The Farmer-led Irrigation Development Guide

A what, why and how-to for intervention design

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Foreword

Water is essential for communities – for drinking, for growing the food we eat and sell, for supporting the ecosystems within which we thrive. Ensuring sustainable management and access to water and sanitation for all is key for resilient livelihoods and for achieving the Sustainable Development Goals.

Climate shocks, inequitable access to water resources, critical weaknesses in the resilience of the natural resources on which much of human livelihood depends and economic woes amplified by the COVID-19 pandemic have resulted increasingly in institutional and economic water scarcity. This impacts heavily on farmers, particularly in Africa, disrupting their capacity to produce and sell and severely affecting income and livelihoods.

Scaling up and accelerating Farmer-led Irrigation Development (FLID) holds significant potential for short-term recovery for the most vulnerable farmers and, in the longer term, can also help to safeguard domestic food security and strengthen farmers' ability to recover from shocks and adapt to a changing environment. FLID recognizes that farmers have persistently filled the gap where public-led irrigation services haven't reached and improved on them where they do exist. They have taken the initiative to expand irrigation, optimize and increase productivity. They have developed technologies, invested, and crafted market linkages. And they have seen quick returns on their efforts, often against all odds.

This guide aims to provide governments with the practical strategies to catalyze FLID and scale it up, making it a faster, more sustainable and inclusive process. Public sector can assist by creating an enabling environment for smallholder farmers, while private sector can contribute through co-created solutions, to open up possibilities for those who are less well connected and resourced, and monitor the environmental and social impacts.

FLID requires a new frame of mind, new modes of engagement, new ways of learning, new technologies, new partnerships and new tools. The World Bank, through its Farmer-led Irrigation Development Initiative, and with many global and regional partners, aims to support solid diagnostics, practical guidance and policy change. The Guide consolidates this knowledge and hopes to inspire informed action!

Jennifer J. Sara
Global Director, Water Global Practice
World Bank

Abbreviations and acronyms

4P	public-private-producer partnership
DLI	disbursement linked indicator
DPO	development policy operation
FLID	farmer-led irrigation development
FLL	field level leadership
GDP	gross domestic product
ha	hectare
i-box	information box
ICT	information and communication technology
IPF	investment project finance
M&E	monitoring and evaluation
MIS	monitoring and information system
MSP	multi-stakeholder platform
NGO	non-governmental organisation
O&M	operation and maintenance
PAYG	pay-as-you-go
PforR	program-for-results
RECA	*Réseau national des Chambres d'Agriculture du Niger* (National Network of Chambers of Agriculture of Niger)
SDG	Sustainable Development Goal
SIIP	Sahel Irrigation Initiative Project
SPIN	*Strategie de la Petite Irrigation au Niger* (Small-scale Irrigation Strategy of Niger)
TOR	Terms of Reference

Get the most from your guide

NAVIGATING THE GUIDE

To move quickly and easily between the interlinked information, set up your PDF reader so that the **PREVIOUS VIEW** and **NEXT VIEW** buttons (as distinct from PREVIOUS PAGE and NEXT PAGE) are installed on the toolbar at the top of your screen. **You can then freely explore the document using the navigation pane on the left of your reader or the many hyperlinks provided in the text, and backtrack to the start by repeatedly hitting the button.**

To install the buttons (in Adobe Reader),

- Right-click anywhere on the toolbar and select them in the **Show Page Navigation Tools** options; or
- open the **View** drop down menu and select them from the **Page Navigation** options.

Alternatively, try using these keyboard shortcuts:
Windows: Press the **ALT** key and ◀ or ▶ arrow
Mac: Press the **COMMAND** key and [or] square bracket

PRINTING

Office desktop printers cannot print to the edge of the paper. To print pages of this document without losing any content,

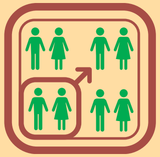
- choose **File > Print**, and in the page sizing and handling area or pop-up menu, select **Fit to Printable Area** or **Shrink to Printable Area**.

1 Why FLID?

Irrigation has multiple benefits for farmers. It allows for early-season planting, production of an additional crop in the dry season and crop diversification, and enables farmers to cope with dry spells in the wet season. Individually or in groups, farmers have, for centuries, introduced, expanded and optimized their irrigated production without dependence on external support. Farmer-led irrigation development (FLID) unfolds without being driven by government and has taken place largely "off-the-record". Over the last two decades there has been increased awareness, by governments and development partners, of the massive areas involved and the potential gains that FLID can bring.

Characteristically, farmers who autonomously develop irrigation are entrepreneurial innovators, targeting new markets and investing their own resources. Hundreds of thousands of farmers have developed irrigation themselves, but many more could benefit from improved agricultural water use practices. Many smallholder farmers are constrained by unfavorable surrounding conditions that slows their growth. They face hurdles which elevate risks and increase both financial and transaction costs. Where there is **natural resource** potential, such as in large parts of Africa, public action can help to address these hurdles. Public interventions with **an expansion focus** have the potential to widen the circle of people who benefit, making it a faster and more inclusive process.

Smallholder farmers take the lead in irrigation development



expansion

Larger areas with more farmers irrigating where resources are plentiful

productivity gains

Better water productivity and yields where resources are increasingly scarce

profitability increase

Better business strategies for higher incomes and improved livelihoods

In places where water and land are more limited, expansion of irrigated areas increases competition over water resources. In water-stressed FLID contexts, such as in selected watersheds in Africa, there is potential for optimization to increase productivity and profitability. Public interventions with **a sustainability focus** can improve the livelihoods of millions of farmers by increasing water productivity and decreasing water access uncertainties.

The FLIDguide is a resource pack to help governments, development practitioners and other key stakeholders design public interventions to catalyze FLID. It has a focus on Africa, but much of the material will be relevant to other regional contexts.

Government motivations to facilitate FLID

All across Africa, governments are setting ambitious targets for irrigation expansion, agricultural intensification and increased productivity over the next decades. Irrigation contributes to the achievement of priority country development goals such as those shown in Figure 1. Irrigation benefits are also aligned to high-level global development objectives such as the Sustainable Development Goals (SDGs).

- Increased agricultural GDP
- Economic growth
- National debt reduction
- Reduced rural poverty
- Improved food security and nutrition
- Better water resource prioritization
- Improved resilience
- Climate change adaptation
- COVID-19 recovery

Figure 1 High-level benefits of FLID

Public-led irrigation scheme development often fails to achieve these promising outcomes. Public institutions seldom have the capacity and funding resources to accelerate irrigation development at the needed rate.

Catalyzing FLID is of interest to governments because of the advantages when compared with conventional public-led irrigation development:

1 **FLID imposes less burden on public finances:** In other words, supporting FLID enables more farmers to benefit for the same public outlay. This is because:

- **The unit investment costs are generally lower** as farmers inevitably initiate their own irrigation activities where water is in close proximity to fields. Limited infrastructure is required to mobilize water. Public costs are typically less than one third and the returns on investment are three to five times higher.
- **Farmers typically finance irrigation development with their own money.** Sometimes public resources might complement farmers' investment, but never replace it.
- **Farmers are primarily responsible for operation and maintenance (O&M).** This is always the case with individual irrigation systems which are privately owned, thereby reducing the long-term public financial burden associated with public schemes.

2 **Farmers get irrigation faster:** Views on "irrigation" are often fixated on concrete and steel which not only are relatively costly, but have long construction timelines. This conflicts with governments' need to respond quickly to natural disasters such as droughts or pandemics, with related economic downturns. In catalyzing FLID, irrigation can be developed in a matter of months as the emphasis is on large numbers of small and simple systems.

3 **More farmers benefit, including women:** When farmers drive the irrigation development process, access to resources and tenure arrangements are less of a constraint than in the case of public-led irrigation development. Catalyzing FLID brings greater inclusion and can be a game changer for women farmers.

Users of the guide

If you are working in the agricultural, food production or irrigation sector, then this guide is for you. Users will include specialists, practitioners and researchers from government agencies, development partners and NGOs, among others. To catalyze FLID you will need a mix of skills on your team, including engineering, agri-finance, irrigation agronomy, marketing, knowledge-exchange, and water resources management. The guide is written by and for people from these fields and is geared for practical application.

FLID defined

Woodhouse et al. (2017), who first popularized the term, define FLID as a process where farmers take the driving seat to improve their agricultural water use. Farmers bring in or develop new ideas and technologies, change investment patterns, and create new knowledge – inevitably involving other actors (such as the surrounding community, government, and the private sector). They are characteristically entrepreneurial, intentionally take risks and farm for cash. They are also widely diverse in their scale, technology use and farming methods. FLID is thus not a typology or linked to one technology (such as small pumps) but is best viewed as a dynamic and unfolding development *process*. Recognition of "process" requires a more reflexive approach that first aims to understand local diversity and the weaknesses in the dynamic system, and then identifies opportune interventions that catalyze constructive change. Some FLID animations can be found here: FLID-WB; FLID-SAFI.

FLID is not limited to a defined range of farm sizes, but in Africa it typically involves farmers on less than 10 ha of land – with most on less than 2 ha. The main focus of the FLIDguide is on smallholders because they are the people generally less equipped – financially and in their access to knowledge – to overcome the binding constraints posed by an unfavorable surrounding environment. This does not mean, however, that FLID has a small impact. On the contrary, while individual farms are mostly small, they occur in such massive numbers that, collectively, they have large impacts on food production, the economy, and their surrounding landscapes.

to catalyze | an interaction at the critical point of transition so that the process requires a smaller push to clear the barrier.

catalyzing FLID | an intervention in the surrounding environment of farmers and the private sector that enables:
- easier entry for new irrigation farmers,
- faster progress for those already irrigating, and
- inclusion of a wider circle of people who benefit.

Ideas on how to pitch FLID

FLID contexts

FLID processes are commonly observed where there are certain combinations of landscape, geographical and water resource features. Water sources are usually near the fields, and the topography generally allows for simple and low-cost technology to be used, although often with a heavy labor requirement for water lifting and earthmoving. Some of the contexts in which farmers take the lead in developing irrigated agriculture are outlined in Figure 2.

Figure 2 Locations and situations where FLID is prominent

The most familiar contexts of FLID

Mountains & hillsides (streams & springs)

In wetter areas, farmers often build diversion structures on mountain streams leading water into gravity irrigation systems using canals and flood irrigation. Where the topography and financial means allow, plastic pipelines feeding hoses or sprinklers are used.

Wetlands (dambos & fadama)

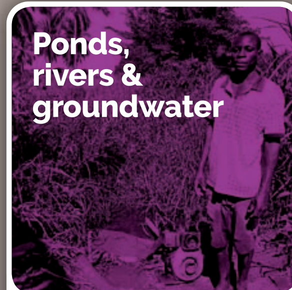
In wetland areas, bunds and drains are constructed to control shallow groundwater levels just below the root zone to enable plant growth through capillary action.

Urban outflows (effluent & drainage flows)

In urban and peri-urban settings farmers use a variety of wastewater sources, such as the outflows from wastewater treatment plants and open roadside drains. Water-quality issues from sewage and urban pollutants are potentially serious.

Near large-scale schemes (tail & drainage water)

Along canals, drains and tailwater outlets of many major irrigation schemes, individuals divert or pump water to land on the periphery. Soils are often marginal and water unreliable. Technologies are similar to open water bodies.



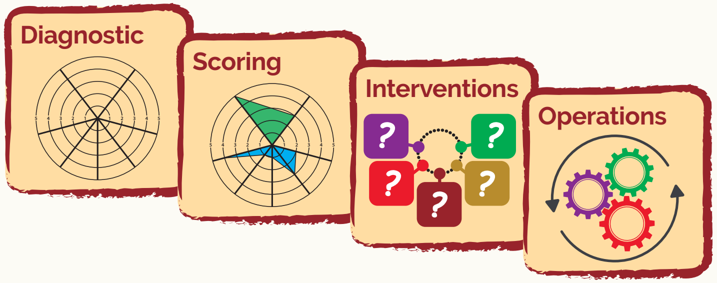
Ponds, rivers & groundwater

In floodplains and flat areas where groundwater is well below the root zone, but still shallow enough to access with open wells (typically < 15 m), petrol and diesel pumps, bucket-and-rope systems, and solar-electric pumps are used. Similar technologies are used alongside rivers and within reservoirs of dams.

mostly farmers' groups ⟷ *mostly individual farmers*

2 Understanding FLID

The FLIDguide describes how to approach the design of public operations to catalyze FLID. The approach is founded on a rigorous yet rapid diagnostic of FLID potential and constraints. Constraints can be prioritized, and example interventions to address specific constraints can inspire and inform the intervention design. How the interventions are packaged together in an operation will be different for each situation.



Seven factors

The FLIDguide captures the complexity of the system by describing seven factors, shown in Figure 3 (details in i-box A). The structure guides the diagnostic of the system and is used to inform the design of public interventions to trigger catalytic change.

It is difficult to understand which interventions will be most effective in catalyzing FLID in a given situation because there are many interrelated factors. Irrigation farming is a complex socio-technical-ecological system that revolves around the irrigation farmer and his or her farm business strategy.

Surrounding the farm is a set of external realities and the factors link to each other and across the different scales – local and beyond. The factors are not only interconnected and interactive, but are also dynamic. A change in one factor affects the others in different measures (much like pulling one string in a net) and often with unexpected outcomes. Providing quality information, for example, about on-farm water management or output-markets, can cascade into a series of benefits for a farmer. The same holds true for access to innovative technology, which can be achieved indirectly, through increased funding for research and development, or more directly by reducing import tariffs or facilitating access to loan-finance. On the flip side, small changes to critical elements can also undermine the farm operation, sometimes quickly. A fuel price hike, unavailability of plant protection chemicals, a water conflict, or theft of a key component, can trigger a rapid cascade into failure of the irrigation enterprise. Identifying the opportunities to trigger catalytic positive changes in the entire system at national, local and farm levels, is the essence of responsive FLID interventions. More examples are provided in i-box A.

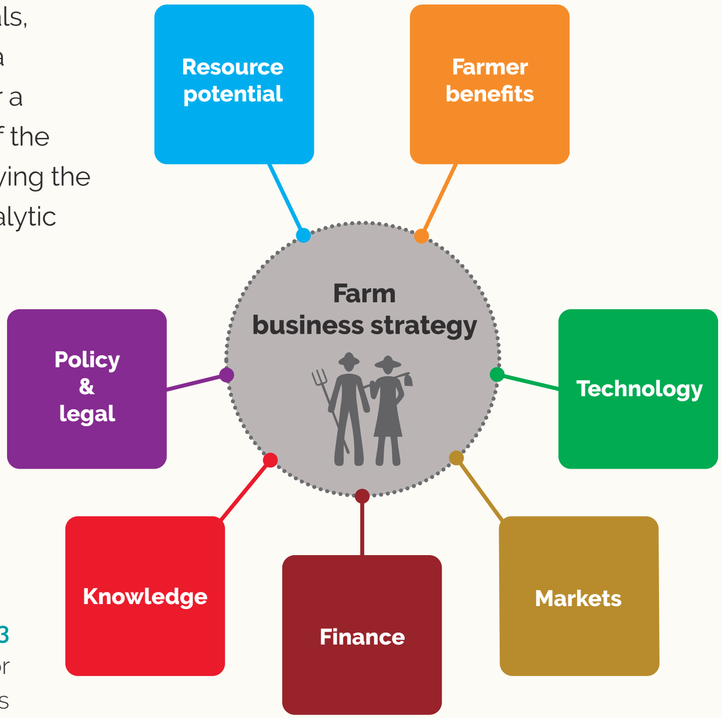


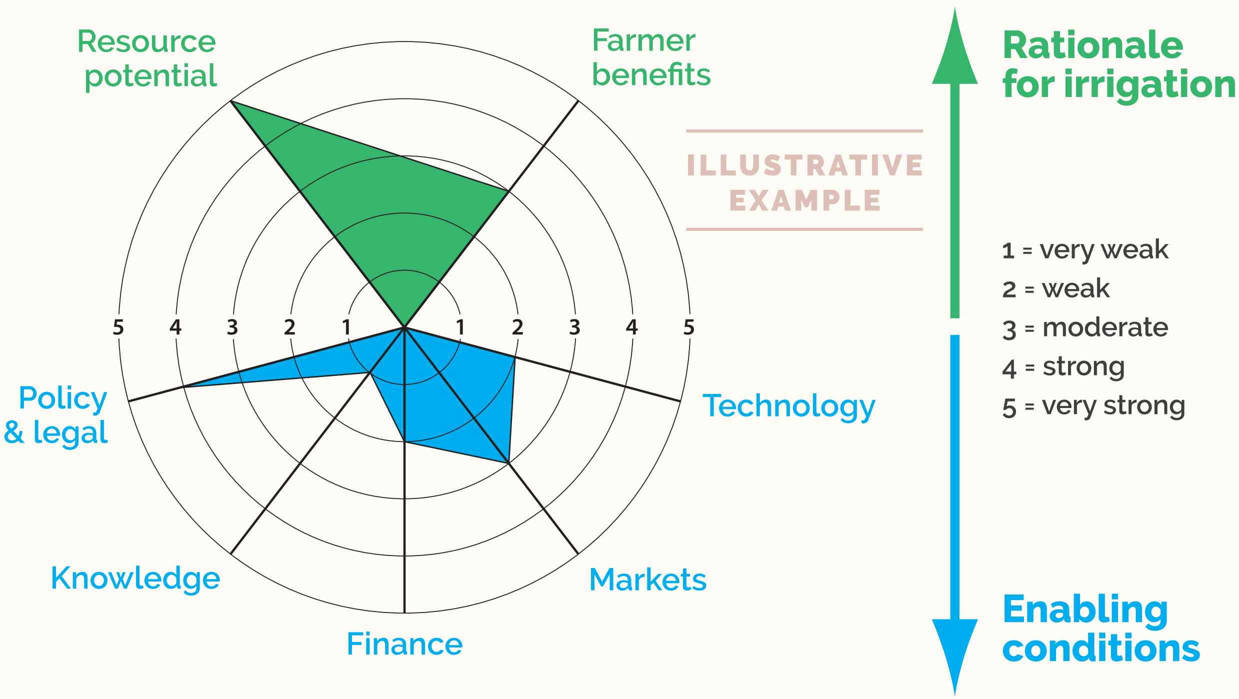
Figure 3
Seven factors for understanding FLID systems

Rapid diagnostic approach

The diagnostic of the seven factors of the FLID framework defines the potential for FLID and the constraints that are faced by farmers who wish to develop or who are already developing their own irrigation systems. Guidance on carrying out the diagnostic and scoring the potential and constraints is provided as a basis for the design of interventions. The outcome of the diagnostic is visually summarized on a multi-axial spider plot (example in Figure 4).

The **rationale** for FLID is presented in the top half of the plot (the two green axes). The higher the score of these two axes (resource potential and farmer benefits) the more reason for farmers to engage in, and private sector to support, irrigation. The status of the **enabling conditions**, where constraints may be limiting FLID, is shown in the bottom half of the plot (the five blue axes). When the surrounding environment is weak, meaning that the constraints to farmers developing their own systems are numerous or severe, the factor will be scored low. A low score means that a public intervention is needed to change, improve, or strengthen the situation to catalize FLID. Where the environment is assessed to be strong, with a high score, interventions are not needed and public effort should be focused elsewhere rather than changing an autonomous dynamic which is working.

Pragmatism is needed when determining priorities and designing interventions. It is important that only the truly significant constraints are addressed.

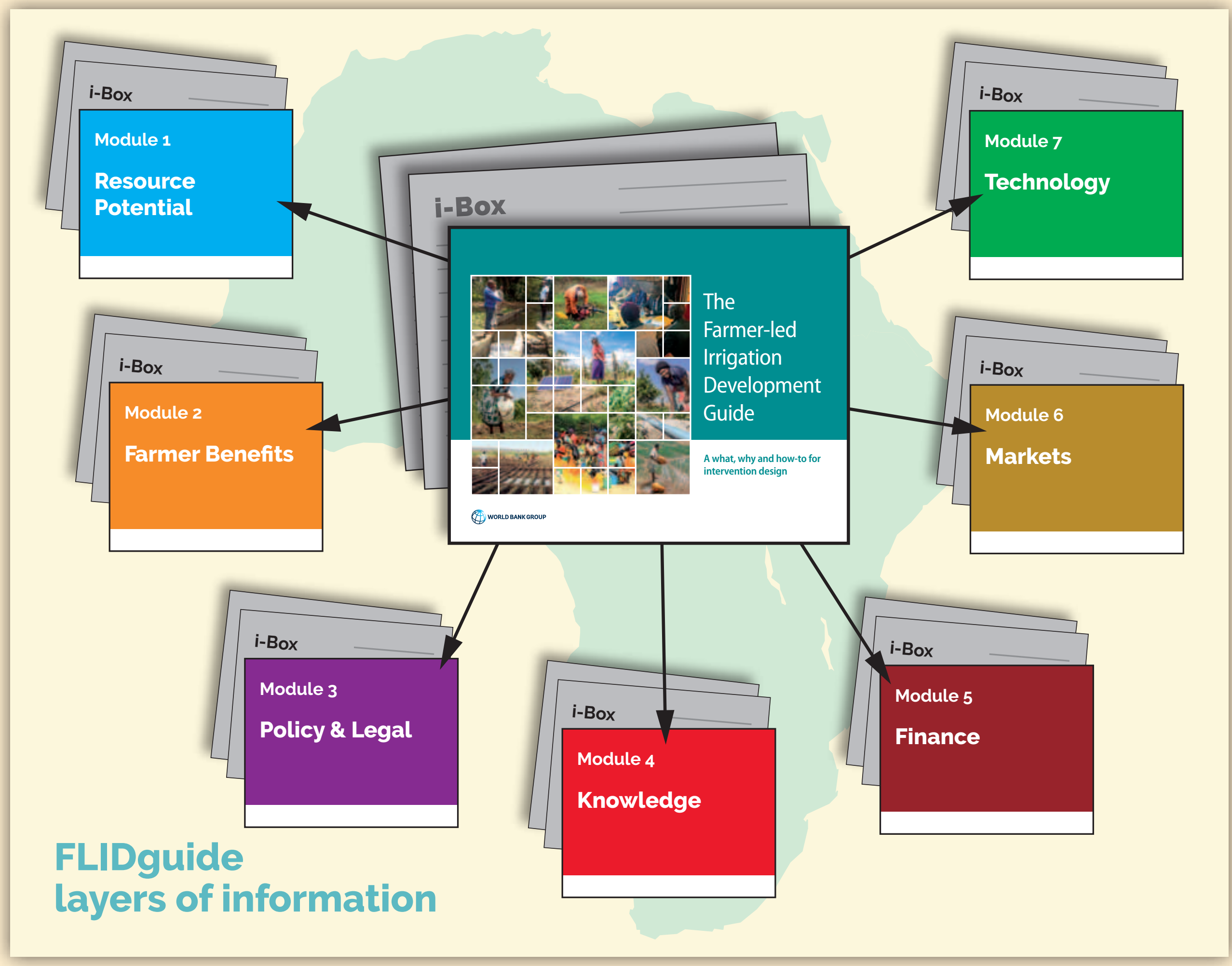


No attempt should be made to "fix things that are not broken" just because they are less than perfect, or do not fit conventional experience. Such attempts can waste scarce program resources – or worse, lead to unintended outcomes.

