Sustainable Inclusive Irrigation

An SNV-organised and facilitated learning event

Arusha, Tanzania
1- 4 July 2024

Learning event proceedings | Prepared by Sandra Ryan, Global Technical Advisor, SNV

Contents

Executive summary

This report provides a synthesis of the 'Sustainable Inclusive Irrigation (SII)' learning event held in Arusha, Tanzania from 1-4 July 2024, co-hosted by SNV and the Nelson Mandela African Institution of Science and Technology (NM-AIST) with over 50 participants from SNV program countries of Bhutan, Cambodia, Ethiopia, Kenya, Mozambique, Nepal, Tanzania, Uganda and the Netherlands. Participants were from local and national government, local water authorities, Nelson Mandela University, and SNV country and global staff.

Irrigation will remain a core climate change adaptation strategy for countries and individuals. The difficulty is to prevent climate adaptation of some at the expense of increased vulnerability for others. Therefore, water management in irrigation systems – both input as well as return flows- will become more important as scrutiny of the water footprint of irrigation systems increases. Irrigation systems with high water losses as well as unregulated self-supply will no longer be acceptable as seasonal water scarcity also starts to affect other sectors and ecosystems' health. However, water efficiency alone will not address this, as that often leads to area-expansion rather than reduced overall water use. Demand management will be needed. Links between irrigation and water for domestic use and livestock will become more evident. Inequities between head and tail end in larger schemes, as well as inequities in access to equipment and knowledge in general, will increase vulnerability of already vulnerable groups, potentially leading to conflict.

The learning event focused on the institutional set up of irrigation in each country, what it means to be sustainable in the host country of Tanzania, sustainability considerations specific to plot level irrigation, and interventions and investments needed to sustain inclusive irrigation long-term. It was organised by SNV as part of SNV's Sustainable Inclusive Irrigation Framework Approach and programming.

The purpose of this report is to provide a reference for participants as well as other practitioners, managers, local government, and other actors interested in SNV's Sustainable Inclusive Irrigation (SII) programming. It aims to capture the key content presented by experts, the irrigation situation in participating countries, challenges, as well as key discussions and reflections generated during the four-day event.

During the three weeks prior to the event participants had engaged in online Egroup forums contributing information on the types of irrigation in their countries, performance and management issues, a forward look at the needs and ambitions for irrigation, and given these contexts, the kind of interventions that would be appropriate, realistic, equitable and sustainable to develop irrigation. Those discussions helped drive the conversation during the event and it is hoped that this report will also serve as a resource for the broader Water sector.

This is the first learning event on Sustainable Inclusive Irrigation and beginning of the learning journey. There are many innovation areas in SII and many perspectives, and jointly we can advance our knowledge and understanding of sustainable inclusive irrigation. While we continue the journey, hopefully the shared learning will contribute to a more sustainable future in each city and area where you work or be the start of many more projects in the countries where SNV works.

Introduction

Official opening

PRESENTATION BY Eng Sadat Kolowa, National Irrigation Commission of Tanzania

Mr Kolowa, on behalf of the Director General of the National Irrigation Commission of Tanzania (NIRC), opened the learning event, welcoming all participants, SNV, and the Nelson Mandela African Institution of Science and Technology (NM-AIST) to Arusha and the event. The hosts were commended for participating in the irrigation sector and for bringing together multiple sectors as participating partners.

Mr Kolowa highlighted that this event had come at the right time as many countries are trying to improve irrigation and manage water resources better under Integrated Water Resources Management (IWRM). He emphasized the need to improve infrastructure for crop production and noted that the changing climate is driving up demand for more irrigation, driving irrigation in Tanzania to be efficient, and driving demand for more dams to supply irrigation schemes.

The 2022, 2023, and 2024 budgets have all catered for more studies, designs, and construction of irrigation rehabilitation projects, and the NIRC hopes that this event will further help in this endeavour, opening up discussions across the many issues that we all face, at all scales of irrigation. On behalf of the NIRC he welcomed the opportunity to learn about the experiences from the different countries that will be presented and confirmed their appreciation for the time and effort of all involved.

WELCOME by Michael McGrath, Country Director, SNV IN Tanzania

Mr McGrath gave a warm welcome to the esteemed Government attendees from Tanzania, and other countries from Africa and Asia, with thanks for travelling so far to attend. SNV colleagues and other guests from around the world were also welcomed, with gratitude to the organising team for opting to host the event in Tanzania.

Irrigation is a critical intervention to support food security and livelihoods, not just for farmers (who are key stakeholders) but other water users. Tanzania suffers drought, with many parts of the country regularly struggling with lack of water. Working with many young farmers we hear the common challenge, *How can we get on the irrigation ladder, upgrading from buckets?*. Helping these 'entry level' farmers progress is a huge challenge but can make a huge positive impact on them and on the region.

The lack of water is not a straightforward problem. It's not just the delayed onset of the rainy season that leads to shortage; it's also about dramatically changed rainfall patterns and intensity. Appropriate changes to irrigation are a key arsenal in our response to climate change. Irrigation is a key topic in which the water, agriculture, and energy sectors need to work together.

Mr McGrath concluded with hopes for great discussions and looking forward to working with everyone.

Expectations of participants by country

Participants from each country introduced themselves and shared their expectations of the Learning Event, as summarised below. The participant list is included in Appendix I.

Table 1: Expectations from SII learning event, by country

Country	Expectations
Bhutan *A small country between China and India.*	• To understand the various irrigation aspects of other countries. • To see how other countries are adapting climate change infrastructure and take new ideas back to Bhutan. • To learn how other countries are adopting the PPP structure to implement irrigation (private sector engagement).
Cambodia	• To find out more information on the challenges and solutions for irrigation. • To learn how other countries work with WUAs (Water User Associations /farmer user communities). • PPP is a key opportunity for Cambodia to work with the private sector. The SNV country team are doing some work on solar but want to learn more. • To learn how other countries manage water resources (farmers in Cambodia are just drilling more boreholes to find and access water). • To find out what the Water Energy Agriculture nexus is – and how it works.
Ethiopia	• To learn how other countries are responding to climate impacts. • To learn about private sector involvement in irrigation in other countries. In Ethiopia irrigation investment is public sector dominant • To find out more about cost-recovery mechanisms. • To better understand the Water-Energy-Food nexus, especially how to come up with better (joined up) indicators. • Learn from others' system-led irrigation water. • How large and medium scheme interventions also increase inclusiveness.
Kenya	• To learn how others are managing the impacts of climate change because Kenya is already significantly affected. Particularly want to find out more about mitigation measures. • The fine out more how other countries are harnessing private capital (irrigation is capital intensive). What are the investments we can bring on board? How have other countries capitalised on exploiting private capital? • Kenya is water scarce. Set priorities for water allocation, then prioritise irrigation, and then domestic. Kenya wants to know how other countries include water resources management/env protection within this hierarchy. • Kenya forecasts water demand, but not water supply. They want to learn how to do it.
Mozambique	• As the downstream country of large river basins and with regular cyclones Mozambique is very vulnerable to climate change and they hope to get some ideas to take away. • Hope to explore energy policy and strategy options that could potentially pay/subsidise irrigation. • To learn more about irrigation and management arrangement options. Especially looking for ideas on operational and management arrangements for small holders. • To learn more about sustainable financing, for small holders to manage irrigation (ongoing financing for irrigation to keep it running).
Nepal	• Cross learning and to increase knowledge on Agricultural water management. • To get insights on how to improve irrigation monitoring. They hope to learn how to customise systems to better address the varying needs across Nepal's diverse terrains.

Country	Expectations
	• To understand the role of energy in irrigation efficiency. The Government has helped design a solar based system but is still planning what is needed and how it could be set up. The team hopes to learn the details of some appropriate interventions.
Tanzania	The team narrowed down a longer list of expectations to: • Multi sectoral learning: understand how we all fit into the discussion, to learn how better to engage with other, find the opportunities to come out of this event, and leverage learning from other countries. • To understand the need for more education for farmers, especially to help farmers tap into existing solutions (and not get drawn into inappropriate private solutions). • To learn new approaches that minimise water inputs and maximise outputs and leave more water available for other uses. • To learn how public and private sectors collaborate in other countries.
Uganda	• Learn irrigation skills and support that Governments can give • Learn about irrigation technology for smallholder farmers (to be inclusive) • Learn to be able to prepare for business opportunities • To find ideas for cross-sectoral cooperation at national and local level. The team wants to know how other countries do it. • Learn about the challenges other countries are facing and what solutions they have put in place.
Global	• To discuss and understand countries' national led priorities • Find out how climate information is or isn't being integrated into irrigation planning. • To build working relationships.

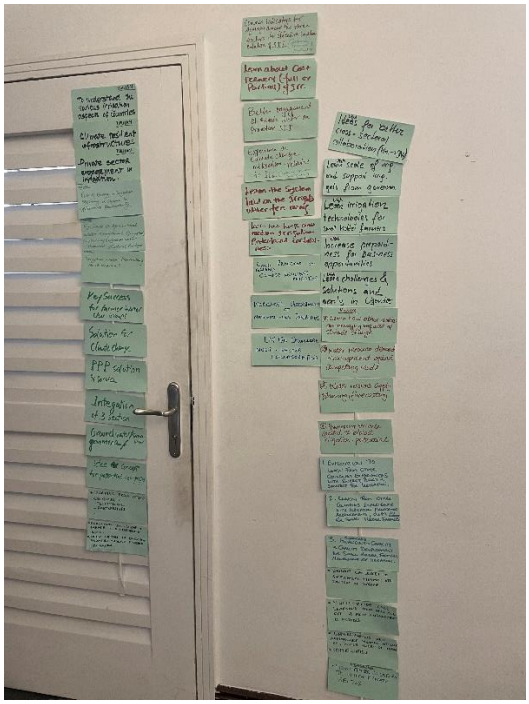


Photo: Country handwritten expectation cards. **Photo credit:** Sandra Ryan.

Country teams and participants had a range of expectations (a broad range and some specifics). It is clear that each part of the Sustainable Inclusive Irrigation framework approach could have its own learning event. This learning event is intended to provide an overview covering learning needs that are relevant and shared between water, energy, and agri-food topic areas. It will meet some of the expectations and participants were also advised to make their connections, create 'sister' cities etc to help progress others.

SNV's Sustainable Inclusive Irrigation Framework Approach

PRESENTATION by Antoinette Kome, Learning Event Facilitator and SNV's Global Head of Water

This is a multi-sectoral learning event (the water, agriculture, and energy sectors are all represented), and its implications mean our discussions will cover different geographic scales, including the plot, scheme, river basin, and country levels.

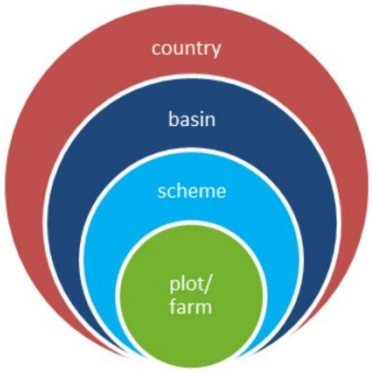


Figure 1. Scales relevant to irrigation development

The purpose of irrigation is to enable people to control water to provide access that meets quantity, quality, accessibility, and reliability objectives. The assumption behind irrigation is that better water control will enable better production, and in turn, this will lead to higher incomes for male and female farmers, improved food accessibility for the country, and higher economic growth for the country. This is a whole chain of assumptions. We assume that if we make the right investment choices, then all the benefits and good outcomes will follow, not just at the household level but also at regional and national levels.

This is why we justify public money going into the system.

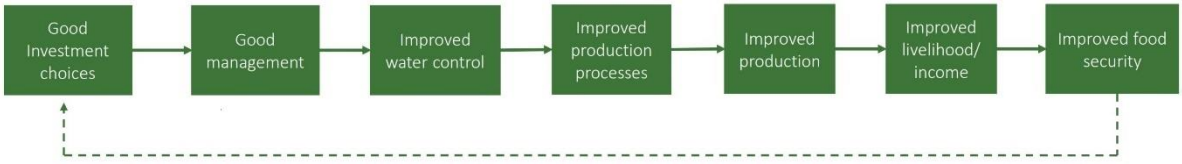


Figure 2 Chain of assumptions

What does this mean in the context of climatic, demographic and economic change?

- Climate change affects the survival of pests and vectors of disease: more pests are spreading into more regions and in greater numbers as climate change supports overwintering and survival. The relationship between insects and their natural enemies that keep them in check will destabilise. This will lead to more outbreaks of agricultural diseases transmitted by insects and lower yields/diminished production.
- Climate change severely alters the hydrological cycle: In mountainous regions, increased melting is increasing water availability in the short term, but once glaciers have melted, there will be less water. This will be disastrous for Bhutan and Nepal. Elsewhere, precipitation is becoming more unpredictable, more intense, but less reliable, increasing the frequency and intensity of droughts, floods, and the other disasters that accompany them. The demand for water from rainfed and irrigated crops will increase as plants' evapotranspiration rates increase.
- Global freshwater withdrawals increased eight-fold over the past 100 years due to population growth, economic growth and rising living standards. Demand for irrigation water is part of this.

Photo: A flooded paddy field in Tanzania.

In summary, the consequences of climate change will include:

- More production challenges, such as higher use of pesticides
- Less income
- Increased disease
- More demand for irrigation
- More flood events, runoff, erosion and increased siltation affecting the lifespan of reservoirs and infrastructure
- More water resource challenges
- More competition for water
- More demand for less food/produce
- Degraded ecosystems that sustain waterbodies.

Energy is a large part of irrigation expenditure, and energy prices are already rocketing; everything other than gravity is challenging.

Climate resilience starts with irrigation that safeguards water security. We should look at all the components involved. We can't talk about sustainable irrigation without recognising water use, pollution (effluent, solid waste, health and safety), floods and droughts, and the security of water resources (not over-abstracting, not badly affecting water quality, not altering flows, e.g. not letting perennial flows become ephemeral).

What about equity and inclusion in irrigation? Key aspects to look at within irrigation schemes and supply chains are:

- the ratio of male to female farmers
- head to tail ends
- landowners to tenants

Despite many women working actively in the fields as farmers, their needs, opinions, and ideas are not always respected as they should be. Even nowadays, many water user committees do not adequately represent female farmers. Underrepresentation in decision-making hurts not only female farmers but the whole farming community. Unfair power dynamics and water access disparities between Head and Tail enders also cause problems. These situations should be looked at within and between irrigation schemes.

Equity and inclusion are issues that should be addressed by looking beyond the perimeter of an irrigation scheme. Actions such as over-abstracting or polluting water by irresponsible farming behaviour affect downstream water users. Things to consider include:

- the impacts on other farmers and other water users
- the impacts on everybody else' human right to a clean, health and a sustainable environment.

Event objectives

The learning event aims to exchange ideas and deepen our understanding of what sustainable and inclusive irrigation in the context of climate change practically entails in different African and Asian contexts. It has three specific objectives:

1. Exchange and reflect about the irrigation institutional set-up and future ambitions in the different countries.
2. Explore different irrigation management models and intervention strategies.
3. Reflect how irrigation best contributes to water security and food security.

The overall learning activity has three components:

1. The preparatory E-group discussions in the weeks immediately preceding the event.
2. The four-day workshop.
3. In-country follow-ups (depending on country priorities).

This is not about SNV. The learning event activities are intended to promote discussion about best practices in irrigation management and development among partners. Through this event, we hope to build on irrigation promises.

Figure 3 shows the logic of the learning event and the five blocks of presentations and workshops intended to achieve the learning.

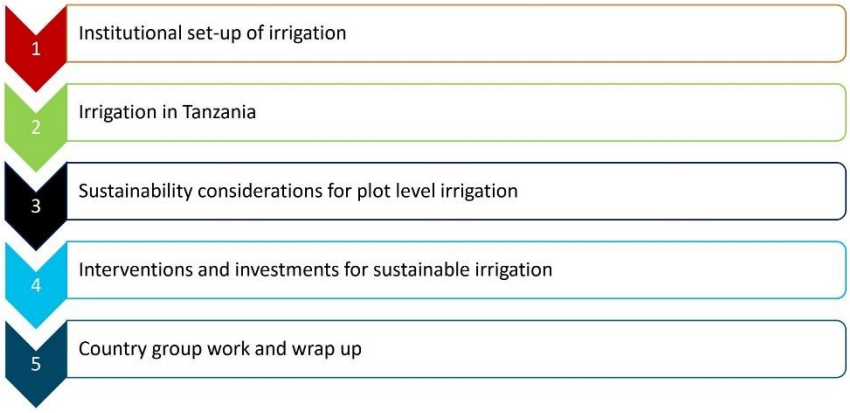


Figure 3 Logic of the learning event

Block 1: Institutional set-up of irrigation in each country

Introduction

The E-group discussion revealed at least eight different ways in which irrigation type is described:

- by source (surface water, groundwater, wastewater),
- by plot level technology used (flood, furrow, watering cans, sprinkler, drip, sub-surface),
- by size (large, medium, small-scale irrigation linked to the size of the area),
- by conveyance method (lined or earthen canals, piped pressurised or piped non-pressurised),
- by energy source for lifting and/or conveyance (gravity, petrol, electricity, solar, manual, animal powered),
- by management system (agency, farmer organisation, third party, self-supply/ individual),
- by distribution method (continuous, rotational, on-demand) and whether it's permanent or supplementary irrigation.

The responses from Uganda also mentioned bottled irrigation (promoted by the President of Uganda). These are just the types that were mentioned in the e-group. It could be that other types were not mentioned.

Gravity-fed irrigation systems are probably dominant in most countries. Participants provided estimates of how much land in their countries is irrigated, but it is fair to say that there are some discrepancies, and it is difficult to accurately confirm this, especially if all types of irrigation are included, as it is very dynamic with a lot of initiatives going on. Irrigation is expanding. Nepal states that 40% of its agricultural land is under irrigation, whilst in Cambodia, it is 60%. Between 2001 and 2020, irrigated agricultural land increased from just 5% to 31%.

It is also clear that the perspective of what farm size counts as small or big varies per country. This is important to clarify when talking between countries, "what do you mean by small?" For example, in Ethiopia, farms between 200-3000ha are considered Medium, whilst in Uganda, anything >1000ha is considered Large.

There is a wide range of irrigation scheme management models and strategies across the countries, typically varying according to scheme size. Using Zambia as an example, four different models have emerged:

1. Government run: Operating since the 1970s with an officer assigned to day-to-day running of the scheme;
2. Small Scale Farmer Cooperatives (5-10 ha): Developed by farmers around the late 1990s using the water from dams constructed by the government;
3. Smallholder Irrigation Project (SIP) /Chiansi Model: Small-scale landowners as a group engage a company to run their group of farms as a business. Upon selling the produce, the company deducts running costs before paying the small landowners their share according to the size of their plot;
4. Irrigation Development Support Project (IDSP) Model: Promoted in 2011 based on the principle of full (operational?) cost-recovery. There are different variations depending on farm size:
    - Tier 1: plots up to 1 ha, owned and farmed by individual small holders;
    - Tier 2: plots up to 5 ha, owned and farmed by emergent commercial farmers or groups of small holders;
    - Tier 3: farms of 50-60 ha, farmed by a professional operator, providing agricultural services to the other two tiers;
    - Tier 4 : large-scale commercial farmers who share the bulk of water infrastructure by the project and develop their own irrigation scheme to utilize it.

Irrigation scheme performance

Participants referred to performance in terms of infrastructure, water efficiency, water control, or financing and lifecycle costs, depending on the issues that they must deal with most. Within these different focus areas are three common issues:

1. Functional versus non-functional schemes (intra-country conversations reveal the need to understand the definition of functional);
2. Planned versus actual irrigated perimeter (actual is often less than the planned area);
3. Planned versus actual lifespan of infrastructure (examples refer to schemes that were planned to last 50 years but problems like siltation contribute to reducing the lifespan).

Water efficiency

The concept of 'water efficiency' can mean different things to different people in different contexts. It is important that the definition as applied to irrigation is understood. Figure 4 illustrates the various losses and efficiencies within an irrigation system that abstracts 10m^3 of water.

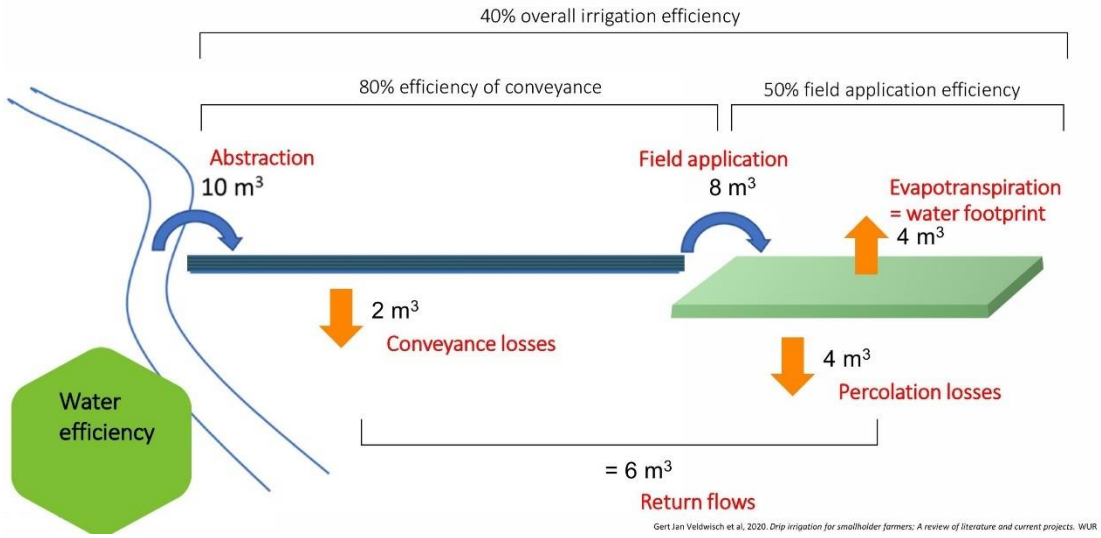


Figure 4 Water efficiency elements in irrigation

In this example, 10m^3 is abstracted:

- 2m^3 is lost during conveyance (i.e. through leaks in pipes or earth canals). 20% of the abstracted water is lost at this point. The conveyance is only 80% efficient.
- 8m^3 is therefore available for field application. 4m^3 of that is used productively by plants through evapotranspiration. 4m^3 percolates into the deeper soil depths isn't available to plants (and so is considered an irrigation loss). In this case, the field application is 50% efficient.
- If conveyance is only 80% efficient, and then field application is only 50% efficient, then the overall irrigation efficiency is only 40%
- The combined conveyance and percolation losses (6m^3) return to the local water environment (either as surface or groundwater return flows).

Things to consider: the percentage losses can be changed by implementing measures to reduce leakage and increase productive evapotranspiration. Note, evapotranspiration by non-crop plants, e.g. weeds is considered non-productive evapotranspiration and another form of loss (depending on if that vegetation is usable). In economic transactions, it is always good to ask: when there are 'losses', who is losing out, and at what scale? From an environmental and water resource perspective, return flows are beneficial rather than loss.

Drip irrigation is often presented as a water efficiency measure because it typically reduces the percolation losses and reduces water use per hectare, but left uncontrolled, farmers often expand their irrigation area and increase the total water footprint. In the Figure 4 example, instead of recovering $6m^3$, the environment and the resource would only recover $2m^3$ of the $10m^3$ that is abstracted. That depletes the resource and can cause problems for downstream users.

When we talk about sustainable irrigation, we must consider the total water footprint and the factors that drive it (unregulated water abstraction, high crop requirements, high conveyance losses from earth channels, inefficient distribution, and plot-level irrigation methods).

Water Control

Water control refers to how water is distributed to users within an irrigation scheme. Without adequate controls, those closest to the water inflow (head tailers) usually take more water than those further away (tail-enders) because they have better access and more opportunity to take the water they think they need. This typically leaves tail enders with very little or no water to irrigate with and can lead to salinity issues. To ensure equitable access to all irrigation schemes need to have agreements in place on how much water must be available to each user and physical control measures to prevent over use by head tailers. Poor management results in less water control.

Finance and lifecycle costs

Irrigation schemes need capital to set up, ongoing expenditures to run, and further capital to repair or rehabilitate the infrastructure.

Figure 5 illustrates how these different categories of costs occur over time. When talking about the overall total combined Capital (CAPEX) and Operational Expenditure (OPEX) of a scheme over its lifetime it can be useful to calculate and refer to this as TOTEX

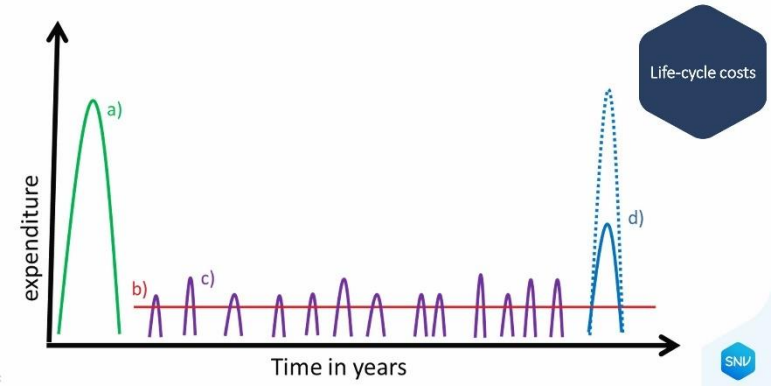


Figure 5 Irrigation scheme TOTEX over time

In this diagram, a) represents the initial CAPEX, b) represents the ongoing OPEX, c) represents repairs, and d) represents rehabilitation of the investment (c and d can be referred to as CAPEX or OPEX depending on the financial modellers).

Irrigation schemes are businesses as well as sources of food and so it is important to understand how much of the cost can be recovered and if it is possible to make a profit. When talking about 'cost recovery' it is important to clarify which of the cost categories are included. For example, it might not be possible to recover the initial CAPEX (a) but through good business practices can the OPEX (b and c) costs be recovered?

A similar 'TOTEX' chart exists for water supply schemes, and it is known that operational cost recovery is higher for water supply than for irrigation schemes. How is that possible? The e-group discussion

highlighted several factors that can make cost recovery in irrigation difficult (different countries mentioned different things):

- **Irrigation data:** when there is too little information on scheme costs, water use, cropping, costs, income, etc, it is difficult to monitor and understand the financial implications of irrigation schemes. This makes it very difficult to plan sensible investments.
- **Poor management:** a lack of overall management at the scheme level, a lack of attention, or in appropriate management practices hinder financial knowledge and controls.
- **Finance:** the absence of irrigation investment criteria can make it more difficult to access good quality finance, leading to higher costs.
- **Implementation:** Even when irrigation schemes are well planned and have access to good finance, problems such as poor-quality scheme designs, poor quality construction, access to good scheme management skills, and the slow pace of implementation (taking longer to implement a scheme always increases costs) all contribute to higher overall costs which are more challenging to recover.

Irrigation management challenges

Irrigation management challenges occur at three levels:

1. Water resource: at this large scale, the issue is the lack of budget to regulate (monitor and enforce) water abstraction volumes and equity issues;
2. Irrigation scheme: at this scale, various issues include inadequate measures to be climate resilient, poor operations and maintenance, gender bias and under-representation in decision-making, and poor water allocation decisions and methods;
3. Individual plot: issues include farmers' capacity to improve water efficiency, limited application of modern practice and technology (the term 'modern' also has different interpretations), gender bias in extension services, contaminated water, unreliable government subsidies etc.

This mirrors the point made in Figure 2 (chain of assumptions) on whether irrigation should be looked at as a supply chain or a system of interlocked scales (you can't avoid looking at both the chain and institutional connections).

Institutional set-up of Irrigation

Many different ministries are involved, but in most countries the apex institution for irrigation is within the Ministry of Agriculture. In some countries, the apex institution falls under the Ministry of Water or Water Resources. In some countries, this depends on the type of irrigation that is present or dominant. For example, in Ethiopia, small-scale irrigation falls under the Ministry of Agriculture, whereas large- and medium-scale irrigation is with the Ministry of Irrigation and Lowlands.

Many countries have some form of water users' organisation that either manages lower levels of large schemes or medium schemes, e.g., Nepal's WUAs. In some countries, irrigation is managed privately by (non-farmer) third parties.

Ambitions

Every country involved in this event has ambitions to expand irrigation, very often to double the land area under irrigation. For example, Tanzania wants to expand from 700,000 ha to 1.7Mha, Uganda wants to add 1.5Mha (50% more), and Ethiopia aspires to expand from 490,000 ha to 1.2Mha.

In addition to expanding land area, other ambitions are to:

- adopt new technologies
- upgrade existing infrastructure
- improve water use efficiency
- strengthen policy and regulatory frameworks for irrigation development
- strengthen water resource governance
- improve access to finance

- increase involvement private sector
- climate proofing irrigation systems

Other unplanned developments are expected to impact irrigation needs and capacities. Some of these are likely to bring positive change, whilst others may be more negative:

Positive unplanned developments	**Negative** unplanned developments
• Technology advancement: precision agriculture, remote sensing, AI, innovative irrigation technologies. • Individual farmers setting up their own irrigation. • Drought and urbanisation increasing demand for food.	• Extreme weather events disrupt irrigation schedules and damage infrastructure. • Increased competition over land and water resources. • Political instability and challenges. • Water resource degradation. • Urbanisation encroaching upon irrigation systems. Lack of labour due to out-migration of youth. • Lack of infrastructure, roads etc.

There is a lot of faith in how new technology and AI are expected to progress and the benefits these will bring to irrigation, and farmers' abilities to change and take more of a lead. On the downside, an increase in the number of farmers seeking to irrigate (and irrigate more land) is expected to drive up competition of land, labour, and increase pressure on limited road infrastructure etc.

More detailed information on this is available in the e-group discussion that is available to review: https://snvwater.groups.io/g/Sustainable-inclusive-irrigation/messages

Country posters on institutional set-up in each country

Prior to the learning event, country teams were invited to prepare a poster showing the institutional set-up relating to irrigation in their country. Each country team presented its poster and national situation with Q&A. During discussions, some teams amended their posters to clarify.

COUNTRY POSTER GUIDING QUESTIONS
1. How is irrigation organised in your country? Stakeholders, the lead institution, who supports, who regulates? 2. What is the ambition for the next 20 years?

The country posters (originals and annotated) are available within the Sustainable Inclusive Irrigation E-Group system. Email Sustainable-inclusive-irrigation+subscribe@snvwater.groups.io to subscribe or request a copy by completing this contact form.

Bhutan

As Bhutan is located at a very high altitude it has a unique mountainous ecology which influences irrigation.

The institutional set-up has three levels: National, District, and Local. This is a relatively new set-up and there are still many struggles in terms of who takes the lead on things.

- **National:** the Ministry of Agriculture leads planning and resourcing. In charge of funding and formulating policies. The Ministry of Infrastructure leads on transport issues. The Ministry of Energy and Natural (Renewable) Resources leads energy policy.
- **District:** The district administrations are responsible for more detailed plans. District planning is done with the district engineering divisions.
- **Local:** block development councils work with users to implement infrastructure development.

