIP and Institutional Capacity

Issue	Objective	Policy Statement
Private Sector <ul style="list-style-type: none"> The participation of Private Sector in overall irrigation development in Tanzania is very low and their capacity to provide such services is limited. On the other hand, the private sector has been sceptical in investing in large scale commercial farming due to high initial capital investment requirement for irrigation infrastructure, doubt on the security to the right on land ownership and reliable water use permit. The challenges with respect to this sector include attraction and engagement of the private sector as investors (in both service delivery and large scale commercial irrigated farming), and the nature of partnership arrangements for PPPs in irrigation development 	To have an effective participation of the Private Sector in irrigation interventions	In order to achieve the above objective, the Government will: <ul style="list-style-type: none"> Continue to dialogue with the private sector on matters related to irrigation development in Tanzania; Create an enabling environment for effective private sector participation in irrigation development; and Ensure establishment and updating of irrigation databank in collaboration with Tanzania Investment Centre for potential investors.

Table 2: NIP and Institutional Capacity

Non-Governmental Organizations (NGOs)		
<ul style="list-style-type: none"> A number of NGOs are already active in Tanzania's irrigation sector. The operations of the majority of these NGOs are financed by a range of sources including the Government and its Development Partners. However, they have no necessary capacity or technical competence in irrigation interventions and the range of their areas of operation are not well known by the beneficiaries. 	To have effective participation of NGOs in the irrigation sector without compromising the quality of end results of the irrigation interventions.	In order to achieve the above objective, the Government will: <ul style="list-style-type: none"> continue to facilitate registration and establishment of an effective coordination mechanism of NGOs that are interested in irrigation interventions; ensure that NGOs work in close collaboration with LGAs in the implementation and backstopping matters related to irrigation development; Ensure that districts support services demonstrated by NGOs in irrigation interventions; and Ensure that NGOs are performing to the required standards when dealing with irrigation interventions.

Conclusion

- National Irrigation Policy (NIP) provides a solid platform for Public Private Partnership (PPP) in Irrigation Development in Tanzania
- Based on NIP, Private Sector and Development Partners can work with or support the NIC in Irrigation Development in Tanzania

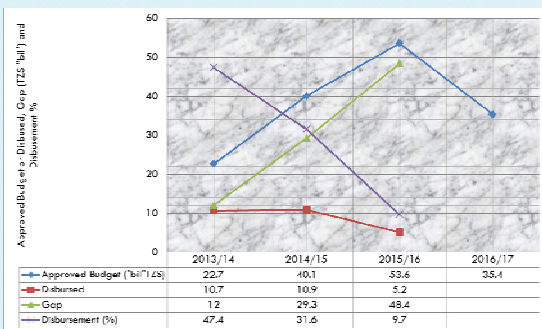


Fig. 8: Approved vs Disbursed Budget and Associated Gap



Key Questions

- Financing Irrigation and Drainage Development, Large Dams as Climate Resilient Infrastructures
- Land Availability for Irrigation Development
- Capacity Building for NIC and IOs

THANK YOU
FOR YOUR ATTENTION

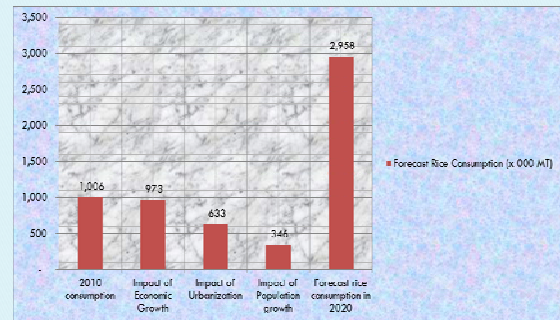


Fig 10: Forecasted rice consumption [\'000\' MT]. Assumes economic growth continues at 7 % p. a, urbanization at 5 %, and population growth at 3 %.
Source: USDA; National Bureau of Statistics Tanzania, 2010