Figure 4
FLID systems framework applied for diagnosis and strategic planning of responses – *As you work through the modules you will be guided to assess and score each of these axes (use the blank spider plot provided on page 12)*

3 Organization of the guide

The main volume of the FLIDguide presents the core body of information that explains FLID and the process of intervention design. Thematic descriptions are included in seven modules. Information boxes (i-boxes) at the back of the Main Guide and each module provide additional detail, and hyperlinks throughout the guide access relevant external publications, websites, animation clips and videos.



If you have little time available, read the Main Guide and then refer to the seven modules as and when you need to.

FLIDguide modules

MODULE 1
Resource Potential – Natural resource availability and the cost of mobilization

The potential for irrigation development that is led by farmers depends on the availability of the water and land resource base, and the cost of mobilizing the water from the source to the land. Farmers initiate irrigation most easily where water is in close proximity to land where irrigation can be undertaken manually, with labor-based construction, or with low-cost equipment. The implications of infrastructure scale are shown to be important. Not only are the unit costs lower for small-scale systems, but the most expansion potential is where many small-scale technologies can be used together to achieve large-scale impacts.

MODULE 2
Farmer Benefits – The case for irrigation from the farmers' perspective

The farmer, and his or her success in irrigation farming, is the main focus of the FLIDguide. You need to understand the different kinds of farmers, their motivations and their farming strategies. Pointers are given on the development of farming typologies to aid the targeting of intervention designs. Irrigation farming benefits, associated with expansion, intensification and resilience, are discussed, along with guidance on the scoring of farmer benefits.

MODULE 3
Policy and Legal – The rules of the game

A systematic approach for the review of water, land and other relevant policies and laws is described. The emphasis is mainly on water and land, as the thematic details in the other modules inform the policy and legal considerations and the scoring of each related factor. FLID expansion and intensification brings not only multiple benefits but also new challenges, especially for water permitting and regulation, and for land tenure systems. Where the policy and legal environment is identified as a constraint to autonomous FLID, examples of interventions – including hybrid water law, institutional "bricolage", decentralized water management, and land tenure responses – are described.

MODULE 4
Knowledge – FLID actors and their information networks

Farmers need relevant knowledge across many disciplines to be successful. They learn from each other, extension officers, the internet, and from the private sector (especially technology and input suppliers, finance institutions and aggregators). The module outlines what to consider when assessing the agricultural knowledge environment for FLID. It describes the actors and their often overlapping roles in services and knowledge provision. Example interventions that are described include multi-stakeholder and innovation platforms; information dissemination through media outreach (including information and communication technology responses); and facilitated farmer-to-farmer learning.

MODULE 5
Finance – Implications and options for irrigation financing

Access to finance is a potential constraint to farmers in acquiring both agricultural production inputs and irrigation infrastructure. This module is focused on equipment and infrastructure financing challenges. The semi-visibility of FLID, its diverse and autonomous character, and the wide range of actors interacting with farmers in the process pose unique challenges when trying to improve financial access. Four financing models that can be included in FLID support interventions, independently or in combinations, are described. The importance of integrated responses is highlighted, where financing arrangements are supported with technical, agronomic and marketing information to increase the chance of successful outcomes.

MODULE 6
Markets – Strengthening output value chains

Smallholder farmers are dynamic economic actors, but often struggle with the reality of weak value chains, where benefits are skewed towards corporate agri-business or powerful market intermediaries. The important role of informal markets, where smallholder farmers often have more agency, is highlighted. Value chain actors have a pivotal role in supporting irrigation expansion and intensification. Market sounding, as a way of assessing capabilities and preferences, is described. When marketing is identified as a constraint to autonomous FLID, interventions can overcome these. Example interventions include: organizing both informal groups and formal producer organizations; digital technologies for networks; and market knowledge exchange platforms.

MODULE 7
Technology – FLID technologies and their social implications

This module describes the multiple ways in which technologies are embedded in wider social and organizational relations at farm level. Transformative technologies with application to many different FLID contexts are outlined. Some risks, pitfalls and assumptions related to technologies and their use are outlined, illustrated by examples from across Africa. Technologies are not stand-alone interventions, but are always part of other interventions, such as the financing of equipment purchases, or knowledge exchange around use and maintenance. The intervention section addresses this integration; it shows that technologies have social requirements and social effects, and why different technologies are suited to different types of farmers.

4 Carry out your diagnostic

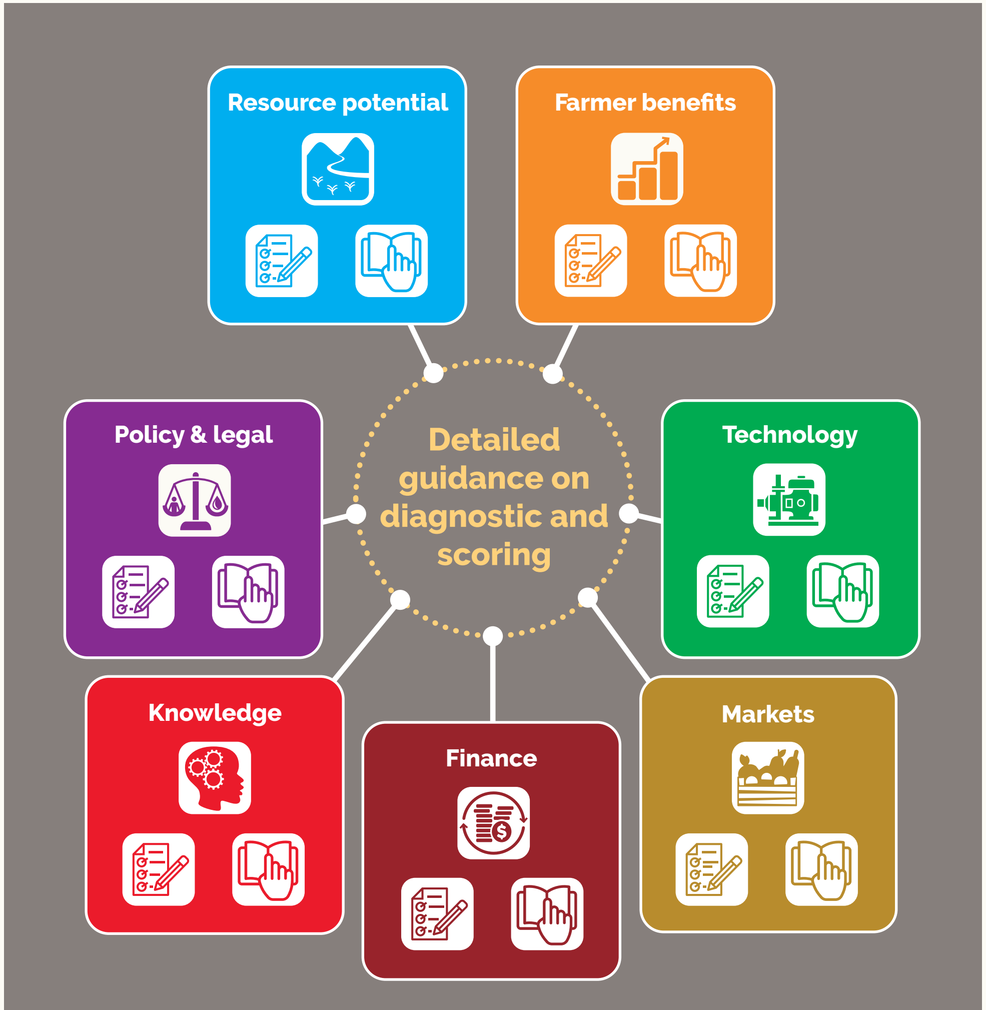
Work through the process

The FLIDguide leads you through the diagnostic and scoring process. Specifically, it helps you to:

1 Explore and gain a better understanding of each of the seven factors. These considerations are "things to think about", intended to raise awareness about the factor in general.

2 Summarize the information to be collected in the diagnostic process for each factor. A sample scope of work in the form of an outline Terms of Reference (TOR) is included in each of the modules. These provide guidance for contracting a specialist to undertake the diagnostic.

3 Score the factor. The score reflects the strength of the factor in relation to the rationale for FLID (upper axes), or the enabling conditions (lower axes). Where opportunities and constraints are significant, this highlights that intervention responses are needed! **Scoring of the factors is indicative at best and the process is more about prompting enquiry into constraints than a definitive conclusion in itself.** Guiding questions for the scoring of each factor are included in an i-box in each module. A blank spider plot is included on page 12 and can be used as a sketch page to summarize your results as they emerge from the diagnostic and scoring activities.



Click on the icons above to access the **modules**, **detailed guidance on scoring**, and **outline TOR** for the respective FLID factors

In the end, the spider plot will capture your justification for scoring the relative importance of factors and the key interventions to be further elaborated.

Who participates in the diagnostic?

In developing irrigated agriculture farmers encounter many private and public stakeholders who have different interests and specializations, often distant from irrigation farming itself (Figure 5). Part of the challenge of catalyzing FLID is to build bridges of understanding across these diverse stakeholders to maximize cross-sectoral synergies to support farmers and achieve meaningful development outcomes. It is critical that all stakeholders have a seat at the table. Having only one or two stakeholders (such as a sectoral Ministry or an irrigation agency) involved in the diagnostic could lead to public action that is based on the roles and functions of the few involved and fails to address the priority constraints.

> Diversity is a strength to capitalize on, both for insights and for action. It is best to involve people from early on in the process.

Some stakeholders may not immediately see the opportunities in driving a FLID agenda and the importance of joining the FLID diagnostic. Some notes on making a persuasive case are presented in i-box C.

The final scoring process is offered as a tool to encourage the various stakeholders to exchange ideas on the potential, on the nature and severity constraints, and on priorities in relation to the other FLID factors. The final score reflects, rather than informs, any conclusions.

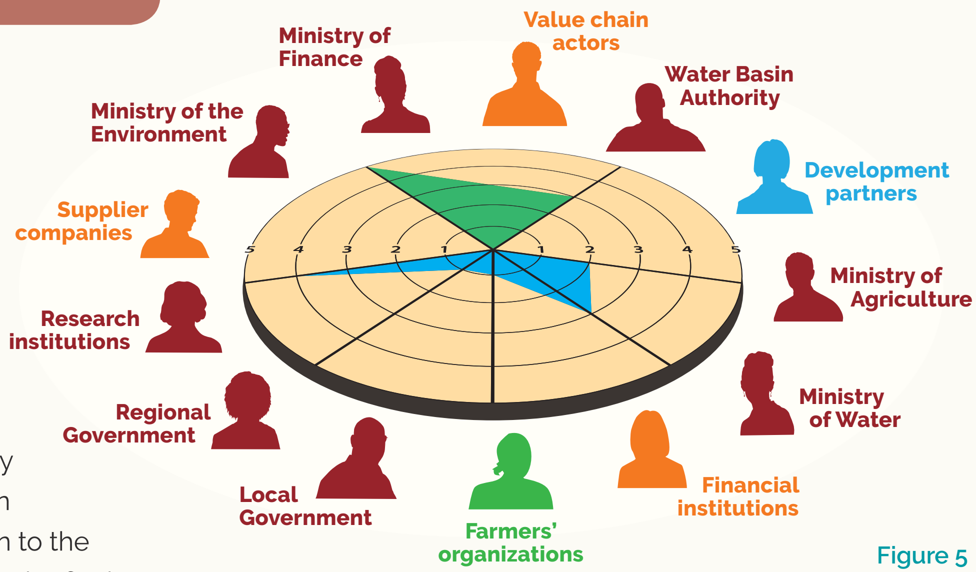


Figure 5
Stakeholders who should have a seat at the diagnostic table

Use the terms that resonate with national stakeholders

Each country has its own terminology, which may not include the term "FLID". Some terminology highlights the scale of the irrigation farm itself (such as micro-scale, small-scale), or the kind of farmers who are targeted. It may be opportune to avoid using "irrigation" in a program title at all and rather use phrases like "smallholder horticulture" or "commercialization of smallholder farmers".

Whatever the term chosen, make sure that it leaves no room for confusion in conveying that supporting farmers in developing their own irrigation systems is about large-scale impact, because of the large numbers of farmers involved.

Assess and score the factors

Illustrative cases:

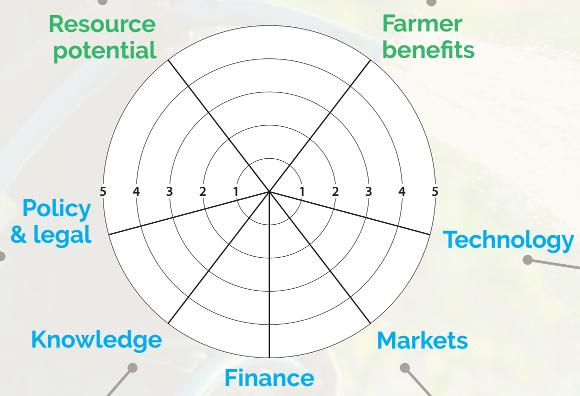
Uganda

Niger

Use the blank spider plot below to summarize the key elements of your diagnostic across the seven axes. Good luck!

Justification for score

Justification for score



Justification for score

Justification for score

Justification for score

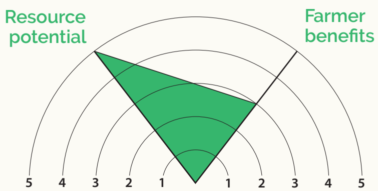
Justification for score

Justification for score

5 Consolidating the diagnostic

Once the diagnostic is concluded, and with the scores in place, it is now time for you to debate the question: ***"Is it worthwhile for the government to intervene in order to catalyze the FLID process, and if so, where?"***

The case for FLID



The **rationale for irrigation development** is reflected in the top half of the spider plot: farmers have more reason to engage in irrigation when there is a combination of high resource potential (Module 1) and high incremental benefit (Module 2).

Water availability close to agricultural land is the most favorable situation for farmers when initiating their own irrigation practices, because it allows for simple and cheap irrigation methods to be used. The less the accessibility to water, the greater the need for infrastructure development to mobilize water. The related **costs** and technical engineering complexity, as well as the environmental, regulatory and resettlement implications of **water mobilization**, result in increased constraints for farmers, making it unlikely that they will be able to develop such costly water infrastructure on their own. Assessment of the resource potential is thus informed by these parameters of water availability and proximity and discussed further in Module 1. The implications of water availability and proximity are illustrated in Figure 6 and summarized below.

Moving from left to right in Figure 6:

- the scale and complexity of infrastructure declines and the unit cost of irrigation development decreases
- there is more individual ownership and autonomy of the irrigation system and equipment
- there is increasing farmer-control of irrigation development (located around small dams, pans, shallow wells and streams, where simpler technology can be used)
- the participation trend is from consultation-style approaches of public-led large schemes to the more participatory domain of FLID
- the rate of return on investment increases (by a factor of 3 to 5 times)
- the viable area for expansion in Africa increases (by a factor of 2), with massive potential for intensification on existing areas developed under FLID.

The nature of the resource potential is a key determinant of the features of the FLID process. Where there is high resource potential, farmers prioritize irrigation **expansion** as costs are low and returns on investment are high. As resource potential becomes constrained, the scarcity of supply and **higher mobilization costs drive farmers towards intensification** to achieve more efficient use of the scarce resources. Increased water productivity, achieved through more sophisticated agronomic and irrigation practices and related business strategies, is an outcome of intensification (i-box 7.2). As competition for water increases, regulation of the resource through basin governance and water management arrangements (Module 3) is needed for long-term sustainability.

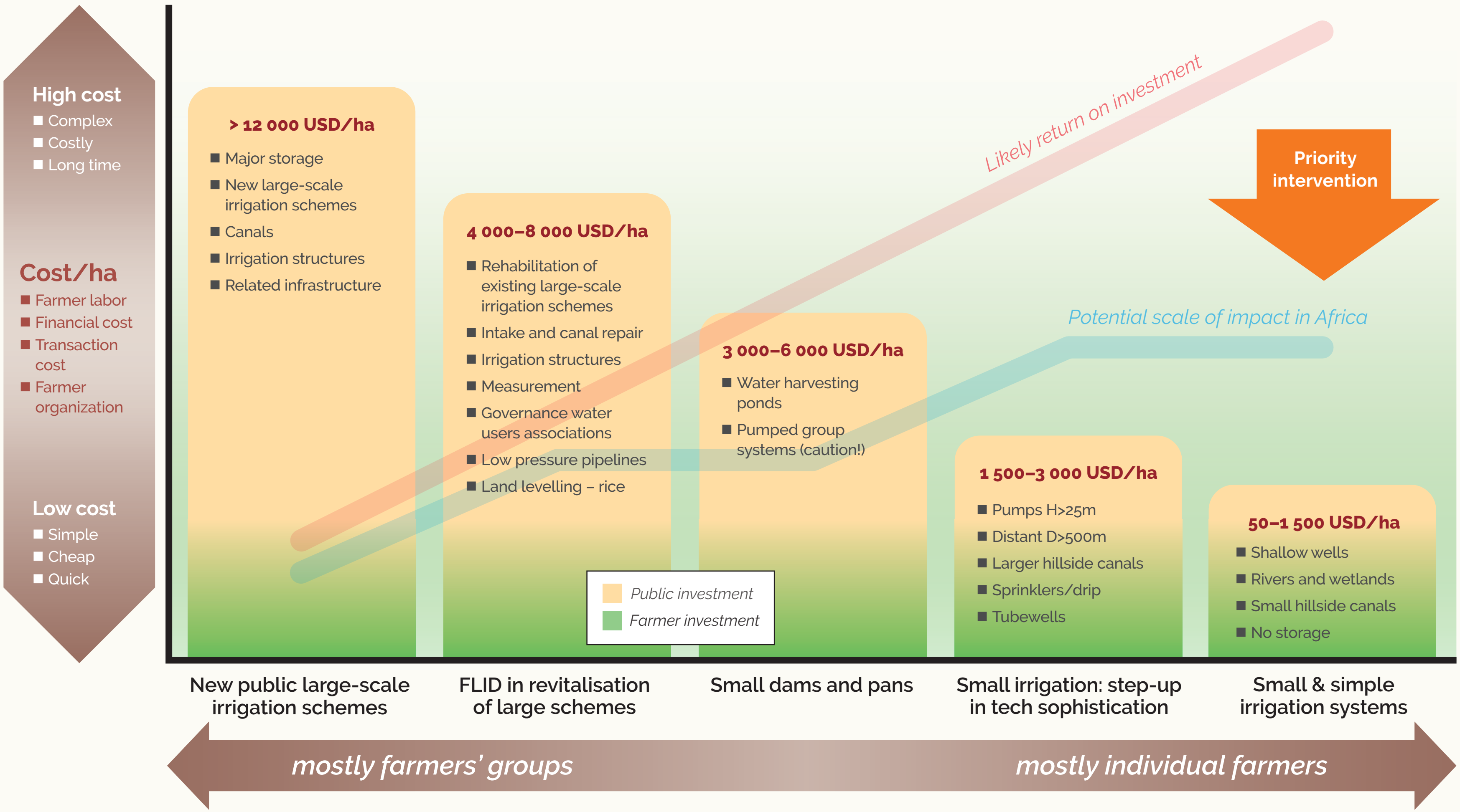


Figure 6 Costs of development, returns on investment and potential impact for different types of irrigation systems (scale, group size and engineering complexity)

For farmers to engage in irrigation, benefits must be significant. Smallholder farmers have experience of hardships and are aware of the substantial risks that come with any change in farming practice. They are most likely to pursue irrigation when they see real possibility of increasing their income and improving their livelihood. When the benefits from irrigation are minimal, farmers do not engage in irrigation, and there is no reason for government to improve the enabling environment for FLID processes.

Consolidating the argument for FLID requires quantification of the benefits for different groups or types of farmers. Farmer types can be characterized by elements such as farm size, cropping

Farmers record higher benefits from irrigation through:

- **early/delayed planting** before/after the rainy season, with advantages in market prices
- **additional cropping seasons**, increasing land-use intensity and generating year-round income
- **greater crop diversification**
- **reduced drought risk**
- stronger production links with dairy and **livestock** with more integrated farming

pattern, agronomic skills, access to natural resources, use of technologies, and marketing strategies (i-box 2.1). Once the typologies of farmers are better understood, interventions can be targeted to meet the different needs and expectations. Cost-benefit assessments over the lifetime of irrigation equipment can be undertaken to predict impacts from interventions (Module 7), in comparison with rainfed farming (Figure 7).