The National Government has developed a **15-year irrigation development roadmap** which includes diversifying into dry lands.

There are two main types of irrigation scheme in Bhutan:

1. **Community led:** this approach goes back thousands of years and has worked very well, although attitudes towards what is 'fair' can differ significantly. Water User Groups (WUGs) have been around for a long time. There are now increasing concerns over how well these schemes function.
2. **Agency led:** these are bigger than the community led schemes.

Water use agreements are based on customary rights, but these are rooted in historic discrimination and bias which leads to conflicts. Most irrigation schemes are gravity fed. Older earthen channels have been lined, and now many are switching to pressurised systems including drip and sprinkler water applications.

Questions & Answers:

Q: how do the Ministries coordinate?

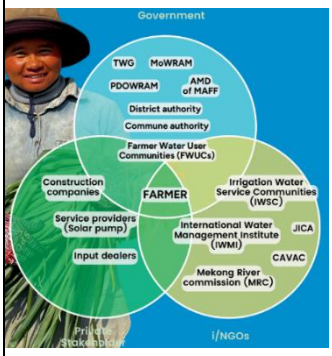
A: Ministry coordination is good but much of the work delivered by the Departments is less well coordinated.

Q: In Cambodia the farmer water user group structure is similar. How do they coordinate so that they function well?

A: After construction irrigation schemes are handed over to the public. They are involved from initial consultation to build ownership. It is the district level that oversees coordination.

Cambodia

The Cambodia landscape is divided into three thirds: lowlands, a plateau, and 'highlands' (with a 100m peak). There are 3 million hectares of farmland, 61% of which is irrigation in the lowland zone. 75% of Cambodia's water flows from upstream countries in the Mekong basin, making Cambodia very vulnerable. 96% of all Cambodia's available water is used for agriculture, the rest is used for industrial and domestic use.



Irrigation conveyance is typically by earthen canals, concrete schemes to a lesser extent, and some pvc piped schemes are emerging. Of the 443 schemes, only 2% are managed by farmer-led water user groups, so more learning is required on what is needed to perform well. Most schemes are gravity fed. Where there is pumping, it is mostly powered by diesel. Electricity is not very accessible due to long distances from power sources. Solar systems are starting to become more available in local markets.

Definition of sizes

Micro = individual farm plots | Small = 500ha |
Medium = 2000 ha | Large =10,000ha

Institutional set-up:

Government: The Ministry of Water Resource and Meteorology (**MoWRAM)** is responsible for surface water. It is also involved in groundwater management, particularly in terms of research, monitoring, and regulation of groundwater use. This includes issuing permits for groundwater extraction for agricultural and industrial purposes. The **Ministry of Rural Development** plays a significant role in groundwater management, particularly in rural areas. It is involved in the development and management of groundwater resources for drinking water supply and small-scale irrigation systems in rural communities. However, improved governance is required to manage, use, and conserve groundwater effectively. **PDOWRAM**: Provincial Departments of Water Resources and Meteorology that fall under MoWRAM. **AMD/MAFF**: Agriculture Marketing Division / Ministry of Agriculture, Forestry, and Fisheries. MAFF is the main body responsible for agricultural policy, development, and management of natural resources related to agriculture, forestry, and fisheries. There are technical working groups (TWGs) (inter-ministry, agriculture and rural development, environment) which have focal points.

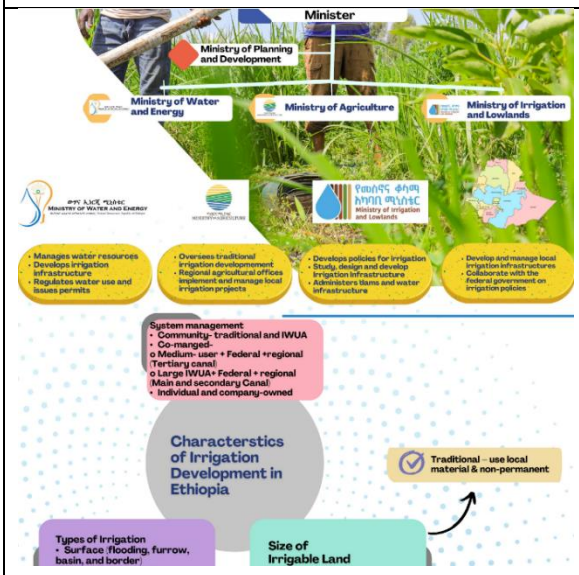
At the provincial scale, stakeholders work closely to ensure local farmers can access water. Cambodia is a small country, and most communes have their own budgets. Normally commune budgets focus on other priorities, but irrigation is a priority. Local levels report regularly to the Provinces and the Ministry. The private sector is an important actor, providing products and education on use of products. INGOs and NGOs also play a significant role.

Challenge and ambition:

Water scarcity and climate change is driving the need to develop irrigation. Normally farmers only irrigate in the rainy season, to augment watering and boost crop yields. There is not enough water available to irrigate in the dry season. There is very little budget for maintenance. There is no licensing system to support private sector involvement, although the policy for this is ready. There is a strong desire to convert more irrigation schemes to concrete canals or piped systems. There is also strong interest in the opportunities to use digital tools (Earth Observation) to support monitoring programmes.

Questions & Answers: Unfortunately, there was no time for questions on this poster.

Ethiopia



The Office of the Prime Minister is the apex institution. The Ministry of Planning and Development acts as a bridging institution with a mandate to organise three other ministries:

1. Ministry of Water & Energy: Responsible for basin-wide water resource management. Develops irrigation infrastructure, regulates water use, and issues permits. It is planning to collect fees from water users, but this is not yet implemented.
2. Ministry of Agriculture: Responsible for ***traditional*** irrigation development and expansion. Its focus is on agronomy not infrastructure. It operates regional agricultural offices to implement and manage local irrigation projects.
3. Ministry of Irrigation and Lowlands: Focuses on policy for irrigation expansion (medium-large schemes), scheme design, development, and management. It administers dams and water infrastructure.
4. Regions: Following recent government administration changes, there are now 13 regional states, and each can plan their own schemes. They develop and manage local irrigation infrastructure and collaborate with the federal government on irrigation policies.

Scheme management: Irrigation schemes are either managed traditionally with communities and irrigation water user associations; individually or company owned; or co-managed between medium users, regional and federal government (tertiary canal level), or co-managed between large IWUAs, regional and federal government (main and secondary canals).

Irrigation schemes are classified as either:

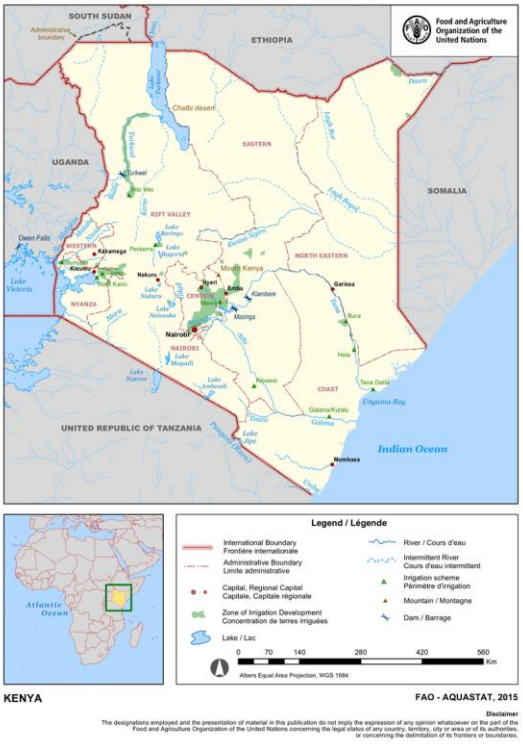
- Traditional - these use local materials and do not have permanent abstraction systems.
- Modern – these have fixed infrastructure that operates permanently (micro – large scale farms).

Types of irrigation: All types are present. Surface water is used more commonly than groundwater (flooding, furrows, and border) but there are pressurised systems. Drip is mostly used on small farms, and sprinklers are generally reserved for larger farms).
The government's 10-year development plan included a mandate to increase the irrigated areas to 1.2 million hectares. This needs to be updated.

Questions & Answers:

Q: Please clarify the role of the Ministry of Water and Energy.
A: They are responsible for drinking water, sanitation, and hydropower. The Ethiopian Renaissance Dam falls under their remit. The energy focus is on large hydropower schemes and uptake of solar power.
Q: How does the Government support / licence the private sector?
A: The private sector is not very active in Ethiopia. The Ministry of Water issues permits and the Government is planning to engage more investors through PPPs, although there are some concerns.
Q: Who is responsible for climate data?
A: The meteorological institution collects the data and gives it to the Ministries. Climate strategy is under the remit of the Ministry of Planning and Development.

Kenya



Kenya's Agenda for Transformation focuses on issues of productivity, to better utilise existing water and irrigation infrastructure.

The map shows the distribution of irrigation development (primarily to the north and north-west of Nairobi, and on the Tana and Athi rivers) and strategic projects (>3000 acres).

At the national level the Ministry of Water and State Department for Irrigation set policy, but political reforms mean responsibility for irrigation is always changing. The 2019 Irrigation Act established the National Irrigation Authority which is currently responsible for regulation and planning trans country projects and schemes >3000 acres. Irrigation Water Users Associations are members of the Water Resources Authority. In some counties the IWUAs connect into the Departments.

Some irrigation projects are still under the Ministry of Agriculture, where they started. The National Water Harvesting and Storage Authority is primarily a flood control agency but is also involved in irrigation.

There is currently around 700,000 acres of land under irrigation, but the Kenya Vision 2030 has high ambitions to increase this to over 1.2 million acres by 2028 requiring an enormous increase in water available for irrigation (from 55MCM to 2379MCM). Ambition in the ASL is to make better use of flood waters.

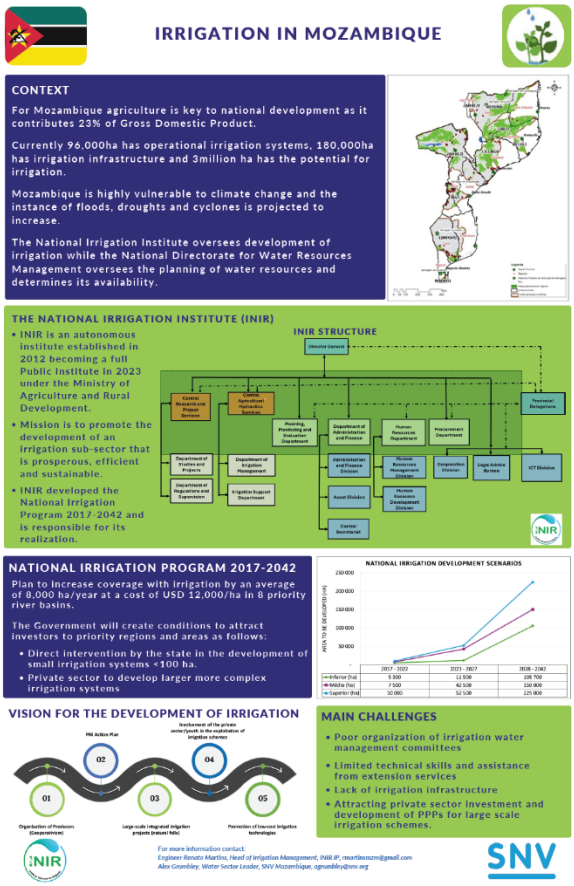
What has worked for Kenya? Increased numbers of public irrigation schemes, community managed schemes, and localised water harvesting providing more water for households and small scale farming. Further work is underway with the World Bank to identify what else can be done, that is not financial to optimise schemes.

Questions & Answers:

Q: Is the NIA an autonomous authority or is it a Department agency?

A: It is a semi-autonomous government agency with full autonomy to choose its projects. It gets funding from the Ministry and is well distributed geographically, which helps enable implementation across the country.

Mozambique



23% of Mozambique's GDP is generated by the agriculture sector. 96,000 ha has operational irrigation, 180,000 ha has irrigation infrastructure (not operational), and a further 3 million ha has the potential to be irrigated. Mozambique is highly vulnerable to climate change, regularly experiencing powerful cyclones and floods.

Institutional set-up:

National:

- The **National Irrigation Institute** oversees irrigation development (INIR) and is a public institute under the Ministry of Agriculture and Rural Development. It's mission is to promote the development of an irrigation sub-sector that is prosperous, efficient, and sustainable.
- The **National Directorate for Water Resource Management** oversees water resources planning and availability assessment (sits within the Ministry of Public Works).

Structure:

INIR is led by a Director General who reports to the Prime Minister. It has a national level body comprising two service functions, 3 administrative departments, and a Department for Planning, Monitoring, and Evaluation. Outside of this it has five Provincial Delegations (decentralised for each priority basin) that oversee delivery of irrigation services. (There are 8 priority river basins in the national irrigation plan 2017-2042*, but they only have resources to establish 5 basin delegations/offices so far)**.

*Extra information: These eight river basins are critical for enhancing agricultural production and ensuring food security in the country: Limpopo River Basin; Incomati River Basin; Zambezi River Basin; Púngoè River Basin; Buzi River Basin; Ligonha River Basin; Licungo River Basin; Save River Basin.

**These delegations cover key regions in the country: Gaza Provincial Delegation; Manica Provincial Delegation; Sofala Provincial Delegation; Zambezia Provincial Delegation; Nampula Provincial Delegation.

Plans and ambitions:

INIR has established a 25-year irrigation programme (2017-2042) to add an extra 8000 ha of irrigation per year, at the cost of US$ 12,000 per hectare, which it is responsible for delivering. The Government plans to direct intervention to more smallholders (i.e. those with farms <100ha) whilst encouraging the private sector to invest in larger, more complex systems.

It has forecast three different investment scenarios, with the greatest deviation between them after 2027 (the lower forecast is to achieve an extra 100,000 ha by 2024, the upper forecast aims for an extra 225,000ha)

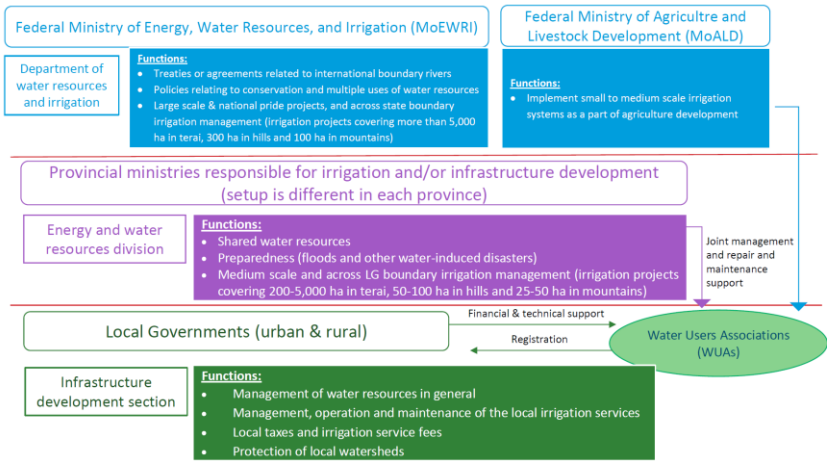
Challenges: The biggest single challenge is poorly organised irrigation management committees. There are limited technical skills and assistance from extension services, a general lack of irrigation infrastructure, and it is currently difficult to attract private sector investment for the large scale systems.

Questions & Answers:

Q: What is the Government doing to encourage private sector investment?

A: With funding from the World Bank they are rehabilitating irrigation projects and cooperative schemes for private suppliers to operate and maintain. The private sector is expected to invest and contribute to Operations & Maintenance (delegated Management Contract, not Build Operate Transfer). They are linking the private sector to the associations and cooperatives to facilitate deal making and agreements.

Nepal



Nepal is a mountainous country, so all infrastructure is expensive. At the national level, the priority is to create inter-river basin water transfers.

Institutional set-up:

Irrigation is managed at three scales: Federal (national), Provincial, and Local.

- **Ministry of Energy, Water Resources, and Irrigation**: Manages international boundary waterbodies; Sets water conservation and multiple water use policies and; Manages large scale and national pride projects. The policy environment is reasonably strong with good frameworks in place. After traditionally focusing on water development, the Government is starting to prioritise water resource management.
- **Provincial Ministry of Physical infrastructure Development:** manages shared water resources, hazard preparedness, and medium scale irrigation projects/trans local government projects;
- **Local Government:** LG is still forming after the Federalisation of Nepal. LG manages local irrigation projects, but as institutional capacity is still developing, they just work on smaller scale systems for now.
- **Water Users Associations:** the WUAs provide some level of on farm water management.

Nepal is the only country where Civil Society is included formally in the institutional set-up.
Small-scale systems get some financial and technical support from Local Government, but for bigger problems, they ask for provincial and federal assistance. Communication between them is well coordinated.

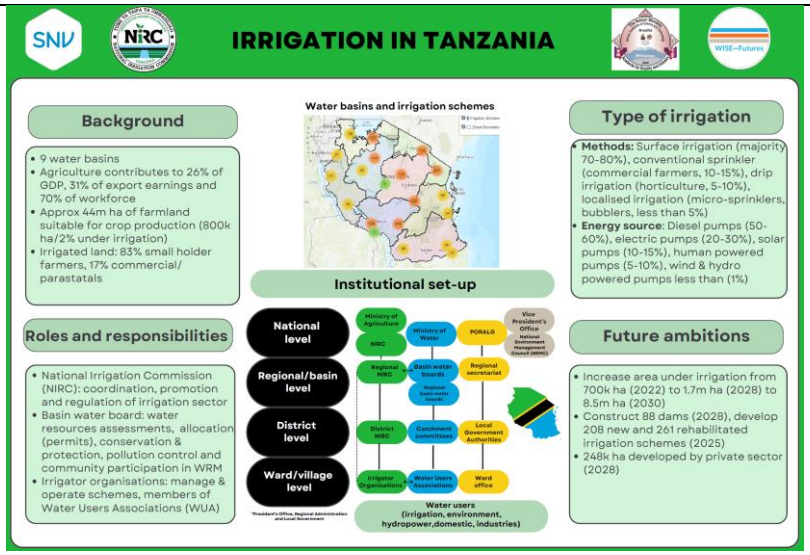
In the Terai, the Government has prioritised bigger irrigation schemes, even including some long tunnelling projects to distribute water. Groundwater systems are well established with interconnected boreholes, etc, that provide flexibility for supply outages to occur without users losing access.
Water resource and irrigation projects are all held by the Government. There is no private sector investment as private funding hasn't been legalised and no irrigation fees have yet been collected. Therefore there is currently no scope for Public-Private systems.

The mountains are referred to as 'water towers', but the volumes of water flowing from them are decreasing, which is a national concern. The Government is planning more water-efficient micro/small irrigation schemes and is drafting strategies to combat the emerging water scarcity.

Questions & Answers:

No time for questions on this poster.

Tanzania



Tanzania has five major river basins. Agriculture contributes 26% of GDP but 70% of the workforce. Out of approximately 44 million hectares of land suitable for crop production, only 2% (800,000ha) is irrigated. 83% of the irrigated land is farmed by smallholders (just 17% is commercial or pastoral). Most irrigation is traditional surface water, although more modernised precision irrigation types are emerging.

Institutional set-up: Four levels

1. National: Ministries of Agriculture and Water; President's Office- Regional Administration and Local Government (PO-RALG); National Irrigation Commission (NIRC), Vice-President's office. The **NIRC coordinates and regulates the irrigation sector.**
2. Regional/basin: regional branches of NIRC, basin water boards, and a regional secretariat. **Basin water boards assess water resource availability, manage allocations, and environmental issues.**
3. District: district branches of NIRC, catchment committees and Local Government.
4. Ward/villages: Irrigator organisations, WUAs, Ward offices.

At the lowest level, there are important distinctions to be made: Irrigation Water User Associations get permits and pay fees. **Irrigation Organisations manage the irrigation schemes**, and Water Resource User Associations take the lead. The people involved in the IOs are also members of the WUAs. All of these groups are involved in catchment/regional water plans although the effectiveness of this varies in different places.

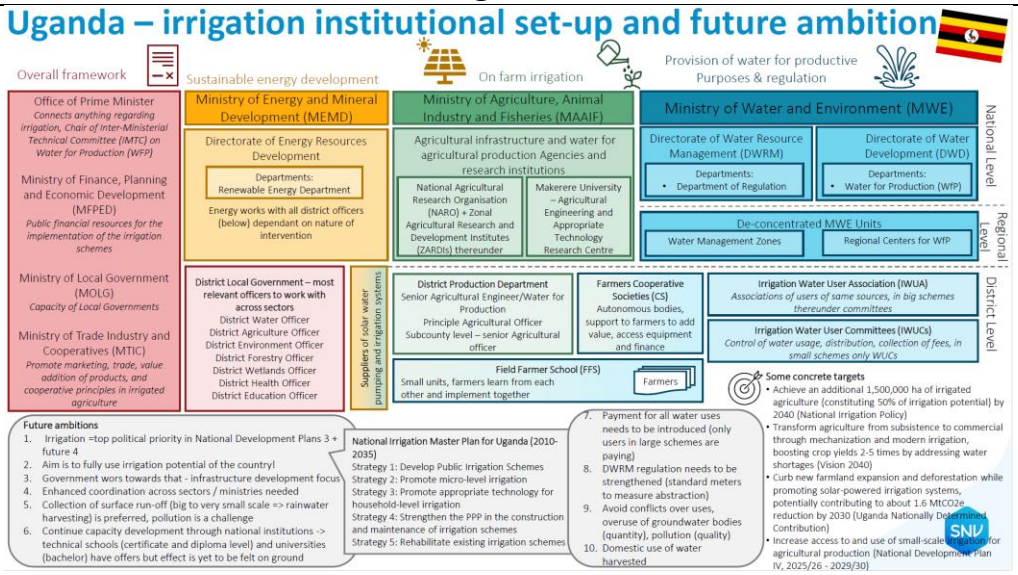
Ambition and plans:

There is a 5-year strategic plan (2023-2028) to expand from 1.7 million ha of irrigated land to 8.5 million ha (248,000ha to involve the private sector). Before the end of 2025, they plan to rehabilitate 261 irrigation schemes and build 208 new ones. To support water demand they intend to construct 88 new dams by 2028.

Questions & Answers:

Q: is the 5-year plan integrated with the plans for hydropower?
A: No, it just considers irrigation.
Q: Is the Government of Nepal considering use of groundwater for irrigation?
A: There is an ongoing drilling programming. The approach is now shifting from rainfed reliance to storing and using more water in dams and increasing use of groundwater.

Uganda



Institutional set-up:

- OPM (Office of the Prime Minister): Coordinates multi- sector government business
- MFPED (Ministry of Finance, Planning, and Economic Development): Responsible for public money to plan and fund development of irrigation schemes.
- MOLG (Ministry of Local Government): Supports irrigation by supporting the local government capacity
- MTIC (Ministry of Trade Industry and Cooperatives): Promote marketing, trade, and cooperative principles in irrigated agriculture.
- Land is privately owned in Uganda so the Ministry of Land is required to navigate finding land for public projects.

Outside of this general structure are three Ministries that specialise in irrigation's vital components:

1. **Provision of water:** MWE (Ministry of Water and Environment): In charge of water resources and water conveyance up to the farm gate. Dam construction, conveyance, primary and secondary canals. It has a few directorates. The two main ones are: Water Development, its Water for Production department is directly in charge of infrastructure; and WRM, its Regulation department (new) regulates how much water is to be used depending on water availability (they meter water and issue water abstraction permits). The MWE also has 5 **regional** deconcentrated units.
2. **On-farm irrigation:** MAAIF (Ministry of Agriculture, Animal Industry, and Fisheries).
3. **Sustainable energy:** MEMD (Ministry of Energy and Mineral Development): supports subsidies for cheaper energy for irrigation and works with District LG. This includes education to ensure knowledge is transferred.

At the **district level** a range of Government and non-Government (autonomous) groups take charge of local issues such as the water user groups, Farmer field schools, farmer cooperatives, and district production officers.

Ambitions and plans:

- The National Irrigation Master Plan for Uganda 2010-2035 sets concrete targets including plans for an additional 1.5 million ha of irrigated land.

TRY THIS

Look again at the posters.

1. What is similar and what is different in the other countries? Levels- functions- responsibilities – ambitions – plans?
2. Do you see things that are better than in your country? Why?

Think about your own country:

- Are all types of irrigation and irrigator (or potential irrigator) given sufficient attention within the existing institutional structure?
- Are all irrigators needs equitably covered by the existing system?
- Are the relationships between who plans and who operates and maintains strong enough?
- Is the availability of water resources taken seriously enough when planning irrigation expansion, or is it assumed that it will become available?
- Is the role of the private sector in providing services appropriate (not too small, not too dominant, sufficiently regulated)?

Block 2: Irrigation in Tanzania

Introduction

This learning event was held in Tanzania due to the range of irrigation types and scales that are available to visit and which are operational during July. This block uses the Tanzania example to introduce the topics of irrigation sector development and the role and activities of basin water board authorities in managing the water resource on which irrigation depends.

Introductory presentation 1: Irrigation Sector Development in Tanzania

Eng. Sadati R Kolowa, National Irrigation Commission of Tanzania, Assistant Director, https://www.nirc.go.tz/

This presentation introduces the importance of Agriculture's contribution to GDP, employment opportunities, the supply of raw materials to factories and the fact that Tanzania already meets 100% of its food needs. It then describes irrigation sector governance reforms, the Vision for Tanzania, and the strategies and measures to ensure sectorial development.

Agriculture contributes 26.1% to Tanzania's GDP, employs 65.6% of the population, and generates US$1.2 billion export earnings. Despite this the country still needs to increase agricultural production primarily for export.
The history of irrigation sector reform in Tanzania began in 2002 and has evolved in six stages:

1. National Irrigation Master Plan (NIMP, 2002). This plan demonstrated how irrigation schemes should develop and was a tool to start evolving the sector.
2. National Irrigation Policy (NIP, 2010). This policy was intended to motivate improvement, to ensure sustainable availability of irrigation water and its efficient use for enhanced crop production, productivity and profitability to contribute to food security and poverty reduction.
3. National Irrigation Development Strategy (NIDS, 2010).
4. National Irrigation Act (NIA, 2013). The NIA established the NIRC to enable development, operation and maintenance of irrigation and drainage systems (to implement the National Irrigation Policy and National Irrigation Development Strategy).
5. National Irrigation Regulations (NIR, 2014)
6. National Irrigation Commission (NIRC, 2014). The NIC is an independent institution responsible for irrigation. It began to operate in 2015, and its main functions are promotion, coordination, and regulation of irrigation development. In Tanzania it currently falls under the Ministry for Irrigation. The ministry in charge varies according to politics in the country.

Current status:
NIRC works closely with Water Resource Management organisations, especially the Water User Associations (WUAs). These are large groups, with many members, formed under the Ministry of Water. WUA members include Irrigation Organisations. New irrigation scheme developments require a Water Permit which is provided by the local Water Basin authority, through the WUA (*more information on permitting is given in Presentation 2: Pangani Basin Water Board)*. WUAs are supported by NIRC and the Basin water boards to build capacity in water source protection and water use efficiency. NIRC also works closely with local governments, Regional or District to formulate and implement irrigation projects that meet local requirements.

Vision of development: Approximately 727,000 ha is irrigated (2.5% of its total potential). Agenda 10/30 is NIRCs vision to ramp up irrigated land to 1.2 million ha by 2025 and 8.5 million ha by 2030. '10/30' refers to increasing production by 10% each year up to year 2030. The ambitions of Agenda 10/30 are

intended to drive forward the changes that are required, to capitalise on the opportunities that exist, and the challenges to overcome.

Opportunities	Challenges
Quantity of **potential land for irrigation**: 2.3 million ha of land with high-potential[1], and 4.8 million ha with medium-potential (the remaining 22.3 ha have low-potential).	**Little private sector investment** due to high capital costs and perceived risks. Most investment is still by the Government. The aims are for new schemes to include private sector investment.
Water sources: lakes, perennial rivers, groundwater	**Droughts, floods, and degraded water sources** (due to climate change and poor land use practice). NIRC is keen to promote and support new technology to increase resilience to climate change[2].
Increased **domestic demand for food** as population increases (62M in 2022, 80M estimated by 2030, 7 million MT increase demand for food).	**Low performance of irrigation schemes** due to poor O&M of irrigation infrastructure by lack of or weak Irrigation Organisations.
Beneficial East Africa location (SADC) large regional **market availability (opportunity to export).**	**History of insufficient Government funding** to development irrigation.
Political will supports **investment in irrigation** (increases from 18 Billion Tsh in 2020/21 to 371 Billion Tsh in 2024/25).	**History of low growth and poorly developed irrigation infrastructure** (due to lack of investment).

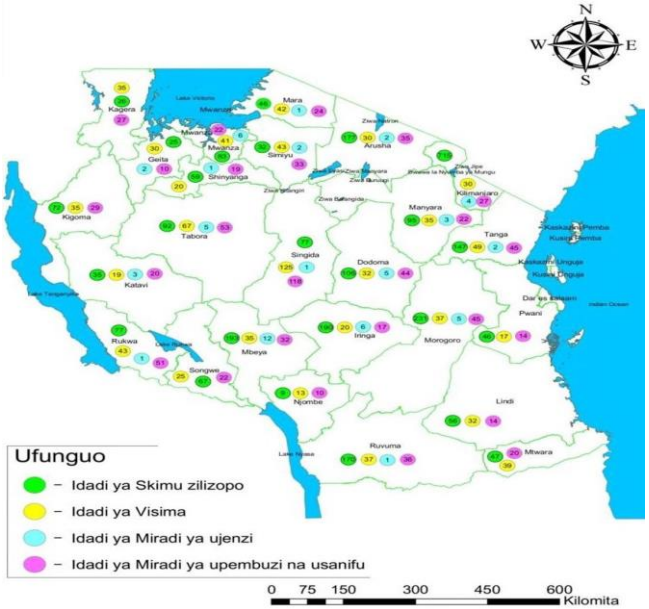
Understanding land area and irrigation potential is fundamental and NIRC has established a system to collect accurate land area data on irrigation schemes including traditional schemes which are difficult to measure.

NIRC is currently undertaking feasibility studies for 22 basins, but they need more money for investment. They have identified four key steps to overcome the challenges:

1. **Construction and rehabilitation** of irrigation infrastructure: currently constructing 25 new irrigation schemes; rehabilitating 30 existing irrigation schemes; and constructing 14 irrigation dams.
2. **Irrigation project feasibility studies** and detailed designs: currently assessing 42 irrigation schemes, 22 potential irrigation basins; and 100 irrigation dams
3. Establishment and registration of **Irrigators Organisations with training** on operations and maintenance (O&M) and water management.
4. **Private sector investment** in irrigation sector: seeking signed MoUs with various companies

Specific Agenda 10/30 promotions include kilimo biashara (Farming as Business) and Building Better Tomorrow (BBT).