Assessing Models of Public-Private Partnership for Irrigation Development in Tanzania

Ruth Meinzen-Dick
Faustin Maganga

Workshop on "New Directions for Irrigation in Tanzania: The Context of Public Private Partnership"
Dar Es Salaam, Tanzania
2 September 2016

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Assessing Models of Public Private Partnerships for Irrigation Development in Africa (AMPPPIDA)

- Collaborative project of
 - International Food Policy Research Institute
 - Institute of Resource Assessment, University of Dar Es Salaam
 - Tanzania Ministry of Agriculture Livestock and Fisheries
 - Institute of Development Studies, University of Ghana
 - Ghana Irrigation Development Authority
- Funded by Dfid/ESRC

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Public Private Partnerships (PPPs) for Irrigation

- PPPs for irrigation becoming widely accepted model for financing irrigation, supported by the World Bank, IFC, ADB and directly by governments
- PPPs in use for a long time in other sectors: energy (power plant), transportation (toll roads), water supply (utilities); less in irrigation
- "Classic" models
 - BOT: Build, Operate, Transfer
 - BOO: Build, Own, Operate
 - Plantation/Core Estate/Outgrower schemes
- Broader sets of models are possible

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Objectives of PPPs

- Reduce Government budget outlays for irrigation O&M and sometimes investment (plays a role in all cases)
- By-pass laws that do not allow the Government to charge for ISF (e.g. irrigation PPP in Morocco)
- Bring in technical know-how on agro-processing, increase national food security, develop agricultural export sector (e.g. irrigation + rice processing in SAGCOT area, Tanzania)
- Develop a new irrigation system (e.g. WB project in Ethiopia, French company, proposed ISF: US\$150/ha)
- Expanding area, increasing efficiency and profitability, including smart water meters (e.g. Bangladesh, but here govt. reimburses private operator)

Little knowledge of extent to which objectives are met, who wins and loses, how to ensure that PPP do not leave local populations worse off

- Case studies in Ghana and Tanzania

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Framework for Assessment of PPP

Balancing risks and responsibilities

Activity	Government	Firms	Farmers
Authorization			
Planning			
Financing			
System construction			
System operation			
System maintenance			
On-farm construction			
Technical advice			
Production			
Processing			
Marketing			
Risks assumed			
Benefits assumed			

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Framework for Assessment of PPP

Balancing risks and responsibilities

Activity	Government	Firms	Farmers
Authorization			
Planning			
Financing			
System construction			
System operation			
System maintenance			
On-farm construction			
Technical advice			
Production			
Processing			
Marketing			
Risks assumed			
Benefits assumed			

Definition of PPPs:
Requires **sharing of risks**
Other arrangements are "outsourcing"

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PPPP: Public, Private, **Producer** Partnerships

- Highlights the role of (small-scale) producers in these partnerships
 - Highest stakes in the outcome
 - Potential source of investment
- Do PPP arrangements crowd out or crowd in producers' investments?
- What is needed for PPPP?
 - Finance
 - Inclusion in negotiations
 - Capacity building

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Kilombero Plantations Ltd (rice scheme)

- Fertile Kilombero valley, good for rice farming
- Redevelop Mngeta Farm, joint venture between North Korea and Tanzania started mid-1980s
- 2007 KPL PPP between Rufiji Basin Development Authority (RUBADA) and Agrica (UK co, investors from Norfund, Capricorn Investment Group, and African Agricultural Capital) + DfID, USAID, JICA support
- 5818 ha estate; 1430 ha irrigated, 3000 by 2016
- 3200 outgrower farmers not irrigated but get SRI advice, link to inputs and microfinance

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KPL Findings

- Land tenure: Former state farm re-occupied, compensation to vacate, tensions with community
- Price volatility: company and farmers losing out
- Taxation policy on imported equipment
- Multiple viewpoints, "realities"