Crop losses due to drought are an increasing risk resulting from climate change, and irrigation can help to mitigate negative impacts. Financial analysis of irrigation benefits is best assessed through drought scenarios, based on farmers' and agricultural officers' experiences of the drought frequency cycle and the related crop losses in rainfed farming. There is a need for caution to avoid over-promoting the idea of "drought-proofing". Attention needs to be given to the seasonal fluctuations of the water resource, as this may be limiting during periods of frequent drought, even when irrigation equipment is available (Module 1).

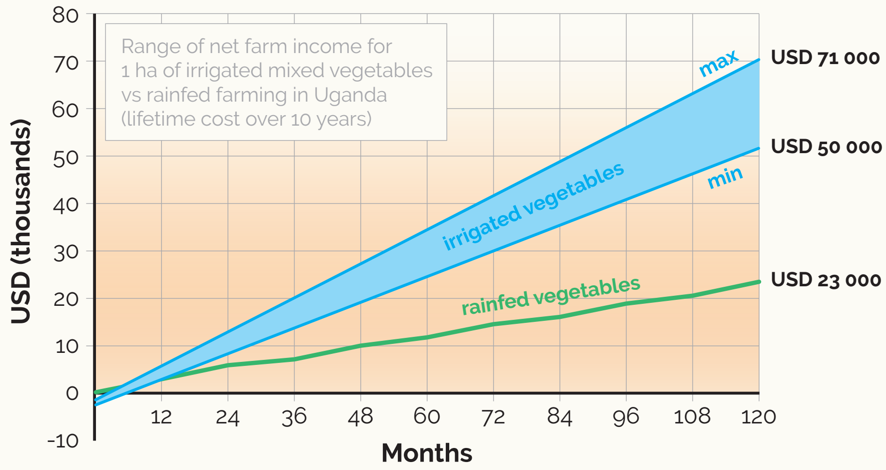


Figure 7 Comparative lifetime cost-benefit assessment of irrigation versus rainfed cropping

At this point in the process you should be able to establish:

The storyline for FLID: Is there potential for farmers to engage in irrigation expansion, intensification, increasing profitability or a combination of these? How much variability exists between basins or sub-basins?

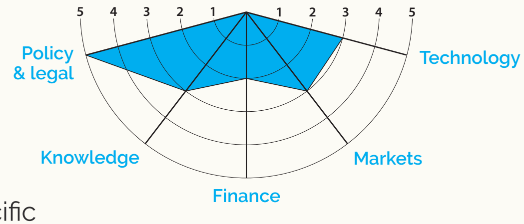
The type and extent of the natural resources to be exploited: Are small and simple irrigation solutions possible, or is there a need to "climb up the ladder" of the more complex and costly options? Based on Figure 6, do you have any initial thoughts on suitable technologies and infrastructure that may be needed (Module 7)? What is the total area of irrigation development, in relation to the country target, in which farmers could take the lead?

The segment(s) of farmers who can gain the most from irrigation: What characterizes these farmers in terms of resources, challenges and aspirations? How much can they gain from

irrigation? Based on natural resource potential, are farmers likely to engage in irrigation individually or is there a need for them to come together as a group?

Constraints to FLID processes

The conduciveness of the surrounding environment is represented in the bottom half of the spider plot. This is specific for the segment(s) of farmers for which the diagnostic is carried out (Module 2). These farmers can more easily expand, intensify or increase profitability of irrigation farming on their own, when there is a high score for:



- **Policy and legal** (Module 3)
- **Knowledge** (Module 4)
- **Finance** (Module 5)
- **Markets** (Module 6)
- **Technology** (Module 7)

In the unlikely scenario where all five factors score highly, there would be no need for government to influence the FLID process as the conditions surrounding the farmers are such that they are not held back by systemic constraints; they have the knowledge and capacity to interact with suppliers for the purchase of the equipment, raise the money from financial institutions, pay back loans, increase their income by profitably marketing their produce, and obtain the required permits and documentation. But more often than not, one or more factors will constrain farmers' actions.

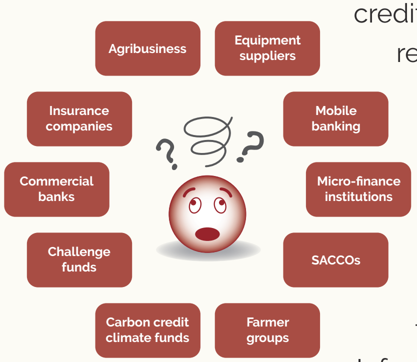
Policy and Legal: Policies, laws and regulations set the rules for water, land, financial, environmental and organizational practices and can enable or constrain FLID processes. Farmers can face constraints in the right to use water; permitting and abstraction thresholds; type of land tenure arrangements; and environmental limitations. These factors impact on perceptions of water and land tenure security and, therefore, willingness to invest. There are also particular gender and other inclusion constraints to access and use of both land and water (i-box 3.12).

Permitting of hundreds of thousands of individual micro-users is administratively impossible in most settings.

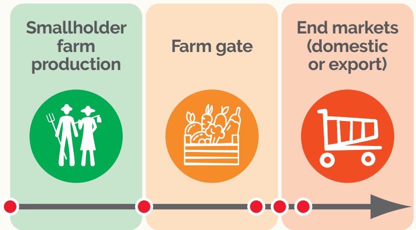
Knowledge: The knowledge factor is constrained when farmers have poor or no access to knowledge on irrigation practices, irrigation technologies, agronomy, finance or running a profitable irrigated agricultural enterprise. Particularly prone to such constraints are small enterprises run by young and/or women farmers. The wider *knowledge environment* is constrained when public

and private sectors have limited or no understanding of, and fail to operationalize support for, FLID processes, with corresponding weak understanding of the real needs of different types of farmers (i-box 4.3).

Finance: The financial environment is constrained when financial policies and regulations are unsuitable for the particularities of the irrigation equipment market, and when farmers have limited appropriate financial product options in the formal credit market. Laws and regulations related to finance pay little heed to equal access, with the result that women and other potentially marginalized groups (e.g. those based on religion or ethnicity) are often constrained in accessing credit by virtue of their gender or other qualities. Information and Communication Technology (ICT) systems can be underdeveloped, with few opportunities to reduce the transaction costs of credit provision or risks of default for borrowers (i-box 5.3).



Markets: Markets are constrained when the rural investment climate established by the government is inappropriate for development of market linkages, for example when there is insufficient spending on rural public goods that are vital for production (such as agro-processing and export of high-value produce); when regulatory and compliance systems restrict farmers' participation in domestic, regional and export markets; and where digitization of value chains is weak, with few opportunities to access market intelligence and reduce transaction costs (i-box 6.2).



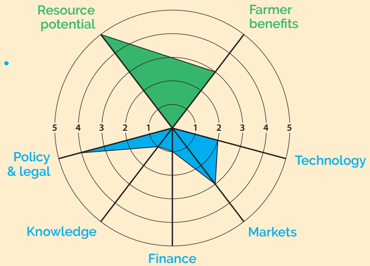
Technology: The technology factor is constrained when farmers cannot easily find suitable technology on irrigation equipment supplier shop floors or cannot afford it, or when national quality standards for equipment are absent or weakly formulated. Access to suitable and affordable technology by farmers is heavily influenced by constraints in related aspects of knowledge, affordable finance, and effective service and supply markets; thus, to an extent, technology constraints are a function of these other limitations (i-box 7.11).

Country-specific diagnostics in three FLID contexts

Illustrative examples of diagnostic assessment are presented for three FLID contexts (Figure 8). These reflect a situation where resources are plentiful and FLID is nascent (Uganda); where FLID processes are well established and irrigated area is fast-growing, but with some resources unavailable (Kenya); and in a selected catchment in Tanzania (Upper Pangani), where irrigated area has expanded to the full extent of the available resources, with FLID processes a dominant contributor to total irrigation area. The regional comparison highlights how different neighboring situations can be, and that site-specific solutions requiring differentiated strategies may be needed. The comparison also illustrates how the diagnostic process guides the focus of public sector interventions.

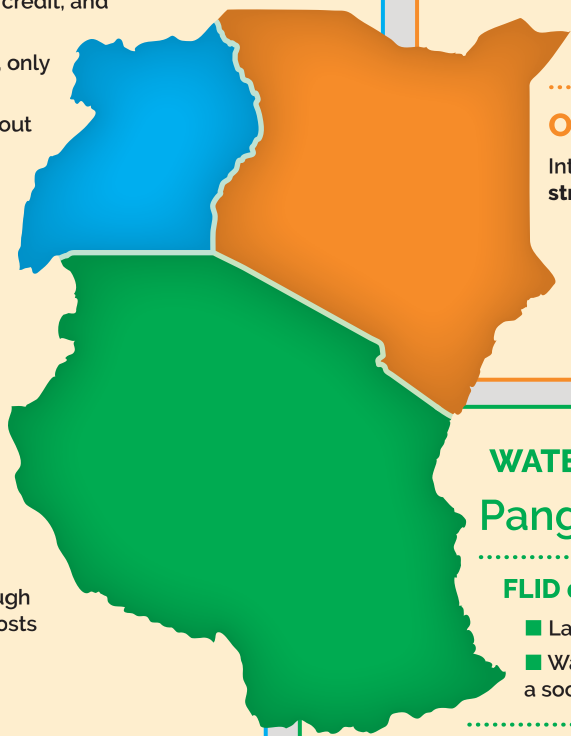
NASCENT FLID CONTEXT

Uganda



FLID diagnostic

- Water-abundant country and resources are widely available
- Limited farmer knowledge on irrigation technology and practices
- Farmers have limited access to credit, and irrigation equipment is expensive
- Centralised technology outlets, only in major cities
- Limited supplier knowledge about suitable irrigation technology
- Gap in national standards



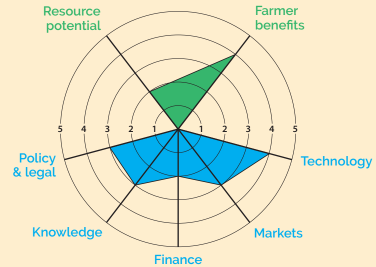
EXPANSION FOCUS

Interventions should focus on **promotion and establishment** of irrigation:

- Pursue knowledge campaigns around irrigation farming benefits and related practices
- Strengthen nascent irrigation equipment supply chains through information and higher sales volumes
- Reduce equipment prices through tariff reductions and acquisition costs through matching grants
- Policy and legal review will set the stage for reforms in water governance

FAST-GROWING FLID CONTEXT

Kenya



FLID diagnostic

- Water scarce country and resources increasingly stressed
- Irrigation practice is widespread and dynamic
- Visible local successes catalyse growth with limited external input
- Farmers have difficulty to afford irrigation development when water mobilization infrastructures are needed
- Offtakers, traders and commercial aggregators are engaged with irrigators
- Production and marketing risks remain significant with benefits accruing to relatively privileged farmers

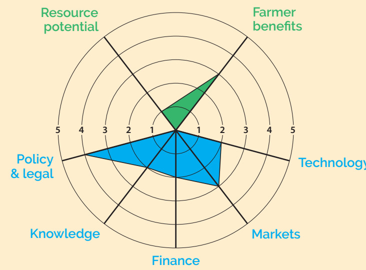
OPTIMIZATION FOCUS

Interventions should focus on improving **farming efficiency and strengthen supply chains**:

- Cheaper more sophisticated technology for energy efficiency and higher water productivity
- Farmer-supplier-financer networks to increase affordability of technology
- Knowledge promotion for better agronomy and soil water management
- Stronger output markets for higher profitability

WATER-STRESSED FLID CONTEXT

Pangani Basin in **Tanzania**



FLID diagnostic

- Land and water resources close to fully utilized
- Water competition between irrigators and across sectors is a social, ecological and political issue

SUSTAINABILITY FOCUS

Interventions should focus on **water governance and optimization for sustainable resource use**:

- Establish FLID-responsive water governance arrangements
- Knowledge and technology sophistication and affordability (optimization)
- Water productivity and energy efficiency (optimization)
- Output markets (optimization)

Figure 8

FLID strategies and intervention responses in three different contexts

6 From diagnostic to interventions

The diagnostic and scoring process will lead to a clear picture of the potential for FLID and the hurdles that farmers face in expanding and intensifying irrigated production to make their enterprises more profitable. Stakeholders involved in the diagnostic need collectively to assess where the public sector can best intervene to lift the most serious constraints, so as to accelerate the FLID process, enable it to take place at a larger scale, and in a more inclusive and sustainable way. The question for you to debate here is: ***"How can the government intervene in the constraints so as to catalyze the FLID process?"***

Identification of interventions – possible options in different combinations

Public interventions should be identified only for the most constraining factors (meaning factors in the bottom part of the spider plot with the lower scores) and must be limited to "no-regret" actions. **The example interventions given here are not prescriptive. Rather, they are intended to prompt ideas and discussion and can be redesigned appropriately for each situation.** Selected examples of interventions are highlighted below, and details are provided in the respective modules.

Policy and Legal (Module 3)

Constraints in the water and land legal framework can be dealt with through policy notes or with regulatory changes that enable more secure access for small-volume users. **Hybrid law interventions** (i-box 3.9) offer a key opportunity and build pragmatically on available laws, regulations, formal *and informal* rules. Possibilities include:

- targeted use of permits
- recognition of customary law
- prioritization of water use
- permit exemptions
- collective permits.

Water resources governance that focuses regulation efforts on the *major* abstractors (usually fewer in number), with less constraints on small users, but with extensive monitoring to enable sound and sustainable management is the optimal solution. These re-oriented priorities can improve both water resources governance practice and environmental outcomes, thus ensuring more equitable access to water.

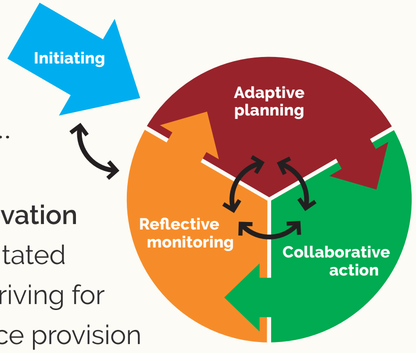
Strengthening land tenure security similarly requires recognition and protection of all legitimate rights, formal and customary (i-box 3.2). Thus land tenure Interventions might include phased implementation and "positive" discrimination to ensure inclusion.

Knowledge (Module 4)

Constraints in the knowledge system can be overcome with interventions aimed at creating and strengthening formal and informal knowledge networks, such as:

- facilitation of **multi-stakeholder platforms** (i-box 4.4) to align the key players and reduce the burden of high transaction costs that constrain private sector services. Multi-

stakeholder platforms (MSPs) can serve high-level policy and innovation processes.

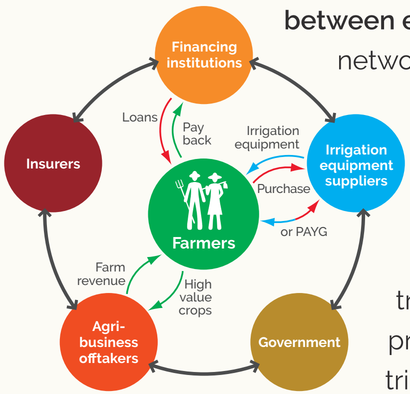


strengthening farmers' problem-solving and innovation capacities (i-box 4.8) through facilitated farmer-to-farmer learning while striving for "demand-responsiveness" in service provision (i.e. meeting real expressed needs).

use of mass-media, information and communication technology (ICT) and communication outreach strategies with targeted messaging for specific groups and stakeholders (i-box L, i-box 5.8).

Finance (Module 5)

When finance is a constraint, interventions can catalyze private sector activity by: **facilitating linkages between existing actors** using knowledge networking approaches to reduce transaction costs and bridge service gaps; implementing **credit guarantee and risk-sharing arrangements** that bring all parties together and transfer the financing risk from private to public sector, thus triggering affordable access. Other interventions can target affordability more directly by reducing upfront and direct costs through hire-purchase-type arrangements or subsidies as follows:



Pay-as-you-go (PAYG) financial products (i-box 5.6) are provided by equipment suppliers and can be blended with credit guarantees (i-box 5.5).

Subsidies (i-box 5.7) are a key instrument for accelerating irrigation equipment uptake when farmer affordability is low.

Partial subsidies can strengthen supply networks and improve agricultural and technical knowledge, along with related services and support.

ICT tools can catalyze and facilitate all of the above (i-box 5.8), and opportunities for ICT to improve efficiencies and accelerate the pace of rollout should be sought across all interventions.

Markets (Module 6)

Smallholder farmers can be constrained in accessing output markets, but there are a number of principles that inform successful interventions:

Establish and support producer organizations so that farmers cooperate to compete, and use collective structures to help gain bargaining power, scale and efficiency so as to enter formal value chains and higher value markets.

Build productive alliances with public-private-producer partnerships (the 4Ps). This involves active facilitation and support for new and ongoing linkages between farmer-groups and private companies who sell inputs,

buy commodities, add value to products, and provide financial and agronomic services.

Digitalization of agricultural markets connects farmers with services and output markets and includes: digitally-enabled value-chain integrators; mechanization access solutions; online retailers of agricultural produce; and agricultural e-market sites.

Technology (Module7)

The possible technologies that are identified in the FLIDguide are not interventions in themselves but constitute a core part of the interventions outlined above. A set of intervention principles is presented. Most important of these is that the farmer must be at the center of decision-making. Highlights of Module 7 include:

Technologies must be best-fit, and solutions co-constructed: A fit-for-purpose strategy allows farmers to develop and/or choose solutions for themselves complemented by the necessary knowledge to enable them to do so.

Technical advancement in FLID often takes place in small steps, rather than a technological "big-bang". Farmers at different stages of irrigation introduction, expansion or intensification will have different technology needs, risk appetite, and financial capacity. It is best to facilitate organic growth.

The advantages and challenges of technical design choices for technologies that are commonly part of FLID processes are also outlined (i-box 7.2 to 7.9). These include pumping (buckets, manual, petrol and solar pumps); irrigation application methods; soil-water management instruments; and ICT innovations. Indicative purchase costs and operational costs are provided to aid planning and design.

The intervention examples that are explained in the FLIDguide modules are listed in Figure 9 and can be accessed via the hyperlinks.

Linkages between interventions

Since the factors in a FLID system are interlinked, a change in one factor will ripple through and impact on others. A policy intervention, for example, can reduce import tariffs, leading to lower shop-floor prices, more affordability, and increased technology uptake. Knowledge exchange through multi-stakeholder platforms or farmer field schools can deepen farmers' understanding of technology, market availability and lead to better informed choices. Other examples are outlined in i-box B.

Factors are also interdependent. When finance is a constraint, for example, a sole emphasis on financing irrigation equipment is unlikely to address the limitations effectively. Farmers also need access to equipment markets, and to knowledge that will enable informed choices, with technical support and advisory services. An integrated financing approach is more likely to overcome key constraints. When planning interventions, the links between factors should be anticipated to maximize the catalytic effect of the chosen interventions and ensure that interdependencies are adequately addressed.

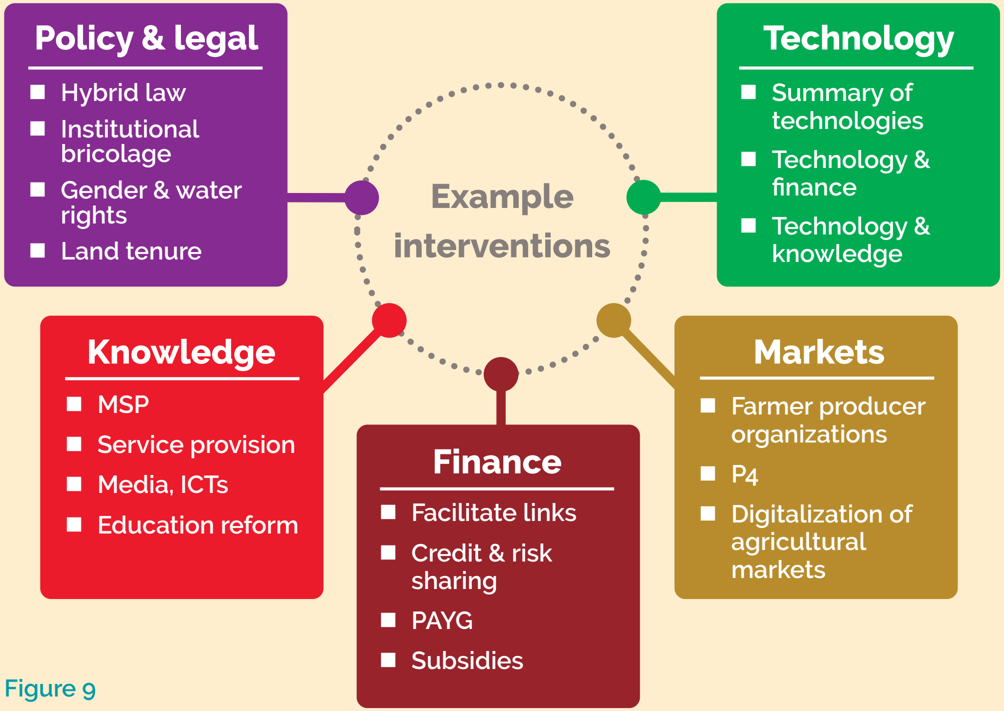


Figure 9

Summary of example interventions for the five factors in the enabling environment (click for details)

Prioritization of interventions

Formulating interventions to address priority constraints should aim for a complementary set of activities that would lead to a stronger enabling environment. Through this, constraints would be reduced, and easier for farmers to overcome. More smallholder farmers could then initiate and develop profitable irrigation enterprises as part of irrigation expansion and intensification processes. Through the diagnostic process, and informed by examples in the modules, multi-stakeholder consultations, and the team's experience, you will have been guided on how to compile possible interventions.