[1] Definitions of high, medium, and low potential not provided during the presentation.



Translation:

idadi ya Skimu zilizopo	Number of existing schemes
idadi ya Visima	Number of wells
idadi ya miradi ya ujenzi	Number of construction projects
idadi ya miradi ya upembuzi na usanifu	Number of research and design projects

Figure 6 NIRC Projects Map

Eight expected results of the ongoing initiatives:

1. Improved irrigation water use efficiency;
2. Improved availability of reliable water for irrigation;
3. Improved production and productivity of the irrigation schemes;
4. Improved country food self-sufficiency;
5. Increased access to employment (both direct and indirect);
6. Improved farmers income;
7. Increased government revenue collection from crop sub sector;
8. Strengthened collaboration with stakeholders, development and management of irrigation schemes.

Q&A: Sadati R Kolowa, National Irrigation Commission of Tanzania

Q: In Uganda climate change is an issue for sustainable systems. How does Tanzania make large schemes climate resilient
A: There are 9 river basins, so organisations have to coordinate. Some rivers are changing from perennial to ephemeral and so there is a focus to build dams to collect flood water.

Q: What makes the NIRC a success today? TZ seems to have resolved what other countries are struggling with.
A: Success depends on the political situation. Which Ministry is in charge of irrigation varies depending on whoever is President. In 2014 Tanzania was able to use the National Irrigation Act to establish an autonomous NIRC. It was **critical to make it independent**. Under the NIA responsibility for the NIRC is with the Director General, not the President. This prevents political interference, and it can organise itself.

Q: How realistic are the plans to reach the ambitious targets, without much money? Is it possible to reach 8.5 million ha?
A: The real expectation is lower than 8.5 million ha, but a high target increases impetus to work hard. The Minister is pushing for the target to be even higher.

Q: There are now plans to use groundwater as well as surface water for irrigation, especially small farmers who are responsible for themselves. What can the authorities do to help increase use of groundwater?
A: The Government has initiated a special programme to explore groundwater availability and use in every region.

Q: What incentives are being used to increase interest in the private sector to invest?
A: The Ministry of Finance with others is working harder to involve the private sector, signing MoUs etc. Now also the Ministry of Planning has a role to engage with the private sector. There are two important distinctions to make when talking about the private sector:

1. Schemes where a company or companies do **Build Operate Transfer,** O&M
2. Schemes where companies are contracted, private sector suppliers, and large commercial contractual farmers.

Introductory presentation 2: Basin overview

Segule Segule, Basin Water Director, Pangani Basin Water Board (Ministry of Water)

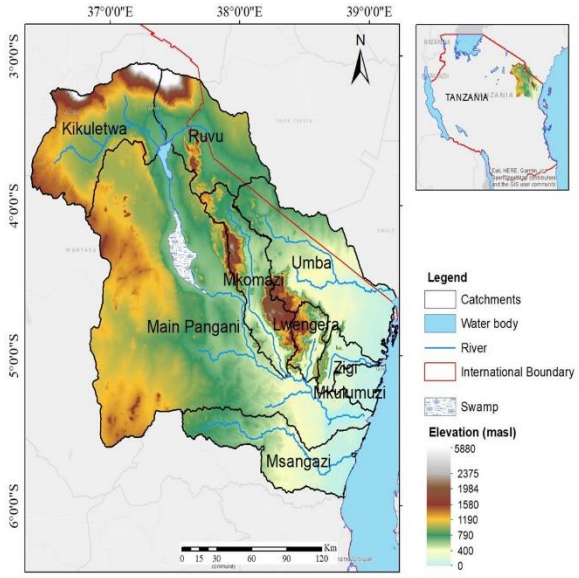


Figure 7 Pangani River Basin

This presentation introduces the Pangani river basin, it's sub-catchments, and the Pangani Basin Water Board's activities to sustainably manage water resources.

The Pangani river basin is in north-east Tanzania. It has a surface area of 58,400km^2. It is a transboundary basin, 93% of it lies in Tanzania, in the Arusha, Manyara, Kilimanjaro and Tanga Regions and 7% lies within Kenya. Within the basin there are 9 sub-catchments. Water flows from Kilimanjaro and the Meru mountains into the Pangani river.

From the volcanic upland areas in the north-west part of the basin to the low-lying coastal zone the rainfall ranges from 1200/2000mm to 300/500mm/year. Arusha is considered to be the basin's water tower. It is home to 6.7 million people (2022) and many important lakes.

Pangani Basin Water Board has the ambition to be best water basin in all of Africa with a Vision to 'Practice Sustainable Water Resources Management and Development while Providing Equitable Opportunities and Benefits to the Basin Population' and a Mission to 'Manage Pangani Basin Water Resources Effectively and Sustainably Using Integrated Water Resources Management and Good Governance Principles'.

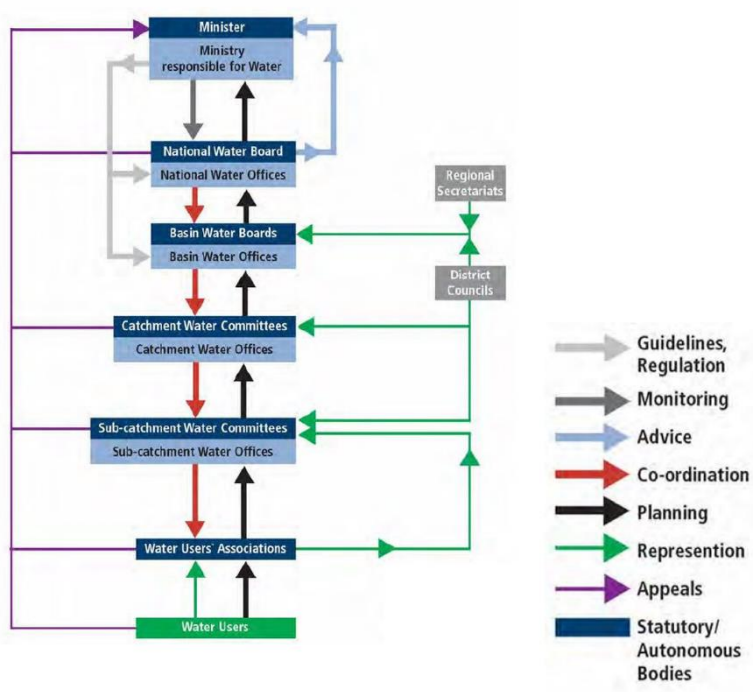


Figure 8 WR Management Structure (Tanzania)

From the top water resources is the responsibility of the Ministry for Water under which sits the National Water Board and National Water Offices. This organisation coordinates the work of the Basin Water Boards who in turn coordinate the Catchment Water Committees and Catchment Water Offices. At the lower level are the water users who organise themselves into Water User Associations who liaise with the Catchment Water Committees. Planning and allocating water resources starts at the lower level and feeds upwards through this hierarchy.

Pangani basin has six main types of water resource: the 'Water Towers' (mountains), major lakes, big dams, large rivers/sub-catchments, large springs, and wetlands. It also has numerous forest reserves, national parks, nature reserves, and mineral deposits. The basin provides 1430 m^3/year per capita (per person) Renewable Water Resource (RWR).

Nine categories of water users are identified. The biggest user is Hydropower (non-consumptive), followed by Irrigation (highly consumptive), followed by the Environment (water demands of ecosystems and wildlife). Far smaller water users are Domestic (households), Industries/Mining, Fisheries, Tourism, Transportation, and Recreation. **Irrigation already consumes approximately 32% of the Renewable Water Resource.**

Pangani Basin Water Board's responsibilities (under the Water Resources Management Act 2009, Amended 2022) include:

1. Water Resource Assessment (collecting and processing data and disseminating information). PBWB has 339 monitoring stations spatially distributed across the sub- catchments;
2. Water Allocation: done by issuing permits;
3. Water resource conservation and protection: the focus is on protecting sources by demarcating 'buffer zones' where no activities are permitted (using beacons);
4. Pollution control: 108 pollution monitoring stations close to industries and utilities and PBWB issues discharge permits.

5. Strengthening community participation in WR management.: PBWB involves the community in management, people meet to discuss allocations. WUAs are the primary organisation for managing WR allocations but the BWB gets involved if problems can't be resolved locally.

Challenges	Steps undertaken
The big challenge is water use conflicts. Supply is well managed, but irrigation is not. Not all farmers are registered with a WUA and use weak furrows with high water losses (long conveyance networks combined with earthen structures).	Formation of WUAs.
Illegal abstractions of water from water sources and a lack of reliable method for compliance monitoring of water abstractions	Monitoring water use by taking measurements in rivers and canals.
Increasing water demand outstripping the limited resources available.	Promoting drip irrigation*
Limited funds for timely implementation of proposed interventions	Constructing dams to increase water availability.
Low level of community involvement in water resources management	Continuing water source protection.
Little infrastructure to discharge excess abstracted water.	
In the dry season there is a lot of fighting.	

Conclusion: Water is a finite and vulnerable resource which is under pressure and becoming scarce as a result of increasing multi-sectoral demands of the rapidly growing population. Pangani Basin has the second lowest per capita of water in Tanzania and so must manage it more strategically. PBWB believes in stakeholders collaboration to ensure water is used sustainably.

Q&A: Segule Segule, Basin Water Director, Pangani Basin Water Board

Q: The pollution monitoring focus is on industrial and urban polluters. How are you controlling agricultural pollution?
A: The water quality from bigger users is checked. PWBW also monitors sedimentation rates in the canals.
Q: Is it mandatory to join a WUA?
A: Yes, if a user is not registered, they are illegal. If a water permit expires the user is illegal.
Q: Water users and payments: how is the PBWB involved in payments? How are fees and prices regulated and organised?
A: Water users submit their water demand quantities in an application form. There is a flat rate for small users (estimate use). Larger, commercial water users must measure their actual water use and submit the data to PBWB.
Q: How is management of transboundary issues undertaken?
A: PBWB receives and provides water to Kenya. There are some forums for the organisations to meet. Sometimes they agree, other times they agree to disagree on issues. Tanzania has more transboundary sources than any other country in Africa (13) so is signature to multiple water agreements, MoUs etc.
Q: What is the potential to dam water flowing from the Kilimanjaro and Meru mountains?
A: These are the water towers. PBWB encourages people there to be part of conservation.
Q: Conflict is a serious challenge: what mechanisms are there to safeguard poorer water users?
A: We experience several kinds of conflicts. Sometimes between big users, but mostly between smaller users, especially in the dry season. There are some written down rules.

Field assignments

The workshop participants broke up into four groups to visit locations in and around Arusha and explore real-life issues relating to Sustainable Inclusive Irrigation. Each group prepared their assignment on the Monday and spent the next day visiting key stakeholders and observing infrastructure relating to one of the four Sustainable Inclusive Irrigation topics.

Figure 9: Field visit groups map

The objectives for each group were to:

- Understand the management of irrigation arrangements, and how that ensures access and control over water;
- Describe the current irrigation infra and management set up, revenue model, water footprint;
- Reflect on financial variability, equity, water security, impact on other users, climate risks, contribution to food security.

Each group comprised participants from different countries with mixed skill sets. The participants shared their findings through a photo diary, a two-page case description, a testimony of a key stakeholder, and a PowerPoint presentation with impressions and recommendations to plenary and a panel of Tanzanian partners.

These more detailed outputs are available in the Sustainable Inclusive Irrigation E-Group system.[3]

[3] Available to all subscribed group members.

Group 1: Field assignment – Shambarai Burka, Meru District

Group 1 visited the shallow wells of Mbuguni (Shambarai Burka, Meru District)

In response to variable and limited rain and increasing competition for surface water, farmers have started using the shallow groundwater. The technique in this area is hand-dug shallow wells (average 12m below the surface), many in combination with pumps (petrol, diesel, solar, electric). Using groundwater began in the 1990s and was primarily for domestic purposes. However, since the early 2000s it has been used to support irrigation during the dry season.

Vegetables are the primary crops, but farmers also grow maize and beans. The main irrigation methods are flooding, furrow, basin, and to a lesser extent drip. Each well irrigates approximately 1-2 ha (constrained by the land available to the famer and the capacity of the pump). It is unknown how many of these wells there are in the area (estimated at hundreds of individual users) and they are not registered and definitely not mapped. The well design, in which a person can walk down a shaft to the water is reminiscent of mine shafts. This area has a history of mining.

Group 1 met with diggers, a contract tomato farmer, the owner of a large pepper farm, a water user leader, and a representative from Pangani Basin Water Board.

Water quality and quantity findings: Irrigation wells often also used for household drinking water, but surveillance and testing water quality is limited (results not commonly provided to communities). Well 'shaft-entry' design runs risk of stormwater flooding and groundwater contamination.

Volumes pumped is constrained by high fuel costs and pump capacities. This reduces risk of collective unsustainable abstraction but limits farmers abilities to expand and increase produce. There has been no noticeable change in groundwater depth since the 1990s.

Tariffs and financing: Irrigation Committee tariffs for irrigation water vary considerably between communities, irrespective of volumes received (hours accessing water) with no demonstrable explanation. Registered Irrigation Associations pay the NIRC $20/season/hectare. Farmers also pay three separate tariffs to their WUA.

Hand-dug wells incur an initial capital investment (payable to the well-diggers) $150 for a small domestic well, $300-400 for a farm well.

Governance: No permits are required to dig or use a hand-dug well, but a permit from Pangani Basin Water Board and the NIRC is required if a pump is used (for irrigation). This generally does not happen in practice. The authorities do not have the resources to do the outreach needed to regulate these abstractions.

WUA governance focuses on regulating surface water abstraction, to ensure everyone has access and to minimise and manage conflict.

Gender: There are clear gender-based equity issues in this area. Whilst female labourers were observed in the fields very few women interacted with the group visits. It was confirmed that culturally the head of household is almost always a man. Women generally do not attend WUA meetings, and the reason given was that conflict is common regarding allocation and negotiation for water resources. This disincentivises women from attending.

Testimony: Martha Justine is married with five children. The family has access to 10 acres of land but only farms/irrigates two. This is sufficient to meet the food needs of the family but little extra. Their

ability to farm the full plot of land is constrained by the limited capacity of the electrically powered pump, and the prohibitive costs of using the diesel pump which is better with a higher pumping rate. They aspire to get a better pump to farm the whole area.

Reflections and recommendations

- The Government's strategic ambition to expand irrigation will need to overcome drought conditions that are increasing due to climate change, and the many practical constraints preventing farmers from expanding into land they already have;
- Flooding is also increasing, and the group observed current coping mechanisms include replanting cash crops into unflooded land that was used for subsistence crops;
- The shallow-well shafts/stairwells would be safer if they were protected from stormwater;
- Community structures provide a good basis for better governance. The current focus is routinely on conflict resolution, but governance is needed to address pricing equity, allocations, and better measurement of water taken and used.
- The only current incentive to use water efficiently is the cost of pumping. However, inefficient use is likely a major aggravator of upstream/downstream water access conflict.
- More support to build existing groups' capacity to organise themselves better would resolve a number of the issues identified during this visit.

Following the presentation, the audience shared their thoughts and asked questions.

Q&A – Group 1

Q: Are there any concerns regarding the water quality requirements of different crops?
A: PBWB confirmed that drinking water tests showed the quality was ok previously, but this may have declined since the testing was done. The main problem identified in the area is the salinity that occurs with drip irrigation, especially in areas where water quality is poor.
Q: Are their any guidelines for the construction of these shallow wells (for better safety and source quality protection)?
A: No, the practice started in 1990s. Mining practices have passed to well construction. There is no market for boreholes.

Comment: the groundwater is at risk from the local mines and sanitation facilities (latrines) discharging/leaking into the shallow aquifer/s. PBWB don't regulate this pollution. Nutrient levels (Nitrates and Phosphates) are elevated. It will be very important to include multi-purpose wells in small homesteads in any new/future regulatory changes.

Group 2: Field assignment – Shamkeri Collective Solar Irrigation Scheme, Arusha District

World Vision initiated this collective solar scheme in 2015 to allow irrigation in an area without water access. During the dry season water is scarce, it is not reliable, and crop production was low. Water scarcity is the starting point for irrigation. After a period of interruptions it became fully functional in 2022.

The irrigation technology consists of solar panels, a deep borehole (deep groundwater is the only source in the dry season), water storage tanks, and drip irrigation infrastructure. The farms grow GAP-certified cash crops for export. The collective farming area is 12 hectares. The number of farmers/users varies per season, but there are more members than can farm in one season.

Technically the scheme serves four villages (Olibiri, Shamabarai burkja, Shambara isokoni, and Kerikenyi) that take water from the Kikuletwa River (Orubuso intake) to meet the needs of their livestock, homes, and agriculture in the rainy season (February to May). During the September to January dry season there isn't enough water. However, the scheme was borne from two of the villages coming together to develop the idea. They do contract farming which gives them access to better seeds and markets. 33 farmers are in the scheme. 80% of the farmers use some form of irrigation, mostly furrows, and some have solar powered drip irrigation.

Findings: System Infrastructure: 120 solar panels (no battery backup), 67m deep borehole, Grundfos pump (>20 Horsepower, 80m^3/hr 22l/sec pump capacity, 9 x 10,000L water tanks (300m from borehole, takes approximately 1 hour to fill 9 tanks), pressurised pipe conveyance, 45 x 50m drip beds per plot. A central pivot system was initially preferred, but land constraints led to change to drip irrigation.

CAPEX was covered by World Vision. This was necessary to kickstart the scheme. OPEX is the responsibility of the farmers and members contribute $40/year to the maintenance fund (pumps, tanks, motors). This is financially viable as the farmers are profitable.

Management Model: The management model has four main components:

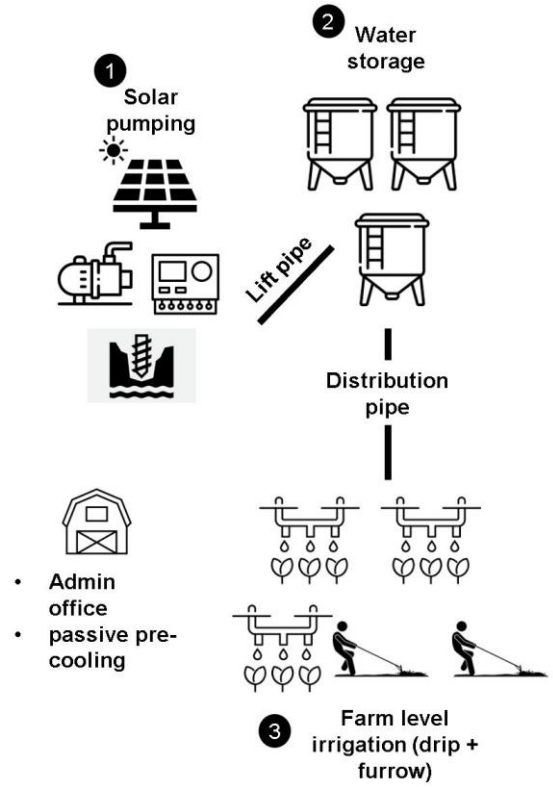


Figure 10 Solar-powered irrigation scheme infrastructure

1. the Producer Organisation (members from the initiating villages who own the asset, are fully responsible for its maintenance, and do contract farming);

2. the Facilitator (World Vision who mobilised the necessary partnerships, governance and capacity building, covered the initial CAPEX and provided technical expertise);

3. the Government of Tanzania (GoTZ), specifically NIRC and the Pangani Basin Water Board (supported World Vision, provides the governance framework, technical expertise, extension services, and is helping scale through the Build Better Tomorrow initiative); and

4. Tanzania Horticultural Association (TAHA), an apex private sector member based organisation that advocates for the growth and competitiveness of the horticultural industry in Tanzania (provides critical technical advice and support, connects farmers to international off-takers which gives them access to farming products, and support farmers access GAP accreditation for quality exports).

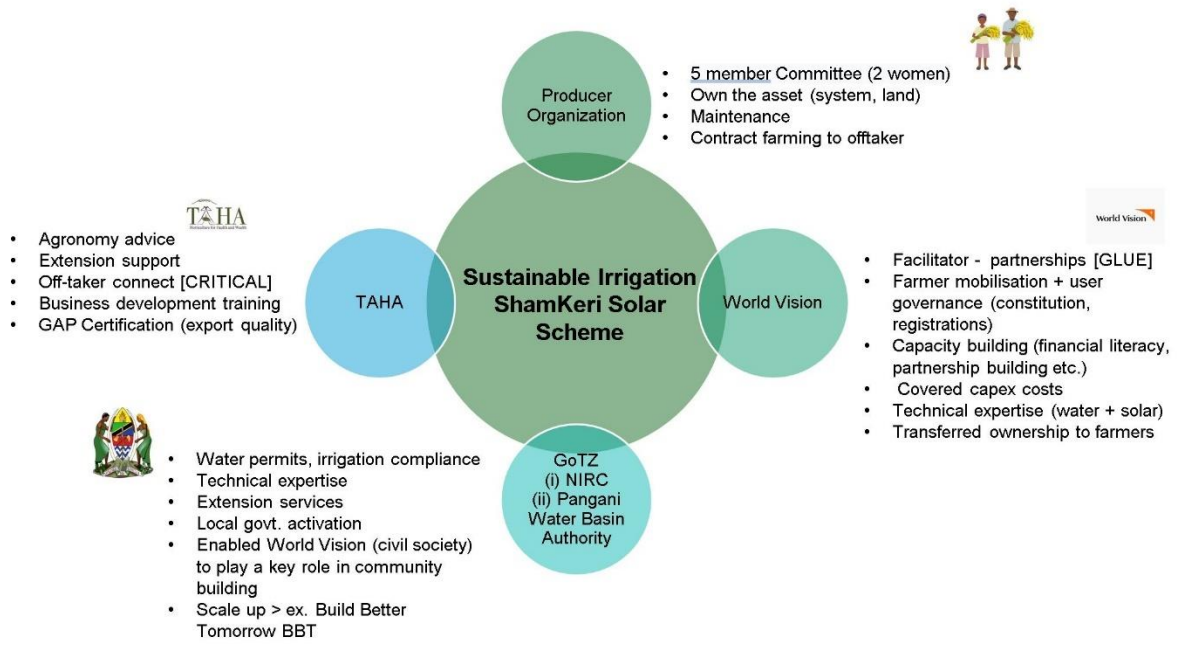


Figure 11 Management model

Water-Food-Climate:

- Water: Found to be clean and very reliable when needed for drip irrigation. Plot level technology uses basic drip materials which are exposed which leads to evaporation and transport of soluble fertiliser). Large volumes of water are lost from the irrigation furrows, and there are high levels of leakage from the pumps and (long) distribution pipes.
- Food: originally the project was to support farming for subsistence and basic markets, but after connecting with off-takers farmers realised the opportunities to switch to high value, highly profitable crops. At the country level there is no information on how this model contributes to food security in Tanzania.
- Climate (and Environment): Poor disposal of plastic material is a problem. Farmers just dump the plastic after use. Water permits are intended to prevent overuse of water. No major climate risks notes.

Impact on farmers: The scheme is operating well so far, with the main obstacle being a stable market for their produce, which will allow them to oversee the scheme's peak. These farmers also own another 120 acres, on which they plan to install a second borehole solar system for further expansion. They anticipate that contract farming will enable them to control operating costs more effectively, increase their profit margin. So far, TAHA has exerted considerable effort in reaching out to these farmers, educating them about superior seeds and efficient agronomic practices, as well as connecting them to the market. Irrigation means these farmers can now achieve two harvests per year (July-Aug, and Sept-Oct). However, some years they only farm one season and must find other work activities.

However, the success of this scheme may bring some negative consequences. Farmers that are not part of the scheme report negative impacts on their incomes and at least 500 additional farmers want to be part of the scheme. This could cause potential conflict when it comes to expansion. There is also a focus on export cash crops at the cost of local, indigenous crops

Recommendations (narrowed down from a longer list):

- **Engage the private sector** to increase mobilisation in irrigation infrastructure to complement Government service delivery;
- **Multi-stakeholder engagement**: promote the GLUE anchors that World Vision initiated. Develop multi-stakeholder platforms. Clarify new NIRC irrigation fee structures. Present "Champion Farmers" to model how a successful farm in the scheme operates. Address the need for access to off-takers and land and asset ownership issues to enable large numbers of new farmers to join the scheme;
- **Financial**: develop access to credit schemes, especially suitable financial products to help more farmers access drip.
- **Energy**: the quantity and speed of pumping requires a lot of energy, but the agricultural impact could be maximised. Provide more budget support: Planning for maintenance of system beyond warranty; and Complex vs basic trouble shooting (supplier vs trained local technical staff). Assess optimal technical designs for more applications (drinking water, domestic use , social institutions etc).
- **Value addition:** Support access to farm level 'post-harvest technology' to increase incomes for women, youth etc.
- **Water quality & efficiency:** Water quality testing is needed (GAP requirement & for domestic use). Target the inefficiencies (leakages) on drip lines and pump leakages.

Following the presentation, the audience shared their thoughts and asked questions.

Q&A – Group 2

Q: What is currently preventing farmers expanding beyond 28 acres?
A: By calculation the system can irrigate 30 acres in a day so there is capacity to expand. Some expansion is happening but not with drip (the land belongs to individuals; most can't afford to invest).

Q: Who is responsible for O&M?
A: No budget plan beyond the 1-2 yr warranty period. World Vision procured the asset but is not providing ongoing budget. So farmers started contributing 40$/year each to make a fund.

Q: Lifecycle costs - are future replacement costs included?
A: the farmers are responsible for future replacement (future CAPEX). They are planning to put more budget to the expansion stage.

Q: How is the private sector involved after solar panels have been installed?
A: So far they haven't. The farmers have struggled to do complex trouble shooting. Going forward they want to include work to expand the role of suppliers beyond installation of infrastructure.\

Group 3: Field assignment – Mawala Irrigation Scheme

Group 3 visited the public owned, farmer-led Mawala Irrigation Scheme. It is a gravity-fed scheme built in the 1980s with support from Japan. It continues to receive some government support to upgrade the infrastructure. The source of water is the high-flowing Milwaleni Spring, which forms the Rau and Njoro rivers. Water is abstracted from the river by a large intake (weir) which diverts flows into the Mawala Irrigation Scheme and to a different scheme (not included in this field visit).

Farmers outside of the irrigation scheme rely on groundwater.

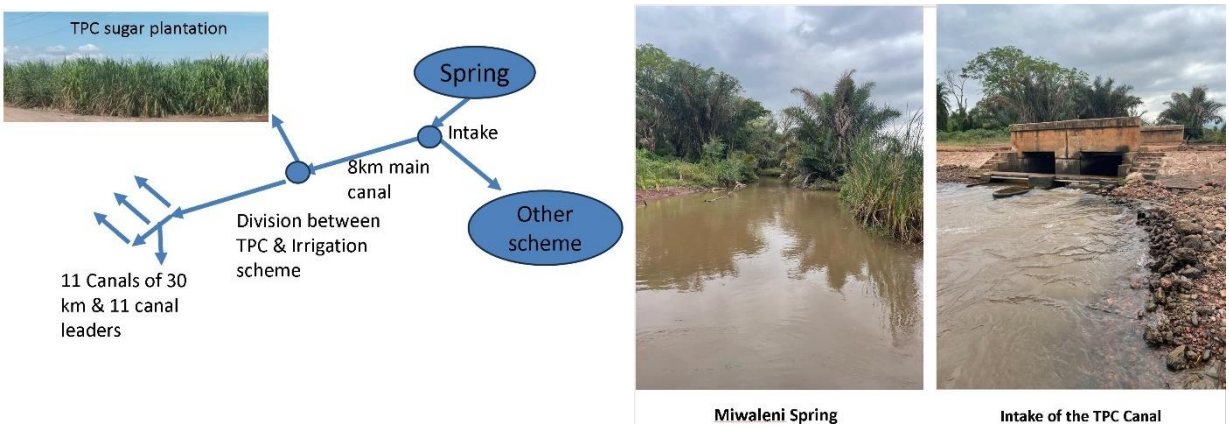


Figure 12 Schematic and photos of Milwaleni spring and the intake

8km of main canal is thought to be lined after which the water is further divided between the Tanganyika Planting Company (TPC) Sugar Plantation, and the Mawala Irrigation Scheme. Flows are divided using gated division boxes.

Mawala scheme - Irrigation Organisation: Farmers formed a formal Irrigation Organisation (IO). In Tanzania Irrigation Organisations must register with NIRC to operate legally, they then work together to develop schemes, comply with requirements, build capacity, rehabilitate schemes etc.

The Mawala Irrigation Scheme has expanded from 1500 ha to 2000 ha. The Irrigation Organisation has 1200 members (500 land owners & 700 renters) from three villages: Oria (the biggest village), Ngasinyi, Mawala that rely on agriculture for their income. The main crops are rice (Head areas) and maize, beans and vegetables (Tail-end areas). Most irrigation canals within this part of the scheme are still unlined, and so lose a lot of water.

The IO has a board with 9 members from the three villages (currently 4 of whom are women). The Board's role covers:

- Conflict resolution (the biggest source of conflict has been siltation in the canals but this has largely been resolved through,
- Coordinated operations and maintenance (TPC agrees to use an excavator to clean the main channel);
- Coordinated water distribution during periods of low water availability;
- Quarterly reporting to NIRC.

A water permit system is used to manage water distribution.

Water Resource Regulation: There is a Water (Resource) Users Association (JUWAMAMI) which started as association only for irrigation but now also addresses domestic water supply, irrigation water (for 2 schemes), and wastewater. It has six board members (voluntary positions, receive only a very small allowance) with a 3-year tenure. Anyone from either TPC or either of the two schemes can apply.

The WRUA is responsible for monitoring permit compliance (but measurement equipment is often unavailable. When water availability declines the WRUA coordinates allocation between users (together with Pangani Basin Water Board (PBWB). The WRUA is required to report water allocations and fees collected weekly to PBWB. It has an annual AGM.
PBWB is an autonomous body responsible for regulating the abstractions and most water users are required to have a permit.

- The environmental flows in the river are set at 100 litres/second.
- Upstream farmers are then permitted to abstract a maximum of 150 litres/second.

- The Mangao Irrigator Organisation (Farmers) has a permit to abstract up to 900 litres/second.
- The TPC has the largest permit, to abstract up to 1700 litres/second. TPC willingly shuts down 1 of its 4 pumps when necessary to allow water to flow downstream to the farmers in the scheme.
- There are no permits on the 8km canal between the spring intake and the users' intake. Water is abstracted without controls.

Beyond this individual scheme, PBWB is responsible for the nine catchments within the whole Pangani basin. However, due to cost limitations they only have two catchment offices. The key functions of the water board are making Integrated Water Resource Management Plans (IWRM), monitoring water levels (20% of the water resource is allocated to Environmental Flows),[4] and conflict resolution (any unresolved issues go to the Ministry of Water).

Their key challenges are the lack of funding available for development, and difficulties ensuring equitable access to water both in upstream and downstream locations.