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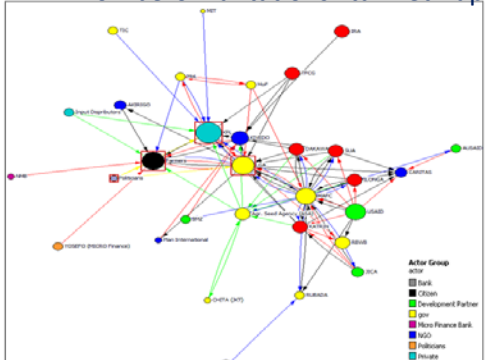
Netmapping

- Overall:** Who influences Public Private Partnership for Irrigation in xxx?
- Links:**
 - Technical advice
 - Funding
 - Inputs
 - Formal oversight
 - Political/ social influences
- Power/Influence:**
 - How powerful is each actor over PPP in Irrigation Development in xxx?



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Kilombero Plantations Ltd. Netmap

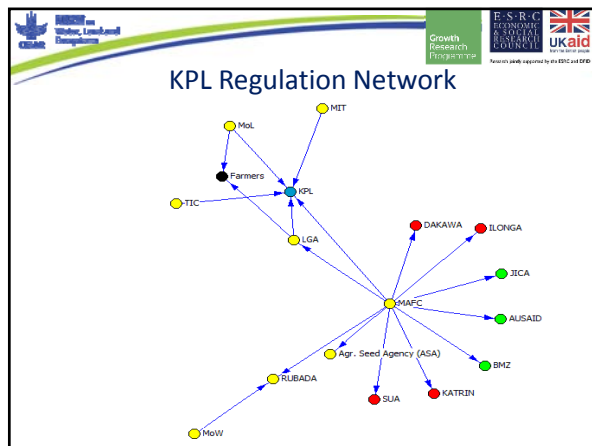


Actor Group


- Bank
- Citizen
- Development Partner
- Micro Finance Bank
- NGO
- Public sector
- Private
- Research Institute

KPL Funding Flows







Activity	Government	KPL	Farmers
Authorization			
Planning			
Financing	+ Donors+MFI		
System construction			
System operation			
System maintenance			
On-farm construction			
Technical advice			
Production			Unirrigated
Processing			
Marketing			
Risks assumed			
Benefits assumed			



Government of
Western Australia
Department of
Agriculture and
Food



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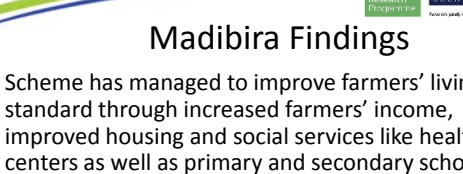
Madibira Case Example

Growth
Research
Project - 11-12

Research funded supported by an ESRC and DFID

Activity	Government	MAMCOS coop	Farmers
Authorization			
Planning			
Financing	ADB loan		Share capital
System construction			
System operation			
System maintenance			
On-farm construction			
Technical advice			
Production			
Processing			
Marketing			
Risks assumed	?	?	?
Benefits assumed	?	?	?

- 
- 
- 
- 
- Research funded supported by the ESRC and ESRC
- ## Madibira Background
- 3000 ha rice irrigation farmer managed scheme established in the late 1990s
 - Constructed through a loan from the African Development Bank, and built on government land.
 - Owned and operated by the Madibira Agricultural Marketing Cooperative Society (MAMCOS).
- Uniting agriculture and nature for poverty reduction