Not all of the identified interventions will be equally realistic or politically acceptable. Some of the interventions in a FLID agenda need more political will than others and may not be opportune at the particular moment. In such cases, the more easily attainable interventions should be pursued, alert to the effects on the system that result from any gaps in implementation. Addressing some of the constraints and making progress along parallel tracks can also change political willingness and priorities down the road.

Political will can be nurtured and encouraged. For example, in your diagnostic you may have identified a major policy and legal constraint in relation to high water permitting fees. Administrative processes for small irrigation abstractors are cumbersome and time-consuming. While this is an important obstacle in the way of farmers, there may be a lack of political willingness to deal with the policy aspect of permitting (Module 3). The lack of interest in this regard should not prevent progress being made in other ways, however, as there will also most likely be constraints in relation to knowledge, finance, markets, and/or technology. Ad-hoc solutions for the water permitting challenges might be possible while other more politically important avenues of action are supported. These could include exemptions, subsidies, targeted administrative support for processing, etc. As the irrigated area and production increases, benefits and consequences will become evident to political decision-makers, while competition for water resources may also increase. Political awareness and priorities can shift. Willingness to tackle policy revisions may be stronger at a later stage.

7 From interventions to conceptualizing the operation

Government action to support FLID

Once you have identified the priority interventions and confirmed political support, the government – through ministries, regional or local governments, public agencies or institutes – can move into action. Getting support for and implementing an intervention is easier when it is not controversial and requires a budget that is aligned to existing political realities.

One intervention alone will rarely make a major difference to how conducive the environment is for FLID. Rather, interventions can be viewed as complementary building blocks which, combined in an operation, can achieve results at scale.

Sometimes, operations can be funded and implemented by governments without the involvement of development partners. When alignment between multiple stakeholders with conflicting interests is needed, operations can unfold more easily when a development partner (such as the World Bank) steps in. Depending on the identified priorities, support from a development partner might come in the form of policy operations, aiming for policy or institutional change; investment operations or results-based operations, particularly useful when infrastructure is to be developed; or guarantees to facilitate involvement of the private sector (i-box 5.5). The multi-sectoral nature of FLID means that several donors might be involved, often with parallel initiatives and different timelines.

> An operation in support of FLID is the set of priority interventions that, packaged together, makes the surrounding environment more conducive for farmers to take the initiative in irrigation.

As we have already pointed out, improving the environment for FLID requires coordination among stakeholders. It is important to be inclusive in the diagnostic process and build understanding and relationships. In the course of the preparation of a FLID operation, **a public sector champion for FLID may be identified**. This ministry, department or public institute could be asked to lead the process because it commands the necessary respect to mobilize political support, bring together public and private stakeholders, and ensure that FLID is promoted in country strategies. The identification of a charismatic figure for the lead role can make the difference between success or failure of an operation.

Theory of Change in a FLID operation

In order to conceptualize the operation that would support FLID, you need to formulate a theory of change based on all the available information (Figure 10). The theory of change provides a schematic of the operational logic from the constraints through to the long-term outcomes. On the left side of the figure are the constraints preventing farmers from taking the initiative in irrigation. These correspond to the factors in the lower half of the spider plot with a low score. For the most constraining factors, you will have identified the interventions that can address the particular weaknesses in the enabling environment. The implementation of the interventions leads to direct results (the outputs), which in turn contribute to the outcome (i.e. the development objective). In a FLID operation, the outcome

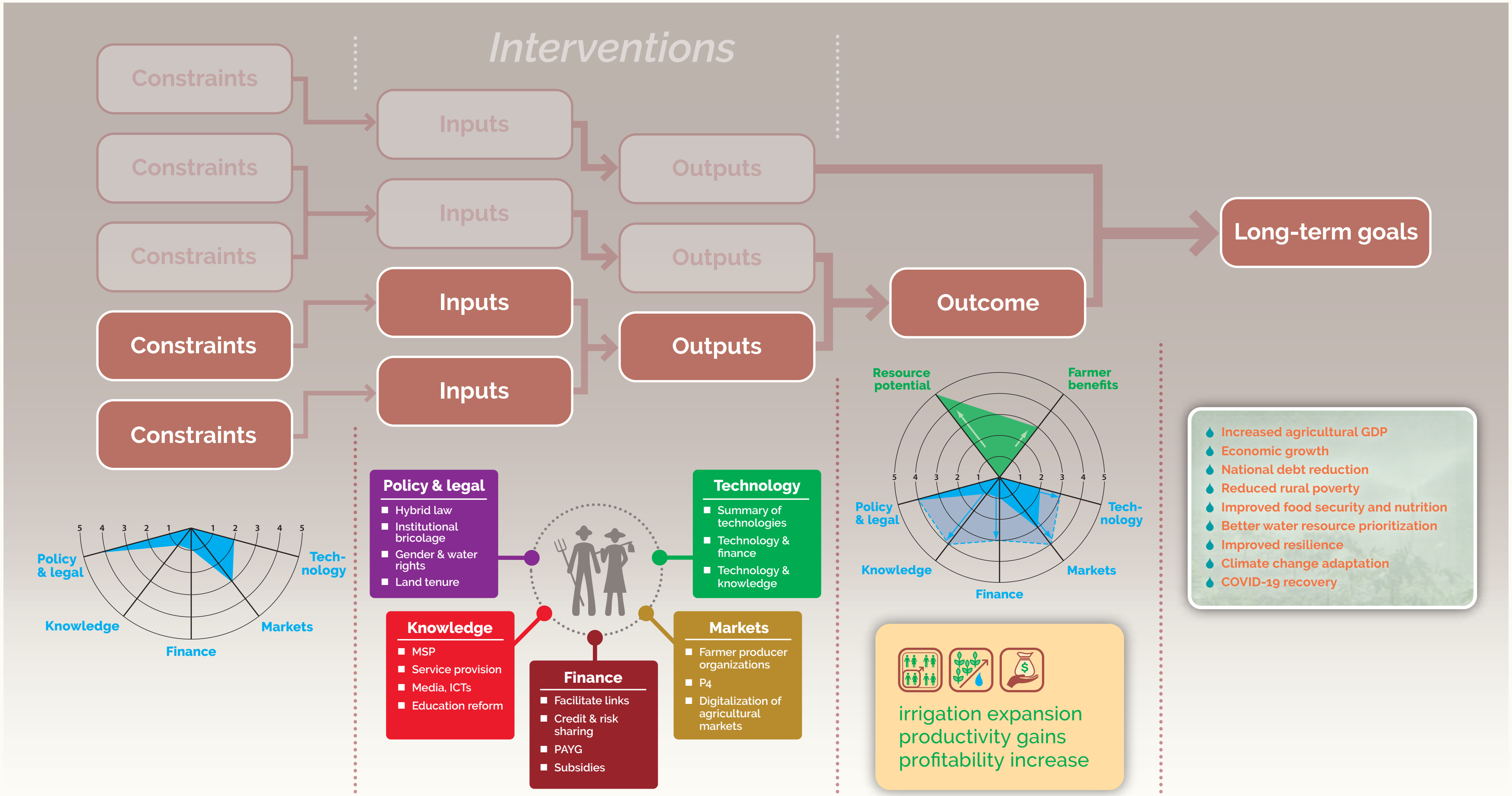


Figure 10 Theory of change in an operation to catalyze FLID

can be defined as a more conducive (legal, knowledge, finance, markets, technology) environment for farmers to expand, intensify or increase profitability of irrigation farming. Stated more simply, it will be easier for farmers to take the initiative, their risks will be lower and more will succeed in comparison to the initial situation. Indicators that can be used for the outcomes are discussed in i-box F. Finally, the theory of change identifies how the outcome of the operation is aligned to the long-term country objectives.

Keep the theory of change simple. In order to avoid an over-complicated operation, you may have to leave out some of the seemingly important interventions. You need to prioritize according to political willingness, financial practicability, urgency, and inter-dependencies with other constraining factors. You may also choose to avoid excessive fragmentation that results from bringing together interventions that depend on too many stakeholders.

Look at the added value that each stakeholder can bring: finding synergies with aligned activities to achieve a common goal can simplify the operation.

Once you have put together the theory of change, **stop and ask yourself:** ***What could be the unintended outcomes if this is implemented?*** Could these changes make the situation worse for a given segment of farmers, or for some private sector actors? Remember to avoid intervening in elements of the FLID system just because they are less than perfect or do not fit conventional experience, and reconsider whether these interventions will indeed facilitate farmers to stay in the lead.

The time element

When you define the outcome of an operation in support of FLID, you are essentially stating what you expect farmers to do differently in a few years' time compared with the current situation. It is difficult, however, to predict how farmers' practices will evolve. A typical mistake is to underestimate the time required for farmers to change what they do. Only a minority of farmers will quickly make radical changes, as farmers understandably avoid risks associated with unfamiliar practices or technologies. While change can improve their livelihoods, it can also tip them (especially those who are already vulnerable) into further poverty.

Time planning is complicated by the defining element of FLID, which relies on **farmers driving the process at their own pace. A scenario timeline map** can be useful to explore the feasibility of achieving the development outcome over the duration of the operation. The changes that a particular farmer might undergo are mapped on a timeline in response to the lifting of various constraints (Figure 11). Different operations will have different starting points. Some farmers will start from rainfed farming while others may already be active in irrigation yet want to increase their scale, or intensify because resources are scarce, or strive for more profitability.

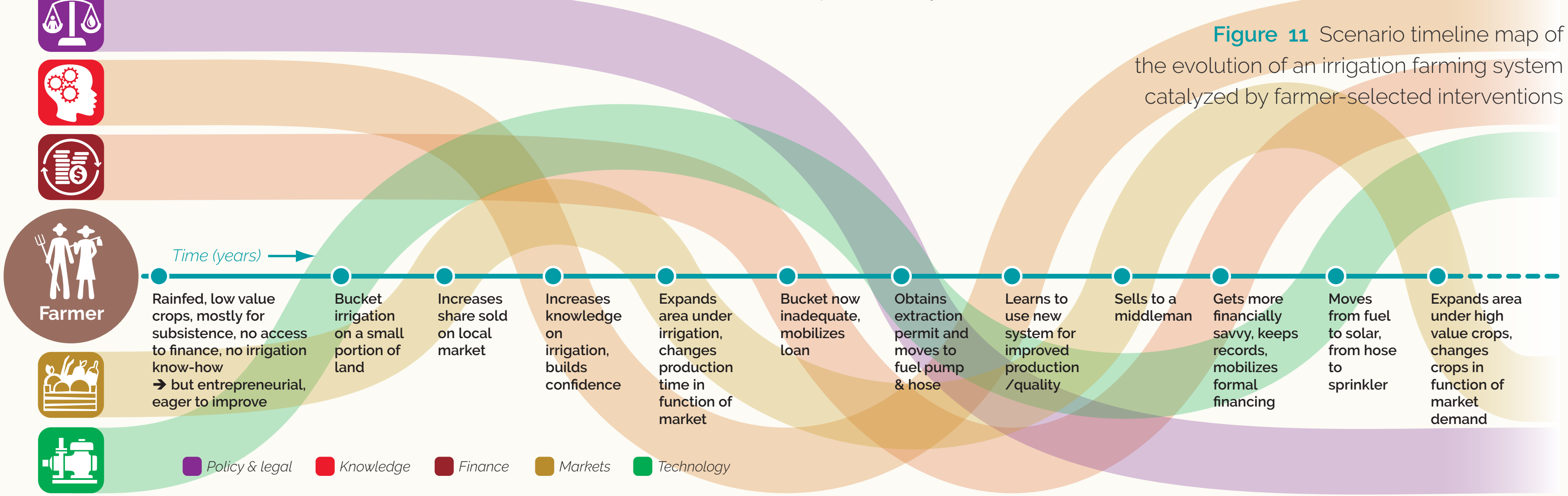


Figure 11 Scenario timeline map of the evolution of an irrigation farming system catalyzed by farmer-selected interventions

8 From concept to operation design

While recognizing the wide variability among operations in support of FLID, this section provides pointers on some key design elements: beneficiaries; infrastructure; scale; stakeholder roles (including private sector); and flow of funds.

Beneficiaries: defining the farmer focus

Smallholder farmers are extremely diverse in their ambitions, capacity, knowledge, access to natural and financial resources, and type of tenure (Module 2 Figure 2.1). In Module 2, you will have characterized the segment(s) of farmers and identified and prioritized interventions with those groups in mind. **Remember: one operation cannot cater for the needs of all farmers.**

The essence of "farmer-led" operations is that these are demand-responsive. While general characteristics of target groups are defined, the farmers themselves are usually not selected at the design stage. Instead, **eligibility criteria – whether for individual farmers, groups, or both – are defined** (i-box G).

Infrastructure: public, private, or not at all?

Operations aiming to catalyze FLID are not compelled to include infrastructure development or upgrade. Operations might bring together policy, regulatory or knowledge interventions only. When infrastructure development is needed, there is a wide spectrum of options, not always directly associated with irrigation. Where markets are identified as a major constraint to FLID, for example, investments in roads or

Women and FLID

Catalyzing FLID is not just about getting more of the same type of farmers engaged in productive irrigated farming. It is also about *including* farmers who, without the interventions, would not be able to participate in the process. FLID can be a game changer for women farmers

Women – as with men – do not represent a homogenous group, and it is important to understand the diversity within communities so that the FLID operation can meet the needs of different individuals involved (i-box D). Suggestions are provided on how to make interventions gender sensitive (i-box H). In relation to knowledge, women may have less access to extension services, media and cell phones, and also have lower literacy levels, making access to knowledge on irrigation strongly gendered (Module 4 Section 4.1). Women farmers face more challenges to access suitable financial products, particularly institutional barriers (Module 5), and experience different levels of access to and conditions for use of land, depending on local tenure systems and national institutions (Module 3).

FLID represents opportunity for women compared to traditional irrigation development. The evolving nature of customary living law is reflexive to change, and this characteristic can be used strategically to improve equality and inclusion (i-box 3.3). The same can be said for hybrid water rights (i-box 3.12). Mobile irrigation technologies enable women to access irrigation services with greater flexibility, without substantial loans or risks of fixed technology investments. Tools are developing rapidly with FLID, enabling new financial products with fewer barriers, and creating access to information on agronomy and markets. Gender relations are dynamic, and FLID has in some cases generated incentives to favor women's engagement in irrigated value chains.

warehouses can have a significant positive ripple effect on profitability. **When irrigation infrastructures are needed, they can be private or public in nature. Whenever possible, FLID operations should focus, as a priority, on catalyzing private infrastructure development.** For example, operations driving an expansion agenda should first attempt to support farmers who have close access to water and can utilize small and simple irrigation systems with privately owned equipment. Only when there is no potential for simple solutions would investigation of more costly, complex and public infrastructure be warranted (Figure 6).

Scale: think big!

When designing an operation in support of FLID, issues of scale dominate in different ways. Scale relates to geographic scope – whether national or regional; to the numbers of farmers potentially involved; and to the irrigation area to be developed or improved. Scale will be informed by considerations of budget, type of supportive interventions (infrastructure vs soft ones), farmers' capacity to contribute (Module 5), and government and private sector capability.

It is now time to scale up support to FLID!

There have been some major FLID programs across Africa, but more often than not experiences have remained at pilot scale. Operations to catalyze FLID should offer farmers, en masse, the chance to take up irrigation, to expand to a larger irrigation area, and/or intensify their farming practice in a demand-driven approach.

Catalyzing FLID should endeavor to reach tens or hundreds of thousands of farmers.

Beneficiaries, infrastructure, scale: How budget ties these together

The amount of *public* and *private* money available for the FLID operation determines its scale and how many beneficiaries can be supported. Budget might be needed for cross-cutting soft activities, like knowledge-exchange platforms, communication outreach or ICT tools, for example. These are "loosely tied" with the number of farmers who can benefit.

But when it comes to operations including irrigation infrastructure, the number of farmers targeted is closely defined by the portion of public budget going into infrastructure *plus* the farmers' contribution, *divided* by the unit costs. **For the same amount of public resource, a FLID operation can have a bigger scale than traditional irrigation development because of the higher contribution to costs by farmers and the *lower unit cost for infrastructure development*** (Figure 6; i-box 7.5 and 7.6). To make the rationale for the FLID operation stronger, you can **relate the scale of the operation to the country level goals (*"How much does the FLID operation contribute to achieving country goals for irrigation expansion, or for increased country food production?"*)**.

Stakeholder roles in the operation: keeping farmers at the center

When designing the operation, the role and responsibility of each of the stakeholders involved must be defined. The provision of irrigation services to smallholder farmers involves many stakeholders across technology, agronomy, marketing, information, and financial sectors. A critical part of the FLID operation is about building alliances between the stakeholders. The multi-stakeholder networking approaches are detailed in Module 4 (i-box 4.4) and applied in the example interventions in Modules 3, 5, 6 and 7.

Catalyzing FLID requires a change in roles between public officials, private sector actors and farmers.

While there are a multitude of possibilities for assignment of roles and responsibilities, one rule always applies: farmers should remain firmly at the center of the FLID operation. The biggest risk posed by public action in FLID is inadvertently to sideline farmers by failing to recognize their driving role, knowledge, priorities and technical preferences. But designing an operation that recognizes the farmer role is easier said than done. **A challenge in FLID operations is that often stakeholders have to adjust their ways of working to align to the new fundamentals of a farmer-responsive and farmer-centered approach:**

Public officials have to shift from being "implementers" of an irrigation project to facilitators of an irrigation process led by the farmers. Ensuring that public officials buy into this shift in focus and proactively support FLID development is not to be taken for granted: they can be threatened by the idea of losing their role, and struggle to understand their new responsibility. Field level leadership is one of many approaches that can make a constructive change (i-box I).

Financial institutions may not be used to working with smallholder farmers who have not been part of their business portfolio in the past and will need information and knowledge, as well as innovative responses, to address the high transaction costs associated with smallholders (Module 6 Section 6.3).

Irrigation equipment suppliers may not have trust in public procurement, which is usually lengthy and more appropriate for large-scale infrastructure and, along with knowledge and information, may require financial interventions such as credit guarantees and risk-sharing (i-box 5.5).

Value chain actors may fail to see a clear entry point for themselves, and some effort may be required first to organize farmers (i-box 6.3) and then to link with them through multi-stakeholder platforms (i-box 4.4).

Farmer behavioral change may also be needed. The traditional approach for supporting farmers with interventions, where the irrigation system is handed over to farmers, may be hard to change. In operations in support of FLID, farmers must stay in the lead and not be relegated to waiting for handouts. Placing farmers in the lead also brings uncertainty because with FLID an individual farmer's involvement is by free choice, and not just because they fall within the boundary of an irrigation scheme perimeter. Their exact localities, numbers, technical and financial preferences cannot be defined in advance. Farmer agency, meaning that they have power over key financial and technical decisions impacting their lives, is a fundamental working principle even if it increases operational risks. Catalyzing FLID requires a fundamental shift that puts farmers and human capital, rather than infrastructure development, at the core.

Public officials will also have a changed role that can be facilitated through field level leadership. Public officials who are involved in implementation will have to make a significant shift from their familiar and relatively powerful role as an implementer bringing an irrigation project to farmers, to one of being a facilitator of a development process that is led by the farmers. This requires a whole different set of skills and processes and a strategy of field level leadership can help that important transition to take place (i-box I).

What does farmer-led mean in operation design?

Farmers have a clear grasp of the "rules of the game": Farmers need to be able to make their own decisions and that means they have to understand the process, technical, and financial content. FLID operations are heavily centered on the human element and adequate resources must be allocated to proper communication with farmers. If farmers do not have knowledge, they cannot be in control.

Farmers are given options: Where an operation supports a very limited set of technologies (such as in a kit approach), farmers may not find equipment well-suited to their preferences. Farmers' choices are sometimes unconventional but justified by experience and practise (Module 7). The same applies to financial products which may not suit their requirements. Choosing a single financial intermediary for an operation (Module 5) would force farmers to open a bank account when they may not be keen to do so.

Farmers pay for irrigation: Being "in the lead" is reflected by farmers' willingness to invest (proportionally to their means). It is important to preserve this principle, even if it translates into risk for the implementation pace. When planning a FLID operation, there is often a real concern that farmers may not show interest. Increasing financial support (through subsidies or other means) makes it more favorable for farmers to join in the operation – but, conversely. affects farmers' priorities when making decisions about involvement and can undermine ownership if excessive.

Farmers can opt out: Contrary to the development of public large-scale irrigation schemes, where a farmer is either within or outside the command area, in a FLID process it is the farmers who decide to develop irrigation by themselves, or in small groups. As the farmer goes through the decision-making process, she/he might realize that the change in farming practice is not the right choice for them. This may be due to costs being higher than expected, ineligibility to take a loan, realization that benefits can be lower than expected, or that risks are too high. The operation should anticipate that a percentage of farmers will opt out throughout the process and should adjust farmer expectations, processes, and targets accordingly.