National Irrigation Commission (NIRC):

NIRC is an important Government body that trains Irrigation Organisations; supports major upgrades, repairs, and development of new schemes; and which is taking on responsibility of Extension Offices from local government.

At the national level NIRC has a National Board (interministerial and with IO members) and a National Director General with 6 directors and 520 staff (including 300 new staff to supervise districts). Within the region there is a Regional Irrigation Engineer, 6 heads of function, and 18 staff.

NIRC also faces challenges from (historical) understaffing and the presence of illegal abstractions and continued unwillingness to pay of farmers in underdeveloped schemes.

Financing: Farmers pay fees to the WUA and the Irrigation Association.

- WUA fees are 5000 Tsh/acre (all crops) per season (10,000 Tsh for two seasons of rice). The WRUA is planning to change this so it is the landowner, not the farmer who pays (then they can charge the tenant, who sometimes moves on without paying). However, in times when there is a problem with the infrastructure farmers are much less willing to pay the fee. For the system to continue functioning it is vital that investments are made to safeguard the infrastructure.
- Irrigation Organisation fees are 10,000 Tsh/acre (all crops) per year. However, this quantity does not cover the organisation's costs, and they want to increase the fee to 50,000 Tsh/acre/year. This is to adequately cover the costs for infrastructure rehabilitation work at the farm level, build capacity, and ensure the scheme continues to comply with Government requirements.
- PBWB funding comes from users to cover operational costs (plus a small amount on maintenance and conservation efforts like reforestation).
- NIRC budget has increased significantly since 2022 (after many years of no increase) and has approximately 371 billion Tsh (with 1.1 billion from donors). It is now establishing an Irrigation Development Fund using 75% of the irrigation service fee it receives from registered members. Its aim is for the Fund to become self-sustainable.

Information about Water users: Farmers and canal leaders work within the irrigation scheme. They are both responsible for cleanliness and using the (makeshift) water distribution gates correctly to comply with water allocation agreements. Water is distributed between 3-4 canals equitably. There is currently enough water for all farmers during both irrigation seasons and so there is little conflict. During the low season farms can yield 6-10 bags of rice/acre per season. This increases to 28-45 bags during the high season (when farmers irrigate). Irrigation has enabled farmers to shift towards more rice cultivation which has improved their livelihoods.

[4] During the field visit observations at the spring source it appeared only approximately 10% of the flow was being left available to support the environment with the rest all being diverted into the irrigation system.

However, there are still challenges linked to poor service:

- The lack of drainage systems exacerbates flooding. This has intensified recently (although farmers didn't seem aware of the issue of climate change);
- There is no measurement or control of irrigation water to farms;
- There is some tension over payments. Many farmers are not aware of how their fees are spent and as a result some are not willing to pay. Some are demanding more or better infrastructure before payment, other tenant farmers believe it is the owners who should pay. The links between payment and services received are not clear;
- Other agricultural issues include the lack of visits by Extension Service providers, poor road connectivity, disease, lack of soil testing (cost related), and a general lack of organisation and poor marketing of their produce. Individual farmers rely on their own ability to find a market.

Testimonies:

The Chairperson of Mawala Irrigators Organisation, Mr Mustafa, considers the biggest success in the development of the scheme being that he was able to bring all the stakeholders together (small and big farmers) and build good relationships. Now for example, he can just call the TPC and they will agree to excavate the canals to clear sediment and maintain water volumes.

Mr Mlay, Canal leader and farmer has been a canal leader for 7 years during which there has only been 1 season with a water shortage. He is particularly proud of the cooperation and commitment in his block to maintaining clear canals and distributing water fairly. **The major concern is flooding during the rainy season** which inundates the irrigation canals and floods the fields, resulting in rainy season yields being only one third of the dry season yields.

Ms Dora, a rice farmer and her family own and farm three acres of land. The rice they harvest earns them *800k-1million shillings* although the diminished harvest in the flood season reduces the amount of profit they make in the year. Good canal leadership enables the farmers to farm securely but having to spend time and energy building and maintaining their own irrigation structures reduces their ability to be productive.

Recommendations (summary of main problems by stakeholders)

Stakeholder	Recommendations
WRUA	• Being paid an allowance may support accountability but this could risk the sustainability of service. • Charging a flat fee rate for all crops is potentially unfair to farmers with lower crop water footprints.
Irrigation Organisation	• Being paid an allowance may support accountability but this could risk the sustainability of service. • The lack of database on users means the IOs do not have full oversight of water users and their water demands.
Farmers	• The IO may be in the better position to break the cycle of farmer unwillingness to pay due to a lack of adequate irrigation and flood management infrastructure. It would require upfront investment and then fee collection. • The IO may be in the better position to increase transparency on how the 80% of collected fees is spent. This could be shared the AGM. This could increase willingness to pay. • Farmer receive poor agriculture services support. They would benefit from enhanced outreach services to improve productivity and disease control, efficient

	water use, and harvest storage facilities. They currently rely on word-of-mouth information on important issues such as understanding the pH level of the soils. • Farmers would benefit from improved access to markets and support to get better prices for their produce. • Improved road conditions would increase farmers ability to access markets. Currently many have to transport their produce manually which is very inefficient.
NIRC	• Irrigation is currently inadequately controlled. Infrastructure needs to be upgraded. • Drainage systems are poorly understood and unmapped. The lack of drainage and knowledge of any drainage assets leads to flooded fields. NIRC has already reserved budget to construct drainage infrastructure in this scheme. Hopefully this can be fast tracked.
PBWB	• More and better communication and transparency with farmers on use of water use fee would increase willingness to pay and other forms of cooperation. • Water levels at different points in the river system need more monitoring to enforce the 20% allocation for environmental flows.

Following the presentation, the audience shared their thoughts and asked questions.

Q&A – Group 3 Mawala Irrigation Scheme

Q: The TPC sugar factory might be a key stakeholder. Did the group get the opportunity to discuss their social responsibilities, e.g. to help mitigate flood risks in the scheme?
A: TPC uses an excavator to clear canals which helps increase water availability to farmers under normal circumstances and maximise space to retain flood waters. They have a pressurised water system which can get blocked, and which adds to farmers flood problems. The group didn't get the chance to meet a TPC representative.

Q: Does the sugar factory pay for water?
A: They have a permit to abstract 1000l/s and they pay for that.

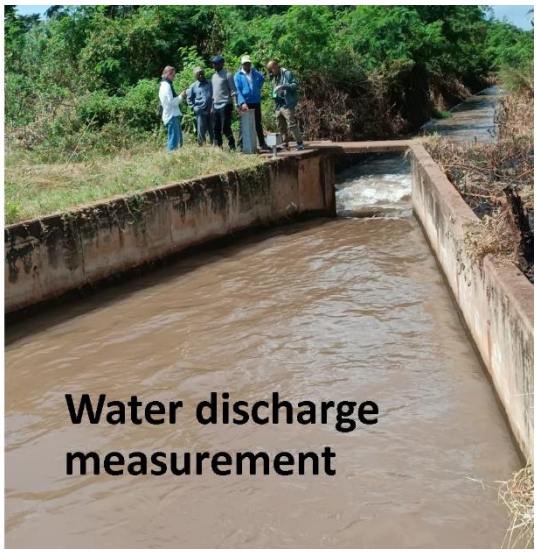
Q: how does planning for the irrigation scheme developments align with regional water resource or irrigation plans?
A: Farmers do not understand catchment management plans, but they do understand flow monitoring. PBWB is developing an IWRM plan, but this is not yet concluded.

Group 4: Field assignment – Lower Moshi Irrigation Scheme

Group 4 visited the Lower Moshi Irrigation Scheme. It is a public, farmer-initiated gravity-fed irrigation scheme built in the 1980s (supported by Japan) that has been receiving Government support for infrastructural upgrading. The original infrastructure is 40 years old, predominantly earthen canals with lined sections. The canals are equipped with metal sheet and shaft gates at distribution or division boxes to control the flow to the different levels of the canals while the tertiary canals are equipped with division boxes fitted with wooden stop logs to serve as control for water application to the plots. These gates are operated by paid operators employed by the Lower Moshi Irrigation Association . Moreover, the system has a partial flume (close to the intake at Rau River) for flow measurement with an automatic water level measuring system.

It is used to irrigate rice and maize, plus beans and vegetables to a lesser degree. It takes water from the Njoro spring and Rau River and has more than 3000 water users farming 1100 hectares (2300 hectares in theory/potential). It is in the headwaters/source area of the Pangani river. The key issues explored during the field visit were how scheme managers deal with tenant/renter farmers and how that category of farmer can join the WUA.

Photo: Lower Moshi Irrigation Scheme and Villages: **Credit:** Members of Group 4.



The Upper Moshi scheme is supplied by a large water spring (Njoro spring) which rises in a protected forest. An intake has been constructed to divert water from the spring area into the Upper Mabogini scheme. The Middle Moshi scheme is the main command area. In this area the group was able to have discussions with the (male) farmers. Female labourers were noted in the fields but were not brought forward and included in the discussions. Due to a lack of water several fields in this area had been forced into a fallow season. Significant quantities of plastic pollution were observed and there was evidence of lots of chemical pollution from poorly managed and disposed of herbicide chemical containers.

As this is a public scheme NIRC manages the infrastructure. There are two intakes for two separate farming units, both of which is a member of the Irrigation Association. The Irrigation Association manages day to day operations, general farming issues, and minor maintenance. The Irrigation Association is member of the Rau Water User Association.

Farmer's testimony: Stephan, a 60-year-old farmer from Rao ya Kati village, owns two rice plots reliant on the irrigation scheme, with 90% of his income coming from rice farming. He hires seven workers per plot each growing season. His income is influenced by water availability, market prices, and the cost of inputs. Although rice is both a staple and cash crop for his family, he sells 70% of his harvest, but profits are slim. Normally, each plot yields 70-90 bags of rice, but recent flooding, the worst in ten years, has significantly affected his crops. The government regulates what and when he can grow, allowing only two growing seasons a year.

Stephan faces challenges from market volatility, high input prices, and climate change. This year, low market demand has made selling rice difficult, and he's considering reducing his rice crop, despite not being allowed to grow alternative crops due to soil restrictions (although close by bananas, papayas etc were spotted growing).

Input costs, especially fertilisers, are a burden, but government subsidies reduce the cost from US$150 to US$50 per bag. Looking ahead, Stephan is concerned about climate change's impact on his profits and believes an early warning system and extension services could help farmers like him make better decisions on irrigation based on weather forecasts.

Positive Findings:

- The irrigation scheme, established 40 years ago, is still in excellent condition and operates efficiently, serving the needs of local farmers. It has a well-developed governance structure with clearly defined roles and responsibilities, ensuring proper water resource monitoring, day-to-day management, and both minor and major maintenance.
- The conflict resolution mechanism is highly effective, contributing to overall farmer satisfaction with the service (there are no major unresolved conflicts). Additionally, a village levy (which farmers are willing to pay) supports the broader community.
- To safeguard the environment, there are plans to protect the river reserve by maintaining a 60-metre buffer zone where trees will be planted. The use of plots for seedling production is rotated to maintain soil health and productivity.
- Farmers work together to develop a cropping calendar, and they have collectively agreed to reduce the growing seasons from three to two.
- Beyond farming, many farmers report having piped water supply at their homes, further improving their quality of life.
- The Water Board collaborates closely with the NIRC and the Irrigation Association on various aspects, including planning, design, and the implementation of water facilities, as well as managing cross-border rivers. The PBWB facilitates platforms for discussions at the catchment level, allowing for effective communication and decision-making.
- Farmers are willing to pay for irrigation water, local development, and operation and maintenance (O&M) services. The Water Users Association (WUA) and the Local Management Irrigation Association (LMIA) employ professionals, such as water managers and gatekeepers, to ensure the daily operation of the system.
- Both the WUA and farmers are acutely aware of the impacts of climate change, which they experience in the form of increased flooding and reduced water flow in the Rau River and its canals.
- Conflicts among users occasionally arise due to these challenges, but they are typically resolved at the Irrigation Association level. Larger disputes may require the involvement of the Water Users Association for resolution.
- The LMIA's revenue primarily comes from irrigation water user fees, which are based on the volume of water used by each farmer. However, there is no indication of a plan to diversify their income sources.
- Unfortunately, poor farmers in the community do not have access to the irrigation system and must rely solely on rainfall. As a result, their production remains low, as they can only cultivate during a single growing season.

Recommendations (to be addressed mid-term)

- To support farmers, improving the availability of hydrometeorological information is essential. The NIRC is encouraged to conclude its research on water footprints and share the findings with the Water Users Association (WUA) and Irrigation Association (IA) for actionable steps.
- Flood management efforts should focus on making early warning systems more specific, and the WUA may undertake the development of necessary measures, possibly as part of rehabilitation efforts. Integrating climate data more effectively into water resource and irrigation planning is also crucial, ensuring that the latest climate science and projections are considered for better adaptation strategies.
- Additionally, efforts should be made to grant farmers outside the system, as well as poor farmers, access to the irrigation system so they can benefit from its resources.

Recommendations that could be acted on:

- Efforts should be initiated to plan and budget for major rehabilitation of the irrigation system, focusing on reducing water losses in the main canal. Regular cleaning of canals is also essential to maintain efficient water flow. During droughts, boreholes could be used to reinforce production capacity.
- Farmers are encouraged to adopt different farming practices, such as the system of rice intensification, and to diversify by intercropping maize and beans. Additionally, they should consider growing new crops like vegetables, sugarcane, and fruits.
- Strengthening market linkages is crucial, as farmers currently struggle to sell their produce. Improving roads and organizing farmers into groups would help address this issue. By organising themselves, farmers could also benefit from value addition, gaining access to better selling conditions and overall improved profitability.

Following the presentation, the audience shared their thoughts and asked questions.

Q&A – Group 4

Q: Is the cropping calendar and crop type plan going to be updated or made more flexible to allow farmers to respond to climate change? [*Kenya has a Government-led model that hasn't worked, and private led/famer-led cooperatives. The Irrigation Act is very clear on Government developed large schemes: the leadership has been appointed but the transfer of management responsibilities to farmers hasn't happened yet. The farmers' fee is not yet enough to be self-sufficient. When irrigation is farmer led, only county government gets involved*]
A: It is updated every year. Farmers rely on experts, e,g. extension farmers to do the assessments of which crops will be the most successful for that year.

Q: Is the fee collected to pay NIRC enough?
A: NIRC receives co-funding from the Government fund to do more than is possible just from the farmer contributions, but it is not yet clear how much money is in the fund, how it is distributed, nor is there much transparency on how it is spent.

Q: What is the flood issue? Is it a problem of insufficient drainage?
A: The group discussed this with the Chair of the Pangani Basin Water Board and Irrigation Organisation Secretary. They have a 3-month Early Warning System but recognise that they can't protect everyone, so they prioritise villages. It is complex and some of their hydrological models are still based on old climate data.

Block 3: Sustainability considerations for plot level irrigation

Introduction

Effects of Field-Level Irrigation Management on Water Resources, Soil Health, and the Living Environment

Field-level irrigation practices, such as drip irrigation, have a significant impact on water resources, soil health, and the broader environment. While drip irrigation is often commended for its water efficiency, it can also lead to issues like soil salinisation and contribute to plastic waste.

Drip Irrigation and Water Resources

Though drip irrigation is frequently viewed as a solution for improving water efficiency, it's important to note that return flows from irrigation don't always make their way back to the point of water abstraction (see Figure 4 Water efficiency elements in irrigation). Instead, they flow to different areas within the catchment, influencing water availability over space and time. This challenges conventional perceptions of drip irrigation, highlighting the complexity of water management systems.

Soil Salinisation

Many types of irrigation, including drip irrigation, can contribute to soil salinity. Salinisation can occur naturally from some soils (primary salinity) or be human-induced, e.g. by inappropriate agricultural practices (secondary salinity), particularly when irrigation is poorly managed. It's the management of irrigation systems, rather than the type of irrigation, that determines the risk of salinisation.

Salinity: is the concentration of dissolved salts in the soil water which are sodium, chloride, magnesium, and calcium. These dissolved salts in soil tend to reduce the osmotic potential of the soil solution which makes it difficult for plant roots to absorb water and nutrients from the soil, reducing soil aeration hence leading to stunted growth, decreased yield, and increase of attraction of pests and diseases to plants.

Sodicity: often caused by high-sodium irrigation water or wastewater, damages soil structure, making it harder for plants to access water. Poor drainage or waterlogging worsens these issues, as salt residues are left on the soil surface after evaporation. Potassium build-up can also compact the soil, further diminishing its fertility.

Downstream Soil Effects

Over-irrigation and poor water management raise water tables and cause flooding, affecting not only the irrigated fields but also soils downstream. These downstream impacts can result in long-term degradation of soil quality and water resources.

Plastic Waste from Drip Irrigation – Why should we care?

The plastic tubing used in these systems contributes to the approximately 20 million metric tonnes of plastic that end up in the environment each year. Plastic pollution is a growing global disaster, affecting ecosystems on land, in freshwater, and in marine environments. Due to factors like solar radiation, wind, and water currents, plastics break down into microplastics (smaller than 5 mm) and nano plastics (smaller than 100 nm), which are increasingly found in living organisms, including humans.

Microplastics have been detected in human blood, placentas, and even in food and drink, raising serious health concerns. Certain chemicals in plastics are known to be carcinogenic and are linked to

developmental, reproductive, and neurological disorders. Given the severe implications for human and environmental health, addressing plastic pollution from agriculture is crucial.

While drip irrigation can enhance water efficiency, it also presents considerable challenges to water resources, soil health, and the environment, especially when not properly managed. Furthermore, the plastic waste generated by agricultural practices contributes to a larger environmental crisis that demands urgent attention.

This session included three presentations exploring the three main sustainability issues associated with drip irrigation: Why 'efficient' drip irrigation may lead to over consumption of water, Salinity and Sodicity in Kenyan irrigation schemes, and plastic waste.

Drip irrigation and water resources

Marcel Kuper, CIRAD, Why 'efficient' drip irrigation may lead to overconsumption of water - Paradoxes in the quest to manage water scarcity

Marcel's encounters with drip irrigation

In 1989, Marcel encountered drip irrigation for the first time during his MSc study on irrigation efficiency for cotton. He engaged physically with the systems, which sparked his interest in this technology. By 2002, he felt significant pressure to focus on drip irrigation as literature heavily promoted it as a miracle solution amid growing concerns about water scarcity. Many experienced engineers in North Africa, with a decade of practical experience, were sceptical, asserting that while drip irrigation was effective in specific contexts, it was not universally applicable. This prompted Marcel to evaluate different irrigation types in a project comparing their effectiveness from a neutral standpoint.

He concluded that drip irrigation was not a miracle solution. One surprising finding was the substantial public subsidies for drip irrigation—up to 100% of the investment costs—while other methods, such as furrows and sprinklers, received little to no support. Additionally, weak but important signals indicated that adoption of drip irrigation could be linked to increased water use. This led him to conduct further research, resulting in the DRiP (Drip Irrigation Realities in Perspective) project, which ran from 2011 to 2015, and culminated in a publication titled "Drip Irrigation for Agriculture: Untold Stories of Efficiency, Innovation, and Development."

Description of 'what drip is'

Very often drip is presented as one technique, but it consists of multiple systems and components. Drip lines can be on the surface or buried, depending on the local context.
Its performance is heavily influenced by how it is designed, installed, maintained, and utilised by people.

Evaluating drip options requires considering the varied irrigation infrastructures, the practices surrounding drip irrigation, and the diverse stakeholders involved in its design, promotion, subsidisation, purchase, use, and maintenance. In the Moroccan case study, local filter systems were more water efficient than imported ones. While many advocate for drip irrigation due to its perceived water efficiency, many individuals opt for it because it is easier to operate and carries an image of modernity (water efficiency is often a secondary consideration).

A growing 'irritation' with the promotion of drip as a miracle technology:

Marcel noted significant water losses at the farmer level and stressed the need for a more realistic application of the principle of "more crop per drop." The gap between empirical evidence and the arguments presented in policy and scientific discourse often rely on lab conditions rather than actual field measurements, and this reality check is something we really must work on. The ongoing discussion surrounding water efficiency claimed drip irrigation was over 90% efficient, perpetuating the idea that it could solve agricultural water scarcity issues. Marcel identified an alarming absence of empirical proof

regarding actual water savings and highlighted the overlooked role of people making drip irrigation function effectively.

Bleak Field Realities:

An example from Morocco illustrated the decline of groundwater tables, which dropped by over 60 metres, despite drip irrigation being adopted in 48% of the area. This situation raised questions about why groundwater levels were declining, pointing to intensification fuelled by drip irrigation. In this example a huge capital investment was made into drip, so they changed rainfed land to irrigated (horticulture) and farmers extended their farms, uphill (easier with pressurised drip). Significant capital investments transformed rainfed land into irrigated horticulture, allowing farmers to expand their operations, particularly in hilly areas where pressurised drip systems are advantageous.

Marcel explained that drip irrigation can inadvertently lead to increased water use through a process of intensification. This sequence involves gaining access to land, groundwater (via boreholes and electricity), subsidies for boreholes and drip systems, shifts in crops and cropping systems, and access to new markets, culminating in a rebound effect.

The aftermath:

In his reflections on the aftermath of high uptake of drip irrigation, Marcel drew attention to research into the untold stories of its efficiency, innovation, and development. The World Bank asserts that, contrary to expectations, the widespread adoption of water-saving technologies might have increased pressure on water resources. It is clear there is an ongoing tension between irritation and fascination with drip irrigation's potential.

Weak but important factors changing attitudes to water:

The younger generation of farmers are taking more risks going into “the casino of entrepreneurial agriculture” with drip. In the Moroccan case study young small holders were the first to get heavily involved in market agriculture, and then later when many more got involved the markets became volatile. In this world of agriculture farmers can lose a lot. The older generation of farmers emphasized that "farmers don’t play." This generational tension was visible in inter-generational cohabitation on family farms.

In Chile, the influence of social dynamics on drought were observed. Farmers acknowledged that previously there were dry years, but there were also fewer plantations. Now wealthy individuals clearing mountain slopes for profit had worsened water shortages in valleys, with poorer communities competing for (and fighting over) dwindling resources. A real conflict occurred between rich and poorer.

Local rejection of imposed irrigation systems by the state drew attention to issues of dignity and care. Farmers announced, “We don’t want imposed life systems, irrigation systems, reservoirs, that kind of thing; the truth is that the state doesn’t accept our way of life” and Irrigation Associations began to redesign state-led, privately engineered drip irrigation projects.

The Importance of Context:

Marcel highlighted the importance of context in decision-making regarding irrigation systems. For instance, in Yunquera, while drip irrigation was introduced in 2009, irrigators in 2017 continued to favour gravity irrigation, weighing various factors beyond water efficiency, such as crop types and labour availability.

In Algeria, the scarcity of water resources prompted innovative approaches, such as using floodwater to recharge aquifers. Water from streets was directed into wells strategically built on fault lines to expedite infiltration, exemplifying the creative solutions necessary in regions where water abundance is rare.

Marcel welcomed participants to get in touch with him, reiterating that drip is neither good nor bad, but that we must have a nuanced approach to understanding it in our project designs.

The presentation is available in the E-group: Presentation 21-1 Marcel Kuper CITRAD.pdf (groups.io)

Q&A – Why 'efficient' drip irrigation may lead to overconsumption of water - Marcel Kuper

Q: If you need more food, but don't want to expand land, can drip support intensification?
A: Lots of people are working on reducing the water footprint of food production (reducing meat consumption etc) to enable more food to be grown with less water. Arguably the bigger issue is the demand for water for biofuels rather than food.

Q: We want farmers to increase the number of crop cycles – but should we not use drip all the time? Is there a way to increase the drip without accumulating salinity?
A: Automatically drip will lead to more water consumption and in water scarce areas it will lead to conflict. Intensifying all the time is not a good idea, at some point you will reach a ceiling. Salinity occurs when the volume of water applied is not sufficient to leach the salts. In north Africa they use gravity irrigation to flush the soils.

Salinity tests and trials in Hola irrigation scheme

Vincent K. Kipngetich, National Irrigation Association (NIA, Kenya)

Introduction to Kenya's Agriculture Sector: The agriculture sector contributes 34% of Kenya's total GDP and employs 40% of the population, with 70% of those jobs located in rural areas. The sector also has significant linkages with other industries, such as manufacturing, distribution, and services. Irrigation contributes 8% to this total. However, the sector faces challenges due to its over-reliance on rain-fed farming, which makes it highly vulnerable to climate change, particularly droughts and floods. These disruptions affect food crop and livestock production, especially in arid and semi-arid lands (ASALs), which account for 80-90% of the total land.

Sustainable solutions are needed to build capacity and resilience in farming communities, focusing on investment in water storage and irrigation infrastructure—currently a priority for the Government. The Government has a strategic plan to bring more land under irrigation, increase water harvesting, and boost rice and maize production.

The ASAL regions are the primary focus for expanding irrigation. However, issues of salinity and sodicity, particularly in the southern areas, pose challenges. Public irrigation schemes are concentrated in certain regions (see green locations in Figure 13). There are ten irrigation schemes in total, but the main focus is on eight: Mwea, Ahero, West Kano, Bura, Hola, Perkerra, and Bunyara.

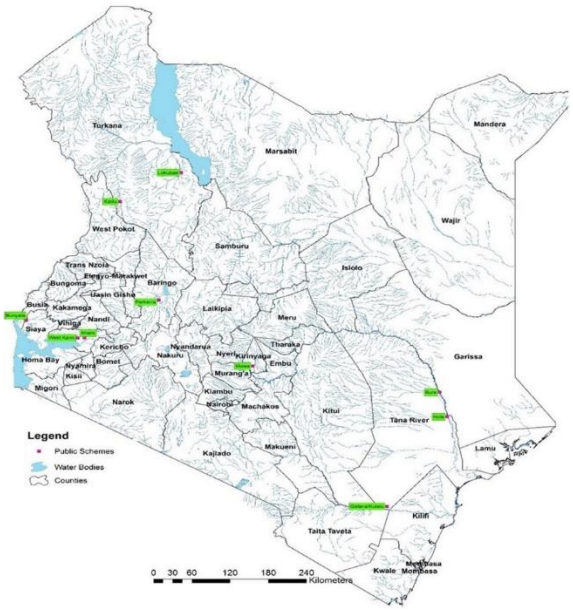


Figure 13 Public irrigation schemes, Kenya

Hola and Bura are underperforming due to salinity. The water source for these schemes comes from the River Tana, although the salinity is attributed to regional characteristics rather than the river itself. Generally, salinity levels in these schemes remain acceptable for most crops, but effective water management practices are crucial to maintain these levels. In response, new technologies and salt-tolerant crop varieties, including two tomato varieties, have been introduced to ensure continuous production. The introduction of paddy production in 2014, with high-yielding salt-tolerant varieties, marked a significant improvement in these schemes.

Salinity and sodicity (the concentration of sodium in the soil) are common problems in the Hola Irrigation Scheme in eastern Kenya. Both issues lead to poor crop performance and reduced yields. Initially, sodicity did not seem like a major issue, but it became clear that sodicity levels varied across different irrigation blocks. Some areas had higher or lower sodicity, following a recognisable spatial pattern. Some farmers were found to flood the furrows, exacerbating the problem. To address this, 'check buns' were suggested to help navigate areas with high sodicity. Reclamation of these areas through better irrigation water management practices was also recommended.

In the Mwea Irrigation Scheme, the largest scheme in Kenya, which is dedicated solely to rice production, several soil amendment technologies have been tested. One successful innovation involved using rice bran as a soil amendment and for weed control. Rice bran contains organic acids that help neutralise salt in the soil and is rich in plant nutrients such as nitrogen, potassium, and phosphorus. It also increases microbial activity due to its organic matter content. Previously, farmers discarded the rice bran, unaware of its potential as a soil amendment. The use of rice bran has helped to restore some soil nutrients, though demand for it remains high, as it is also used as animal feed.

Kenya is currently developing a concept proposal to manage salinity, with the objective of testing different management strategies and exploring high-value crops for sustainable production.
These irrigation schemes hold great potential, particularly since there are no significant water issues. If the soil problems can be addressed, the schemes will be well-positioned to achieve their ambitious goals.

Q&A – Salinity tests and trials in Hola irrigation scheme - Vincent Kipnegetich

Q: It looks like the River Tana is the same source of supply for the two schemes with salinity and sodicity issues. Could a study have been done to check if the river is the source?
A: No there is a new irrigation scheme upstream of the two existing scheme which is not saline despite using the same source. The salt issue is more of a farm management practice issue.

Q: If the river does not have a high salt content, can we improve soil drainage?
A: Drainage and environmental factors contributing to salinity in these areas.
Q: Is there an option to plant salt tolerant plants?
A:Most farmers there are livestock farmers but with the introduction of salt tolerant rice, they have realised food production can give extra earnings.

Q: Ploughing, the land below the blade becomes a hard pan and salts can build up. Is there an option to plough deeper?
A: Not really, their ploughs are already quite deep. The issue is the water is very close to the surface – so drainage is the issue.

Q: Does salt in the soils lead to increased sodium levels in food?
A: No, this is a conclusive answer. The salt leads to the plant not being able to absorb the water and blocks transfer of nutrients. With rice, in costal zones, the roots go down to the deeper layers where salt has accumulated. Thinking about coastal irrigation schemes, with salts below the root zone that is a dilemma.

The situation with drip irrigation can be compared to the evolution of cars: initially, cars were small but had large, inefficient engines. As engines became more efficient, people expected fuel consumption to decrease, but instead, cars got bigger and more people began driving, leading to a significant increase in fuel use.

Similarly, while drip irrigation improves water efficiency for individual farmers, it often leads to an increase in water use at the watershed level. The overall water footprint of the watershed grows as return flows to the system decline. Though beneficial for individual farmers, this counterintuitive effect can make communities more vulnerable to water shortages, rather than more resilient. Therefore, drip irrigation should not be implemented without proper water resource management controls, and it should not be portrayed as a solution to water conservation at the watershed level, as this misunderstanding has caused significant confusion.

Plastic waste in irrigated agriculture

Chris de Bont, Nelson Mandela African Institution of Science and Technology (NM-AIST)

Agriculture is producing increasing amounts of plastic as farming becomes more intensive. This includes plastic from greenhouses, netting, plastic mulch, containers, fertiliser sacks, and irrigation systems. The installation of drip irrigation systems, in particular, generates a significant amount of plastic waste, primarily from offcuts of irrigation pipes, but also from fertiliser sacks, seedling pots, mulching films, greenhouses, pesticide containers, and pond liners.