- 

IFAD
International Fund for Agricultural Development

FAO
Food and Agriculture Organization of the United Nations

UKaid
United Kingdom
Department for International Development

ES-RC
Economic and Social Research Council

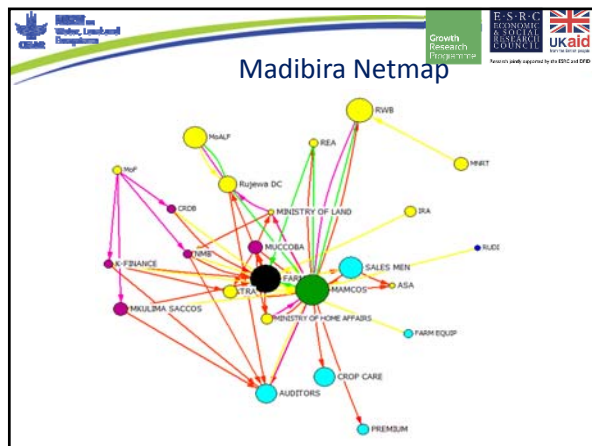
**Growth
Greenwich
Programme**

Research jointly supported by the DFID and ESRC

Madibira Findings

 - Scheme has managed to improve farmers' living standard through increased farmers' income, improved housing and social services like health centers as well as primary and secondary schools.
 - Challenges to be addressed include poor access roads, non-operation of the rice milling plant due to unreliable energy, market unreliability, shortage of farming equipment such as tractors and power tillers, as well as noticed changes in decrease of water for irrigation.

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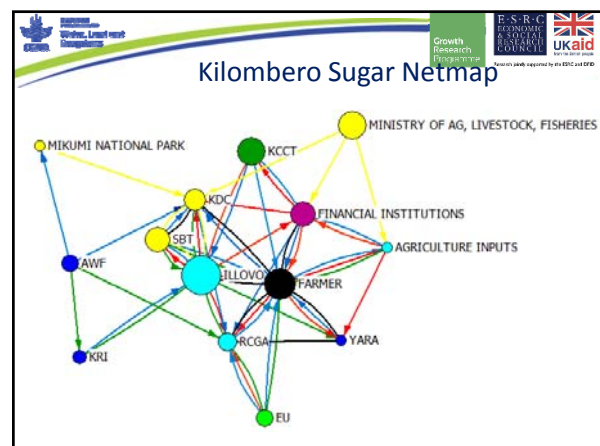


- # Kilombero Sugar Background
- Kilombero Sugar Company Limited - a registered sugar miller, grower and producer
 - KSCL owns estates 2: Msolwa estate (5000 ha), established in 1960 and production began in 1962, Ruembe (5000 ha), developed in 1974 and came into operation in 1976.
 - Divested in 1998 to Illovo Sugar Ltd and EDF Man Ltd by selling 75 per cent of its shares The remaining 25 per cent is still held by GoT and will be sold, eventually, to Tanzanians, through the stock market.

- # Kilombo Sugar Sugar Findings
- Important players linking the investors and smallholders are the producer organizations for cane growers.
 - The associations negotiate the terms of business between out-growers and millers, and to provide essential agricultural services to their out-growers. In recent years these services expanded in scope into areas like cane harvesting, loan brokerage and administration, and extension support.
 - Have enabled out-growers to negotiate and transact collectively through CSA, reducing transaction costs to both parties. They also negotiate with CRDB Bank and National Microfinance Bank

- # Kilombero Sugar Findings
- Sugar production has increased from 61,688 tons in 2000/01 to over 125, 374 tons in 2014/15. Mill expansions have allowed Out Growers to increase their production area from 3,855 ha in 1998/99 to about 12,000 ha in 2014/15.
 - A cane supply agreement has been introduced incorporating a division of proceeds formula for Outgrower cane payments.
 - Capable of exporting electricity to TANESCO
 - Maintains > 800 km of farm access roads

- # Kilombero Sugar Findings
- University of
Rugby
Research jointly supported by IFAD and
DFID
- ## Challenges:
- Transparency on measurement of weight of sugarcane for each farmer
 - Measurement of sucrose content which is done in closed laboratories of the nucleus farm
 - Governance issues related to operations of the farmer associations



Modified Framework											
Activity	Donors		Government			Banks		Firms		Farmers	
	A	B	A	B	Local	Com- mercial	MFI	A	B	Associa- tion	Indivi- duals
Authorization											
Planning											
Financing											
System construction											
System operation											
System maintenance											
On-farm construction											
Technical advice											
Production											
Processing											
Marketing											
Risks assumed											
Benefits assumed											

Key Challenges Identified

- Difficulty in aligning profit and development objectives
- Information on water availability and use (competing uses, climate change)
- Needs beyond irrigation infrastructure (technology, taxation, training, markets, inputs)
- Land and water rights
- Dominance by governments / limited involvement by farmers, communities & markets
- Challenges to build trust (history matters)
- Who bears cost of supporting smallholder development?
 - Who enforces and regulates that?