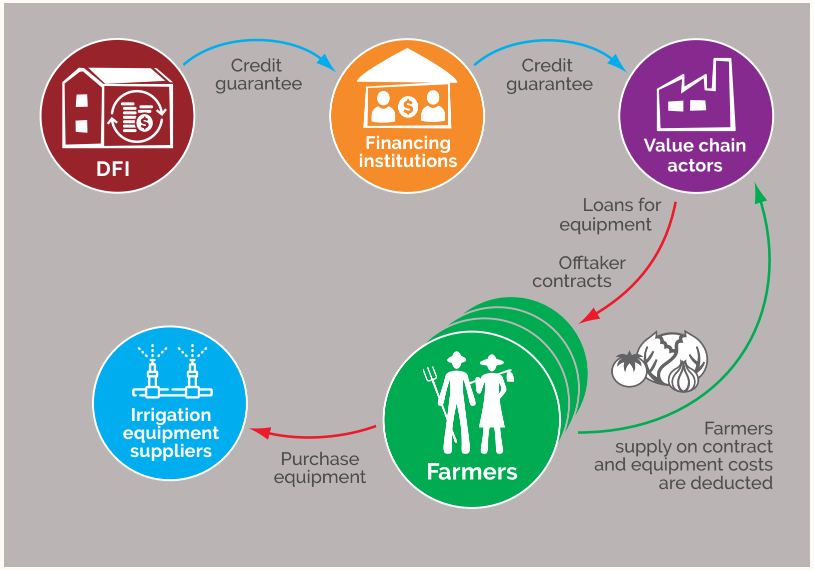
Farmers can influence operation design (and re-design): Farmers' organizations should be involved in the diagnostic assessment. However, the farmer-led nature of these operations means that the farmers who are consulted are not necessarily the same ones who will benefit. This is why FLID operations should allow for adjustments along the way, based on farmers' feedback.

Flow of funds: how to blend public and private money

The government – through ministries, regional or local governments, public agencies or institutes – would allocate budget to a FLID operation aiming to create a more conducive environment for FLID. In parallel, private stakeholders (farmers and farmer groups, but also other private actors) may also allocate money. This section discusses how these two budgets can come together, and how money could flow.

When it comes to the budget needed for the "hard elements" of development or rehabilitation of irrigation infrastructure, different options are possible depending mainly on the ownership of the infrastructure (public or private). In the case of public infrastructure, for example rainwater harvesting facilities that are used to supply water for irrigation, the budget is usually managed by a public entity, sometimes with farmer contribution such as in-kind manual work. When there is private infrastructure, to be owned by farmers or farmer groups, different options should be explored. Ideally, farmers – individually or in groups – should be responsible for covering the costs and for the procurement process of any privately owned equipment and infrastructure. Where farmers own their equipment, this leads to more sustained operations and better maintenance.

When farmers cannot afford to cover the full cost of equipment or infrastructure – even when access to credit is facilitated (Module 5), blending with public resources is needed. Farmers could nonetheless remain in charge of the procurement process and ownership can be promoted through co-payments. One arrangement is when the public contribution is provided to the farmer, wired through a financial institution, an electronic voucher (i-box 5.9), or directly to the irrigation equipment supplier.



When farmers do not have the technical capacity to carry out this process, public or private entities could take responsibility for the procurement on behalf of the farmer. Financial institutions can play this role, merging the farmers' contribution and the public funds (i-box 5.5 [Variations A and B]). In situations where the FLID support operation has a strong market entry point, an option would be for the value chain actor to procure the irrigation equipment on behalf of the farmer or farmers' group (i-box 5.5 [Variation C], Rwanda example in i-box 5.7).

A further option is that the procurement role is assumed by a public entity (ministry, irrigation agency, local government), in which case public procurement rules prevail. The challenge in all cases is to ensure that the farmer or farmers' group plays a meaningful role in defining key decision points during the procurement process to ensure that farmers maintain agency in the rollout process.

Working principles in FLID interventions

Engaging with FLID processes is people-centered, involving farmers, government and the private sector. Co-planning of interventions with this wider group will yield the best results.

Engaging with stakeholders, or actors, requires ethical sensitivity and attention to some working principles. Now that you have designed your operation, make sure that it resonates with the working principles that are summarized below. More detail is provided in i-box D. This is the right time to make revisions to the design if needed..

1 **Catalyzing the system – reducing hurdles and speeding up processes**
FLID intervention design should maximize collaboration between actors and ensure that responses play a catalytic role.

2 **A wider view of benefits**
Interventions should aim to support broad development processes, with goals that extend beyond the economic internal rate of return on investment, to include a strengthened natural resource base; water for multiple purposes; nutritional security; social stability; dignity through work; social equity; and giving voice to marginalized groups.

3 **Intervention teams as temporary participants**
When interveners engage with FLID processes they are temporary participants. Any action should keep farmers firmly in the driver's seat of development, without undermining farmer control.

4 **Recognizing diversity in interests**
Farmers and the communities around them are not homogenous entities. Women or youth – as with men – do not represent a homogenous group. It is important to understand the diversity within communities to meet the needs of different individuals involved.

5 **Facilitating influence for less powerful actors**
Interventions are processes of negotiation, and it is part of the social-facilitators' responsibility to create an environment in which less powerful actors also have the opportunity to participate in the process. Failing to engage women, youth and other marginalized people may deepen inequalities, reduce access to water, and leave some people worse off than prior to the interventions.

9 Readiness

Moving toward the end of the preparation cycle for the operation to catalyze FLID, there is a need to define its readiness. Similar to a Community Driven Development operation, beneficiaries and activities are not identified during preparation.

What defines the readiness of the operation is linked to the establishment of the processes, organization of the stakeholders, training of personnel, and the development of the media and digital tools needed for implementation. FLID operations also require preparedness of private sector actors through market sounding and pre-qualifications, etc.

Readiness in a FLID operation

"Readiness" means that everything is in place for the rollout to commence. In a FLID context it is judged by very different parameters to traditional irrigation investments. It is not about feasibility studies and designs, but processes, capacity and people.

Establishing processes means clarifying who is expected to do what, by when, and in sequential order. But it is more than that: Readiness can be achieved only once appropriate knowledge of these processes is held by all stakeholders involved – and this is often where the real challenges start. It is one thing for processes to be perfectly described in an operational manual, but quite another to ensure the requisite knowledge is disseminated to those involved in implementing them. A key element in defining the readiness of the operation is to ensure that each stakeholder knows the "rules of the game" in a way which is accessible to them and appropriate to "what they need to know" to set the operation in motion. Strategies for communication, outreach and media are needed at different stages in the operation (Figure 12).

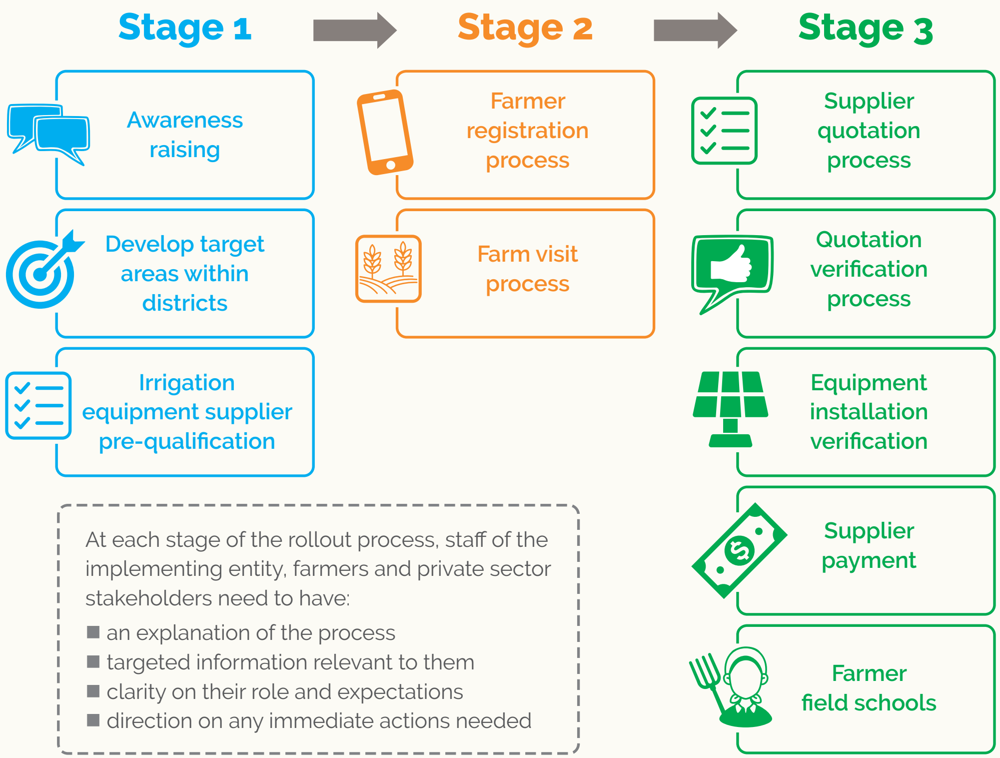


Figure 12 Example intervention stages of a FLID operation needing targeted and specific information for each of the different stakeholders involved

10 Learning during implementation

Design at your best, but keep re-designing

Farmers continuously change their practices based on the evolving situation around them, sometimes in unpredictable ways. Optimal solutions to the evolving needs are rarely static and cannot easily be found through a linear and time-bound pathway. The insights gained from action and experiences need to be used to inform implementation adjustments as the process unfolds.

The farmer-led nature of the FLID process means that you will more than likely have to adjust the operation "on the go". The best approach is to preset milestones for reflection and assessment and periodically bring together all of the involved actors. In this reflection and replanning process, you would assess data and stakeholder feedback, verify that the theory of change and the timeline for the anticipated changes is valid, and re-design the operation according to updated information. When following a process of learning, reflection and modification, there is a risk of constant "renegotiations" which should be avoided. This is particularly the case when subsidy programs are involved, and farmers may hold back from acting early in the hope of getting a higher subsidy if they delay their participation.

Five rolling stages for the revision of operational designs can help with the setting of milestones for the timely review of activities (modified from Andrews, Pritchett, and Woolcock 2017):

1 Design your FLID operation.

2 Define the milestones for review of the operation throughout the implementation process.

3 Conduct the review with relevant stakeholders: Reflect on the assumptions made, what has been achieved, whether this confirms that the theory of change and the timeline for change remain valid, and what lessons have been learned.

4 Adjust the operation, including the estimated timelines. Document the learning and redesign.

5 Proceed to implement (act) in line with the revised plan.

Repeat steps 3, 4, and 5 periodically.

Invest in communication

FLID operations have a more prominent human element than public-sector-led initiatives that are more infrastructure focused. Well-informed, capable and motivated people are central to successful operations and this translates to higher investments in "soft elements", such as knowledge exchange platforms (i-box 4.4), capacity building, app development (i-box L), and communication outreach (i-box N and 4.10). The bulk of the budget for these soft activities will usually need to be supported with public funds. It may be a challenge to advocate for this budget, as the Ministry of Finance or line Ministry often favor public financing of infrastructure. Furthermore, the causality chain of these soft activities can be difficult to establish, i.e., how the spending of public money in knowledge exchange translates into more irrigated hectares or higher productivity of irrigated land. You will need to highlight how these soft actions play a critical role for the whole change to happen. This means explaining how the development outcomes will be negatively affected if these soft actions do not take place.

Account for costs during implementation

There is sometimes the misconception that operations aiming to facilitate FLID have less overhead costs compared to more conventional heavy-infrastructure irrigation operations. In medium and large-scale irrigation development, approximately ten percent of the construction costs are required for the study, design and supervision of construction.

Operations to catalyze FLID have different but significant overhead costs. It is critical that resources are put aside to ensure that the government has the personnel, physical and material resources to successfully support implementation.

Operations in support of FLID do not require heavy engineering design and supervision due to their technical simplicity, but **there are different and equally important support functions. These have overhead costs that need budget allocated from the various stakeholders to achieve success.** The human element is far more dominant than technology (which also plays an important role), and you have to plan for diverse support including: specialists to address critical support activities such as media; app development; technical quality and costing studies; financial studies; online training (i-box M); communication materials and outreach (i-box 4.10); support for training and information exchange (i-box 4.4 to 4.7); and leveraging digital technologies for rollout at scale, as well as for monitoring and evaluation (M&E) (e.g. apps, tablets, GPS).

11 Illustrative examples of FLID operations

A FLID operation can be assembled in many ways. Two examples, from Uganda and Niger, are presented here and illustrate how the thinking process unfolded from the diagnostic of FLID potential and constraints, to the identification of interventions, to operation design and implementation. The two cases reflect quite different situations, with more detail given in i-boxes J to M, and O respectively.

Uganda is a water-rich country, but one where farmers are finding rainfed production increasingly difficult due to climate change, and where irrigation is not widely practiced or well-known. Niger is a dry country where irrigation farming is well-established and has historically been beneficial in overcoming the prevailing climatic constraints. Both countries have resource potential for irrigation expansion and incremental benefits are substantial. Smallholder farmers in both countries are constrained from initiating irrigation development by a knowledge deficit, weak financial environment, and lack of suitable technologies that are easily available. The governments in each country moved to create a more conducive environment for farmers to take up and expand irrigation but used different strategies: by leveraging on the existing decentralization agenda in Uganda; and on a regional knowledge exchange initiative across the Sahel in Niger. Both FLID operations were supported by the World Bank, in the case of Uganda with a results-based financing, and in Niger with an investment financing.

It is worth remembering that a FLID operation must be relevant to many stakeholders. A clear narrative on the operation is needed, with a widely shared understanding on "Why the FLID operation matters in the bigger scheme of things". Some tips for ensuring relevance are shown in Figure 13, using the Uganda case as an example.

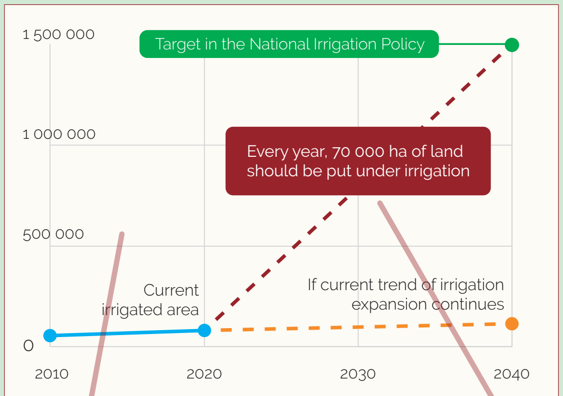
Do not present FLID as an end per se but link it to the role it can play for the achievement of country high level goals.

Give a sense of scale: how much FLID can contribute to the achievement of the irrigation expansion country goal?

Compare this unit cost to the one for recently completed irrigation development in the country: this is a quarter to a third of the average cost for public-led irrigation development in Uganda!

Country context

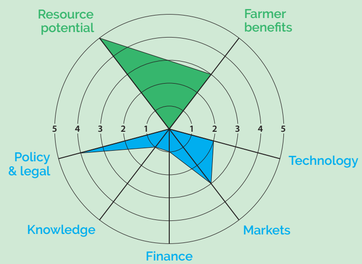
Increased agricultural production for internal and regional markets is a **priority growth path for Uganda**. Historically, the favorable rainfall pattern allowed farmers to produce two rainfed crops per year. Climate change has now made weather the main risk for smallholder farmers. Expansion of irrigation has become a government priority. Public-led irrigation development is **far from matching the need**, due to limited institutional capacity and insufficient budget.



This indicates the need for the governments to change their irrigation strategy if they want to achieve their goals: business as usual will not bring them where they want to be!

You can multiply the annual expansion goal by the average unit cost of public-led irrigation development to give a sense of how much public money would be needed annually.

There is a strong case for FLID in Uganda. **Half of the irrigation potential** is close to surface water resources, making it possible for farmers to develop irrigation without a need for major water mobilization infrastructure (unit cost 3 000 to 5 000 USD/ha). Smallholder farmers can benefit from a more conducive environment for irrigation, notably the 21 percent of smallholder farmers who are attempting to transition to more commercial agriculture, but do not have the means to do so.



Knowledge and finance are the major constraints holding this segment of smallholder farmers back from taking the initiative in irrigation on their own, followed by access to technology.

UgIFT MICRO-SCALE IRRIGATION PROGRAM Improving farmers' livelihood

Interventions and operation

The Government of Uganda has structured the Micro-scale Irrigation Program, which is aimed at supporting individual smallholder farmers to develop irrigation through a partial subsidy system combined with facilitated access to loans, and increased knowledge. The World Bank supports the Micro-scale Irrigation Program with a USD 50 million loan, expected to be matched by up to USD 24 million of farmers' contribution.

Highlight how much private money is leveraged!

Impacts

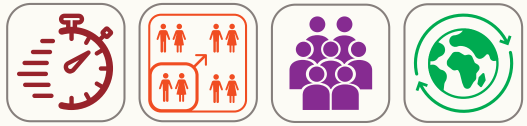
The Program in the first few months of implementation has seen 16 000 farmers expressing interest (20% women). The establishment of a more conducive environment is expected to translate into between 12 000 and 28 000 smallholder farmers establishing irrigation. The program is expected to contribute between 5 to 10% to the annual irrigation expansion target of the National Irrigation Policy for 2022 and 2023.

Highlight the achievement of impact at scale, by referring to contribution to high level country goals.

Figure 13 Simple narrative on a FLID operation for all involved stakeholders

12 Conclusion

Faster Scale up Inclusive Sustainable



Farmers across the world are leading an agricultural revolution, increasing food production and strengthening resilience through irrigation practices. As countries aim towards "building back better" in their recovery from the effects of a pandemic, accompanying economic crises and climate change impacts, catalyzing FLID can achieve locally rooted and robust outcomes that have direct impact on large numbers of people. While farmers lead this process, often in interaction with other private actors, governments also have a role to play. The public sector can take action to improve the enabling environment around farmers that will allow a greater number and more diverse groups, including women, to participate in a faster-paced process. Removing barriers to financing, enabling access to technology and markets, building capacity and catalyzing knowledge transfer are powerful ways to accelerate FLID. Governments must ensure that the FLID process remains a sustainable one, particularly in view of groundwater depletion, pollution, wetland use, and water security. While benefits are numerous, there is also the risk of unintended outcomes – not least, the sidelining of farmers themselves.

The environment for FLID is constantly changing. The constraints faced by farmers today are different from those that farmers will face in a few years from now. It is thus important to keep assessing changes in the enabling environment, to remain flexible and adapt responses accordingly, in order to better support farmers as conditions around them evolve. Opportunities for expanding knowledge on FLID include:

- Better mapping, as the extent of irrigation that is developed through FLID is not well defined and mapping is needed.
- Improving the knowledge on FLID by documenting diagnostics and harvesting cases of both success and failure. The more that FLID is quantified, recognized and documented, the easier it will be to support it.
- Enhancing interventions and operations by twinning, adaptive learning, and exchange between countries and regions.
- Improving outcomes for farmers in changing conditions by exploring further how governments can create space and use new technologies that can usefully disrupt the status quo.
- Better understanding of how FLID can contribute to building resilient communities in fragile contexts where climate adaptation and mitigation can go hand in hand with irrigation development.
- Exploring how farmers can be acknowledged and strengthened in their role as stewards of the natural resources on which they depend.

We hope that the FLIDguide will prompt a willingness to find new solutions for irrigation development in the most opportune and sustainable ways. The more irrigation is practiced, the more the knowledge networks will be strengthened with increased farmer-to-farmer exchange and higher demand for knowledge from both public and private actors. The real measure of successful FLID operations will be when inclusive and dynamic farmer networks are initiated, and the resultant benefits extend far beyond the intervention scope and timelines.

i-Boxes

FLID systems framework

The seven main elements impacting on the farming business strategy

In order to achieve outcomes from an intervention in a FLID process, whatever those may be, analyzing the process dynamics and tentatively predicting the impact of the intervention is essential. This i-box briefly explains the origins, justification, and characteristics of the simplified systems framework that is central to the diagnostic and intervention planning that the FLIDguide aims to support.

Facing complexity head-on

Many practitioners argue that there is no need to get overly theoretical, and that it is essential to "keep things simple". While the authors would fully agree, there is a reality to be faced that has nothing simple about it. Irrigation development initiatives globally are well-known for their unpredictable – and too-often failed – outcomes that have resulted from simplistic interventions, whether technical, agronomic, marketing or organizational. Systems thinking itself dates back to Aristotle (350 BC), who famously noted that "the whole is more than the sum of its parts". The concept was formally popularized half a century ago by Von Bertalanffy (1968), though it was observed and analyzed in irrigation in the preceding decade (Republic of South Africa [RSA] 1955), and probably even earlier by many others. A complex system view of irrigation is now viewed as important and has become increasingly mainstream in theory and in practice.

Theoretical foundations

Studies on agricultural and irrigation development over the last 60 years have highlighted the multiple factors that must be considered to grasp irrigation success or failure (RSA 1955; Bembridge 2000; Perret 2002; Bolding 2004; Prieto 2006; Ostrom 2009; Van Averbeke, Denison, and Mnkeni 2011; Sender 2015; Mutiro and Lautze 2015; Lankford et al. 2016; Van Rooyen et al. 2017). Irrigation farming activity has a special character because there are so many different biophysical, social and technical elements that interact in a complex, highly dynamic and interactive process. A small change in any one of the elements can trigger a series of follow-on events that impact on the whole irrigation system, in ways both expected and surprising. A shift in weather, equipment functioning, markets, water stress, social or political environment, among many other factors, can cause the system to cascade in a domino effect in upward or downward trajectories.

Factors everywhere, but it's the big picture that counts

There is broad agreement in the literature on the factors that can be used to describe the irrigation system. Yet there is no standard categorization or definition. Definition is complicated by the reality that factors have a different character at different scales. What happens at the farm, on a scheme, in the immediate locality, in the sub-basin and nationally, are all variations of each other. There is also interconnectedness between the factors at any scale and across the scales in varying degrees. While care and attention is needed in defining and assessing key system factors, and in

understanding their relationships, a central focus on the *big picture* needs to be maintained. The 'whole' is something quite different from an aggregation of factors, with its own character created by the 'chemistry' of interacting factors. In simple static terms, salt is chloride plus sodium, but the taste is neither. All the more so for a dynamic multi-factor FLID process. Intervention planning, by definition, is the intentional interference and adjustment of factors with the aim of changing the big picture dynamics to achieve better outcomes. In real terms, this translates to the theory of change. To trigger the right kind of change, the status of the factors must first be assessed, the effect they have on each other has to be explored, and the implications of planned changes in one or more factors for the big picture must be predicted. The FLIDguide framework aims to be an instrument that helps develop the theory of change.