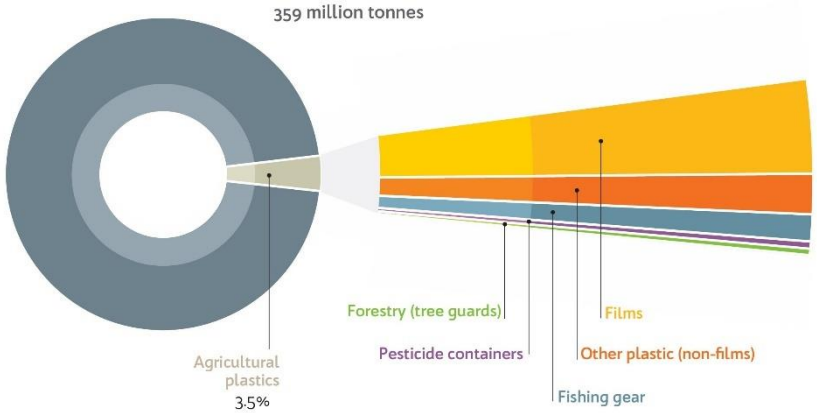


Figure 14 Agriculture as a Component of Global Plastic (Source: FAO. 2021. Assessment of agricultural plastics and their sustainability. A call for action. Rome. https://doi.org/10.4060/cb7856en)

Global plastic production and share of agricultural production: In 2019, global plastic production reached 359 million tonnes, with a portion attributed to agriculture, especially from films and irrigation products. While the agricultural share of global plastic production is currently small, it is expected to grow.

Concerns for soil, water and air quality: The use of plastics in agriculture raises concerns about its impact on soil, water, and air quality, particularly due to improper disposal. Plastics used in irrigation, such as drip pipes, are often non-degradable and are used for short periods, typically months to a few years. As they degrade, they break down into microplastics, which pose risks to ecosystems and even human health. For example, microplastics have been found in animals and humans, although the full extent of their effects is not yet understood. It is estimated that there is more plastic in soils than in the oceans.

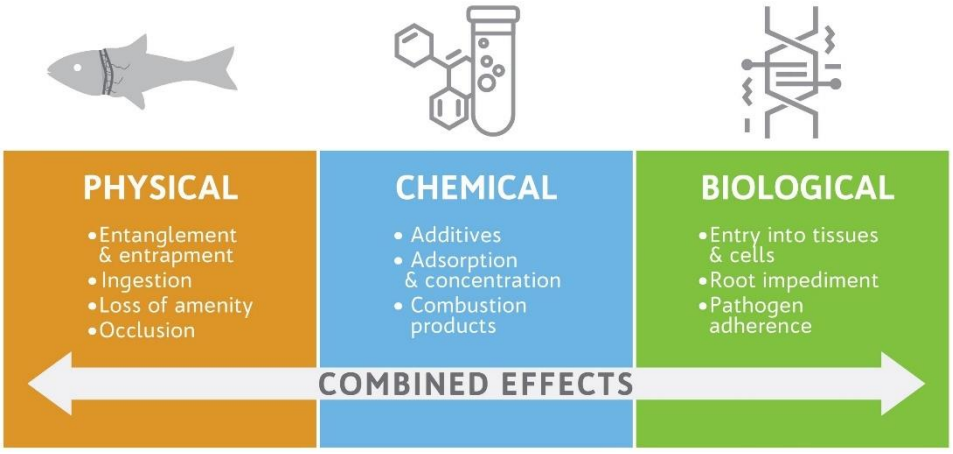


Figure 15 Combined effects of plastic pollution (Source: FAO. 2021. Assessment of agricultural plastics and their sustainability. A call for action. Rome. https://doi.org/10.4060/cb7856en).

In the case of drip irrigation, there are concerns about drip tape and irrigation pipes. Drip tape, which has a lifespan of around eight months, and irrigation pipes, which last about 24 months, are in direct contact with the soil, and without proper disposal methods, these plastics leach into the soil or are left to pile up on farms. The problem is exacerbated by the lack of recycling systems in most countries, where agricultural plastics, including discarded drip lines, often remain on farms to slowly break apart or are burned, releasing toxic fumes.

Some considerations for drip and solid waste: When considering the materials used for drip irrigation it is important to consider the type of plastic, its toxicity (especially if it contains PVC), and how easy it is to recycle. Reducing the number of polymers used and using single-polymer systems can make recycling easier. The lifespan of the system, the amount of plastic per hectare, and whether a recycling or disposal service exists are also key factors that influence the environmental impact.

What if we do increase the amount of drip? If the use of drip irrigation is expanded without addressing the waste issue, the environmental burden will worsen. Countries currently lack systems for collecting and recycling agricultural plastics, making it essential to consider these issues in the design of irrigation projects.

Drip system Info and Assignment: At this point participants were invited to calculate an estimate of the annual tonnes of drip irrigation plastic waste generated in their countries.

<table>
<tr><td colspan="2">TRY THIS:
Using the following information calculate how many km of drip line and tonnes of plastic your country would generate in ten years:</td></tr>
<tr><td>Drip system information (Netafim):
Driplines replaced after three seasons.
2500m dripline for 0.25 ha = 10,000m/1 ha.
2500m coil weighs 26.3 kg, so 1 ha 105.2kg</td><td>Information needed:
Country size
Agricultural area/irrigable area/irrigated area
Country level ambitions: e.g. X% of agricultural area under drip (If your country has not formulated anything, make an assumption).</td></tr>
</table>

During the event participants reported a range of results, all of which were much higher than they had imagined.

How to think about solutions: To address the plastic waste problem, solutions include refusing or redesigning systems to make them more durable, reducing plastic use, or making products from stronger materials. The FAO suggests improving the robustness of drip systems, extending their use, and increasing recyclability. Regulations are also needed to prohibit the use of PVC in drip systems to avoid toxic fumes, promote single-polymer systems for easier recycling, and integrate drip irrigation with existing solid waste management systems.

Figure 16 lists six different ways in which individuals, groups, and even countries can tackle the problem of plastic waste, starting with refusing to use a product (if that choice can be made).

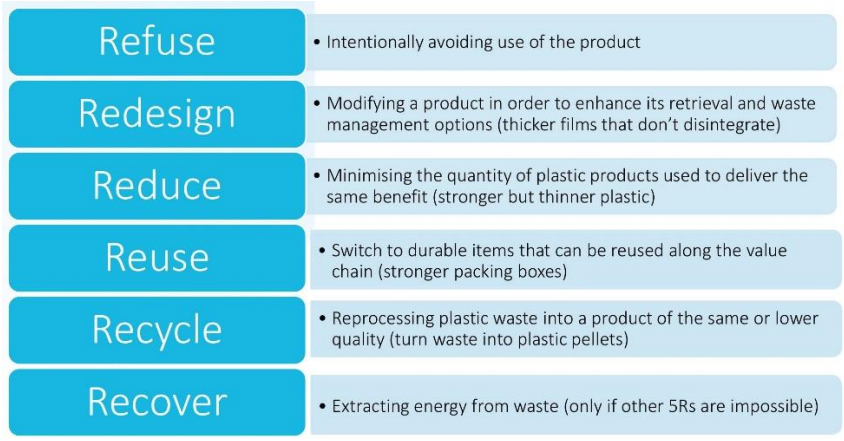


Figure 16 Six R's to tackle plastic waste

It is better to consider these options like an inverted pyramid. Figure 17 shows how the most desirable action to minimise plastic waste is to REDUCE the amount of plastic being produced in the first place (this includes refusing products to reduce demand and reducing overall plastic by focusing on better quality plastic with more longevity). At the other end of the spectrum, littering/dumping plastic waste is the least desirable action.

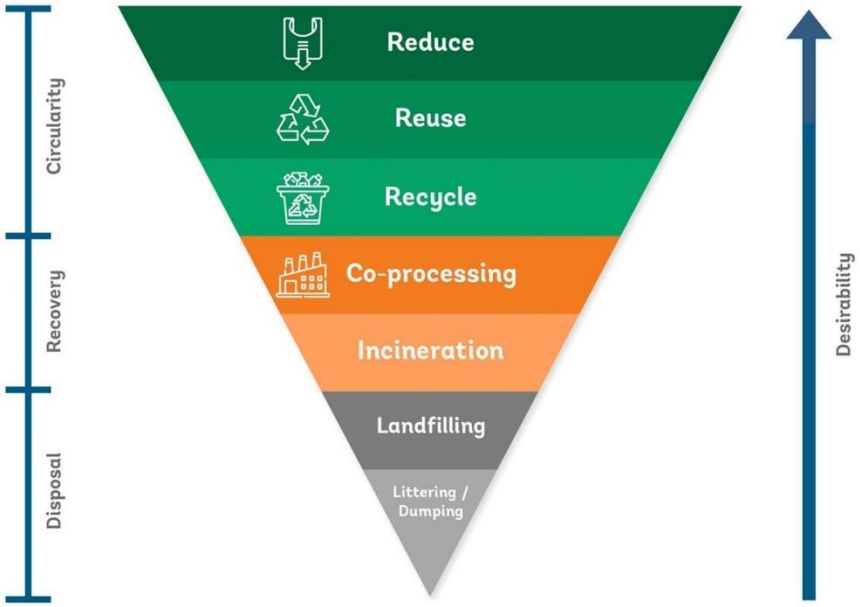


Figure 17 Plastic waste hierarchy

The key message is that solid waste management must be a central consideration when designing irrigation projects. A crucial step towards this is implementing regulations, such as banning the use of PVC in drip systems due to its harmful environmental impact. Drip irrigation systems should be integrated with existing solid waste management (SWM) arrangements wherever possible, and given the significant volume of waste produced, setting up dedicated recycling systems is essential.

When developing irrigation policies and programmes, regulating the production, distribution, and use of drip irrigation systems is vital. This could involve:

- Treating drip irrigation as a service, where a single company supplies, replaces, and collects drip kits and lines to facilitate recycling under Extended Product Responsibility (EPR).
- Prohibiting the use of PVC in drip lines and tapes to avoid the release of toxic fumes.
- Promoting single-polymer drip systems to simplify recycling processes.
- Linking drip systems to existing solid waste management frameworks.

As soon as there are large volumes of plastic waste being generated it is worth setting up a recycling system. This is especially possible if all (or most) of the plastic is of the same type. Figure 18 shows the six main types of plastics (and a 7th 'other' category) and the types of products they are found in. ** In some cases, **polyvinyl chloride (PVC)** or **polypropylene (PP)** might be used for specific components of an irrigation system, but polyethylene is by far the most common material for drip lines.*

Figure 18 Different types of plastics

Recycling plastic is much easier when there are bulk quantities of the same material. As with any technology, it is essential to establish the necessary conditions to ensure that drip irrigation is implemented sustainably and minimises its environmental impact.

Q&A – Plastic waste in agriculture – Chris de Bont

Q: Could you provide examples of where agricultural plastic recycling works?
A: France collects 98% of drip tape. It is the producers' responsibility after sales, to collect it, and then it goes for recycling. There the problem had been collection not recycling, but they are successfully doing it now.

Q: Are there other materials that could be used instead of plastic?
A: Probably, but plastic is too cheap now to incentivise research /manufacturing of other materials.

Q: What is the impact of all this plastic on CO_2e emissions (disposal at landfill)?
A: If you ***only*** consider landfill it is approximately 8-16 million tonnes/year, comparable to Mozambique's 2022 total CO_2e emissions. If you consider the full lifecycle (from production and use) that figure would be even more.

Debating game

Participants were put into two opposing teams to debate the Statement:

Countries should regulate the Extended Producers' Responsibility (EPR) in drip (also responsible for disposal)

The purpose of the game was to encourage participants to explore the ideas emerging from Block 3 and possibly to challenge their own internal views on the topic. Participants were allocated to a team and so were not necessarily debating their own personal view. One team was challenged to argue in favour of the Statement, the other team against. Three participants volunteered to form an 'honourable jury'.

The objective: to convince the jury of the position of the group.

The debating game follows a series of instructions and strict rules:

- The decision of the jury is based on the consistency and coherence of the arguments as well as the response to the arguments of the other group.
- Each team has 3 minutes each to present their arguments without interruption.
- After both teams have argued for 3 minutes the first team counters with 2 more minutes, and the second then follows.
- After both teams have used their total of 5 minutes, they both retreat into their teams for 15 minutes to consider the flaws of the opposition and prepare their final counter arguments.
- The debate recommences with a further 2 minutes and then a final 1 minute each.
- The 'Jury' then retreats to consider the quality of the arguments and decide on a winner.
- The 'game' was very lively with very passionate arguments from both sides! The text in the table below reflects participants' actual statements as closely as possible.

Photo: Photograph of the debating game in progress. **Photo credit:** Sandra Ryan.

Arguments from the Debating Game

Round 1:

AGREE	DISAGREE
First 3 minutes:	
• If Governments don't force this then who will make it happen? Government is the power player to set the standards and create a conducive environment. • Polluters should pay. The polluter is not the company that's already squeezed. • Responsibility should be on the BIG companies making big profits from production of plastics. • Circular thinking creates value chains. • New requirements will generate innovation and spin offs.	• These products are imported so the option to force them to comply isn't there. • It could result in shipping used drip lines back around the world. • Producers already taking on tasks to make lines more sustainable. • It's a business – you will increase the costs to the farmers. No business sense.

Round 2

AGREE	DISAGREE
Final 1 minute:	
• It's not all about money. • Greenwashing will happen if it is not regulated.	• It will make poor farmers poorer

• Companies can enter partnerships for transport etc. • Recycling will offset some costs.	• Governments are already not regulating things well.

Jury deliberation:

The jury set three criteria to assess the quality of the arguments:

1. The argument/point must be coherent,
2. Responses must be well considered (throwing 'shots' would not be viewed positively)
3. The debaters must show passion for their arguments.

Both sides put forward some strong arguments. The jury liked Agree's argument that as duty bearers Governments should take responsibility for action, and that once one type of plastic (or sector) starts to recycle properly then this would create a ripple effect. However, they also accepted Disagree's argument that it involves pursuing 'polluters' located overseas, and it would still generate an extra burden on already poor farmers.

Overall, based on the level of passion 'Disagree' won hands down. However, based on the level of coherence and relevance the Jury determined 'Agree' the overall winner.

Block 4: Interventions and investments for sustainable irrigation

Introduction to Block 4

Antoinette Kome reflected on the discussions in the E-Group that preceded the learning event and provided insightful reflections on the historical and current trends in irrigation management.

Irrigation has a long history (over 7,000 years), and how the approach to managing it has changed over time. It's interesting to note that government involvement in irrigation is relatively recent, only really starting a few hundred years ago. In the colonial era, governments led major construction projects, and by the 1950s, large state agencies were running many of these systems. However, in the 1980s, we see a shift towards participatory irrigation management, with a strong focus on handing over control to farmers—although this hasn't happened everywhere. In Peru, for example, we see a success story where 20,000 farmers are fully managing their irrigation systems professionally, showing just how much farmers can take on. Now, we're seeing new trends like farmer-led irrigation and the professionalisation of irrigation management, which is quite promising. What's important is to acknowledge this shift and to understand how much has changed over time.

We need to be careful not to fall into the trap of blind optimism. Whether it's technology, markets, government, or civil society, we can't rely on one solution to fix everything. Instead, we need strategic thinking, where we look at what works in each context. It's about understanding the type of goods we're dealing with—whether they're excludable, meaning they can be controlled by the market (and where if someone takes, there is less for everyone else, e.g. bottled water, field irrigation equipment, agricultural inputs), or non-excludable, where everyone has access (e.g. water resources). Then, there's the issue of rival and non-rival goods. For example, with water supply systems, more connections benefit the utility, so it's a non-rival good. With public goods there is the common problem that no one cares too much until there is a problem.

SNV is advocating for a broad, adaptable approach that takes all these factors into account, so we can develop irrigation strategies that make sense for the specific resources and situations we're dealing with.

So what was discussed in the E-Group?

In the E-Group, several key topics were discussed regarding irrigation investment strategies, management models, and the future of irrigation systems. The conversation was broad ranging, with participants sharing insights from different countries and contexts.

Investment Strategies for Irrigation

The group explored various investment strategies, particularly in relation to individual farmers. Some members highlighted the importance of providing support through mechanisms like grants. Ethiopia was mentioned as an example where farmers are selling water to their neighbours, showing a localised approach to water management. The question of whether more finance is needed was raised, and there was some support for models like "pay-as-you-go" systems that make irrigation more accessible to small farmers.

Small vs. Large-Scale Irrigation

There was a lively debate around the benefits of small-scale versus large-scale irrigation schemes. Ethiopia's experience was cited as a successful case for small-scale irrigation, with participants noting that it offers faster implementation, lower risks, reduced costs, and fewer impacts on the environment. It's also seen as easier to organise. On the other hand, some members pointed out that larger schemes still have a role to play, especially in terms of food security. However, they stressed that these large schemes often include smallholders and require rehabilitation to function efficiently. The need to involve women and respect traditional knowledge was also emphasised by several participants.

Table 2 Small scale vs Large scale

Prioritise small scale because:	Prioritise large scale because:	What to do?
• Less expensive, faster • Lower O&M costs and technical requirements • Greater social coherence • Less environmental/ social impact • Suitable in many places	• Large numbers of smallholders depend on large schemes • Produces staple foods, important for food security	• Rehabilitation and upgrading • Put in place appropriate management models • Strengthen governance structures and WUAs • Strengthen the participation of women • Valorise Indigenous knowledge

New Management Models

Discussion then turned to new management models for irrigation. Third-party management for large schemes was brought up, along with examples of foreign direct investment in larger community projects. Examples of large-scale Public-Private Partnerships (PPP) were mentioned, including a $4.8 billion collaboration between Ethiopia and China for 150,000 hectares. Despite these examples, the group agreed that details around these arrangements are often unclear. There's a general over-optimism about private sector involvement, with some assuming it will automatically function well. However, there was a clear call for more oversight, and notably, no one mentioned the importance of regulation in these partnerships.

Irrigation as a Service

An interesting example came from Cambodia, where irrigation is provided as a service (IaaS). In this case, a monopoly controls the sales of irrigation services, meaning farmers have no option to switch suppliers. This led to concerns about tariffs, as any price increase could make it difficult for farmers to pay for irrigation.

Water Management Models

There was a brief mention of water management models, particularly the concept of bundling water management services, but participants didn't explore deeper discussion on this topic. However, the relevance of these models to irrigation schemes was acknowledged.

Irrigation Operators of the Future (IOF)

A new concept that came up was the "Irrigation Operators of the Future" (IOF) which can be seen as a specific application of the World Bank's broader **Utilities of the Future** framework[5] (formerly known as the utility turnaround framework). The World Bank has developed the agricultural version of this framework, which is worth exploring further as a potential model for improving irrigation management[6].

[5] https://www.worldbank.org/en/topic/water/publication/utility-of-the-future

[6] Toolkit: https://documents1.worldbank.org/curated/en/099537308252239234/pdf/IDU0b823b4db02ab4047f308f4208c4deb4d7e98.pdf

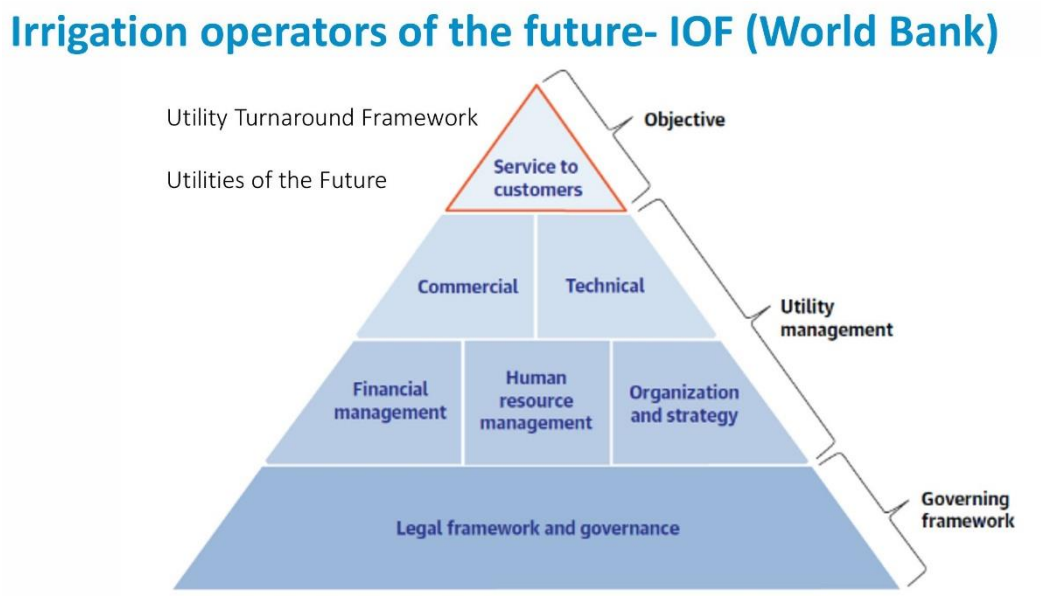


Figure 19 World Bank Irrigators of the Future

Pre-Conditions for Successful Irrigation Development

Several pre-conditions for effective irrigation development were discussed. The group agreed that more investment is needed in water resource management, regulation, and water storage capacity. There was also a call to consider self-sufficiency, with Nepal mentioned as an example where changing diets and food imports have put pressure on local agriculture.

Leadership in Irrigation Development - Who should take the lead?

When discussing who should take the lead in irrigation development, most participants agreed that government should play a central role in both leadership and investment. The reasoning was that market structures in many regions are not mature enough to handle large-scale irrigation investments without government involvement. Governments are in a strong position to take the lead on building capacity, promoting and raising awareness of irrigation needs, mapping water resources, supporting demonstration projects and funding subsidies where necessary.
However, we should avoid **'Government Optimism'** ("Everything can be done by government alone") as much as '**Market Optimism'**.

Challenges in Funding and PPPs

The discussion highlighted various approaches to financing irrigation investments, emphasising that contributions should come from a combination of taxes or loans, depending on the stakeholders involved. Commercial farmers, for instance, were identified as being capable of funding their own irrigation systems, while small-scale irrigation efforts could be self-funded or co-funded through other mechanisms. Government's role should be focused primarily on capital expenditures (CAPEX), leaving operational expenditures (OPEX) to be managed by Water Users' Associations (WUAs).

Support for early adopters of new irrigation technology is also essential, as these farmers often face the highest risk in implementing new practices. Similarly, companies investing in irrigation systems may require assistance until their ventures become profitable, pointing to the need for targeted support mechanisms. Public-private partnerships (PPPs) were recognised as a valuable model for investment, although they too would require initial support, particularly in terms of technical assistance and access to credit facilities to cover **the full lifecycle of irrigation projects**. Without appropriate funding, there is a risk

that these investments will eventually fall apart. Upfront investment, including variations of delegation contracts could help sustain these projects.

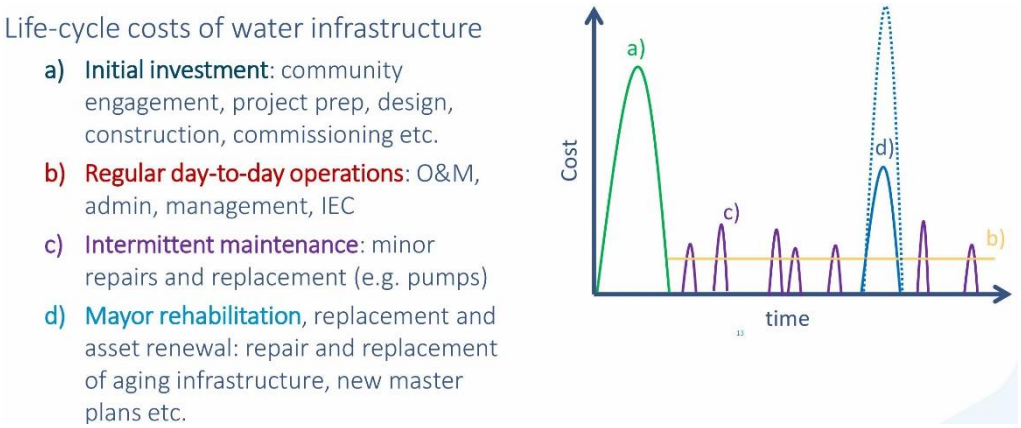


Figure 20 Cost components in the full lifecycle of irrigation projects

Figure 21 shows Which funding sources are there to cover the life-cycle costs (a,b,c,d) including loans or private sector contributions. The critical point regarding loans/private sector is that this is not necessarily **extra** money rather that it can be pivotal cashflow **earlier** in the investment and development process.

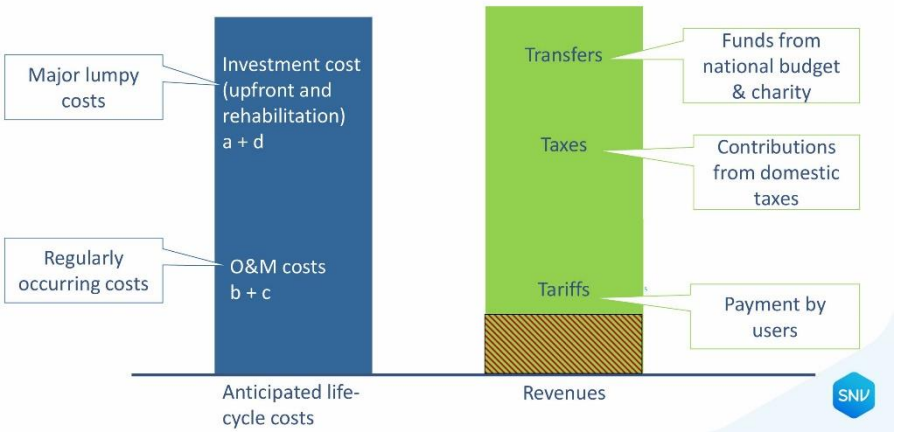


Figure 21 Sources of funding for different cost components

The discussion on who benefits from such investments remained broad, generally pointing to smallholder farmers and highlighting the potential for significant national and macroeconomic benefits. However, there was a sense that further exploration is needed to clearly define these beneficiaries and their specific needs in the context of irrigation development.

Sustainability and Equity

On sustainability, the general view was that as long as companies remain profitable, irrigation schemes will be sustainable and could potentially expand. However, there were concerns that many contributors overlooked CAPEX when discussing long-term sustainability and equity in irrigation management.

Overall, the group explored a wide range of topics, reflecting the complexity and importance of strategic thinking in the future of irrigation systems.

India: Support for Irrigation Modernisation Program

Lance Gore, Principal WR Specialist, Asian Development Bank

India's Irrigation Potential and Modernisation Efforts

India's irrigation potential is vast, estimated at 139.89 million hectares (CWC, 2020). Of this, 58.47 million hectares (42%) are from major and medium irrigation (MMI) projects that cover areas larger than 2,000 hectares, while 81.43 million hectares (58%) are from minor irrigation systems serving smaller areas. By an 11th Plan, the country had realised 81% of its total irrigation potential, with significant progress in both major (47.97 million ha) and minor (65.56 million ha) systems. However, there is a growing recognition that the focus needs to shift from new developments to modernising existing irrigation systems to increase crop productivity and water efficiency.

Key Initiatives Leading to the Support for Irrigation Modernisation Program (SIMP)

The groundwork for India's irrigation modernisation was laid through several studies, including the National Water Use Efficiency Improvement Support Program (NWUEISP) in 2013-14 and the Innovations for More Food with Less Water (MFLW) study in 2015. These identified the potential to improve water use efficiency through better management of surface and groundwater resources and the introduction of modern technologies such as SCADA, micro irrigation, and prepaid metering.

Building on these studies, the Support for Irrigation Modernization Program (SIMP) was launched in December 2020. Led by India's Ministry of Jal Shakti and supported by technical assistance from the Asian Development Bank (ADB), the SIMP is designed to assist Indian states plan and implement modernisation investments for irrigation systems. The programme's phased approach includes developing a modernisation framework, preparing investment-ready projects, and implementing and monitoring the improvements.

Modernisation Objectives and Approaches

The primary objectives of SIMP are to increase water availability for agriculture and other users, improve land and crop productivity, and boost farmers' incomes. Additionally, the programme aims to apply best practices systematically, consolidating national expertise to improve the financial sustainability of irrigation systems. This includes enhancing asset management, establishing cost recovery mechanisms, and increasing private sector involvement.

The approach under SIMP utilises frameworks like FAO's RAP-MASSCOTE and incorporates extensive consultations with stakeholders, including farmers and Water Users Associations (WUAs). The planning process involves institutional, agricultural, technical, and financial assessments to ensure the modernisation plans are tailored to the specific needs of each irrigation scheme.

Selected Pilot Projects and Challenges

Out of 57 proposals submitted by 14 states and 2 Union Territories, **four pilot projects** covering a total command area of **246,000 ha** were selected for modernisation, with a **total investment of $569 million**. The projects are:

- **Vanivilasa Sagara** in Karnataka (constructed in 1907, irrigable command hectares: 16,284 modernisation cost: $4813/ha) (***the oldest, the smallest, and the most expensive per hectare***);
- **Purna** in Maharashtra (constructed in 1968, irrigable command hectares: 57,988, modernisation cost: $2741/ha);
- **Palkhed** in Maharashtra (constructed in 1982, irrigable command hectares: 41,580, modernisation cost: $3762/ha);

- **Loharu** in Haryana (constructed in 1980, irrigable command hectares: 128,157, modernisation cost: $1345/ha) (***the newest, the biggest, and the cheapest per hectare***).

The challenges faced by these projects include issues like water logging, groundwater depletion, and inequitable water distribution. For instance, in the Loharu scheme, only 15% of the area is irrigated by canal water due to insufficient supply, with groundwater resources being overused and depleted. In the Palkhed scheme, surface water availability has declined due to increased demand for drinking water, forcing farmers to rely on groundwater and invest in drip irrigation systems. These issues highlight the urgent need for modernisation to enhance water management, ensure equitable distribution, and reduce reliance on unsustainable groundwater use.

Modernisation Activities
The modernisation efforts focus on **upgrading the main canal systems** through **lining**, introducing **pipe distribution networks**, and implementing **groundwater recharge schemes**. For example, in the Loharu scheme, canal lining with geomembrane underlays is proposed to reduce seepage losses and increase water delivery efficiency. Additionally, **automation and SCADA systems** will be installed to improve operational efficiency and reduce water losses across the main infrastructure. In the Palkhed scheme, modernisation will involve constructing **sediment traps**, replacing undershot gates with **overshot gates** for better water control, and adopting **gravity-based pipe distribution networks** to replace minor canal systems and improve water conveyance. Similar measures are planned for the other schemes, with a **strong focus on integrating groundwater recharge and managing water resources more effectively.**

Financial and Institutional Support

The SIMP also seeks to strengthen the financial sustainability of irrigation systems by introducing cost recovery mechanisms and encouraging private sector participation. Training programmes and capacity development initiatives are key components of the programme, aiming to empower local stakeholders, including WUAs, in managing and maintaining modernised systems. The Government of India, in collaboration with state governments and international partners like the ADB, is committed to ensuring these modernisation projects are financially viable and deliver strong economic returns for farmers.