Implications

- Add finance to interdisciplinary mix for irrigation
- Is irrigation likely to be profitable for investors? Logic for state investment, less for private sector.
- “Beyond panaceas”
 - Need to engage with complexity
 - Tools for understanding complex arrangements
 - Range of options for “PPP” arrangements
- Time: Needed to build trust, but time/cost tradeoffs

Further Resources

- Bernier, Q. and R. Meinzen-Dick. 2015. Public private partnerships for irrigation: Expanding access or increasing inequality. Washington, D.C.: International Food Policy Research Institute (IFPRI).
<https://www.ifpri.org/publication/public-private-partnerships-irrigation-expanding-access-or-increasing-inequality>
- <http://www.ifpri.org/project/assessing-models-public-private-partnerships-irrigation-development-africa-ampppida>

African Farmer-led Irrigation Development: re-framing agricultural investments?

Hans Komakech, Philip Woodhouse, Gert Jan Veldwisch, Jean-Philippe Venot, Angela Manjichi, Dan Brockington



Studying African Farmer-led Irrigation

www.safi-research.org

- Policy-oriented academic research project (2015-2017)
- Cases in Mozambique, and Tanzania



- How can external agencies relate to farmers' irrigation initiatives more effectively?
- Study of the initiatives, the agencies and their interactions
- Both deepening understanding of processes and quantifying the outcomes



Farmers' irrigation initiatives

not "unplanned" or "spontaneous"
not small-scale
not (only) individual
not in isolation

What is farmer led irrigation?

- A process where farmers drive improvement in their water-use for agriculture by:
 - changes in technology use,
 - investment patterns,
 - the governance of land and water.
- Farmers exhibit entrepreneurial and risk taking behavior and interact with a range of other actors

Main characteristics

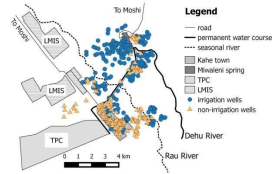
- Farmers invest substantially in irrigation;
- Reactive to external drivers, especially markets
- Irrigation development does not require formal land tenure
- Irrigation is part of broader farming systems
- Prompt social and economic change

Farmers invest substantially

- Ghana:
 - Farmers have invested up to \$8 million in purchasing motorized pumps for irrigation
 - Farmer-led irrigation > 180,000 ha (10 times public irrigation system)
- Mozambique:
 - 115,000 hectares not appearing in the official statistics

Farmers invest substantially

- Kahe
 - > 500 irrigation wells
 - > 800 hectares



In a productive way

- Yield data in Mandakamanono, Mijongweni, Kahe and others (and compare to target yields)
 - Mandakamnono: rice : 3.1 - 8.9 t/ha
 - Mijongweni: rice: 1.8 – 2.8 t/ha; maize 3.5t/ha; beans 1.9t/ha
 - In Kahe maize yield: 1.2 - 4.9 t/ha (mean: 2.2t). (national average 0.8 - 1.0 t/ha)
 - Tomatoes (Messica, Mozambique): 12 to 28 t/ha (mean 16.7 t/ha)

Reactive to market

- **Opportunistic development**
- **Reactive to market conditions**
 - Mozambique: supports/feeds in vegetables border trade
 - Mozambique: Link to private agro-companies (out-grower schemes and/or contract farming)
 - Importance in peri-urban area
- **Challenges for classic planning exercise**

Technical awareness and innovation



Flexible access to land

- Involves land transactions in an informal land market (purchase/rental)
- Investment (pumps, wells, furrows, inputs etc.) takes place despite absence of formal land titles
- Farmer-led irrigation often promotes in-migration

Part of a broader farming systems

Food only

Maize/beans, <1.2ha



Food plus

Maize + tomatoes/veg <1.2ha



Source: De Bont et al. forthcoming

Part of a broader farming systems

Local commercial

Primarily tomatoes and onions >1.2ha



Source: De Bont et al. forthcoming

Commercial plus

Onions and tomatoes >1.2ha, rented



But is it efficient?