Pragmatism and compromise

The framework outlined here is the simplest combination of factors that the authors could devise that still adequately captures the complex dynamics of evolving FLID processes. Pragmatism and the need for ease of reference (terminology) and practical application (diagnostics) necessitated some theoretical compromises. Some factors had to be combined, and nuances in their descriptions across local and external scales simplified.

The FLIDguide framework – seven factors

The seven main factors for diagnosing FLID processes and planning interventions are shown in the schematic and outlined in the table below. The many related considerations and issues are covered in more detail in the seven modules of the FLIDguide.

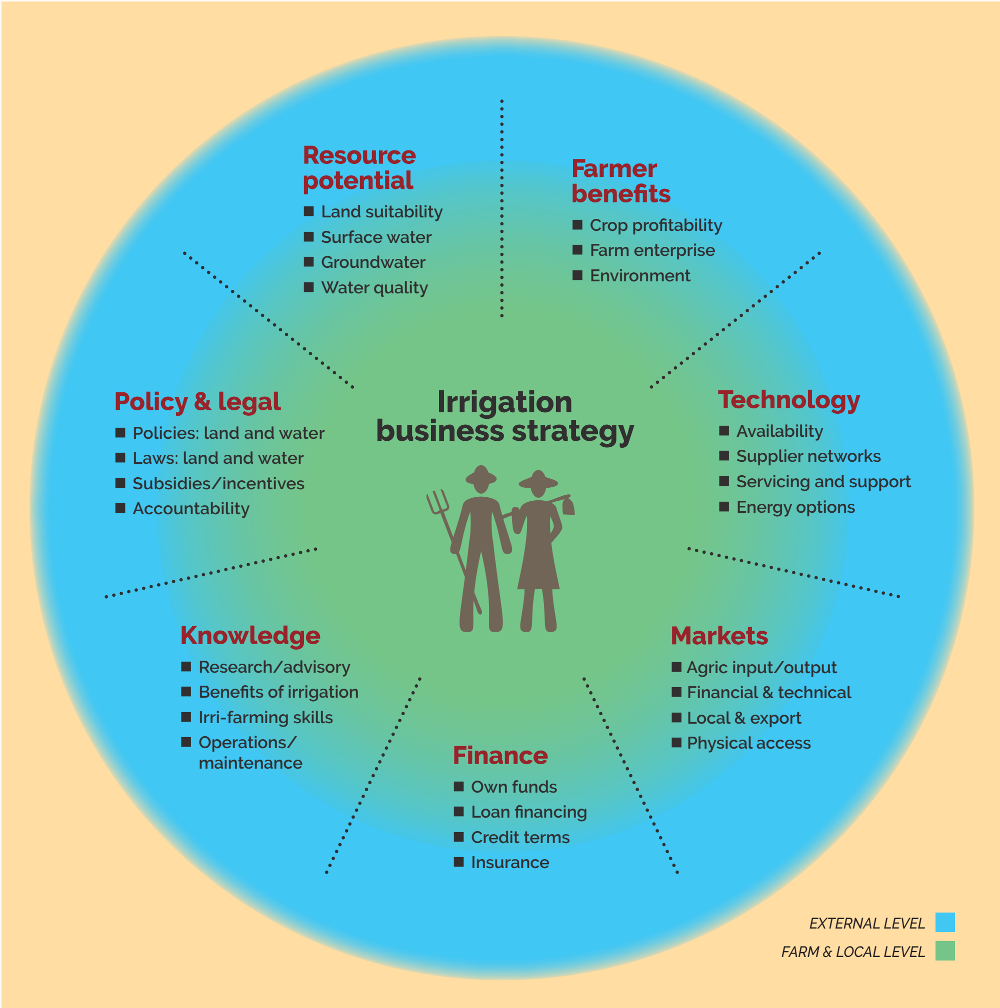


Table 1 Seven factors for diagnosing and planning interventions aimed at catalyzing FLID processes

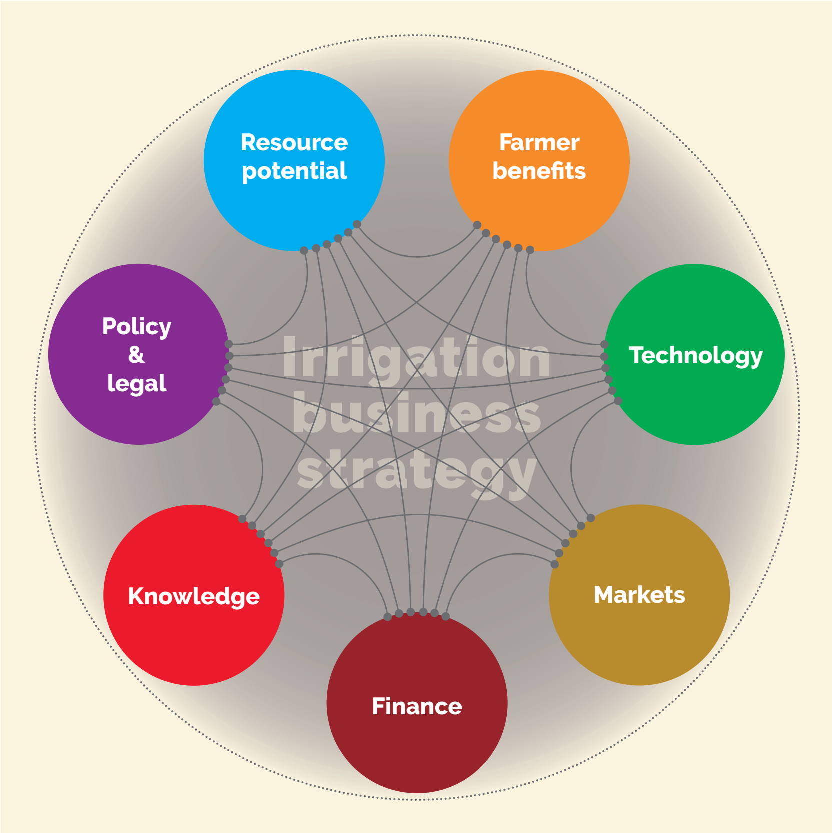
FLID *process* factor and summary elements	Description
Resource potential ■ Land suitability ■ Surface water ■ Groundwater ■ Water quality	The natural resource factor comes down to the potential for irrigation development based on climate, soil and water resources. Considerations would include rainfall; number of growing seasons; soils (drainage and salination); surface water and groundwater resource adequacy and reliability over time (i.e. changes over multiple years) and across seasons (wet/dry); and water quality, particularly in terms of siltation, nitrates and urban or agricultural pollutants.
Farmer benefits ■ Crop profitability ■ Whole farm system ■ Environment	Irrigation farming brings a range of additional benefits over and above rainfed farming activities. These additional, or 'incremental', benefits result from higher yields from irrigated crops being produced due to intensification, additional cropping seasons, and expansion of the irrigation farm. Typically, irrigation returns would be two or three times that of rainfed farming, with a global average of 2.6 (Molden 2007). The direct benefits can be quantified in terms of cash and food benefits to the farmer, to the extended farm system, and to wider society. Irrigated production is often connected to the farmer's other rainfed and livestock activities, and is just one part of the wider farm enterprise. Thus there are potential direct agricultural benefits that extend beyond irrigation production through livestock feed, marketing and scale synergies, cash-flow management, etc. There are also less quantifiable benefits of irrigation that must be considered, such as reduced risk exposure, increased resilience, reduced poverty, and improved nutrition and health.
Policy and legal ■ Policies: land & water ■ Laws: land & water ■ Subsidies/incentives ■ Accountability	Policies, and the laws and regulations that institutionalise water, land, financial and environmental institutions, can enable or constrain FLID processes. The status of the rule of law, and the de-facto ability of a farmer to assert his/her rights is one high-level consideration. The right of access to water, and maximum thresholds of abstractions before permitting is required, are particularly important for FLID. Similarly, the rights of use of wetland resources and the legal basis for water management organizations – and how those are given effect – impacts on conflicts and uncertainties where water is stressed. Environmental enforcement limiting wetland cultivation, and ensuring riverine conservation and soil erosion protection are important, but can also marginalise farmers. The type of land tenure arrangements, the numbers of farmers under different tenure types, land rental rates, perceptions of tenure security, and gender issues in regard to access to and use of land are further elements to consider. These all provide insight into farmers' risks in relation to their farming investments, and their ability to consolidate land, or expand the farm size through land exchange processes and achieve economies of scale.
Knowledge ■ Research/advisory ■ Benefits of irrigation ■ Irri-farming skills ■ Operations/maintenance ■ Labor	The knowledge factor is a synthesis of the "human resources" factor commonly described in the literature. It primarily addresses the *knowledge of irrigation* across all possible involved sectors and stakeholders. Enquiry into knowledge needs to assess the formal education system and extension services as well as non-formal, farmer-to-farmer learning in relation to agronomy, business-oriented farming and technology use. All knowledge is important, including that which farmers have of technical alternatives; that suppliers have of smallholders' technology needs; and that financing institutions have of irrigation farming profitability, risks and potential market value. In considering the reality of FLID processes, there is also the need to consider labor availability, and this is an additional human resources consideration that is not captured by the chosen title of "knowledge", but has some bearing on diagnosis and planning. Expansion of farming beyond a certain size means that family labor becomes insufficient to sustain production, and willing labor availability can be a constraint.

FLID *process* factor and summary elements	Description
Finance ■ Own funds ■ Loan financing ■ Credit terms ■ Grants ■ Underwriting funds ■ Insurance	Access to finance is one potential constraint to farmers acquiring both agricultural production inputs and irrigation infrastructure. The FLID process is rarely supported with formal financing, and in most cases the step from rainfed farming to irrigation farming is financed by own savings, or money borrowed informally from family or local lenders. Access to financing can unlock and fast track the growth process, by enabling acquisition of technology to intensify or expand in a significant jump, rather than in many small micro-steps. The large range of actors interacting with farmers in the process combine to pose important challenges when trying to improve financial access. The formal banking system is largely hesitant due to risks and lack of collateral, with limited appreciation of benefits. Suppliers provide financing as a way of achieving sales, while aggregators and processors may do so to ensure sustained produce supply. Unlike agricultural (input) financing, which only has a seasonal debt servicing cycle, infrastructure finance extends over multiple seasons or years. There are different challenges involved for different potential financial sources, whether from savings and informal loans or formal loans from aggregators, suppliers or financial institutions. Matching grant arrangements can reduce the upfront cost of equipment purchases, while crop insurance and underwriting of loans can reduce lending risks.
Markets ■ Agric input/ouput ■ Financial & technical ■ Local & export ■ Physical access	Markets, as a factor, is a cross-cutting consideration that applies to agricultural, technology and financial markets. Key market stakeholders, their roles, scope of services, and ability and interest in servicing the varied target groupings of farmers have to be assessed. Key players include agricultural input suppliers, credit and savings institutions, agricultural banks, co-operatives, technology suppliers, aggregators and processors. Smallholders, who are the main focus of the FLIDguide, are characterised by their *weak linkages* to markets and *loose value chains* which combine to undermine their profitability and add risk, thus increasing vulnerability to shocks. Market considerations need to include the maturity of FLID activity in a country, and the extent of services, financial, agricultural input supply, output markets and technologies, in terms of their de-facto accessibility, suitability to needs, and affordability from a smallholder's perspective. Decentralisation, represented by physical distance from markets, is an illuminating determinant. Where services are decentralised and output markets, aggregators, or suppliers are located in small centres, this indicates accessibility. Affordability is essentially addressed in the cost-benefit considerations under the factor of "farmer benefits", while suitability to available technology would be assessed under the technology factor.
Technology ■ Socio-technology ■ Types of technology ■ Servicing and support ■ Energy options	The availability of suitable irrigation technologies is one of the factors that enables farmers to drive the irrigation development process. Labor, cost and water-saving innovations have tremendous potential to radically transform the irrigation enterprise in terms of benefits and operational risks. Yet technologies cannot be separated from the people who use them and how they manage their time, learn skills, or organise their activities and other resources around them. Technologies are thus not inanimate but have important social requirements and effects. Technology types in relation to energy source, pumping, on-farm irrigation system, and soil-water management are particularly important in FLID processes. The range of equipment that is available on the market, the purchase and operational costs, operational and maintenance skills required and the implications for servicing and support are all important elements.

Policy and subsidy

Examples of catalyzing new irrigation activity through policy changes or subsidies include the removal of tariffs on irrigation equipment, establishing matching grant arrangements for irrigation equipment, or subsidizing agricultural energy supply (among others). These kinds of interventions have a set of follow-on implications for other factors. The net positive result is that technology and/or pumping costs are made more affordable. This lowers the financial hurdle for farmers who want to transition to irrigation, and for existing irrigation farmers to intensify and expand.

While positive benefits include more food and increased profits, there are also effects on other elements of the system. Market saturation at a local scale can result if crop diversification or access to more distant markets are not addressed. Increased water- and land-resource use can lead to competition within the immediate locality, requiring attention to social dynamics. At sub-basin levels, water permitting, environmental redress, or decentralized water governance responses may be needed. Thus a policy intervention needs to consider both potential limitations and the impact on other factors to achieve stated goals. In addition to the policy or subsidy interventions, parallel responses to maximize benefits and mitigate potentially negative outcomes may be needed.



Technical shifts

Another example of system interconnectedness is the popular, though sometimes disappointing, introduction of drip irrigation on pumped systems to replace furrow or micro-basin irrigation setups. While the aim is to increase profits by reducing pumping costs, as smaller volumes are needed, this change has a set of follow-on requirements, such as the need for new knowledge of irrigation practices. The amount of irrigation applied is no longer easy to observe and can be far off what is needed. Labor is reduced, which may not be a good thing if job creation is a priority or if labor has no opportunity cost. Timely access to spares is required, along with the means to pay for spares at short notice. New maintenance skills

are needed. If filtration and flushing is sub-optimal, or the physical integrity of the piped system is not well maintained, distribution of water across the field can be poor. Thus the technical shift can result in lower production and financial losses, rather than the intended gains, due to reasons that go beyond the limitations of the technical change itself. A meaningful response must consider all of these interlinked realities and address those that are critical to the achievement of the intended goals.

Value chains and marketing

Somewhat differently – and stepping away from a technical focus, but ending up with technical opportunities – FLID can, for example, be catalyzed by strengthening a producer organization. The organization can link farmers to new higher-value markets. Economies of scale from increased aggregation volumes, attention to sorting, packaging and quality control can all improve profitability without any technical changes to the irrigation system. New markets can trigger demand for different crops, leading to the need for a host of other system changes in response, including demand for new irrigation technologies.

Notes on persuasive approaches

A good starting point when promoting a FLID-support agenda is to reflect the current pace of irrigation development in relation to the growth that is envisaged in policy. The required annual budget can be calculated by multiplying the envisaged area by the current unit cost of public irrigation development (in excess of USD 10 000/ha).

It is useful to look at national and sectoral strategies such as: the Country Partnership Strategy of the World Bank; continental strategies; and other relevant documents in which the high-level priorities are clarified. These would be identified in the policy review discussed in i-boxes 3.4 and 3.5; see also Minh et al (2021). A well-thought-out, strategically linked, and well-pitched one- or two-page motivation might be all you need to get the concept approved and to move into operational design. In preparing a FLID pitch there are some useful tactics that can help make impact and get traction.

Give them credit for what they are doing right: Acknowledging the good work done, despite multiple challenges or failures, can set a tone of positive engagement and willingness to listen to new information.

Solve their problems: You need to find out what problem they have that a FLID intervention will solve. Decision-makers need key messages that resonate immediately, in the first ten seconds, with their own interests, purpose, and current burning problems. It is important to establish through formal and informal research, with colleagues and advisors to the decision-makers, what kinds of problems they must solve right now, and what outcomes are important for them. Weave the FLID pitch around those.

Speak their "language": identify the common terms and phrases used to describe the subjects you are working on. If you don't use their words and concepts, they won't get your message. Don't assume they understand your terms, or expect them to adopt your conventions – that is a process that may come about with time.

Dress in a way that is familiar to your audience: To be believable, you must use every instrument at your disposal that enables the person to identify with you. These may include compliance with dress codes, social norms, document and presentation styles, and professional and cultural etiquette.

Convince their advisors first: Find out who the decision-maker listens to, or considers an authority on the subject. Engage with them and get insight into what might prevent the FLID pitch from resonating easily. Address those issues, either in the pitch itself, or through lobbying the advisor.

Avoid being too dogmatic: While conviction is important, your point of view is more likely to be accepted if it is couched in ways that leave the decision-maker to make the decision, rather than having to concede to things put forward to them.

Pitch the message in a series of communications: Pitch the information in small but increasing bites. Allow time (even weeks) in between to let the idea settle in before getting to the detail. Start with just the idea or concept and avoid any attempt to convince, even where there is evidence. Allow the ideas to seed. Follow up with more detail, and in subsequent sessions, proceed into the full pitch.

Finally, keep it short and interesting: Visuals, images and charts with a few key big-letter messages are more likely to sink in than a barrage of facts.

Working principles in FLID engagement

The rate at which FLID unfolds is slow compared to the need for scaling up in order to meet the increasing demand for food and job creation. The surrounding environment is rarely highly conducive in terms of markets, financial and technology access, and knowledge. Constraints require effort to be overcome them. Farmers and other agents of change involved in FLID have inevitably faced high transaction costs in improving their situations, and it is usually the better-off individuals in society who are able to negotiate the hurdles, and who get the most benefit (Lefore et al. 2019). Engaging with FLID processes is intentionally and unavoidably people-centered – from consultation to co-planning and detailing the designs of interventions. Engaging with stakeholders requires an ethical sensitivity and attention to some working principles, outlined below.

1 Catalyzing the system – reducing hurdles and speeding up processes

Supporting FLID is *essentially a catalytic intervention to allow easier entry for new irrigation farmers, enable the process to move more easily and faster, and widen the circle of people who will benefit*. Working with FLID processes requires a quantum shift in thinking, particularly for engineers and specialists, who are used to a conventional design process: study, plan and design, construction and perhaps some training along the way. By contrast, the FLID facilitator must work with potential and existing irrigation farmers (including men, women and youth), suppliers, credit institutions, technology providers, traders and government to analyze dynamics, collectively identify problems, and then formulate solutions. The planning process and the intervention design should thus aim to support collaboration between varied actors in irrigated agriculture to target the system weaknesses and ensure that responses play a catalytic role.

2 A wider view of benefits

Engagement with FLID processes can build on expected positive effects on a wide array of development-related indicators. Interventions should aim to support broad development processes, with goals beyond the internal rate of return on investment, and also contribute to sustaining the natural resource base and the environment; providing water for multiple purposes; nutritional security; social stability; dignity through work through providing jobs; social equity; and giving voice to marginalized groups. Evaluating the economic and financial returns on interventions that catalyze FLID is one important part of planning. Returns are usually highly favorable, as farmers often carry a significant part of the overall direct investment cost. Yet, in addition to financial evaluations, it is important that effort is made to maximize these other benefits that are less easily quantified.

3 The intervener as a temporary participant

Across Africa, farmers continue to develop irrigated agriculture, finding creative solutions to obstacles they encounter. When interveners engage with FLID processes, they are facilitating an ongoing change process as temporary participants in

that process. Any action should have the eventual goal of keeping farmers firmly in the driver's seat of development, and without undermining farmer control. In a participatory perspective, it is the intervener that participates in the farmers' projects, rather than the other way around.

This requires a mindshift for development practitioners in the irrigation sector, who are sometimes used to replicating projects with the same modalities in different situations. Interventions catalyzing FLID are by their nature limited in time, and dialogue needs to be continuously reshaped, and new solutions identified as old challenges are resolved.

4 Recognizing diversity in interests

The intervener steps into and engages with a complex and dynamic process in which people not only seek to improve their irrigation practices together, but also struggle to obtain or further their control over resources. This can be to the detriment of others. Recognition needs to be given to the fact that farmers and the communities around them are not homogenous entities. Women or youth – as with men – do not represent a homogenous group; they play varied roles in agriculture, sometimes with divergent interests that depend on local context. Competing interests and goals are the norm, rather than the exception.

It is important to explore and understand the diversity within communities and their sub-groups, failing which the proposed solutions risk missing the diversity of interests, opportunities and needs of the different individuals involved.

5 Facilitating influence for less powerful actors

Irrigation interventions are processes of negotiation, and it is part of the facilitator's responsibility to create an environment in which less powerful actors also have the opportunity to participate in the process. *Facipulation* – the balancing act between facilitation and constructive manipulation – is a useful concept to draw on. Facilitators have the power to steer participatory processes by setting agendas, informing and managing discussions, framing analyses and summarizing conclusions. They can use processes and techniques to provide vulnerable people with the possibility to advance their position. Failure to include all stakeholders, albeit at different levels of collaboration and decision-making, can result in conflict, undermining positive outcomes.

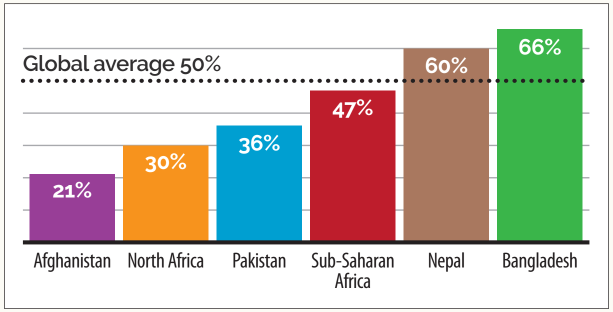


Figure 1
Women in the agricultural workforce in selected regions and countries

Women and youth often lack 'voice' in household and community decisions. Failing to engage women and youth may deepen inequalities, reduce access to water for households, and leave some people worse off than prior to investment. Interventions need to ensure equity in access to the inputs required for irrigated production, and expertise on gender and youth may be required to support design and implementation.