Summary of Modernisation Recommendations

The key recommendations for modernisation include:

1. Upgrading canal systems with proper lining and automation to ensure efficient water distribution and management.
2. Implementing groundwater recharge systems to address groundwater depletion, particularly during the monsoon season.
3. Introducing gravity pipe distribution networks and pressurised irrigation systems to improve the efficiency of water delivery.
4. Progressively automating infrastructure to reduce water wastage and enhance operational control.
5. Developing robust data monitoring and management systems using remote sensing and forecasting technologies to optimise irrigation scheduling.

These efforts aim to enhance the resilience and productivity of India's irrigation systems, ensuring they can support the growing demand for agricultural productivity while maintaining long-term sustainability.

Q&A – Support for Irrigation Modernisation Program - Lance Gore

Q: Some of these irrigation schemes are enormous in scale by Tanzanian standards. The unit costs per hectare seem reasonable, but did any of these schemes have farmer managed components that were also modernised? Obviously, there has to be central control over supply.
A: In India there is more Government support for Agency managed systems with the objective to transfer at tertiary level. The more minor components tend to be farmer managed. WUAs are generally not present or not always functioning. This is a problem as we want them to participate in the design process. That's a lot of work and it depends on location, crops, and WUA capacities.

Q: Which techniques have been introduced to recharge the groundwater?
A: there are local firms that have been investing in **constructed systems**. There are also a few innovative **recharge tubewell systems**. Located off the major canals. A firm based in Karnataka has a strong offering.

Farmer-Led Irrigation Development (FLID): Opportunities for Building

Hans Komakech, Nelson Mandela African Institution of Science and Technology (NM-AIST)), hans.Komakech@nm-aist.ac.tz

Hans is a Ugandan living in Tanzania for the last 15 years. At NM-AIST he heads a centre called WISE Futures (**W**ater **I**nfrastructure and **S**ustainable **E**nergy Futures). He introduced three key points to guide his presentation on Farmer-Led Irrigation Development (FLID):

- what FLID is about,
- lessons learned to catalyse FLID, and
- how to engage with FLID, and its pitfalls.

What FLID entails: Farmer-led irrigation (FLI) is defined as an approach in which **farmers take the lead to improve water use for agriculture**. This approach includes a wide range of technologies. FLID is not a specific technology, but **a process characterised by farmers' planning and investment,** often in collaboration with collectives, private sector actors, and governmental bodies. Farm sizes in FLID projects typically range from 0.5 to 2 hectares, but collective initiatives can cover larger areas.

It is certainly not "unplanned" or "spontaneous". It is not done in isolation. Farmers invest with a plan and ambition that is not necessarily small scale or individual, and it is usually a collaboration between farmers, government, and the private sector.

The SAFI (Studying African Farmer Led Irrigation) project was highlighted as an important policy-oriented research initiative, running from 2015 to 2017, that explored how external agencies can more effectively relate to farmers' irrigation efforts in Mozambique and Tanzania. The project illustrated the importance of understanding farmers' irrigation activities and the role of various actors in supporting these processes.

Farmer-led irrigation was further defined as a process whereby **farmers drive the establishment, improvement, and expansion of irrigated agriculture**. Key features include:

- market-oriented planning and investment,
- the use of diverse technologies (such as sprinklers, drip irrigation, or hose pipes), and
- a predominant focus on entrepreneurial activities.

However, FLID **often goes unnoticed in policy discussions**, leading to its exclusion from official data.

Characteristics of FLID: it is highly responsive to external drivers such as market conditions. In Mozambique, for instance, FLID supports cross-border vegetable trade and is integrated with private agro-companies via out-grower schemes and contract farming. This development is particularly significant in peri-urban areas.

FLID Technology: FLID is technology diverse, including shallow wells and dams, small on-farm water storage, use of inland wetlands/valley bottoms, petrol or diesel pumps, bucket irrigation/backyard farming, use of wastewater in (peri)urban agriculture, furrow/traditional irrigation systems, and solar powered drip systems. Whichever forms of technology are used, the overarching point is that **FLID is neither unplanned nor isolated**, and it often involves significant investment from farmers in irrigation infrastructure, aiming for productive and profitable outcomes. **Policymakers frequently overlook this** in their assessments of irrigation coverage.

Two programmes designed to catalyse FLID were presented.

1. In Rwanda, the Small Scale Irrigation Technology (SSIT) programme [http://www.safi-research.org/], launched in 2014, demonstrated how local design and government subsidies helped to reduce irrigation costs and drive the upscaling of irrigation technology. They are now looking to upscale it to the next phase;
2. In Uganda, the UgIFT (Intergovernmental Fiscal Transfers) Micro-Scale Irrigation Programme, initiated in 2020, highlighted a similar approach, providing subsidies for irrigation equipment and training, with a particular focus on growing high-value crops. https://www.agriculture.go.ug/micro-scale-irrigation-program/

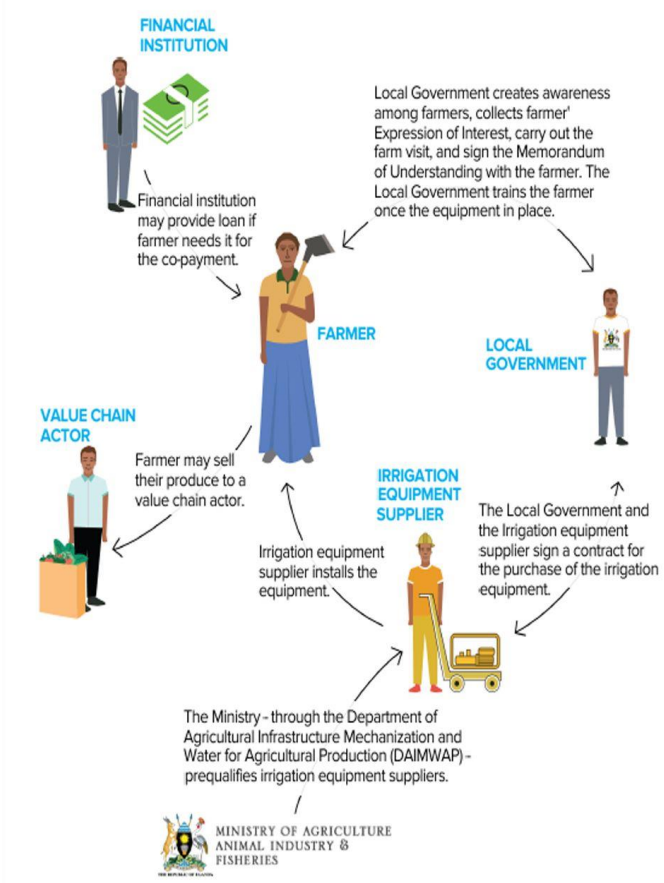


Figure 22 shows the six key actors of the programme and their relationships with one another. Farmers are at the heart of the system, accessing loans from financial institutions, working with local government to access training etc, taking charge of irrigation equipment from suppliers, and then selling their produce to a value chain actor. Local government also has a direct relationship with equipment suppliers, signing contracts etc, whilst the suppliers are granted approval from the Ministry of Agriculture. The Government also provides subsidies to purchase equipment (tanks, soil moisture kits, etc). There are different categories of financial subsidy depending on the type of farm (25 -75%, to a maximum of $2000 per acre per farmer). A data tool and Management Information System (MIS) has been specially developed, building on what had already been created.

Figure 22 UgIFT Structure

One of the UgFIT focal points was the specific requirements that farmers must meet to participate in the programme. To qualify, a farmer must be interested in irrigating a small plot of land, typically up to 2.5 acres, have access to a reliable water source near their land, and be able to contribute financially towards the cost of the irrigation equipment, which is a key aspect of the programme's cost-sharing model. Most crucially, the programme is designed for farmers who aim to grow and sell high-value crops, such as horticultural products and coffee, as the primary focus of irrigation is on market-driven, commercial farming.

Hans then outlined the progress of UgIFT in numbers. The programme has reached an estimated 320,000 farmers, with over 70,000 expressing interest in participating. Field visits have been conducted for more than 27,000 farms, and over 1,600 farmers have received irrigation equipment to date. Farmer field schools (FFS) have been established to provide training on the beneficial use of irrigation.

Both programmes demonstrated the importance of cost-sharing mechanisms, farmer training, and the involvement of competent suppliers to ensure successful roll-out. For instance, the UgIFT programme structure involves collaboration between financial institutions, farmers, local governments, and value chain actors. It offers subsidies of up to 75% for solar-powered irrigation equipment and 25% for petrol-powered systems, with farmers required to cover the remaining costs.

Despite the broad reach, the offer of subsidies, and significant interest, the actual uptake of equipment remains relatively low. This decline in numbers—where many show interest but fewer commit—is a key issue. Several factors may explain the drop-off in participation. One of the primary reasons is the challenge of ensuring cost-sharing readiness among farmers. Many farmers are new to irrigation, and adopting this new practice can take time, which contributes to the slow uptake. Additionally, the selection criteria for farmers may not have been well-communicated or aligned with the farmers' expectations. The availability of sufficiently qualified and knowledgeable technical staff and competent suppliers is also an issue, as farmers need to be well-informed to make good investment decisions. Hans suggested that if the project had been more effective in design, a higher uptake, ideally around 50%, could have been achieved.

The SSIT programme in Rwanda similarly illustrated the benefits and challenges of government-led irrigation initiatives. The programme was developed to promote demand-driven, affordable, and locally assembled irrigation technologies (diesel/ petrol pumps and hose pipes, solar-driven irrigation units, treadle pumps, or dam sheets). By providing subsidies (around 50%) for irrigation technology, the programme aimed to reduce irrigation costs from an estimated US$4,000-14,000 per hectare to approximately US$1,500 per hectare, with ambition to upscale. The programme's success was measured by the development of 25,000 hectares of irrigated land by 2024 and a high satisfaction rate among participating farmers. However, issues such as equipment availability, pricing, and lack of engagement by companies at the field level were identified as constraints.

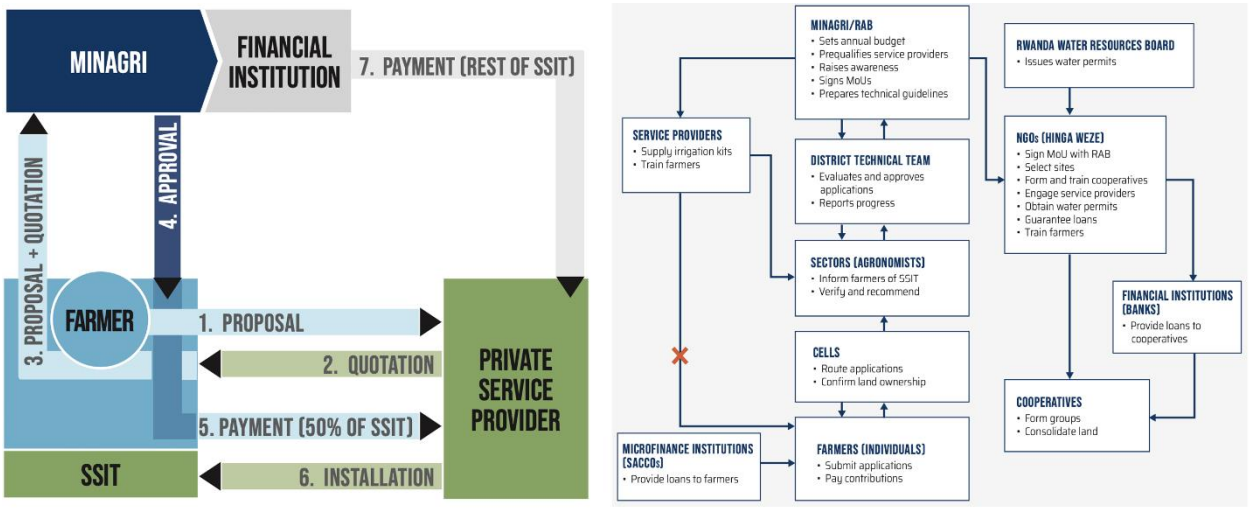


Figure 23 Designed SSIT Subsidy Process vs Actual SSIT Subsidy Process

Figure 23 compares how the SSIT programme thought communications and processes would work at the design stage, with the much more complex reality that was identified as the programme progressed. Initially it was thought that farmers would be the central player, making proposals, getting quotes, getting approval and subsidy funds from the Ministry, and then receiving technological installations from private service providers. In reality, there are many more actors involved, and farmers are far from the centralised player.

Key lessons from SSIT: The SSIT programme provided several key lessons regarding the implementation of small-scale irrigation initiatives. On the positive side, it successfully facilitated the development of new irrigation areas and incentivised the growth of irrigation service providers. Farmer satisfaction was notably high, with an average rating of 3.99 out of 5, highlighting the programme's effectiveness. A key factor in its success was awareness creation, driven by local agronomists, community meetings, and radio broadcasts, which helped engage farmers. Additionally, reducing the capital required for irrigation investment proved beneficial.

However, significant constraints were identified: the availability and pricing of equipment posed significant challenges for farmers. The knowledge component was also undervalued, with many farmers experiencing crop damage due to inadequate understanding of irrigation practices. Land access was a limiting factor, as most farmers owned only around 1 hectare, and many companies did not engage directly with farmers at the field level, which hindered the programme's overall impact.

A key takeaway from both the UgIFT and SSIT programmes was the need to provide fit-for-purpose technologies and to **ensure that irrigation investments support commercial agricultural goals**. The programmes highlighted the importance of lowering capital requirements through subsidies, raising awareness among farmers, and fostering collaboration between stakeholders.

Misconception of Farmer-led Irrigation development hypothesis: The programmes revealed a significant flaw in the hypothesis that a sequence of interventions, starting with simple tools like buckets and progressing to more advanced technologies such as petrol and solar-powered systems, would trigger an upward spiral of farm-enterprise growth.

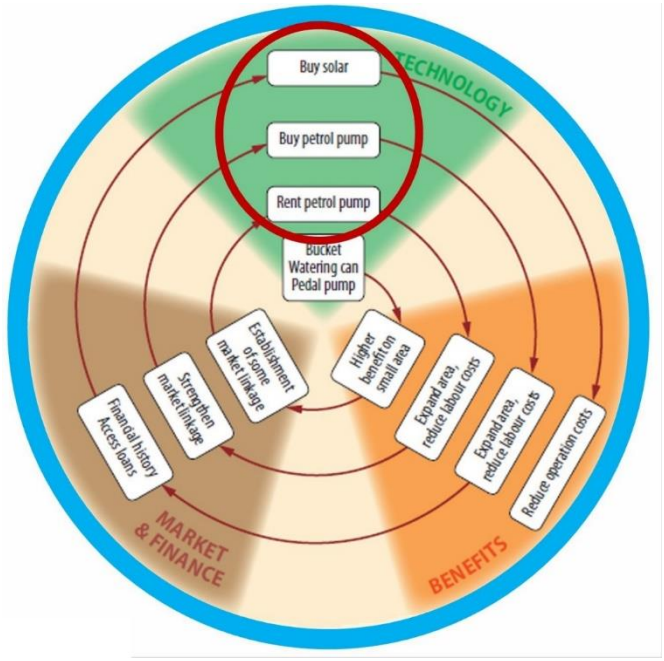


Figure 24 Misconception of the FLID hypothesis

This linear model overlooked key constraints that limit farmer growth, such as inconsistent water availability, gaps in knowledge, and market access challenges. These factors disrupt the expected progression and demonstrate that the simplistic "more technology equals more growth" approach does not necessarily translate to improved outcomes for farmers.

In conclusion, Hans emphasised that FLID is about more than just technological intervention. It is a process driven by farmer initiative and ambition, with the potential for significant scale-up if the right support systems are in place. However, external agencies need to be mindful of the specific needs of farmers, the variability in farm sizes, and the importance of market-oriented investment strategies to ensure that FLID remains a productive and profitable endeavour.

Q&A – Farmer-Led Irrigation Development (FLID) - Hans Komakech

Q: Even in shallow wells pumps still need to be attached, but those weren't shown in the presentation. Also about water application, should we consider flood application to be modern? Do orchards and peach tress use basin irrigation? Irrigation is also common for small scale farms even if it is not common in Tanzania. Finally, which technology is used to recharge?
A: The learning event field visits were carefully designed. Hand pumps are used more for domestic use and in Tanzania they are trying to move away from individual hand pumps to community systems.

Comment: In Moshi they counted more than 2000 shallow wells. There is no river or spring in this part of the country that is NOT used for irrigation.
Response: Agree, that is not technology led.

Q: The is regular emphasis on the need to significantly subsidise equipment costs, but credit mechanisms often remain a challenge. Beyond kit subsidies, what can we do to build local financial institutions. e.g. to develop financial products, within financial institution?

A: there are number of institutions, Vison Fund (WV) is a credit guarantee system that gives credit to farmers, Private Agriculture Sector Support Services (another NGO), but the credit guarantee works with the banks to loan to farmers. However, most farmers are reluctant to get a loan. The administration is too slow. They prefer to borrow from neighbours (at a much higher rate). Most farmers are willing to invest IF there is a profit pathway.

Q: Maintenance only happens in the warranty phase. How can we incentivise more after sales O&M?
A: The Government assumes that service providers would locate themselves closer to farmers, but this is often not profitable, so we must find another way to incentivise the suppliers. It must go beyond supplying the equipment.

Comment. It is interesting FLID is more than just about technology or individuals. In Cambodia the Water User Groups (WUGs) don't work so this FLID model could be useful.
Response: when it is a government scheme there are challenges with managing the large infrastructure. At least 50% of the large schemes, with Irrigation Organisations are not functional, but a lot of the older smaller schemes here (in Tanzania) are still working (even though we consider them inefficient and rudimentary). It's not clear how we could replicate those 'old systems' in the form of an intervention, but it could be worthwhile.

Irrigation Modernisation, Cambodia Context

Mr. Sao Ena, Vice Chief of WM Office, Ministry of Water Resources and Meteorology (MowRAM)

Irrigation modernisation in the context of Cambodia: In the context of Cambodia, irrigation modernisation refers to improving and upgrading the country's irrigation systems, which are classified by size into large, medium, and small schemes:

- large schemes cover areas of more than 5,000 hectares,
- medium schemes span between 500 and 2,000 hectares, and
- small schemes include those under 500 hectares.

These scales are quite similar to other countries represented at the learning event. In Cambodia they always measure land are as hectares, not acres. Most schemes are made from earth and concreted, constructed in the 1970s.

Cambodia's irrigation schemes, mostly located in flat, lowland areas, face challenges of flooding in the wet season and droughts during the dry season, making it difficult for farmers to invest.
Out of 2,730 irrigation schemes, only 60% are fully functioning, 25% are partially functional and in need of rehabilitation, while 15% are no longer operational due to a lack of adequate operation and maintenance (O&M). This is a big challenge for the Government as its limited irrigation budget does not stretch to O&M for farmers.

The responsibility for Operations & Maintenance: This is divided between several bodies:

- The government constructs and manages dams and weirs, with funding from the national budget and development partners.
- Main canals are built by the government and managed through a collaboration between the Ministry of Water Resources and Meteorology (MOWRAM) and provincial departments (PDoWRAMs).
- Secondary canals, also government-constructed, are operated by farmers' water user communities (FWUCs) in partnership with MOWRAM and PDoWRAMs.
- Tertiary canals, built jointly by farmers and MOWRAM, are operated and managed by farmers' groups.

- On-farm irrigation is entirely the farmer's responsibility for both construction and operation, with management handled by a farmers' water user commission or group.

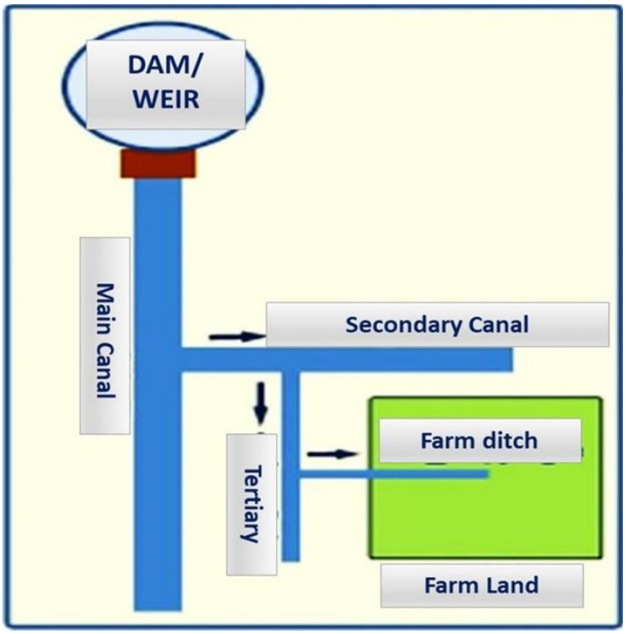


Figure 25 Irrigation scheme components in Cambodia

Farmers and local governments cooperate on irrigation construction and maintenance, with farmers contributing fees to support the infrastructure. There is also collaboration with Public-Private Partnerships (PPPs), working closely with the Ministry of Water Resources to maintain and improve systems.

Table 3 Annual Budget for O&M (2018-2022)

Year	Total No. of Irrigation Schemes	Small and Medium Schemes	Large Schemes	Total Expenditure (USD)
2018	205	199	6	$11,136,000
2019	206	199	7	$15,254,086
2020	167	160	7	$16,565,678
2021	169	161	8	$18,53,788
2022	166	158	8	$17,661,352

Cambodia is currently involved in several modernisation projects through loans and external support. Three major projects include:

1. the West Tonle Sap irrigation and drainage rehabilitation and improvement project (JICA), costing $80.84 million. This project includes soft and hard components (i.e. canals and a WUG office to get together and discuss issues and solutions). Construction has just started
2. the Southwest Phnom Penh irrigation and drainage rehabilitation project (JICA), costing $69.6 million; and
3. the Daun Try Dam Development Project (Koica), costing $46.7 million (constructing a dam and a WUG office).

These projects include both physical infrastructure improvements and the creation of farmer water user group (WUG) offices to facilitate discussions on irrigation issues.

Modernisation ambition: Looking towards 2030, Cambodia's irrigation modernisation ambitions include converting the earth channels to concrete or pipe systems to increase production and improve livelihoods, digitising data collection and monitoring for better management, and enhancing the functionality and efficiency of FWUCs to ensure sustainability. The government also aims to strengthen PPPs and there is a need to link irrigation schemes to energy efficiency and climate adaptation, for example by introducing business licences for irrigation schemes.

Modernisation efforts are focused on increasing irrigation efficiency, ensuring the long-term functionality of water user groups (FWUCs), and integrating technology and private sector collaboration to address the evolving challenges of water management in agriculture.

Q&A – Irrigation Modernisation, Cambodia Context - Sao Ena, Ministry of Water Resources and Meteorology

Q. The presentation referred to a few big loans with long payment times.
A. Loans for O&M are issued from the Ministry of Economy and Finance through the Department of Irrigated Agriculture from the Ministry of Water Resources.
Q. Was the $17 million in 2022 for all required O&M or just the bit done by Government?
A. It was only for secondary canals upwards. It was not for smaller scale O&M which is done by the WUGs . I they can collect member fees they can allocate budget for minor repairs, restore small scale erosion, clearing grass etc.

Thematic Group Work, Rik van Keulen

Rik reminded the participants of the three diverse and insightful presentations in the morning session, covering projects in India, Farmer-Led Irrigation Development (FLID) in Rwanda and Uganda, and modernisation efforts in Cambodia. Some of these projects were already established, while others were still in the early stages of development. Following the presentations, attendees were given instructions for a group exercise.

In this exercise, the objective was **to explore ways to enhance both equity and sustainability within existing irrigation schemes** (assumed to be already operational). Participants were asked to consider **which interventions could be introduced** to achieve these goals.

The discussion on equity so far had primarily focused on issues such as the disparity between head and tail users, the inclusion of people inside and outside the irrigation schemes, and how fees directed to the basin board benefitted different users.

The exercise was structured around four key topics:
1. Private sector supply chains to individuals and groups within schemes (covering inputs and equipment);
2. Small-scale irrigation schemes that are operational but facing issues or in need of upgrades;
3. Large-scale modernisation, which includes the possibility of private sector management and bundling of components;
4. Irrigation management transfer from government to farmers.

Participants were asked to choose one of these topics and work in groups for 40 minutes to develop proposals. Each group was instructed to select a facilitator to guide the discussion and a reporter to present their findings. It was recommended that groups begin by clearly defining the issue they intended to address, as the topics were quite broad. Once the group work was completed, teams would present their proposals to the plenary.

Group Proposals:

Group 1: Private Sector Supplying Individuals and Groups within Schemes

To ensure the system becomes more equitable, Group 1 explored the role of the private sector in supplying individuals and groups within irrigation schemes. They highlighted that the financial product needed for such schemes must be flexible and tailored to different needs, while also promoting education for both farmers and financial institutions. Farmers, often hesitant to borrow due to the need to use land as collateral, require a better understanding of the costs, benefits, and risks associated with financing. On the other hand, financial institutions need to be educated on how to de-risk lending to farmers, as they are often viewed as high-risk borrowers.

Photo: Group 1 presents their proposals. **Photo credit:** Sandra Ryan.

For sustainability, the group suggested the use of Public-Private Partnership (PPP) approaches, with the Government playing a vital role in regulating, licensing, taxing, and providing incentives. Beyond financial gains, they also pointed to intangible benefits like individual pride in ownership, status elevation (such as being a model farmer) and gaining control over irrigation activities. These win-win situations could inspire wider participation, though education at all levels would be crucial to its success.

In terms of the broader equitable approach, they saw Farmer-Led Irrigation Development (FLID) as a viable strategy. From the farmers' perspective, this approach would give them access to financing for the first time, while also offering benefits like lower capital expenditure, scalability, and the elimination of ongoing water fees. At the societal level, FLID was seen as cost-effective, potentially reducing capital costs by 80% compared to non-FLID schemes. It also promotes efficient water use and is easier to implement on smaller parcels of land.

Challenges identified included the need for comprehensive training, particularly on irrigation practices, access to markets, reliable water sources, and technology. A holistic approach with expertise in these areas was recommended, along with system design services and after-sales support.

Group 2: Small-Scale Irrigation Schemes in Need of Upgrades

Group 2 focused on small-scale irrigation schemes that are operational but facing challenges or requiring upgrades. A key point raised was the variation in how different countries define 'small'. They pointed out that the initial investment for these schemes is often capital-intensive, requiring significant funds for infrastructure development. Access to finance is a major challenge, especially for expansion, while issues around land ownership, particularly for women and youth, restrict access to loans as land is often required as collateral.

To improve the sustainability of these schemes, they emphasised the importance of community engagement from the outset to secure buy-in and ownership. Organising irrigators into cooperatives could help pool resources and address challenges collectively. They also stressed the need for clear roles within management committees and the introduction of by-laws for affordable tariffs to cover operations and maintenance. Strengthening agricultural value chains and creating an environmental monitoring plan at the community level were also seen as crucial for sustainability. Capacity building, both in terms of agronomic practices and technical services, was identified as another key intervention.

For greater equity, the group advocated for diverse government subsidies for inputs like seeds and fertilisers, as well as financial and social protections for the poor. They also called for government action to ensure land access and its use as collateral for loans, alongside equitable water allocation and fee structures based on land size and crop type. Ensuring equal representation of women in irrigation communities and fair water distribution from head to tail-end farmers were also considered essential for equity.

Group 3: Large-Scale Modernisation and Private Sector Involvement

Group 3 explored the challenges and opportunities related to the modernisation of large-scale irrigation schemes, particularly where private sector involvement was a factor. In Ethiopia, large-scale irrigation schemes built by the government decades ago now require modernisation, but the role of the private sector remains unclear. In Mozambique, a private company managing rice and sugarcane schemes faces challenges with farmers selling produce outside the system for better prices, which threatens the financial sustainability of the scheme.

To ensure sustainability, Group 3 noted the need for clearer investment requirements and financial sustainability models. They suggested working closely with farmers to incentivise them to pay for irrigation services and inputs, which could involve negotiation and clearer incentives. Improving data on water resources and production was seen as key to both sustainability and equity. The group also discussed modernising infrastructure, such as lining canals or replacing them with pipes to deliver water more efficiently, which would benefit tail-end farmers and reduce salinity issues.

In terms of equity, these changes would lead to new opportunities for women, both in production and sales, by making water more accessible.
The group concluded that better management practices must go hand-in-hand with modernisation, which would require both regulation and the involvement of the private sector in a more clearly defined role.

Group 4: Large-Scale Modernisation Involving the Private Sector

Group 4 discussed the process of transferring irrigation management from the government to farmers in the context of large-scale modernisation projects involving the private sector.

For sustainability, they emphasised the importance of building capacity at the governance level and providing a robust finance mechanism. Technical expertise was seen as essential, particularly during the design phase of schemes. They suggested that while some parts of these schemes, such as headworks or intakes, should remain under government control, other components could be transferred to farmers.

They proposed separating operations and regulation, with day-to-day operations and maintenance being handled by an irrigation association, while major repairs would remain the responsibility of the government. A clear calendar for operations and maintenance was also recommended, along with farmer co-financing of projects.

Photo: Group 4 presents their proposals. Photo credit: Sandra Ryan.

For greater equity, the group proposed internal by-laws with regular meetings to ensure accountability. They also stressed the need for involving local government in decision-making and establishing performance indicators to track progress. A continuous capacity-building process for all stakeholders was seen as vital to ensure equitable outcomes.

Block V: Country groups sessions and wrapping up

World Cafe

The World Café is a group exercise where two representatives of each country pose two urban water cycle challenges that they are facing to participants who 'pitch' their proposed approaches to solve the problems. Participants form 'consultancies' and do a round of interviews. The global team also participated as one of the teams.

Summary of challenges and preferred 'solutions':

Table 4: World Café – Problems and Ideas

Challenge	Preferred solutions
Bhutan: i) How can we support the management (model/structure) of an integrated water scheme (domestic and irrigation water)? ii) What sort of technology would best support a solar lift irrigation system (river intake) and what are the estimated costs? iii) Advise on the engagement process needed to build a Public-Private-Partnership (and other considerations).	• Establish/support a catchment / basin level committee to ensure coherent and holistic view of catchment water processes are understood. Establish a higher level committee combining domestic and irrigation interests, plus a specific committee for each to deal with detailed issues. • Go for community-CAPEX, community managed. Software is available that can calculate specific requirements. Parameters to be known: command area, river depth, water velocity, lift height, GPS location. Pumps use 1KW to lift water 15m vertical, 400m needs approx. 30KW, 20-30 horsepower (HP) pump. Grid power would be a good option. Contact Hiwote for more information. Be aware of the erosion risks around the pump and along the river bank. • Be aware of different modalities: BOT approach (requires clear guidelines for the bidding process); Be aware of government position on PPP; be very clear on the scheme parameters; Hold participatory events to invite potential partners/requests for EoIs); Make the offer attractive to the private sector e.g. longer term contracts, subsidy incentives, bank guarantees etc – outsource the facilitation of the participatory event.
Cambodia: i) How can we regulate groundwater abstraction and usage? What steps should we take?	• Establish a clear water management structure from national to sub-national levels, ensuring well-defined resources and decentralising authority to district levels for better local governance. • Develop legal frameworks and policies, including Public-Private Partnerships (PPP), and implement registration systems and payment structures for water usage, ensuring fairness across sectors. • Promote diverse water sourcing and regular hydrological surveys to assess water availability, support recharge interventions, and conduct annual water assessments for sustainable use.