- Scheme level (Kamumama traditional furrow)
 - >600 ha, 600 farmers
 - Av. crop yields (t/ha): maize 2.8, beans 1.2, Eggplants 17.5, tomatoes 17.4, green pepper 18.1
 - Measured conveyance efficiencies (%): main 70 - 80; secondary 50 - 80; tertiary 23 - 63; and scheme level 8 - 43
 - Measured application efficiencies (%) 52 - 73; within the range for well-managed/designed furrow system (50 - 90)
- Watershed/basin level:
 - Loss of some furrows are gain of others;
 - Mitigation of floods (spate for instance)

Farmer-led irrigation development

- We know that it prompts social and economic change
- There may be losers and winners
- To what extent there will be losers and winners, we don't know
- SAFI is undertaking research on this

A variety of actors relate to these initiatives

- Basin water Offices
- Local politicians
- Local agricultural offices
- NGOs
- Private investors
- Traders
- Transport operators

How can external agencies relate to farmers' irrigation initiatives more effectively?

- Engage to Support and replicate
- Engage to contain
- Ignore
- Overhaul
- Shutdown



Thank you



Unfulfilled potential Irrigation and small farmers- 2 case studies from Tanzania

Dr Anna Mdee

Mzumbe University/University of Sussex



Research jointly supported by the ESRC and DFID

PPP – critical questions for water supply

PPP can take many forms

Public management needs
a more strategic approach.

Whose water needs have
priority?

Irrigation needs cannot
ignore water-energy-food
nexus



Assumptions in Irrigation Policy

- 'Traditional' irrigation is wasteful and inefficient- suggests training the farmers on better water use and encouraging the private sector, NGOs etc. to contribute.
- 'Improved' traditional irrigation- investment in upgrading traditional systems (can be seen in Pare Mountains- see paper by Mul)- suggest gov. will oversee technical requirements and encourage PPP
- Water conflicts can be avoided if all are organised properly in 'associations'

New schemes

- Challenge to establish and bring in private investment while benefiting small holders
- Gov promises 'demand-driven' scheme identification (sometimes an excuse for doing nothing!)
- Management must formalised.....
- Zonal Irrigation Units support LGAs (until the private sector can fill the gap).
- But private sector is risk averse- land and water rights are too risky
- Policy is short on specific actions particularly on managing water supply

A political ecology of irrigation Fieldwork - May 2013-Jan 2014

2 case studies of irrigation:

Dakawa Rice Farm- a 2000 hectare former state rice farm. Now managed by a co-operative society for small farmers with large inputs from USAID – donor supported PPP for small scale farmers

Uluguru Mountains- hosepipe irrigation for cultivation of high value fruit and vegetable crops. Latest evolution for small scale farming by indigenous WaLuguru people. Private irrigation without public consent

Dakawa- an example of a formal irrigation scheme

- Dakawa- former NAFCO farm- 2000 hectares of paddy
- Built by N. Korea but never operational at full capacity
- Now revived by UWAWAKUDA (a water user's association and co-operative of small Farmers.
- Large investments by USAID- Feed the Future
- Improved production (30-40 bags per acre) through use of system of rice intensification

Dakawa

The official story:

- Farm is divided into 12 acre blocks.
- 1 farmer can own a maximum of 1 block (but many of the 900+ members own 1 or 2 acres and share blocks as small farmer groups).
- The land/water is owned and managed by UWAWAKUDA on behalf of the members.
- Training on the 'system of rice intensification' (sri) has led to big increases in productivity
- See <http://www.feedthefuture.gov/article/feed-future-press-tour-tanzania-marks-global-economic-statecraft-day>

12-acre block – Dakawa Rice Farm



Water for Dakawa

- Water is pumped from the Wami river
- There are an increasing number of upstream users
- Rivers levels are too low to allow the scheme to operate outside of the wet season (March-June)
- Water is supplied to blocks by a strict rotation. Bye-laws control water theft- but there are disputes within and between blocks
- The Chinese Ag. Research station in Dakawa is seeking access to river water but has not been successful.

but.....

- Are these really small farmers?
 - Who owns the land?
 - Who controls the organisation?
- Is the scheme sustainable?
 - Competition for water-upstream users- dropping level of wami river
 - Poor water use efficiency
 - High costs of power-15m Tsh per month
 - Subsidised by donor
 - Lack of marketing options for small farmers
 - Illegal rice importation leading to price falls

Dakawa and the politics of aid

Dakawa is an aid hotspot

- proximity to Dar-Es-Salaam
- reliable local stars- Veronica Urio story
- China-US aid nexus
- 'all of the world is coming to Dakawa....even the queen of Denmark'

'Traditional' and informal

- Luguru produce vegetable and fruit crops on small land holdings.
- Past- used traditional furrow systems but these were banned
- Records show concerns over agriculture in the Ulugurus since German colonisation- promotion of terracing has been contentious in the past
- Now- use hosepipes from the waterfalls and rivers to feed sprinklers

Improved livelihoods

- Some good production with market linkages
 - Vegetables, herbs and fruit in Morogoro
 - Strawberries- Arusha and Dar (and cannabis)
- Evidence of improved livelihoods-
 - Improvement of housing
 - Purchase of motorbikes
 - Construction of road by community
 - Secondary school for children

Terraced farming on the Uluguru Mountains



But

Their activities are seen as illegal- it is informal and unregulated- characterised as competing with drinking water supplies in Morogoro and beyond to Dar-Es-Salaam local hydropolitics

In 2006/7 the Municipal Council tried to evict the farmers from the mountain- they took the case to the President.

Were told they can stay if they do not farm within 60m of the water sources and use environmental conservation practices.

A number of NGOs are supporting this approach- e.g. Through 'payment for watershed services' and organic farming initiatives

See <http://kilimo.org/WordPress/>

Win-win – a new form of PPP

Work by NGO Sustainable Agriculture Tanzania:

Organic/agroecological production enhances livelihoods and environmental protection.

It can does not contaminate water resources and potentially enhances them- terracing and increasing soil organic matter

Opportunity for new form of PPP- local stakeholders are already on board

Who is managing water supplies?

Ulugurus-water is a freely available resource- shared informally by those with access to land and capital to buy pipes.

"Government have done nothing so why should they be paid for water? " Government says use is illegal and should be formalised. 2009 Water Resources Act cannot deal with multiple tiny intakes.

Dakawa- the scarce water to the scheme is only available for a limited period. Therefore water must be managed fairly through the formal rules of the scheme and on a strict rotation. Transgression of rules leads to punishment and/or conflict. Outside users have caused the shortage of water and need regulation by the RBO.

Wami-Ruvu River Basin Office- Excellent understanding of the challenges but no capacity to monitor actual water use. "We just sell water" – anonymous

Summing up

- Small-scale irrigation is not a quick fix for agricultural growth without solving bigger issues of hydropolitics
- Insufficient attention is given to competing uses of water (e.g. Agricultural use vs power generation)
- Current policy frameworks and approaches are inadequate, contradictory and ineffective
- Inadequate capacity of RBOs to regulate water use- 'we just sell water'.
- Climate change, economic growth and increasing population make water supply a critical issue
- Negotiated solutions must account for water-energy-food nexus