Choice of financing instruments

One of the key decisions during the preparation of a FLID operation that is supported by a development partner concerns choosing the most appropriate financing instrument. While different agencies have different instruments, they can be broadly organized along the following lines:

The choice among these financial instruments depends on the kind of interventions to be implemented through the operation. For example, if the operation is "infrastructure heavy" an appropriate investment operation might be one that is similar to a traditional irrigation operation. But more often than not, operations involve small infrastructures, technically simple and low-risk in nature, which are replicated across high numbers of farmers and farmer groups and will be better addressed through a results-based operation. The results-based operation allows mechanisms to be established in order to rapidly achieve rollout at scale. Rollout happens, inevitably, through decentralized structures and personnel and the results-based approach is not unduly burdened by procurement and safeguard rules. This instrument also facilitates rapid scaling-up, by building on country systems and partnerships, and in so doing, establishing a model that is easily replicable across the country. By using existing structures and systems, support for FLID is not rigidly tied to a single project operational model, the latter being associated with challenges of sustainability.

Investment financing might have a role to play at an early stage of the FLID process, when the country is still testing the theory of change for FLID. You can test if and where the pilot operation effectively translates into an improvement of the enabling environment before going to scale. Investment financing can also

Types of financing

Investment operation: Loans, credits and grants financing activities are used for creating physical and social infrastructure. The main focus is infrastructure development which is achieved by concentrating on procurement processes and safeguard requirements. It is usual to adopt the procurement framework and safeguard requirements of the development partner. Disbursement is made against eligible expenditure as agreed in a Financing Agreement. In the World Bank, this is called Investment Project Finance (IPF).

Result-based operation: The main focus is on the achievement of results, rather than on the physical inputs to achieve those results. This helps the country to improve the design and implementation of a development program by strengthening institutions and building capacity. It also helps strengthen partnerships between government, development partners, and other stakeholders by providing a platform for collaborating in a country's program. The country procurement and safeguard framework is usually adopted. Disbursement is linked to the achievement of agreed measurable and verifiable outputs and outcomes indicators, establishment of processes, or institutional changes. In the World Bank, this is called Program-for-Results (PforR).

Policy operations: This provides rapidly disbursing financing to help the country address actual or anticipated development financing requirements of domestic or external origins, against the implementation of policy and institutional actions. In the World Bank, this is called Development Policy Operation (DPO).

Private sector operations: Guarantees facilitate involvement of private sector stakeholders for mobilization of private investment.

allow farmer appetite for a FLID intervention to be tested. Irrigation development is farmer-led so it is not possible to fully predict farmers' behavior until actual opportunities are made available on the ground.

Each financing instrument has its place in supporting the variety of needs in a FLID intervention and it is opportune at the preparation stage also to look at "hybrid" operations. Investment and results-based operations can play complementary roles in the evolving FLID dialogue in a country. While a results-based operation might be better suited to support FLID interventions at scale, an investment operation could be used to pilot interventions and explore solutions, as a way of informing decision-makers about how to keep improving catalytic interventions for FLID. These interventions blend the advantages of more than one financing instrument. This might be appropriate, for example, when there is the need to ensure that some hard or soft activities take place in order to allow the results-based design to thrive. For example, training activities, purchase of key tools for staff, or hiring of key consultants might all warrant the extra processing for the inclusion of a small investment component into a results-based design.

An investment financing project with few disbursement-linked indicators (DLIs) might become appropriate, for example, when the FLID diagnostic has identified a key institutional change without which the lifting of other constraints would not result in the expected change for FLID farmers. If there is no expectation of complementarity with a policy operation in the medium term, the inclusion of a DLI might be a strong enough incentive to create the needed political willingness.

The hybrid option

A results-based operation with an investment component is a good solution to catalyze FLID at scale while ringfencing some key activities.

While it is important to choose carefully the best instrument, based on the specific context, it is also important to be opportunistic. When designing a FLID operation, the government and the development partner might not have complete freedom to choose from among the various financing instruments. With the increasing push towards bigger, and often multisectoral, operations, there is the need to strategically assess the pros and cons of each financing instrument in the light of the rest of the portfolio. For example, a FLID results-based operation could be embedded in a larger one focused on local government service delivery, or a larger investment operation looking at community-driven development activities. This is particularly true when there are policy or legal constraints as timing of policy operations is sometimes difficult to predict. In this sense, the best approach would be to have the rationale for the policy change drafted, and then "pushed through" when the opportunity arises.

Outcome and choice of indicators for the FLID operation

One element to keep in mind as the operation to support FLID is conceptualized through the theory of change is to keep the causality chain clear. The operation will not necessarily address all of the major constraints identified. Some of the constraints may be addressed by the government, with or without the support of other development agencies, or by another operation, either in parallel, or down the line. **It is fundamental to understand the linkage between these parallel interventions and the development objective of the operation in order to catalyze FLID** (parallel interventions are shown schematically in Figure 10 of the Main Guide as shaded boxes of inputs and outputs). It is important to bear in mind that:

1 **There might be other interventions that are necessary to achieve the outcome.** As much as they are not included in the operation design and support, their role in the achievement of the outcome needs to be recognized (such as legal covenants in the operation documents). Any related risks must be factored in as a risk to the development outcome of the operation to facilitate FLID.

2 **There might be other interventions which are not essential to achieve the outcome** but will be instrumental in the longer term. Examples include the intention to allow more farmers to be involved in the FLID process beyond those involved in the operation, or the need for environmental sustainability in the FLID process. It is important to keep an eye on this higher-level dialogue in parallel with the operation.

Quantifying indicators in operations in support of FLID is uncertain

FLID is demand-driven, so **farmers respond on a free-choice basis to opportunities made available**. Predicting the responses to interventions is inherently uncertain at the start. Scenario-setting with ranges is needed, and data from early-stage uptake can inform adjustments.

Outcome indicators are a proxy measure of what you want to achieve through the operation to catalyze FLID. Outcome indicators should quantify the change in irrigation expansion, intensification, and/or increased profitability resulting from the constraints that were lifted by the FLID operation. Together, the set of indicators is the matrix on which basis the success of the operation will be assessed. While there is no quick and easy answer to defining indicators that will work for all FLID operations, they can be formulated along the following lines:

Number of beneficiaries: Assessing the number of farmers who will benefit from a FLID operation is not a simple endeavor. Operations are intrinsically demand-driven, and it is difficult to define up front how many farmers will benefit from them. The situation is quite different for an intervention on a scheme with a boundary perimeter, where the number of farmers, plot sizes, farmer typologies, etc., are known. In a FLID operation, subsidies may be given for a range of technology options that are made available to farmers. The choices of technology can be estimated, but not well defined in advance. When new financing instruments are introduced to overcome the affordability hurdle, it is hard

to say how many farmers will actually apply for different technology options, no matter how detailed a market assessment may have been.

Gender disaggregation: In the same vein, the gender disaggregation of beneficiaries might not be obvious, but it is necessary to think in these terms as the operation is conceptualized. The risk of sidelining some groups of farmers – notably women – if the interventions are not carefully assessed, is a real one.

Scenarios and indicator values: The best approach is to determine a range of indicator values, based on the potential uptake of scenarios. To estimate numbers, scenarios need to be defined during the conceptualization process, and the reasoning behind uptake should be elaborated. In this way the number of beneficiaries, irrigation areas, and other key indicators can be set with a lower and upper range.

Establishment of mechanisms: A FLID operation is not only about the farmers who, by the end of the operation, might have implemented a change in their farming system. These farmers will be the most entrepreneurial, but they are usually followed by a larger second wave of farmers who might be more risk averse but who will benefit from the more conducive FLID environment at that later time. It is thus important that indicators for the project development objective (PDO) record the establishment of mechanisms which might, in the future, benefit a larger number of beneficiaries.

Beneficiaries of a FLID operation

One operation cannot cater for the needs of all farmers. Eligibility criteria should be clearly identified at the preparation stage, including whether the operation caters for individual farmers, farmer groups, or both (Module 2 i-box 2.1). Opening up an operation too much across the spectrum of farmers can become unmanageable and disperse focus and energy. Therefore, you need to target strategically – avoid pressure to respond to every opportunity in one operation. Keep in mind that working with a certain segment of farmers can have a ripple effect, through demonstrating the benefits to others. Start with those farmers for whom a relatively small change in the enabling environment can more easily catalyze action.

One decision you need to take as the operation is designed is whether to respond to the needs of individual farmers, or to groups of farmers, or both. The challenges faced by each category are quite different, as are the interventions needed. In many countries, public interventions have most frequently revolved around group organizations at community level which may be a "comfort zone" for government agencies and development organizations alike.

Eligibility criteria should be clearly identified at the preparation stage, including whether the operation caters for individual farmers, farmer groups, or both. The essence of "farmer-led" operations is that they are demand-responsive. While general characteristics of target groups can be defined, the farmers themselves are not selected at the design stage. Selection criteria can help determine boundaries and maintain focus, and might include:

- maximum farm area that can benefit (i.e. could be limited to smallholder farmers or include larger farms)
- minimum land tenure requirements (must have official or acceptable informal documentation)
- water access (maximum distance from the water source)
- water source (available water)
- existing value chain linkages (connection to output markets)
- financial means (capacity to contribute a set amount)
- collateral or credit history (needed to access a loan)

Facilitating inclusion and shared benefits from irrigation

Gender and generational inclusion at every project step: Women, youth and other resource-poor farmers often face added barriers across phases of technology adoption compared with male farmers at higher income levels. Project engagement should therefore target gender and generational inclusion across each project cycle: participatory project design, implementation, and impact measurement. Attention should be given to gendered and generational roles across all project activities, including identification of opportunities and priorities for support, both in the technological domain and beyond. This includes awareness or reach of technologies and practices, trying out a technology, and continued or sustained use of the equipment along with improved practices.

Women face more constraints: Within male-headed families, women also face intra-household barriers, which can add another layer of blocks that prevent them from participating in project activities, owning technologies or assets, and contributing to decisions about the use of technologies and use of income from technologies. Women may be excluded from informational events, field days and trainings, which prevents reach and awareness. This exclusion may be intentional and based on local gender social norms, or it may relate to men controlling means of information, such as cell phones and radios. In order to achieve the first step in technology adoption – awareness – projects must pay heed to the barriers women face in accessing information and make efforts to reach women through available or innovative communication tools.

> *Awareness* is the first step in technology adoption.
>
> You must understand the barriers women face in *access* to information.

Asset ownership: the shift from a men's-only domain: Projects that seek to increase access to irrigation technologies also need to understand asset ownership for women and youth. Irrigation pumps and related tools are often considered substantial assets (similarly to cattle), and ownership may default to men in a household or extended family, even if women purchase or are given technologies. This is particularly true in many countries in sub-Saharan Africa.

Default ownership by men reduces the ability of women in a household or extended family to access irrigation technologies for use on their own or joint plots, or control decisions about the use of technologies or the products of irrigation. This is worsened where women cannot access credit and thus cannot purchase complementary resources, such as farm inputs and labor, for their own or joint plots. Irrigation technology in the household may not reduce the labor of women and may even add to their labor if women must simultaneously contribute to the men's expanding areas of production. Women may be expected to continue to draw and apply water on separate fields manually, even if a male in the household owns a pump. In addition, women tend to lack influence over decisions about, or benefit from, income earned through irrigation. They also tend to lack information about income that can be earned from irrigated production, in cases where men control sales in the market; women commonly

> Default ownership by men reduces the ability of women (in a household or extended family) to access irrigation technologies for use on their own or shared plots.

cannot exercise influence over decisions regarding income except for relatively low amounts. While women may have an interest and try out technologies, especially if those technologies can be used for multiple purposes, the lack of control over technology use and decision-making on income earned from irrigated production can lead to lack of sustained investment or even disadoption.

Changing access to other critical resources: Even where women may overcome the external constraints, such as access to credit, land and labor, irrigation technology adoption may not benefit women. Women and children may face increased labor demands, but without improved income or nutrition in male-headed households. Women in female-headed households may be unable to invest at all without external support. These are examples of contextualized constraints that projects will need to understand in order to develop strategies that go beyond gender mainstreaming. Projects will require specific actions and dedicated budget to remove or mitigate constraints for women farmers, and to achieve the impacts on food production and nutrition associated with empowering women farmers. A useful guideline with suggestions is the resource, "Considering Gender When Promoting Small-Scale Irrigation Technologies" (SNV; posters).

Field level leadership

1 A different way of working with farmers is needed in FLID interventions

One of the challenges in a FLID operation is that private and public sector stakeholders have to adjust their ways of working to align to a farmer-responsive and farmer-centered approach. Financial institutions, equipment suppliers and value-chain actors have to be supported and encouraged to view themselves as service providers who need to gear their offerings and products to respond to farmers' expressed needs, rather than what they think is best for farmers. Example interventions that can facilitate change in private-sector dynamics are covered in Modules 4, 5, 6 and 7.

Public officials who are involved in implementation will also have to make a significant shift from their familiar role of being a powerful implementer in an irrigation project, to being a facilitator of a development process led by the farmers. This requires a whole different set of skills and processes; a strategy for dealing with this through field level leadership (FLL), is described here. Ensuring that public officials buy into this shift in focus and proactively support FLID development cannot be taken for granted. Public officials can be threatened by the idea of losing their role, and struggle to understand their new responsibility. The effort to equitably support small farmers may be hamstrung by corruption and elite-dominated patronage networks.

Formal policies have limited impact on personnel behavior in the public sector. Institutional reforms targeted at changing policies and restructuring organizations do not account for informal culture and norms, which often trump the formal rules and incentives (Helmke and Levitsky 2004). A World Bank review indicates a more than 50% failure rate for the reform efforts aimed at improving the performance of civil service and administration (Independent Evaluation Group [IEG] 2008). **Therefore, success in FLID would require going beyond policy and knowledge, in order to inspire and motivate the staff of irrigation and agriculture departments, who literally embody the service delivery mechanism for FLID.**

2 Agents of behavioral change through field level leadership

One successful way of prompting the needed change in role for government personnel is to create scores of change agents through field level leadership. The conventional wisdom is to pray for a caliber of leader who can organize and inspire the ranks. More recent advances emphasize the importance of decentralized, multi-agent leadership, where progress happens not because of one heroic individual at the top of the organizational pyramid, but from the cumulative efforts of numerous champions at different levels, exercising different types of leadership (Andrews 2016). FLL is an operational approach designed for public-sector programs where attitude and behavior of the "last mile" actors is a key determinant of success. The FLL approach aims to create change leaders at all ranks of staff, and is designed for efficient and sustainable implementation in public organizations (World Bank forthcoming 2021).

3 Intervention elements and process

The field level leadership process includes the following elements: collective reflection by staff in safe spaces; networks of change champions; and individual commitments to rapid results (90 days). It uses an internal, peer-to-peer model of behavior change, and is therefore more cost-effective and sustainable compared to trainings by external coaches.

Field level leadership in action

Process Description: Field level leadership is intended to be implemented through a peer-to-peer learning model, whereby a public agency that has successfully implemented an FLL program provides the initial training and implementation support to a new agency. The full program requires 12–18 months for implementation, depending on the number of agency staff. Implementation of FLL is organized in four phases:

Phase 1: Creation of a Vanguard Group of FLL Facilitators. The process starts with the selection of a small seed group (10–20 people) of agency staff, who will become FLL master trainers for their organization. This group trains closely with the FLL experts from another agency, for a period of 10–12 days, to understand the FLL approach, develop an FLL workshop curriculum specific for their own organization, and learn how to lead FLL workshops.

Phase 2: Collective Introspection to Reveal Values and Motivations for Change. After the master trainers complete their training, they facilitate a series of 4-day workshops for their colleagues. The workshops create a safe-space environment for reflection and self-assessment. Participants are asked to share their individual hopes and aspirations; they discuss the challenges facing their organization. Difficult subjects such as corruption are also broached. Workshops conclude with each participant adopting a few goals that they believe can be achieved in the next 90 days.

Phase 3: Spontaneous Networking, Experimentation and Community Outreach. The workshops serve as a mechanism for people to find others who share their values and motivation. After the workshops, some of the participants start connecting with like-minded colleagues, by setting up regular meetings and virtual/online groups to share knowledge and support each other. A small group of champions is thus initialized within the organization.

Phase 4: Making Sense of the New Changes and Culture. A follow-up workshop is organized for each cohort, allowing the participants to share their experiences of successes and failures. There is significant discussion of possible changes in workplace systems and procedures for improving public service delivery.

Costs: The main costs of implementing FLL include the training of the vanguard group of facilitators and the room and board costs for the FLL workshops. The FLL training program, hosted by a public agency with FLL expertise, spans 8–10 days, and costs about USD 50 000 for a batch of 20 facilitator candidates. The cost of local FLL workshops depends on location, and ranges from USD 30 000–80 000 for a department with 100 staff members.

Network of FLL Expertise Providers: FLL expertise is provided through a public-public partnership, by public service delivery organizations that have successfully implemented their own FLL programs. Currently there are two centers for FLL training: Centre for Excellence in Change (Chennai, India) and the Legedadi FLL Training Centre established by the Addis Ababa Water and Sewerage Authority (Ethiopia). FLL expertise and trainings are likely to be available in French and Portuguese in future, in Morocco and Mozambique.

4 Results and outcome

From feedback on the various pilot implementations conducted by UNICEF and the World Bank, this intervention has shown remarkable success. Examples include:

- 34–77% higher outreach to communities; 80% increase in women reporting positive behavior from staff during community meetings (Tamil Nadu Water and Drainage Board, India)
- 30% increase in site visits and 40% increase in satisfaction with irrigation staff, reported by communities (Tamil Nadu Irrigated Agriculture Modernization Project, India)
- 55% improvement in reliability of scheduled water supply (Dar-es-Salaam Water and Sanitation Authority, Tanzania)
- 47% increase in revenues; 50% reduction in employees coming late to work (Addis Ababa Water and Sewerage Authority, Ethiopia)

Some quotes and testimonials:

"Our staff have changed a lot. Key performance indicators have changed a lot. This is the area where we are investing more: Changing the attitudes before investing in material projects"

- Cyprian Luhemeja, CEO

(Dar es Salaam Water and Sanitation Authority, Tanzania)

"I live in Mlandizi, more than 50 km from Dar es Salaam. After the training I leave my house at 5am every day and I don't have specific time anymore to go back home"

- Technician

(Dar es Salaam Water and Sanitation Authority, Tanzania)

"I can say that I have full job satisfaction. The people in these villages welcome me now when I go there. They call me Sir or refer to me as their elder brother"

– Irrigation Engineer

(Tamil Nadu Irrigated Agriculture Modernization Project, India)

"During my entire career, I was a technocrat. I would just prepare MIS tables. I didn't know anything about water management. Now I feel ashamed about that. I feel that with this training, I have been able to understand the traditional wisdom of the community, their views, their needs"

– Executive Engineer

(Tamil Nadu Water and Drainage Board, India)

"Initially I was hesitant in sharing my phone number with the villagers. Now I give my number easily."

– Junior Engineer

(Tamil Nadu Water and Drainage Board, India)

"Prior to the training, if someone approached me for drip irrigation pipelines, I would say 'This is not my department'. Now I take his problem and connect him to the right people"

– Agriculture Officer

(Tamil Nadu Irrigated Agriculture Modernization Project, India)

Uganda country case

Country context

In Uganda, agriculture plays a critical role for income generation, particularly for the poorest 40% of the population. The sector contributes 22% to gross domestic product (GDP) and 50% of exports. The sector plays a fundamental role in job creation, employing 70% of the total population and 80% of the poorest segment of society. It is a major source of employment for the younger generation, with around 50% of household heads under the age of 40 engaged in agriculture. **Increased agricultural production for internal and regional markets is a priority growth path for Uganda.** The government, in the Second National Development Plan, has defined agriculture as a key economic sector in Uganda's transition to a middle-income country and has emphasized the importance of value addition, commercialization, building resilience to climate change, and job creation.

Nevertheless, the agricultural sector growth rate remains far below potential: 70% of farmers are engaged in subsistence agriculture, and market dysfunctions are exacerbated by the small size of farms (1.1 ha on average). Unreliable quality of agricultural inputs is a major problem, which discourages farmers from investing their limited resources, and indeed the country records the lowest utilization of inorganic fertilizers in Africa. Most of the tilling is done by hand.

Climate change has added a further challenge: while historically the favorable rainfall pattern allowed two rainfed cropping seasons per year in most parts of the country, the change in precipitation is creating the need for irrigation, currently practiced on a mere 1% of the agricultural area. The rainy season, traditionally lasting eight to nine months in a year, has become shorter, averaging six to seven months a year since 2010. **Smallholder farmers perceive weather to be the greatest risk to their agricultural activities** (Figure 1). When facing a shock, smallholders have little means to fall back on, with a ripple effective on the livelihoods of a large share of the population.