Challenge	Preferred solutions
ii) How can we make Farmer Water User Communities work efficiently?	• Organise Farmer Water User Communities (FWUCs), manage collective boreholes, and allocate a national budget for ongoing monitoring and evaluation of water resources. • Support FWUCs by creating market access for agricultural products, involving the community early, providing agronomist extension services, and engaging the private sector for irrigation pumping services. • Build a strong legal/policy framework, raise community awareness, and conduct surveys to set fair water fees and borehole payments. • Conduct hydrological studies to map groundwater use and monitor the implementation of water management interventions.
Ethiopia: i) How can we engage financial institutions to provide CAPEX finance for water users and private sector service providers? ii) How can we make sure we don't leave anyone behind in irrigation? iii) How can we increase collection of irrigation water fees?	• Do a financial analysis, show the potential Return on Investment, get farmers to co-fund the system. • Provide government subsidies to support poorer farmers. • Introduce regulated rules, if fees are not paid, then no service is provided.
Kenya: How can we increase interministerial coordination and collaboration for irrigation modernisation?	• Multi-sectoral coordination for seamless process at all levels. • Establish an Information Management System (IMS) database. • Create a joined-up irrigation fund.
Mozambique: i) How can we facilitate efficient outreach / extension for O&M of irrigation schemes? ii) How can we facilitate efficient extension / after sales services for irrigation equipment? iii) How best can we advocate to the ministries to fund & establish this system?	• Translate existing policies to District level; Assess capacity, feasibility, and cost to deliver policy services; Phase implementation focusing on the most viable schemes; sub-contract on an annual basis for technical support. • Provide a guarantee period supported by the government; Taka a % of private sector profit to pay for government extension services; Require stewardship from service providers; Require agreed periods of after sales support (or be blacklisted); RBF for irrigation equipment; segment farmers (commercial, semi, subsistence) and support as relevant. • Enable cross-visits to other countries to demonstrate; Provide cost-benefit analysis (CBA); (Political will must be developed); Include in government manifesto; Provide business case of costs of NOT taking action.
Nepal: Over the years, the government has been handing over management of	• Create/adopt an integrated approach for irrigation management at the local level, i.e., irrigation management should not be looked at as a stand-alone initiative at a local level, but local government should

Challenge	Preferred solutions
irrigation systems to water user groups. This process is done through a series of steps and takes a few years. Nevertheless, there are many challenges in sustainable management of systems and users are not willing to pay irrigation service fees (ISF). How can users be encouraged to pay fees and how can water user groups be supported to manage systems sustainably?	link it to other farmer-oriented activities by (e.g. capacity building in agronomy, equitable distribution and use of water, linkages to market). In this way, farmers would be motivated to pay ISF because they would feel the support by local government and the benefits of having properly functioning irrigation systems.
Tanzania: i) How can we use the aquifer recharge zones to recharge groundwater whilst people are living there? Specifically, what risks of pollution and inhibited infiltration do settlements pose? ii) How can we develop the Pangani basin Integrated Water Resource Plan with limited budget? iii) How can we facilitate smallholder farms to purchase their own irrigation systems? And how can we encourage them to use water efficiently, so none is wasted?	• Get data and map where this issue is most critical. Don't underestimate the role of farmers. As well as abstracting their land-use activities can either enhance or reduce infiltration. Identify measures to increase water retention and infiltration (as opposed to runoff). Educate farmers on the benefits of these measures and on pollution control. If necessary, explore alternative livelihood options. Subsidise, and enforce prohibited anti-infiltration activities. Identify high-impact areas and actively control human movement. • All parties must be involved. Map stakeholders and prioritise them, some may have funds to support catchment management (get farmers to help with this and ask bigger businesses, e.g. tourism to contribute); Create a coordination group; Understand the various power dynamics but try to organise meetings online; Use existing national processes and other IWRM plans in the country as a model (government should own the process); Break the work into smaller steps that can be funded. • Investigate behavioural drivers, e.g. some farmers do not want to switch to solar power (despite cheaper fuel) because the output power is not strong enough for their needs. Traditional canals may be owned by the Association and individual farmers do not have capacity to strike out on their own and purchase their own equipment. Many farmers still have perception that more water means higher yields. This needs education, demo farms etc.
Uganda i) How can we scale farmer-led irrigation without external support? ii) How, and which approach, should the Government of Uganda take since this is affecting the performance of the large and medium schemes?	[solutions not made available to the report].

Country shopping bags

At the end of the learning event participant country teams were asked to consider what they have learned that they will immediately take back to try to apply in their home countries.

Bhutan

1. Connections and contacts made at the event;
2. Understanding range of scheme management models and linkages: Regulatory issues/accountability, and private sector issues and services;
3. Solar power: new experiences in Bhutan they are just starting. Have learned insights and specifications during this event.
4. Irrigation, agriculture, and waste management: Going for smart irrigation /thought drip was the best answer. Now will consider impacts on the water basin.
5. Fees collection from users – make sure the funds are equitably divided between local/small scale needs, and government funds for bigger investment needs.

Cambodia

Learned a lot from Tanzania, where farmers need permission to take water etc.

1. Regulate Groundwater: Start with mapping and assessment to provide evidence that Government should take action. Then develop national and provincial level policy. Improve the institutional set up. Learn more about groundwater recharge techniques.
2. FLID and FWUCs: Build capacity and transfer responsibility, in a phased way. Consider equitable fee rates: balance farmer and commercial needs. Allow farmers/communities to step into schemes at earlier stages of project planning and design
3. PPP: Regulate licensing for IAAS. Implement licensing, accountability, and tariffs. Build capacity to improve the financial set up and private investment. This should not be ad hoc contracting, but longer-term (e.g. 5 year) plans for PPsP with longer term responsibilities. Determine what sort of financial enabling environment is needed.
4. Learning event methodology: The structure works very well and could be replicated: e-group discussion; field visit assignments; consultancy role play 'World Café', and the country shopping bags.
5. Next steps (for Cambodia): Presentation to MoWRAM, internal report, possible idea for pilot interventions (August).

Ethiopia

1. Small holder farms market linkages (exports) eg. Bitter gourd.
2. Automated scheme level water data collection, e.g. LMIP – Hubo Connect.
3. The paradox of drip irrigation (plastic and water)
4. World Café format can be used as a tool to get broad inputs from stakeholders.
5. Appreciate the collaboration between Basin Water Boards, WUAs, Irrigation Associations, and NIRC.
6. Creating links between TAHA and Ethiopia HPEA.

Kenya

1. Multi sectoral coordination: learning from Tanzania, Ethiopia, and Nepal: Delineate mandates and functions at the national level. At the implementation level (regional or county) one office should be able to coordinate development and management of irrigation with sufficient staffing.
2. Irrigation data: Create a dedicated MIS unit. This can build on NIA efforts. Got some good examples during world café. Data sharing between relevant agencies. Will borrow from a few examples. Clarify the data gaps that they have, determine the scope of MIS, and improve data monitoring. Arrange a data sharing agreement between relevant agencies.

3. **Irrigation Funding:** Set up an Irrigation Fund. Establish a tax or levy, e.g. on exported irrigation products, or a green tax. Seek donor contributions to a portion of irrigation services. Set up a trust fund with trustees from government and other key stakeholder representatives.
4. Water Governance at sub-catchment and irrigators level: WUAs are not voluntary in Tanzania, make them mandatory in Kenya. Seek payment for services.
5. Opportunities for collaboration and research: Work on soil health aspects of salinity and sodicity in Bura & Hora irrigation schemes. Work on water and land productivity in small holder irrigation schemes.

Mozambique

1. Understanding hectarage of small, medium and large schemes.
2. Operations and maintenance funding Advocacy Strategy. Strategies for advocating around operational maintenance are important.
3. Importance of including O&M (state) budget lines in the same budget (learned from Nepal).
4. Sustainability issues relevant to irrigation.
5. Cross-visits to successful schemes (e.g. Bangkok) can have powerful influence on government.
6. Business case to fund O&M and the impact of not funding O&M.
7. Considering what is a fair tariff for farmers to pay for O&M services from the private sector (improvements to after sales services), and to enable it to be regulated.
8. Heard about Nepal having local government contract for consultants to provide technical O&M services on an annual basis. In Mozambique the Ministry of Public Works has a similar set up but more thinking is needed around that process. It can be hard to find engineers and keep them to provide support. Some pilot schemes could be explored to show viability and profitability which could then spread and scale to other schemes.

Nepal

1. The world café process and this “shopping bag” exercise were useful for exchanging expertise and getting practical advice on real issues and reflecting on learnings from workshop.
2. It is important to work within the basin model of water management rather than political boundaries. Try to have a single management system from upstream to downstream areas even with different districts etc. The basin model for irrigation management is beneficial because it considers: Upstream to downstream; Equity perspective; and Sustainability perspective. Learnings from the Pangani Basin Water Board.
3. Drip irrigation should be considered from more than technological perspectives and should also assess impact on: Water resources; Soil health; Plastic pollution.
4. Groundwater is depleting. Nepal needs to plan and act on recharge and take advantage of the flood season. Resource regeneration is a crucial part of sustainable water management.
5. Integrated approach for irrigation management at local /field level (get the different sectors to come together and agree joint targets);
6. Integrate energy issues. Solar is a good option for water lifting – interested how they can take it forward especially in rural areas.

Tanzania

1. Multidisciplinary engagement of sectors: all activities should consider water, energy, agriculture, and the private sector supply chain.
2. Realisation of scale of impact that irrigation has on the environment.
3. Enabling groundwater to recharge is critical.
4. Integration of climate change in irrigation project planning. Current and future projects that will be designed.

5. Avoid over reliance on surface water or groundwater. Improve subsidies to other sectors (such as solar) to help diversify the resource base (expand farmer-led borehole based irrigation with solar pumps)**and appropriate management*.
6. Promote water efficient technology and (catchment) water saving impact assessments.
7. Continuous monitoring of water abstracted from boreholes.
8. Involve stakeholders small and large in water resource management.
9. Keep a database of farmers up from the village level – for inclusion in current and future irrigation planning.
10. Importance of modernisation of irrigation schemes.
11. Integrate data (collection and analysis) and find better ways to communicate the information in them to the stakeholders
12. Adhere to sustainability and equity of small and large scale irrigation farmers.

Uganda:

1. Collaboration between Ministries of Water and Agriculture: Learn from Tanzania how to continuously engage the Office of the Prime Minister and community involvement. Tanzania has been in same situation as Uganda so want to organise another meeting for officials to meet each other.
2. Mobilise resources for farmer-led irrigation. Link to and tailor financial services. "New" farmers should begin with traditional measures;
3. When considering the sustainability of schemes widen the scope to include equity issues. The Uganda delegates learned a lot especially how to ensure equitable water allocations. In Uganda everybody pays the same, and there is no payment for water, beyond paying for the permit. The permits allow abstraction, but they do not contain any conditions to protect/conserve water resources;
4. Strengthen capacity and accountability of water user management;
5. Payments that can be provided to the people providing the resource (inc the catchment conservation)
6. Lots of new learnings about drip irrigation (it's not a miracle solution);
7. Advice on stakeholder involvement (how to ensure all stakeholders in the value chain are included)/ Mapping value chains for larger schemes;
8. UgIFT lessons, the importance of shifting from highly subsidised programmes;
9. The need for continuous support to help farmers adopt changes;
10. Farmer-led irrigation can help close the gap.

Global team:

1. Identified knowledge gaps that need technical support;
2. Paradox of drip irrigation/water efficiency/ and water resource management;
3. Range of potential irrigation management models;
4. Various lessons to apply to project designs, e.g. the multiple levels of governance involved; consideration of plastic waste; risks of unintended negative consequences; and 'optimism' must be carefully considered.

Appendix 1: List of participants

Country	Name	Organisation	Position
Special Guests			
Tanzania	Mr Saadat Kolowa	National Irrigation Commission	Assistant Director
Tanzania	Ms Pamella Temu	Ministry of Water	Assistant Director-Water Resources Division (Planning, Monitoring and Assessment)
Tanzania	Mr Mkama Kimasa	Ministry of Agriculture	Principal Engineer
Tanzania	Mr Segule Segule Ally	Pangani Basin Water Board, Ministry of Water Resources & Meteorology	Director
Tanzania	Mr Safiel Msovu Fahamuel	Attended day 1	
Tanzania	Mr Michael McGrath	SNV	Country Director
Participants			
Bhutan	Mr Dorji Kinley	Irrigation Division, Dept. of Infrastructure Development, Ministry of Infrastructure and Transport	Chief Engineer
Bhutan	Mr Kensho Wangdi	SNV	Water Sector Leader
Cambodia	Mr Sao Ena	Research & information office, Cambodia	Vice-Chief of Water Management
Cambodia	Mr Naluch Lim	SNV	Livelihood and Value Chain Advisor
Cambodia	Mr Rik Overmars	SNV	Agri-Food Sector Leader
Ethiopia	Mr Ashenafi Lekasa Akawka	Ministry of Irrigation & Lowlands (MoIL)	Head, Irrigation Infrastructures Operation and Maintenance Desk
Ethiopia	Mr Aschalew Abiebie	SNV	Irrigation and Water Resources Advisor
Ethiopia	Mr Yigzaw Bekele	SNV	Fruit Production Advisor

Country	Name	Organisation	Position
Ethiopia	Ms Hiwote Gebretsadik	SNV	Energy Sector Leader
Ethiopia	Mr Befekadu Temesgen	SNV	Project Manager, Transform project
Ethiopia	Mr Mahteme Weyetu	SNV	Water Sector Leader
Kenya	Ms Florence Ndai	National Irrigation Authority	Principal Planning Officer
Kenya	Mr Amos Kiptanui		
Kenya	Mr Vicent Koskei	SNV	Agri-food Sector Leader
Kenya	Ms Leah Mwaura	SNV	Agri-food Project Coordinator
Kenya	Mr James Mwangi	SNV	Nexus Advisor
Kenya	Mr John Muchiri Ngigi	SNV	Energy Sector Leader
Mozambique	Mr Renato Victor Martins	National Irrigational Institute	Head of Department of Scheme irrigation Management
Mozambique	Mr Alex Grumbley	SNV	Water Sector leader
Nepal	Mr Dipak Bharadwaj Niroula	Ministry of Agriculture and Livestock Development (MOALD)	Senior Agricultural Engineer
Nepal	Mr Subash Dhakal	SNV	Project Manager – Endev project
Nepal	Ms Nadira Anwar Khawaja	SNV	Water Sector leader
Tanzania	Mr Hassan Ally	RIVACU	-
Tanzania	Ms Chris de Bont	Nelson Mandela University	Irrigation Consultant
Tanzania	Mr Abdon Joseph Hamaro	TAHA	Assistant Production Lead
Tanzania	Mr Godwin Lucas Kapama	Pangani Basin Water Board, Ministry of Water Resources & Meteorology	Hydrogeologist
Tanzania	Ms Emma Laswai	TAREA	Deputy Executive Secretary

Country	Name	Organisation	Position
Tanzania	Mr Safiel Msovu Fahamuel	Agrigrow (T) Limited	Director
Tanzania	Mr Bonface Sadik Moshi		
Tanzania	Ms Marianne Walpert	Simu Solar	Co-CEO
Tanzania	Mr Olivier Germain	SNV	Sector Leader
Tanzania	Ms Leyla Khalifa	SNV	WASH Advisor
Tanzania	Mr John Mlay	SNV	Senior Energy Advisor
Tanzania	Mr Donald Mpuya	SNV	Water Resource Management and Irrigation Advisor
Tanzania	Ms Pirosca Mvanda	SNV	Operations Assistant
Tanzania	Mr Corjan Van der Jagt	SNV	Agri-Food Sector Leader
Tanzania	Ms Helena Fubusa	Nelson Mandela University	Student
Tanzania	Mr Octavian Lasway	Nelson Mandela University	Student
Tanzania	Mr Paschal Massay	Nelson Mandela University	Student
Tanzania	Mr Denis Musiige	Nelson Mandela University	Student
Uganda	Mr Eric Ocan	Ministry of Water and Environment	Senior Engineer/Regional Manager – Water for Production Regional Center North
Uganda	Ms Sharon Biira	SNV	Farming Systems Advisor
Uganda	Mr Ibrahim Mutebi	SNV	Project Manager - Sustainable Energy for Smallholder Farmers
Uganda/HO	Ms Sonja Hofbauer	SNV	Global Technical Advisor: Water Supply/Sector Leader
HO	Sarah Alexander	SNV	Global Technical Advisor: Off-Grid Electrification

Country	Name	Organisation	Position
HO	Claire Belilos	SNV	Knowledge & Learning Advisor Energy
HO	Ms Svetlana Frenova	SNV	Global core theme lead climate
HO	Mr Rik van Keulen	SNV	Global Technical Advisor: Horticulture
HO	Ms Antoinette Kome	SNV	Global Sector Head
HO	Mr Rajeev Munankami	SNV	Multi Country Programme Manager
HO	Ms Sharon Roose	SNV	Senior Advocacy Officer WASH
HO	Ms Sandra Ryan	SNV	Global Technical Advisor: Hydrology

Appendix 2: Summary of E-group discussion

Egroup discussion:

Sustainable inclusive irrigation in the context of climate change

Topic 1: The current state of irrigation

This first topic looked into the state of irrigation currently in the different countries: understanding a bit better how much irrigation there is and how it performs.

We received 24 messages from 13 countries (Ethiopia, Uganda, South Sudan, Peru, Nigeria, Tanzania, Bhutan, Zambia, Nepal, Kenya, Cambodia, Burkina, and Bangladesh). We have done our best to make a summary of this for you.

As you remember, the questions for this first topic were:

1) What are the different types of irrigation in your country?
2) How do you describe the performance of these irrigation schemes/ arrangements?
3) What kind of challenges do current irrigation schemes/ arrangements face? Why?

Below you find a summary. We've done our best to keep it as short as possible while also reflecting people's messages. This inevitably means we ended up generalising on certain topics. All participants are encouraged to look back at the messages in the E-group to see the richer information and detail.

Ad 1. What are the different types of irrigation in your country?

In the introduction to the topic 1, it was mentioned that irrigation can be characterised in many ways:

- by source (surface water, ground water, waste water),
- by plot level technology used (flood, furrow, watering cans, sprinkler, drip, sub-surface),
- by size (large, medium, small-scale irrigation linked to the size of the area),
- by conveyance method (lined or earthen canals, piped pressurised or piped non pressurised),
- by energy source for lifting and/or conveyance (gravity, petrol, electricity, solar, manual, animal powered),
- by management system (agency, farmer organisation, third party, self-supply/ individual),
- by distribution method (continuous, rotational, on-demand) and

- whether it's permanent or supplementary irrigation.

Most of you characterised irrigation by the technology used at plot level, size of the irrigation schemes and a few by management model.

In the table below the technologies mentioned for each country are listed. As can be seen, essentially all countries have the main types of irrigation of flood, sprinkler, drip, and bucket irrigation. Many also have more specific technologies such as rain guns and spray tape/ tube. There are several more technology variations. It was also clear that in most countries, flood, furrow, basin irrigation is by far the predominant type of irrigation. Sprinkler and drip irrigation, due to their high upfront investment cost are mainly used for smaller areas and higher value crops. **Berhanu Niguse** from **Ethiopia** and **Santiago Casas** from **Peru** show in their messages how the choice of technology is closely linked to the terrain, soil conditions, scarcity/abundance of water and types of crops.

	Ethiopia	Uganda	Nigeria	Tanzania	Kenya	Zambia	Nepal	Bhutan
flood	1	1	1	1	1	1	1	1
furrow/ basin	1	1		1	1	1	1	1
spate[7]	1							
sprinkler[8]	1	1	1	1	1	1	1	1
centre pivot	1		1			1		
lateral move	1							
rain gun			1					
drip[9]	1	1	1	1	1	1	1	1
spray tape/ tube		1	1					
subsurface[10]	1					1		
containers or buckets	1	1	1	1	1	1	1	1

There are many different types of irrigation technologies in **Ethiopia** as described by **Tesfa Ayalew** (see list above and the descriptions in his message), surface irrigation is by far the most common in the country. Sprinkler and drip only represent up to 2% of the irrigated areas.

[7] https://sswm.info/sswm-university-course/module-4-sustainable-water-supply/further-resources-water-use/spate-irrigation
[8] https://sswm.info/sswm-university-course/module-4-sustainable-water-supply/further-resources-water-use/sprinkler-irrigation
[9] https://sswm.info/sswm-solutions-bop-markets/affordable-wash-services-and-products/affordable-technologies-and/drip-irrigation
[10] https://sswm.info/sswm-solutions-bop-markets/affordable-wash-services-and-products/affordable-technologies-and/subsurface-drip-irrigation

Irrigation is also classified by size and by history, as Befekadu Kassahun, Mahteme Tora and Yigzaw Dessalegn explain. By size the Ethiopian government distinguishes:

1. Small-scale irrigation (<200 hectares): managed by individual farmers or local communities.
2. Medium-scale irrigation (200–3000 hectares): often funded by the government or other organizations. They require more planning and infrastructure, including canals, pumps, and reservoirs.
3. Large-scale irrigation (>3000 hectares): having significant investment, advanced technology, and centralized management.

Furthermore, by history and management set-up, the distinction is made between traditional schemes (usually small scale, local materials, and community managed), modern communal schemes with concrete structures, modern public (government enterprises) and modern private schemes (privately owned).

Befekadu writes that the potential irrigable land averages 3.5 Mha. As per 2001 data, there was an estimated 160,000 -200,000 hectares under irrigation (5%). Aschalew Demie Abiebie adds that per 2020 figures, a total of 1.07 Mha is under irrigation (31%), of which 55% is small scale irrigation and the remainder medium, large scale irrigation. In its Ten-year development plan (2021-2030), the government estimated that sprinkler and drip was 2% of the irrigated surface.

In Uganda, David Tusasiibwe shares that I Uganda the main types of irrigation are flood, sprinkler, and drip, and that "bottle irrigation" is promoted at small scale by some politicians. Drip irrigation is promoted by the Micro-scale Irrigation Programme of the Ugandan Ministry of Agriculture. It helps farmers to buy and use equipment. Flood irrigation is largely used in rice farms in the East, and sprinkler is an upcoming technology due to versatility and cost. Pivot irrigation is used in some sugar cane plantations.

Sonja Hofbauer and Eric Ocan share four different classifications from Uganda, including that the Uganda National Irrigation Policy categorizes irrigation schemes by land size:

- Micro Scale Irrigation Schemes with less than 5 hectares
- Small Scale Irrigation Schemes with 5- 100 hectares
- Medium Scale Irrigation Schemes with 100 – 1,000 hectares, and
- Large Scale Irrigation Schemes with greater than 1,000 hectares of irrigated land.

In Uganda, Farmer Based Management Organization (FBMO) manage the large and medium-scale schemes through the following Farmer Based Management Institutions (FBMI): Farmer Field Schools (FFS), Irrigation Water User Committees (IWUC), Irrigation Water User Association (IWUA), and farmers Cooperative Society (CS), each with different roles. Whereas the FFS organise farmers to learn and jointly run on-farm water structures, the IUWC collects fees, operates and maintains smaller facilities that provide water. IWUA are put in place for bigger schemes and can work through IWUCs. Farmers CSs are autonomous bodies supporting farmers in value addition and access to equipment and finance. All levels aim to resolve disputes at their level. Users of small schemes are often not paying for water, larger ones do.

Ephraim Asoo Tyokighir describes the technology-based classification of irrigation for Nigeria (please refer to the message for details).

Corjan van der Jagt describes that in Tanzania only 33% of the 44Mha arable land is cultivated (2014), Of this only a very small part (3%) is irrigated. However, he adds, the figure could be 10-20% higher, as the official figures do not include all the irrigation done by individual farmers on which it is difficult to obtain information. In Tanzania, distinction is made between:

- Small holder farmers, usually practicing surface irrigation through lined or unlined canals. These represent 83% of the irrigated land.
- Commercial farmers, both commercial and state companies. These often use sprinkler irrigation and represent about 17% of the irrigated land.

Drip irrigation is very minimal and mainly found in commercial horticultural operations and large-scale plantations (coffee, tea).

In Bhutan, Khandu Tshering writes, irrigation has been practised since time immemorial. Government intervention started in 1961. Currently, Kencho Wangdi shares, the schemes can be distinguished in two types:

- Community Managed Irrigation System (CMIS) where the irrigation system is constructed and managed by the farmers/community and government provides co-financing. There is more involvement of local governments and lesser involvement of central agencies.
- Agency-built Community Managed Irrigation System (ACMIS) where the irrigation system is constructed by the government and handed over to the community for management.

The three irrigation methods are surface irrigation which is gravitational fed (89%), sprinkler irrigation (9%) and localized irrigation which is more like drip irrigation (2%). Kinley Dorji as well as Khandu Tshering describe that in the early days, there were only earthen canals, but now there are also lined canals, pressurised piped and lift irrigation systems.

In Zambia, there are essentially three types of schemes, Andrew Songiso and Davies Sampa say, namely: community, government, and commercial farmer schemes. Most community level/ small holder schemes are gravity-based surface irrigation. Moreover, more than 80% of small holders will use some form of irrigation by buckets. Especially those located close to wetlands or other water sources. A classification of schemes can also be made based on history and management model:

- Government Run Irrigation Schemes: government established schemes from the 1970's, with an officer assigned for day-to-day running of the scheme.
- Small Scale Farmer Cooperatives run Irrigation Schemes: developed by farmers using the water from dams constructed by the government (end 1990's, early 2000's). Average size 5-10 ha.
- Smallholder Irrigation Project (SIP) /Chiansi Model: small-scale landowners as a group engage a company to run their group of farms as a business. Upon selling the produce, the company deducts running costs before paying the small landowners their share according to the size of their plot.
- Irrigation Development Support Project (IDSP) Model: promoted in 2011 based on the principle of full (operational?) cost-recovery. There are different variations depending on the sizes of the farms:
    - Tier 1, plots up to 1 ha, owned and farmed by individual small holders.

- Tier 2, plots up to 5 ha, owned and farmed by emergent commercial farmers or groups of small holders.
- Tier 3, farms of 50-60 ha, farmed by a professional operator, providing agricultural services to the other two tiers.
- Tier 4 : large-scale commercial farmers who share the bulk of water infrastructure by the project and develop their own irrigation scheme to utilize it.

Zambia has similar irrigation technologies as neighbouring countries: surface, sprinkler, drip, subsurface.

In Nepal, about 40% of the agricultural area is irrigated writes Subash Dhakal, but only 19% is year-round under irrigation. Nepal has gravity flow irrigation in its hilly and mountainous areas. The most common method is surface irrigation, including in terraced fields. There is also furrow and drip irrigation, the latter more for vegetables. Deep tubewell irrigation is practiced in the low-lying area of the country (Terai).

Irrigation is also distinguished by management model. Nepal has:

Large-scale agency-managed irrigation systems in Nepal are operating under the joint management model. The irrigation management department of the government (IMD) manages the main structure up till tertiary level, and below tertiary level the water users' group (WUG) manages the allocation, distribution, coordination, and maintenance.

Furthermore, Nepal is known internationally for its Farmer Managed Irrigation schemes, which have been developed and managed by farmers themselves.

Also, Kenya has surface, sprinkler and drip irrigation Herbert Akoru describes. Furthermore, James Mwangi explains the three management types:

- Private community based small and medium farmer managed systems where farmers collaborate in an irrigation water users' association (IWUA) or self-help group. This represents 3.600 schemes or about 43% of the area under irrigation in Kenya.
- Private commercial farms, which can be owned by an individual or a company. This represents about 39% of the area under irrigation.
- Public-owned irrigation schemes are large scale (800-1200 ha), managed by either the national irrigation authority (NIA) or another public entity. These cover 18% of the irrigated area.

Naluch Lim writes about his country Cambodia, where 61% of the agricultural land is irrigated. Many of these are not yet "modernized" and have management challenges. There are also private irrigation water providers who pump water from rivers or streams. Farmers pay them based on land size and number of cropping cycles.

In Burkina Faso, a distinction is made between irrigation for rice farming in the wet season in the low lands, and irrigation development in other irrigable land. The total area under irrigation has been expanding rapidly and is now estimated to be at more than 152,000 ha, Soumahila Coulibaly from Burkina writes. About 33% is gravity irrigation, and a very minor part is drip. Most irrigation involved lifting, transporting, and applying water via containers/ buckets. In addition to the lowland rice farming, irrigation is categorised by size:

- Large areas: areas of several hundred or even a few thousand hectares for the cultivation of rice and sugar cane.

- Average perimeters: areas from 20 ha to 100 ha. Located around dams for rice growing and horticultural.
- Small irrigation: perimeters of a few acres to 20 ha. These perimeters are privately (Individual) or collectively (village). Owned Crops other than rice, horticultural and cereal crops.

Ad 2. How do you describe the performance of these irrigation schemes/arrangements?

Across the different contributions, we see that performance is described in different ways:

1) At the level of the infrastructure itself, namely :
    a) Functional, non-functional
    b) Whether the entire (planned) perimeter is irrigated
    c) Whether the scheme is running per its expected life-span (design life)
2) Water efficiency, which in itself can be seen at different levels namely :
    a) Whether the scheme contributes to a reduced total water footprint in the watershed
    b) Whether the scheme has less conveyance and distribution losses
    c) Whether the scheme contributes to more crop per drop at the plot level
3) Water control, whether the scheme ensures both access as well as drainage, and whether the access is equitable
4) Financial, whether the scheme has operational cost recovery, breaks even or is lower cost than alternative options.

Other performance aspects that you mentioned are around productivity, income, or nutrition. These typically depend on many more factors beyond the irrigation scheme and its management, such as access to quality agricultural inputs, output markets, agronomic practice etc. In his contribution, Herbert Akoru from Kenya shows that the productivity (yield per hectare) in public irrigation schemes between 1998-2010 were strongly related to resource allocations from the government.

1a Functional versus non-functional infrastructure

Mahteme shares that in Ethiopia, 50% of the irrigation schemes are considered as providing functional services, the remaining 34% of the implemented schemes are not fully utilised, and 16% are non-functional. Kencho shares that in Bhutan, 9% of Community managed irrigation schemes are dysfunctional, due to damages by rural roads, landslides, and water resource challenges. Similar challenges are faced by irrigation schemes in Nepal Subash says. Also, Eric and Sonja refer to the functionality of schemes in the case of Uganda.

1b Planned versus actual irrigated perimeter

Yigzaw from Ethiopia talks about performance in terms of planned versus actual irrigation area (perimeter). He says that many schemes perform below their potential leaving users and farmlands out.

1c Planned versus actual lifespan of infrastructure

Aschalew mentions this issue in relation not only to poor quality design and construction, but also lack of proper operation, maintenance, and management. Yigzaw also mentioned the reduced life span of dams

and reservoirs due to siltation related to poor watershed management. This is also mentioned by Naluch Lim from Cambodia.

2a Efficiency at watershed level, i.e. total water foot print

Yigsaw is concerned about the unregulated and overexploitation of water resources, due to increased uptake of irrigation (and unpredictability of the rainy season), leading to conflicts between community members. Ruhul Munshi from Bangladesh is concerned that the current irrigation performance represents a huge water footprint.

2b Conveyance and distribution losses

Khando from Bhutan is concerned about the losses from open, earthen channels in the context of Bhutan. Therefore, the government is supporting piped schemes for all new irrigation projects. Berhanu also mentions inefficient water distribution and soil erosion in surface irrigation schemes, if not managed properly.

2c Plot level water efficiency

Many of you speak about the water efficiency at plot level in relation to different field level irrigation technologies.

Mahteme shares that in a study on 10 irrigation schemes in Ethiopia, there is a huge variation in plot level water use between farmers. The ratio of irrigation supply to crop water demand ranged from 0.5 (under-irrigation) to 8.0 (over-irrigation). Yigsaw added that this over-irrigation is leading to waterlogging and salinity problems.

3 Water control

Corjan shares that the small-scale irrigation in Tanzania suffers from several performance challenges, including Inequitable distribution of water from head-end to tail-end users. Subash shares that in Nepal the large schemes under joint management between IMD and WUAs, face challenges in management of the main system which then affects the WUAs at lower level. Ben van Ooij adds that this has led to conflicts around water distribution and misunderstandings around payment, which in turn affects maintenance and fair distribution.

4 Financial performance

Tesfa Ayalew from Ethiopia states that large-scale irrigation schemes have more promising returns than smallholder irrigation schemes due to their limited access to finance, high operational costs, and other constraints. Mackenzie Masocha from South Sudan also refers to the difficulties of sustaining operations for smallholder farmers. A similar comment is made by Andrew Sipawa and Davies Sampa from Zambia about small-scale farmer cooperatives. They suggest that new partnerships between smallholders and companies work better because the land size is normally more than 200 ha. Also, the studies quoted by Herbert show a correlation between performance, and scheme size. All these contributions seem to focus on the income for farmers, not so much whether the scheme has operational cost recovery or breaks even. Interestingly, Herbert also shares that higher O&M cost collection rates positively impact scheme performance, whereas increased donor funding showed negative effects.

Corjan also talks about the financial performance, stating that the initial high investment costs of solar powered irrigation are recovered within 2-3 years, when compared to fuel-powered pumps.

David from Uganda shares that the rate of return on investment is not economically viable for most irrigated crops due to their low value. Khando raises a similar point for Bhutan, that the introduction of pressurized piped irrigation, lift irrigation and micro-irrigation, involve large CAPEX whereas most agriculture low returns.

Ad 3. What kind of challenges do current irrigation schemes/arrangements face? Why?

The type of challenges that are mentioned across the different contributions can be divided between those related to irrigation development and related to irrigation management, and further categorised as follows:

Irrigation development challenges

Planning of the development of irrigation	Finance for development of irrigation	Implementation processes in the development of irrigation
Lack of an irrigation master plan (Zambia) Lack of studies and finance to develop irrigation (Zambia) Limited application of IWRM principles in planning of irrigation (Kenya) Weak institutional and governance frameworks (Kenya) Absence of National Irrigation data for planning (Tanzania) Lack of coordination for irrigation development (Tanzania, Kenya) Focus on a scheme-based approach rather than a watershed-based approach (Ethiopia)	Inadequate financing (Burkina, Kenya, Uganda Low allocation for rehabilitation (Cambodia) Investment risks due to the common pool resource character of water (Zambia) Scattered settlements and mountainous terrain make it financially unattractive (Bhutan) Absence of National Irrigation Investment criteria (Tanzania)	Inadequate design or low-quality construction (Uganda, Ethiopia) Need for weather resistant technological solutions (Cambodia) Inadequate participation processes (Kenya) Lack of coordination of development initiatives with other stakeholders/ authorities locally (Kenya, Ethiopia) Inadequate technical knowledge about design (Bhutan, Uganda, Ethiopia) Slow pace of implementation of policies and regulation (Tanzania) Low capacity and participation of private sector (Tanzania)

Irrigation management challenges

At the level of water resources	At the level of the irrigation scheme	At plot/farm level

Budget of water resource data and monitoring (Zambia, Cambodia, Bhutan, Ethiopia) Limitations in water resource management, regulation and enforcement (Zambia, Ethiopia) Clashes with traditional water resource allocation practices (Zambia) Low water storage/ harvesting capacity (Zambia, Burkina, Kenya, Cambodia, Ethiopia) Degradation of reservoirs (Cambodia, Ethiopia) Weak collaboration in WRM (Cambodia) Increasing pollution (Cambodia) Water scarcity and competition (Uganda, Kenya, Zambia, Ethiopia) Water quality challenges e.g. salinity, heavy metals (Kenya, Zambia) Climate change both floods and droughts (all)	High CAPEX (Zambia, Uganda) Limited OPEX, including high energy costs (all) Limited public support/ resources (Zambia Water distribution issues (Zambia, Uganda, Ethiopia) Limited farmers' participation in O&M (Cambodia) Poor maintenance (all) Gender-bias in decision making bodies (Kenya, Ethiopia) Lack of skilled staff for O&M (Uganda, Bhutan, Ethiopia) Functionality of the Water Users Group (Bhutan, South Sudan, Ethiopia) Lack of authority vested in Water User Groups (Bhutan, Ethiopia) Inadequate support systems for O&M, spare parts (Uganda)	Farmers' capacity for efficient and appropriate irrigation (Burkina, Bhutan, Uganda, Ethiopia) Limited application of modern agronomic practices and technologies (Kenya, Uganda) Gender-bias in extension and support services (Kenya, Ethiopia) Highly complex and partially informal land tenure (Zambia, South Sudan, Ethiopia) Lack of credit for farmers (Zambia, South Sudan, Ethiopia) Lack of research data on agronomic practices (Bhutan, Ethiopia) Traditional crop preferences of farmers (Bhutan) Contamination of water bodies and risk to health for downstream settlements (Bhutan) Unreliable government subsidies (Uganda) Quality of technologies (Uganda) Soil degradation (Ethiopia)

Egroup discussion:

Sustainable inclusive irrigation in the context of climate change

Topic 2: The future ambition for irrigation

This second topic tried to look forward. It asked what the future of irrigation will bring or should be. An important aspect of this future is of course the context of climate change that we are all living, but there is also urbanisation, demographic changes and changes in markets that may influence future ambitions of irrigation.

We received 15 messages from 9 countries (Nigeria, Zambia, Kenya, Tanzania, Uganda, Ethiopia, Bhutan, Burkina Faso and Cambodia). Many thanks to Chris de Bont from the Nelson Mandela African Institution of Science and Technology for making this summary.

As you remember, the questions for this second topic were:

4) What is the institutional set-up (roles & responsibilities) in irrigation in your country?
5) What are the planned ambitions and developments for irrigation in your country in 20 years?
6) Do you see any other/unplanned developments within irrigation in your country in 20 years?
7) What do you see as implications of all these developments for the future of irrigation in your country?

- *Ad 1. What is the institutional set-up (roles & responsibilities) in irrigation in your country?*

This question aimed to understand the roles and responsibilities for irrigation development, from national level downwards. Several things became clear when reading the answers to this particular question:

1. In all countries, Irrigation management and development engages different public sector agencies and ministries, ranging from agriculture, food security, rural development, domestic water supply and sanitation, water resources management, and mechanisation. Often, the main responsibility lies with the Ministry of Agriculture.

For instance, **Ephraim Tyokighir from Nigeria** explains that his country has three government entities that are responsible for irrigation: the Ministry of Agriculture and Rural Development, the Directorate of Foods, Road and Rural Infrastructure, and the River Basin Development Authorities. In **Burkina Faso**, six different institutions have to work together to develop and manage irrigation infrastructure, plan the use of water resources sustainably, and support the agricultural sector by improving access to water for irrigation, as explained by **Coulibaly Soumahila:** Ministry of Agriculture and Hydraulic Development, General Directorate of Development and Agricultural Equipment, Directorate General for Water, National

Office of Water and Sanitation, General Directorate of Development and Integrated Water Management, and the Water Agency. For Bhutan, Kinly Dorji and Kencho Wangdi show how in their country the responsibility for different aspects of irrigation is divided over various institutions, all the way down to district and gewog (group of villages) level. At national level there are specific departments within the ministries of Agriculture and Livestock, Infrastructure and Transport, and Energy and Natural Resources. At District level it is the engineering and agricultural sectors that primarily engage with irrigation development.

An exception to the rule that the agricultural ministry is the main ministry in charge of irrigation is Cambodia, where Naluch Lim tells us it is the Ministry of Water Resources and Meteorology serving as the principal governmental entity for the country's irrigation portfolio.

2. Only a few countries have a special irrigation authority to balance different needs and interests.

Examples of these are given by John Ngigi for Kenya (The National Irrigation Authority (NIA)), Corjan van der Jagt for Tanzania (National Irrigation Commission (NIRC)). These authorities generally have the responsibility to coordinate irrigation investments and play a key role in realising irrigation master plans and national irrigation policies. Ethiopia is a special case, being a federal state. Though it does not have a national irrigation authority, each Region does have its own Irrigation Bureau, as explained by Michael Mehari. Furthermore, at a national level the Federal Ministry of Irrigation and Lowlands is responsible for the development of medium and large-scale irrigation schemes anywhere in the country. The Ministry of Agriculture on the other hand is mandated with development of small-scale irrigation schemes.

3. Irrigation management and development is not only a task of the government but is aided by private investment (commercial farmers but also smallholders), (I)NGOs and other stakeholders.

Emily Banda from Zambia rightfully points out that in her country organizations such as the Food and Agriculture Organization (FAO), the International Fund for Agricultural Development (IFAD), and various NGOs support irrigation through funding, technical assistance, and capacity-building initiatives. A similar thing is mentioned by Befekadu Kassahun and Aschalew Demie for Ethiopia, who in addition emphasise the role of individual companies developing irrigation. John Ngigi from Kenya mentions the importance of Water Resource User Associations (WRUA) to ensure sustainable and equitable water use, and Mahteme Tora points out the role of farmers in managing irrigation schemes in Ethiopia. Naluch Lim from Cambodia also mentions different NGOs, private sector actors and farmer organisations as important actors in the irrigation sector.

- *Ad 2. What are the planned ambitions and developments for irrigation in your country in 20 years?*

This question asked about the ambitions for irrigation, both from a government perspective as well as from other stakeholders in society such as farmers, private sector or social enterprises.

All contributors mention that their country has the ambition to expand the area under irrigation. Some countries have formulated very specific targets in terms of irrigated area expansion. Examples are given by Corjan van der Jagt for Tanzania (from 700k hectares in 2022 to 1.7 million hectares in 2028), Nestar Coffee for Uganda (add 1,500,000 Ha of irrigation - constituting 50% of irrigation potential - by 2040), Michael Mehari, Befekadu Kassahun, and Mahteme Tora for Ethiopia (construction of medium and large-scale irrigation networks from 490,000 hectares to 1.2 million hectares), Kencho Wangdi for Bhutan (expand the irrigated area from 64,000 acres in 2014 to 91,000 acres by 2032), and by Naluch Lim for Cambodia (provide dependable irrigation to over 1,375,000 ha). A few countries have an irrigation master plan, or a similar guiding document. One such country is Bhutan, which Kinly Dorji describes as

having “a 15-year irrigation development roadmap” through its irrigation master plan. Other countries are Kenya, Tanzania, Ethiopia and Cambodia.

In addition to area expansion, there is the ambition to tackle some of the challenges mentioned in the discussion in week 1 (poor performance, low water use efficiency, financial challenges, etc). Some of the solutions are sought in:

- The adoption of new technologies (Uganda, Ethiopia, Burkina Faso)
- Upgrading of existing irrigation infrastructure (Zambia, Tanzania, Ethiopia, Bhutan)
- Improving water use efficiency (Zambia, Uganda, Ethiopia, Bhutan, Burkina Faso)
- Strengthening the policy and regulatory frameworks for irrigation development (Zambia, Ethiopia)
- Improving Access to Finance (Zambia, Tanzania, Ethiopia)
- Increase involvement of the private sector (Zambia, Tanzania, Ethiopia, Bhutan)
- Strengthen the management and governance of water resources (Zambia, Ethiopia, Bhutan, Burkina Faso)
- Climate proofing irrigation systems by making them more resilient to extreme events (Zambia, Burkina Faso, Cambodia).

It is important to note that in most countries the ambition to expand and improve irrigation fits into other national goals. Ephraim Tyokighir for instance links Nigeria’s target to develop irrigation facilities to the country’s growing population and the need to cater to changing food demands while improving livelihoods. This link to food security and economic development is made by several other contributors, for instance Emily Banda from Zambia, John Ngigi from Kenya, and Coulibaly Soumahila from Burkina Faso. Corjan van der Jagt links irrigation development in Tanzania to the country’s target of reaching food security and producing cash crops for export. Adaptation to current and future climate change is also a strong driver for irrigation development ambitions, as explicitly mentioned in the irrigation policy for Uganda, shared by Nestar Coffee, by Aschalew Demie who cites the Ethiopian vision for the smallholder irrigation and drainage sub-sector, in which irrigation is to “enhance resilience to climate change and thereby ensure food security, maintain increasing income and sustain economic growth”.

- *Ad. 3 Do you see any other/unplanned developments within your country that will impact irrigation in the next 20 years?*

This question concerned unplanned developments in the irrigation sector or other drivers outside the irrigation sector or at macro level that influence the development of irrigation. Most contributors referred to developments that they expect to *negatively* impact the irrigation sector, but there was also hope for some *positive* development. We start here with the positive, to then get into the developments that pose possible threats to irrigation development.

The most frequently mentioned positive driver for irrigation expansion is the possibility of technological advancements and innovations in the irrigation sector. Emily Banda (Zambia), Mahteme Tora (Ethiopia), Coulibaly Soumahila (Burkina Faso) and team from SNV Uganda all point out the possibilities of new technologies in increasing water efficiencies and productivities, as well as the overall uptake of irrigation by users. Precision agriculture, remote sensing, use of artificial intelligence, and innovative irrigation technologies are specifically mentioned as possible developments.

Apart from technological development, Befekadu Kassahun from Ethiopia also mentioned the individual development of small-scale irrigation outside of the government plans as an unplanned contribution that can speed up irrigation expansion. Interestingly, the team from Uganda (Eric Ocan, Ibrahim Mutebi, Sharon Biira and Sonja Hofbauer) mentioned some developments that others mostly see as a threat as a positive force: they see how climate change will push farmers to adopt irrigation technologies due to increasing drought, how increasing food demands due to urbanisation can also push farmers to intensify and adopt irrigation.

Apart from these positive drivers, a lot of contributors mostly see threats for future irrigation expansion/intensification. Climate change is the major development mentioned by all contributors. Primarily, climate change is expected to:

- Increase the competition over increasingly scarce land and water resources and lead to conflicts between different water users. Ephraim Tyokighir specifically highlights already ongoing conflicts between herders and farmers in Nigeria; and John Ngigi from Kenya emphasises the need to promote water harvesting, storage, and recycling technologies to enhance the availability of water for irrigation in the future.
- Lead to extreme weather events that can disrupt irrigation schedules and damage infrastructure (Zambia, Tanzania, Ethiopia, Mahteme Tora, Bhutan Kencho Wangdi, Burkina Faso, Cambodia, Uganda)
    - Naluch Lim from Cambodia explains how this climate variability necessitates frequent monitoring of underground water levels and security alerts for flood emergencies to ensure preparedness and response.

A second development expected to negatively impact irrigation development is the increased competition for water between users and sectors, strongly driven by population growth. Coulibaly Soumahila from Burkina Faso warns that population growth could lead to increased competition for water resources, including for irrigation, and that this in turn can lead to stricter policies and regulations on water use. Similar opinions were voiced by contributors from Zambia, Kenya, Ethiopia, Cambodia and Uganda. Mahteme Tora from Ethiopia specifically mentions how increased demand for water in urban areas will negatively impact water availability for the rural water sector, and Michael Mehari reminds us that apart from increased internal competition there might also be increased competition between countries that might impact water availability, such as in the case of Ethiopia.

A third category of possibly negative developments concerns political and policy challenges. Several contributors mention that overlapping institutional roles and responsibilities can impede irrigation development. Corjan van der Jagt in Tanzania states that there is often overlap between institutions leading to inefficiencies and slow implementation. Supportive or un-supportive policies, laws, and regulations that control water, land, financial, and environmental institutions can enable or constrain irrigation. If the policy environment is not supportive, scaling of irrigation will be practically impossible. Similar statements are made by the contributors from Kenya, Tanzania, Bhutan and Cambodia.

A fourth concern is the trend of water resource degradation. Emily Banda from Zambia and Mahteme Tora from Ethiopia warn how deforestation, soil erosion, agricultural expansion, urban sprawl and the related pollution, can impact water availability and quality for irrigation. Naluch Lim from Cambodia highlights how the overexploitation of groundwater can lead to the depletion of that particular resource.

Already mentioned briefly in the previous development for its impact on water resources, is the increasing urbanisation and the related land use and demographic changes also form a concern in terms

of land and labour availability in Zambia and Bhutan. For the latter country Kinley Dorji and Kencho Wangdi specifically describe how the rise of urbanization will likely cause a decline in farmland and rural-urban migration, making less labour available for intensive irrigated agriculture.

In addition to these more frequently mentioned issues, there are a few developments that are only raised for specific countries, but that one can imagine are also relevant for other locations:

- Lack of infrastructural development in other sectors such as roads and electricity.
- Emergence of new pests and diseases.
- Changes at macro level: volatile global markets, pandemics, trends in international development assistance.
- Changing Consumer Preferences: Growing demands for agricultural products grown in sustainable and environmentally friendly ways could influence irrigation practices and cropping choices.

- *Ad. 4. What do you see as the implications of all these developments for the future of irrigation in your country?*

This question asked about how you see the future of irrigation in your country, especially in terms of sustainability (e.g. water resources quantity and quality, solid waste issues from irrigation, energy use, soil degradation) or equity (e.g. water conflicts, distribution of benefits from irrigated agriculture across society, water distribution between sectors). Here again, we can see some expected positive developments, and some expected challenges/negatives, both in terms of reaching the irrigation targets and as the result of irrigation expansion. We are starting here with the positives.

There are strong expected benefits from expansion and intensification of irrigated agriculture across countries. Emily Banda from Zambia lists increased agricultural productivity, economic growth, food security, and increased water use efficiency (due to new technologies and farmer capacity building programmes). Corjan van der Jagt from Tanzania adds expected increase in tax revenue, improved gender equality, poverty reduction and increased resilience to this, while Befekadu Kassahun from Ethiopia points out improved nutrition, job creation and an increase in export revenue. Naluch Lim from Cambodia expects irrigation systems to support high-value crops, offering farmers additional income streams and choices due to improved irrigation access. Michael Mehari from Ethiopia sees many challenges, as outlined under question 3, but is hopeful that if these can be addressed that the irrigation sector will be driving the national economy in many aspects.

One concern in terms of realising the irrigation ambitions of different countries lies in the capacity of national government to create the circumstances in which irrigation programmes can be successfully implemented. Ephraim Tyokighir for instance, fears a lack of implementation in Nigeria due to resources falling in the wrong hands, lack of oversight, and limited expertise in top positions. In addition, the insecurity in the northern part of the country is expected to continue, preventing farmers from cultivating and expanding irrigation. John Ngigi emphasises the need for proper sector and cross-sector coordination as well as an integrated approach to implement planned irrigation development in Kenya. Similar statements are made by Corjan van der Jagt from Tanzania and Befekadu Kassahun and Mahteme Tora from Ethiopia. Emily Banda from Zambia points out the how crucial stable policies are, and the danger of abrupt policy shifts for realising irrigation programmes.

Another concern is the availability and quality of land and water resources. Contributors from Tanzania, Ethiopia, Zambia, Uganda all mention the availability and reliability of water as being both impacted by,

and impacting irrigation management and development. Mahteme Tora therefore sees an increased need for water management and regulatory frameworks in Ethiopia. The Uganda team (Eric Ocan, Ibrahim Mutebi, Sharon Biira, Sonja Hofbauer) sees that the increased demand for water for various uses from different sectors will result in reduced water quantity and quality, hence potential conflict. They state that there is need for monitoring of collective water use and regulation and clear water allocation processes across all uses. They also warn of increased pollution of water due to urbanisation and industries.

Where the contributors from most countries foresee irrigation expansion, Kinley Dorji has great concerns for irrigation in Bhutan. He worries that if nothing is done by the institutions responsible for irrigation, the future of irrigation is at risk of disappearing. Especially urbanisation, reduced labour availability and decreasing farmland is a threat, though he also writes that this could be a catalyst for improving crop productivity to ultimately ensure food security.

Overall, all contributors share concerns about the many challenges that face irrigation management and development and see the need for interventions in the areas of finance, governance, water resources, documentation and data management, and environmental management, but ultimately, they have high hopes for irrigated agriculture's contribution to development targets.

Egroup discussion:

Sustainable inclusive irrigation in the context of climate change

Topic 3: Interventions and investments for sustainable and inclusive irrigation

The third topic focused on **Interventions and investments for sustainable and inclusive irrigation** and the questions for this topic were:

1. In the context of your country, what do you consider the most appropriate approaches to invest in irrigation? Why?
2. In your view, who should be leading these investments and interventions ?
3. Who will carry the costs and benefits of these interventions?
4. To what extent will these approaches ensure sustainability and equity ?

Ad 1. In the context of your country, what do you consider the most appropriate approaches to invest in irrigation? Why?

Irrigation development and improvement can be achieved in a variety of ways and focus on different types of irrigation schemes. You made various suggestions around technology choices, but mostly about the size of schemes and management models.

Technologies

In terms of technology, **Subash Dhakal** from Nepal suggests introducing solar for water lifting where gravity is not suitable. Also **Ephraim Tyokighir** from Nigeria sees solar as the most appropriate approach due to the reduced energy costs in operations. However, if there are no batteries or storage, it does imply that irrigation should happen when its sunny (which is not desirable). **Coulibaly Soumaila** from Burkina Faso and **Ephraim** see drip as an appropriate technology due to the water saving potential. However, **Befekadu Kassahun** from Ethiopia suggests that surface irrigation is still very appropriate for different levels: households, communal, private, due to its low operational costs. Subsurface irrigation could have potential for Ethiopia as well but needs to be explored further.

Individual farmers investing themselves

Talking about the size of schemes and management models, you mentioned a spectrum of intervention options. Firstly, individual farmers investing themselves in pumps, wells, rainwater harvesting. **Ashalew Demie** describes this practice for Ethiopia and also how these farmers sell part of their water to neighbours. A good supply chain and support services are key to enable farmers to do this, and as **Corjan van der Jagt** from Tanzania says, affordability can be a significant barrier. **Marianne Walpert** from

Tanzania points out that a number of enabling environment conditions should be in place to accelerate farmer self-investment, both at the company and farmer level:

These are for example direct investment in companies, either equity or debt, grants to support market outreach, market expansion, educational and training programs, new product development, etc., preferential tax treatment for solar water pumps to reduce costs to farmers, results-based payment programmes providing a discount to farmers, either directly to farmers or through a subsidy to the company. Subash adds to this that further financial incentives may be needed to encourage farmers to invest in the equipment.

A specific payment modality for farmers is pay-as-you-go (PAYG), which means that capital costs do not need to be covered by farmers, but payment is only on the basis of use. Of course this involves risk for companies and can only work if the uptake is significant. Therefore risk-reduction strategies for PAYG financing would be part of the enabling environment conditions for companies in this case.

A variation of individual investment by farmers is the investment by commercial farmers. These are bigger but will also need support though of different nature. Commercial farms may also sell the water to neighbouring (small) farmers.

Small-scale irrigation and large scale irrigation

Several people, including Mahteme Tora from Ethiopia, Aschalew and Coulibaly, consider that small-scale irrigation should be prioritised over individual as well as large scale schemes. Arguments in favour of prioritising small-scale irrigation are that these are less expensive, take less implementation time, are easier to manage, have lower O&M costs and technical requirements, are rarely dependent on transboundary waters and are suitable in more places. Others like Yigsaw Dessalgn from Ethiopia state that medium and large scale irrigation is still needed due to its importance for food security (staple foods whereas small schemes produce more vegetables) and the fact that these provide livelihoods to large numbers of small holder farmers. The focus should therefore be on rehabilitation or upgrading these schemes and putting in place appropriate management models (not so much building many new large schemes). Subash also mentions the need to strengthen governance structures and WUAs to manage the schemes more inclusively and efficiently, the need to strengthen the participation of women, and to value the indigenous knowledge about water management.

New management models

In terms of new management models, Kinley Dorji from Bhutan puts strong emphasis on the benefits of privatisation of scheme management either to farmers or to a third party. This can initially be a delegated management arrangement with the government, but over time can be concessions. For larger schemes combining hydropower and irrigation, Design Build Operate Transfer (DBOT) arrangements can be made. Corjan is rather thinking about Foreign Direct Investment (FDI) for large as well as community schemes. Mahteme provides several examples of how these PPPs are already happening in Ethiopia for example in both the Kesem Irrigation Project (1.2 billion USD) and the Tekeze River Irrigation Project are joint investments by the Ethiopian government and Saudi Fund for Development. Both aiming to provide irrigation to 100,000 hectares of land. The Gilgel Gibe III Dam is a PPP built by the Ethiopian government and the China Gezhouba Group Corporation. It is expected to cost 4.8 billion USD, generate 1,870 megawatts of electricity and provide irrigation for 150,000 hectares.

Among the different contributions, nobody is very explicit about asset ownership. The expectation is that management performance will be better because it is privately managed. That is of course an illusion. Management performance improves when checks and balances (accountability) are well organised.

A specific management arrangement is Irrigation as a Service (IaaS). Corjan provides an example from his work in Cambodia where the abstraction from the river is done by one party which then sells the water to individual farmers (there is no WUA). Hiwote Teshome from Ethiopia provides the example of small irrigation service providers (private company, individual, youth group) providing irrigation water service for small holder farmers individually or as group. Another model is the investment of one party (private sector, cooperative or government) in an irrigation scheme and then providing water to groups of farmers in clusters (note: this sounds very similar to the co-management done in Nepal).

Providing an irrigation water service is generally a natural monopoly in the area, because farmers cannot switch providers. This calls for tariff regulation just like in drinking water supply services. The renting of irrigation equipment (pumps) shared by Chris de Bont from Tanzania, does not create a natural monopoly.

Pre-conditions for irrigation development

Most of the proposed intervention and investment strategies are geared directly towards expanding or improving irrigation. However there were also several contributions suggesting more foundational interventions or pre-conditions. Mahteme, Coulibaly, Subash and Donald Mpuya (from Tanzania) emphasize the need for more investment in water resource management, regulation and development. For example to increase water storage capacity in the country (reservoirs, ponds, rainwater harvesting, soil moisture conservation), but also to set up early warning systems and better forecasting.

Furthermore, Subash pointed out that investments in irrigation should be guided by considerations about food self-sufficiency of the country. There seem to be a downwards trend in Nepal. In 1988 Nepal was 90% food self-sufficient, whereas in 2011 it was 83%. This seems to be influenced by increasing household income from remittances, and increased dependency on imported foods, especially non-cereals.

Ad 2. In your view, who should be leading these approaches and interventions ?

Though there is a large variation in what you see as priority interventions in irrigation, there seems to be a wide consensus – nearly all- that government should be leading and investing. Though some state that ideally the investments would be farmer-led, you point out that the market is not yet mature and thus contributions include a lot of expectations from government as much for individual investments by small holder or commercial farmers as for PPPs. Corjan mentions among others: promotion and awareness raising among farmers, demonstration projects, subsidies, mapping of water resources. Of course there are also roles for other stakeholders mentioned, such as private sector (of different sizes and nature), farmer's groups, development partners, banks, civil society. Befekadu adds that small-scale irrigation development can be initiated by groups or communities. Marianne also sees a role for impact investors, development organisations and grant makers, in addition to government.

Ad 3. Who will carry the costs and benefits of these approaches?

Similarly as for the leadership in irrigation interventions, most contributions suggest that a significant part of the cost should be carried by government from either taxes or loans. Nuances in this are the views that: 1) commercial farmers can invest themselves, 2) small-scale irrigation can be self-funded or co-funded by users, especially if there are credit facilities (Befekadu), or 3) government should focus on providing CAPEX but leave OPEX to WUAs (Aschalew). This aligns with the view of Subash who shares that tariff payment in Nepal is common. Marianne ideally sees a bigger role for farmers and companies. Farmers would get increased earnings, but early adopters may need support as they are risks in trying a

new technology. Companies also invest themselves unless and until they become profitable. Due to these risks involved, it can be supported by government and development partners.

Even for the large PPPs, government will initially need to invest Kinley shares.

In terms of who will benefit there is limited specificity. Of course it also depends very much on the local context. In general the expectation is that small holder farmers will benefit through improved income and reduced dependency on (variable) rainfall. This will also improve their climate resilience. Moreover a range of macro-economic and national benefits are expected: improved national food security, improved rural livelihoods, economic growth, more tax revenue from increased food production and trade.

Ad 4. To what extent will these approaches ensure sustainability and equity ?

Marianne writes that as long as private companies become profitable, they will be financially sustainable and expand. Financial sustainability is also a key factor in other contributions, though it is not always clear whether the CAPEX is part of that equation. Yigsaw writes that CAPEX should be covered by government. Corjan points out that if the affordability barrier of equipment is not addressed, smallholder farmers will not be able to benefit (though it's not clear whether this implies addressing affordability through subsidies or through market innovations). In Ethiopia, some equipment is distributed by government.

Management performance is the main issue for sustainability Befekadu writes. This is particular timely O&M to avoid functionality issues. Generally he considers that small-scale schemes perform better. Ashalew agrees with this. Kinley expects better management performance through private sector engagement.

Environmental and water resource sustainability is another key issue. Befekadu and Aschalew expect the impact of small-scalle schemes on water resources or chemical pollution to be limited, due to their small scale. (This is of course correct for each individual scheme, but the collective impact could potentially be large.) Befekadu does have concerns about the impact of small-scale irrigation on water borne diseases. Mahteme and Corjan both advocate for better regulation of water resources as a pre-condition for sustainability in irrigation.

In terms of equity, a number of contributions mention the need to make more efforts to ensure nobody is left behind. Hiwote suggests that starting with high-potential smallholder farmers would be easier, but she does see the challenges of this in terms of equity. Irrigation is of course inherently unequal because people who have irrigation are generally privileged over those who don't. Marianne feels that private sector will contribute to greater equality in the country by generating jobs in the companies and income for the farmers.

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