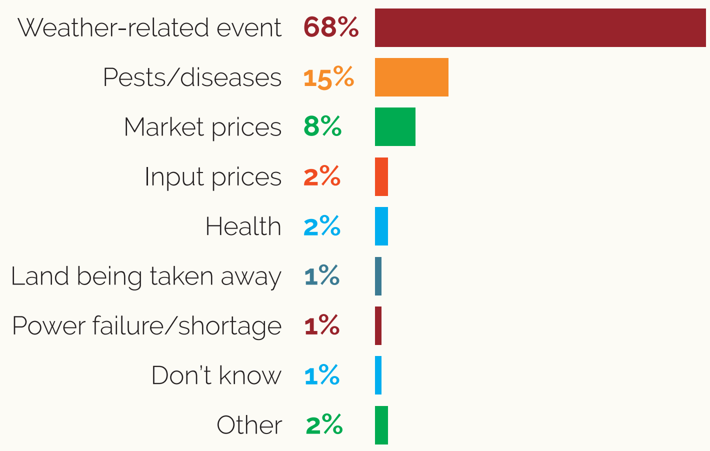


Figure 1 Most significant risk to agricultural activities according to smallholder farmers (National Survey and Segmentation of Smallholder Households in Uganda (reproduced from Anderson, Learch, and Gardner 2016)

The Government of Uganda recognizes the potential of the agricultural sector for food security, jobs for a young population, and sustaining the transition to a middle-income country. However, these goals cannot be achieved if the agricultural sector remains vulnerable to climate change by relying almost exclusively on rainfall. The Government, in its Vision 2040, appropriately lists irrigation as a high priority, and the 2018 National Irrigation Policy sets the ambitious targets of 1.5 Mha irrigated by 2040, compared to the current 77 000 ha (although this does not account for existing FLID areas, which are

unknown). Public-led irrigation development is far from matching this need, with only a few hundred hectares of newly irrigated land each year. The Government of Uganda requested the World Bank to support irrigation expansion in 2017, in the form of an investment operation for large-scale irrigation schemes development. The preparation of the operation was also a chance to analyze the potential and constraints for individual micro-scale irrigation development, resulting in the diagnostic, scoring and identification for interventions to catalyze FLID. The process, from diagnostics to the operationalization of interventions, is presented below

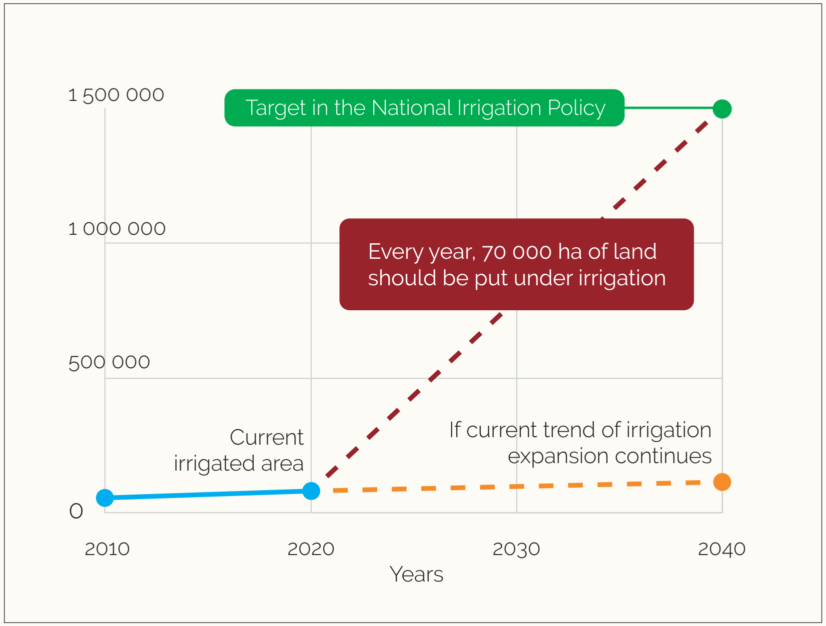


Figure 2 An example of current trends and future acceleration to achieve targeted irrigation areas

Diagnostic and scoring

Half of the irrigation potential in Uganda is close to surface water resources, making it possible for farmers to develop individual irrigation and small group schemes without need for major water mobilization infrastructure. The estimated unit cost of 3 000 to 5 000 USD/ha is a quarter to a third of the average public-led medium-scale irrigation development in the country.

The high **Resource potential** is accompanied by a high increase in **Farmer benefits** derived from irrigation. The benefits result from a combination of an additional crop during the dry season, the ability to deal with dry spells, and earlier production in the wet season, thus ready to hit the market when prices are higher. However, the relatively high cost of irrigation equipment in Uganda negatively impacts the cost benefit analysis.

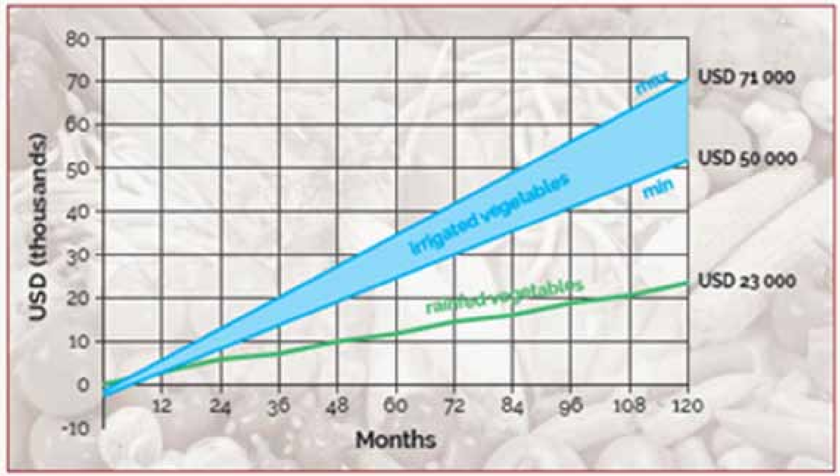


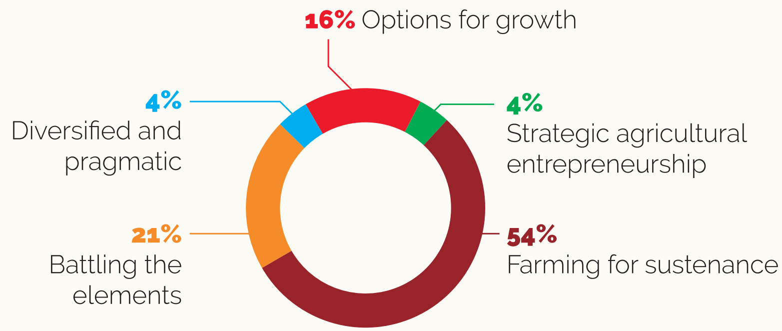
Figure 3 Range of net farm income for 1 ha of irrigated mixed vegetables versus rainfed farming in Uganda (lifetime cost over 10 years)

Irrigation would greatly benefit **smallholder farmers who are attempting to make the change towards more productive agriculture but do not have the means to do this.** Constraints are

particularly limiting for an estimated 80% of farmers who live below the poverty line, identified as a segment of the farming population called "battling the elements" (Figure 3).

Finance, knowledge and technology are the major constraints holding smallholder farmers back from autonomously developing irrigation in Uganda. The scores for the factors are shown in the diagnostic spider plot together with the rationale.

Overall in Uganda, there is a strong case for FLID: irrigation expansion is a high-level government priority, there is a large natural resource potential, and there are proven benefits for smallholder farmers to irrigate. Indeed, the upper part of the spider plot ("Making the case for FLID" diagnostic) shows a large area of green. However, smallholder farmers are not autonomously developing irrigation because the environment for FLID is significantly constrained, as represented by the small blue area in the lower part of the spider plot in Figure 5.

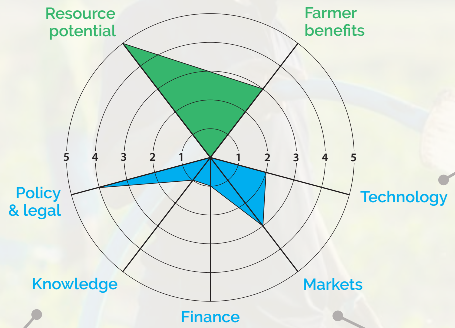


Segment	Farming for sustenance	Battling the elements	Diversified and pragmatic	Options for growth	Strategic agricultural entrepreneurship
Above the poverty line	14%	20%	100%	62%	100%
Below the poverty line	86%	80%	0%	38%	0%

Figure 4 Uganda smallholder segments (Anderson, Learch, and Gardner 2016)

Irrigation is still very much underdeveloped (1% of agricultural land irrigated), thus there are large land resources. The country also has large potential in untapped water resources (1 540 m^3/yr per capita). The National Irrigation Policy sets the goal of 1.5 million ha of irrigated land by 2040, of which half can be FLID with individual irrigation and small group schemes.

Irrigation can allow farmers to introduce a third crop production during the dry season, as well as to deal better with dry spells and slightly shift production during the rainy seasons to hit the market when prices are higher. This translates into considerable increase in benefits for the farmers. However, high cost of irrigation equipment negatively impacts the cost benefit analysis.



Water and land tenure do not represent a constraint to farmers to independently develop irrigation. While Uganda requires smallholder farmers to apply for an extraction permit with unaffordable charges, the large water potential translates into low enforcement of these regulations, with farmers developing irrigation that is not formally recorded. A progressive land tenure system recognizes customary rights..

Irrigation equipment is available in Uganda, with suppliers from nearby countries – Kenya primarily – looking with increasing interest to Uganda. Widespread use of solar for domestic water supply makes transition of the technology to the irrigation sector straightforward. However, cost of irrigation equipment is considerably higher than in neighboring countries due to the low number of transactions. In addition, suppliers have limited penetration in the countryside, and quality of the products is sometimes questionable.

Irrigation is nascent in the country, thus the knowledge network is strongly underdeveloped. Most of the farmers have never seen irrigation. Public sector is still in the process of recruiting irrigation engineers, a profile which did not exist until a few years ago. Irrigation equipment suppliers are mostly located in major cities, with limited contribution to knowledge dissemination.

Smallholder farmers do not have sufficient savings to develop irrigation. They have very limited access to finance, due their lack of collaterals, risk aversion, and lack of knowledge of financial institutions for irrigation. Some irrigation equipment suppliers provide pay-as-you-go, but this applies to an extremely small portion of the potential business scale. Even with access to finance, cost of equipment would remain unaffordable.

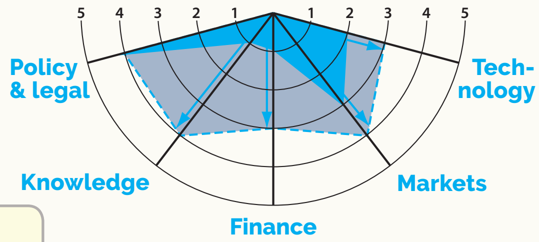
Market linkages for smallholder farmers are generally weak, but the value chains expected to benefit more from irrigation – coffee and horticultural – are the better organized ones. The coffee value chain is well established and based on millions of smallholder farmers. Horticultural value chains could benefit from diversification, with only a handful of value chain actors currently controlling the market.

Figure 5 Scoring rationale for FLID in Uganda

Interventions that address the priority constraints

The assessment of weaknesses in the enabling environment (i.e. the scores) shows that the Government of Uganda can catalyze FLID through a set of interventions that minimize the main constraints faced by smallholder farmers. These targeted interventions are summarized in the schematic and described thereafter.

The interventions with the highest priority are the ones that aim to improve the weakest factors, which are irrigation knowledge and access to affordable finance. These two require a higher level of public investment while private sector actors and farmers themselves can contribute more directly to addressing the other constraining factors. However, the diagnostic also revealed the critical underfunding of local governments which greatly restricts their ability to implement various interventions, despite their mandate in the National Irrigation Policy to support micro-scale irrigation development..



Intervention 1: Public sector officers' knowledge development
Intervention 2: Farmer learning and demand-led service provision

Intervention 3: Improved access to loans
Intervention 4: Partial subsidy

Intervention 5: Ensuring quality standards
Intervention 6: Using IT to reduce overhead costs

An overview of the operation to catalyze FLID

Since 2017, the World Bank has been supporting the Government of Uganda with its decentralization agenda, with a results-based loan aimed at improving the adequacy and equity of fiscal transfers and the fiscal management of resources by local governments for health and education services.[1] The Government of Uganda and the World Bank agreed that this same vehicle could be used to implement the interventions needed to catalyze FLID. In 2020, the results-based loan was increased and expanded to support the Ministry of Agriculture and local governments in the implementation of the irrigation interventions.[2]

UgIFT MICRO-SCALE IRRIGATION PROGRAM Improving farmers' livelihood

The theory of change (Main Guide Section 7): At the core of the Program is the creation of a budget line for micro-scale irrigation at local government level, of which 25% is to support awareness-raising

1 Uganda Intergovernmental Fiscal Transfers Reform Program (P160250)
2 Uganda Intergovernmental Fiscal Transfers Reform Program – Additional Financing (P172868)

activities among farmers, the establishment of demonstration sites, and farmer field schools (i-box 4.8); the major portion of 75% is for the partial subsidy to farmers for the purchase of individual irrigation equipment (i-box 5.7).

The Ministry of Agriculture supports capacity development of local government staff (Main Guide i-box N); sensitization of financial institutions to increase their knowledge of both irrigation and of the risk-mitigation measures provided by the Program, thus increasing chances for farmers to obtain financing; and the pre-qualification of suppliers to ensure quality equipment. The Program did not directly intervene in market linkages, given the unavoidable realities of time and budget and the need to prioritize interventions. Strengthened market access and functions were important, however, so a strong focus was put on value chains through the information outreach (see brochures in Main Guide i-box M) and in the program knowledge interventions, relating to both stakeholder information exchange and farmer field school content. This addressed the marketing element to the extent that it was possible. The World Bank supports the Micro-scale Irrigation Program with a USD 50 million loan, expected to be matched by up to USD 24 million of farmers' contributions.

Impacts

The Program in the first few months of implementation has already seen 17 000 farmers expressing interest. Of these, 20% are women farmers. Among the male farmers, 80% also provided details for their wives so that they were included in the decision-making process and capacity-development activities. Over the period 2020–2023, the establishment of a more conducive environment is expected to translate to between 12 000 and 28 000 smallholder farmers establishing irrigation, as well as strengthening the knowledge of farmers and public stakeholders. The program is expected to contribute between 5 to 10% to the annual irrigation expansion target of the National Irrigation Policy across 2022 and 2023.

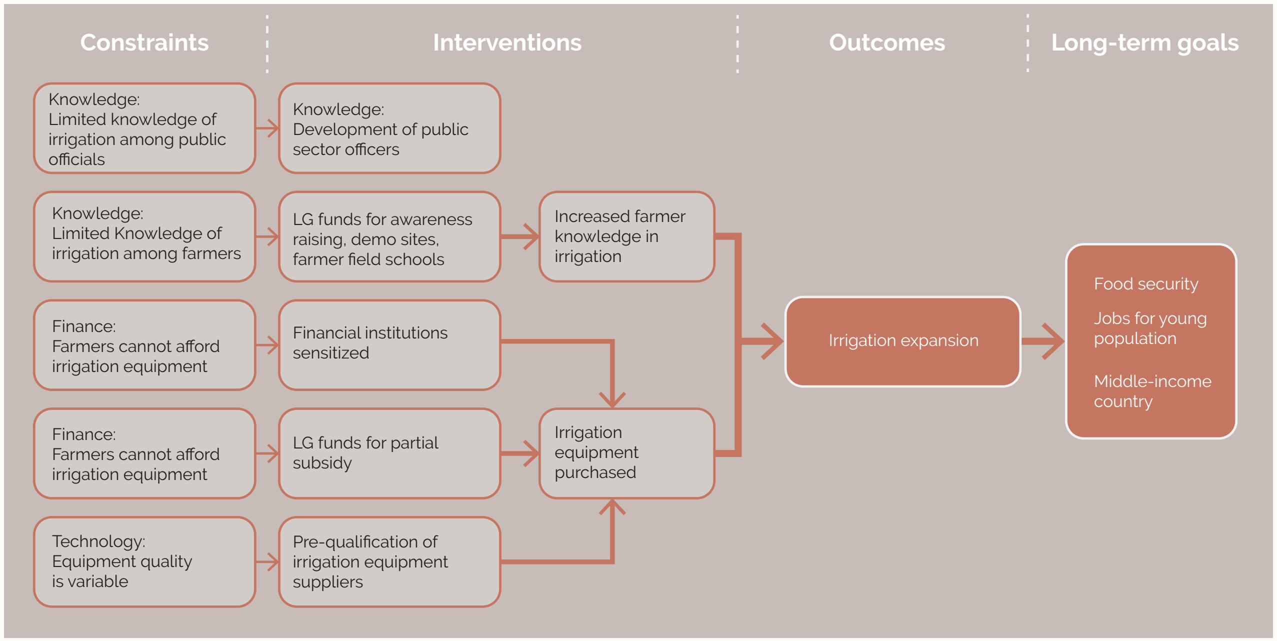


Figure 6 Uganda theory of change

Uganda country case – Setting up the (partial) subsidy intervention

When farmer affordability is low, subsidies are a key instrument for accelerating irrigation equipment uptake and intensification. Under the Uganda Micro-scale Irrigation Program, the farmer and the local government co-finance the purchase of the irrigation equipment, which is then owned, operated and maintained by the farmer. The farmer selects the typology of equipment (solar vs petrol vs diesel pump; hosepipe vs sprinkler vs drip on-farm equipment; tank vs no tank) and provides his/her co-payment to the local government, either using savings or obtaining a loan. The local government tops up the farmer contribution through the subsidy, and competitively procures the irrigation equipment on behalf of the farmer. In other words, the subsidy is blended into equipment-purchasing financing arrangements using **matching grants** where the farmer contributes a part of the cost.

In order to ensure that farmers lead in the irrigation development process, subsidies should be **partial**, aiming only to bridge the affordability gap for the smallholder farmer and nothing more. In setting the farmers' contributions, attention needs to be given to considerations such as realistic affordability levels; the way the grant impacts on market costs; broader awareness of the project from communications over time; and the government's ability to finance. Subsidies are a quick and effective way of achieving affordability when the financing environment is weak, but caution is warranted to avoid dependency. The potential downsides must be carefully assessed. In the case of the Uganda Micro-scale Irrigation Program, the subsidy level is set as a percentage of the equipment cost, depending on the energy choice by the farmer (25% subsidy in the case of a petrol or diesel pump; 75% for a solar pump). A cap is set on the subsidy amount as a function of the area to be irrigated, so as to focus the public support on farmers who have the best conditions for irrigation expansion (e.g. proximity to the water, enabling low cost of mobilization), and always capping at 1 ha per farmer to ensure focus on smallholder farmers.

Setting up the level of the partial subsidy depends on the capacity of the segment(s) of farmers targeted by the intervention to provide the co-payment. This in turn is dependent on the possibility for the farmer to raise a loan. In the case of the Uganda Micro-scale Irrigation Program, the level of farmer co-payment was determined so that, if the farmer required a loan, he/she would be able to pay it back after six months in the case of a solar-powered system, and over 12 months for petrol-powered equipment, taking into account the benefits from irrigation. Under the Program, sensitization of commercial banks offering products for smallholder farmers was carried out, to increase the chance of smallholder farmers being granted a loan where needed.

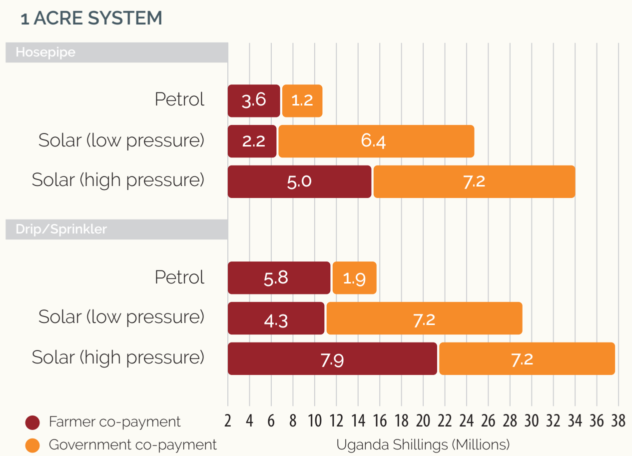


Figure 1 Indicative farmer and government contributions to equipment costs in the Uganda micro-scale irrigation program

Uganda country case – Leveraging digital

Digital can be a game-changer in the implementation of interventions to catalyze FLID. In the case of the Uganda Micro-scale Irrigation Program, local government staff carries out a farm visit for farmers who have expressed interest in the Program, collecting farm data through a Program-dedicated App – IrriTrack - and feeding the data in real time to a monitoring and information system (MIS).

Benefits of using an App for farm data collection:

Can capitalize on the advisory service role of public extension officers to afford smallholder farmers the opportunity to develop irrigation in the specific farm context: Knowledge has been identified as a major constraint for smallholder farmers in Uganda (i-box J). This impedes their capacity to autonomously assess the pros and cons of irrigation development for their farm context, and leaves them dependent on the advice of irrigation equipment suppliers, which may result in sub-optimal decisions.

When using information tools and Apps, you need to ensure appropriate training is given as well as the provision of suitable devices for field staff. Remember to set aside money for this as you design the operation in support of FLID!

Increases competition among irrigation equipment suppliers while reducing their overhead costs: The dispersed nature of FLID farmers, coupled with their small size and the limited presence of suppliers beyond the major cities, means that suppliers have high transaction costs in carrying out farm visits, and would often prefer losing a prospective client rather than incurring the cost of a farm visit without the certainty of getting the contract. Thanks to the data collected through the App, suppliers can bid without having to visit the farmer (although this is given as an option) which allows for better competitive strategies among suppliers. Plus, increasing the number of farmers served in a certain area allows the suppliers to curb overhead costs, and set up aftersale services more efficiently.

Improves central monitoring: By feeding the information into a centrally managed MIS, the App allows for easy monitoring of the performance of the Micro-scale Irrigation Program initiated by the Ministry of Agriculture. In addition, the App opens up the opportunity to link to water resource management monitoring, assessing, for instance, how water withdrawals by small irrigators impact a water-stressed hotspot.

Uganda country case – Training public officials in a COVID-constrained setting

Projects and Programs aiming at catalyzing FLID, by definition involve a large number of staff in their implementation. FLID might be a phenomenon of interest for smallholder farmers, but the number of farmers can be huge, with, consequently, large-scale impacts. Training a large number of staff is not an easy endeavor, even more so in view of COVID risks and restrictions.

In the case of the Uganda Micro-scale Irrigation Program, 40 local governments districts are at the core of the implementation structure, thus the Program was faced with the challenge of how to train a large number of public officials (about 15 per district) while limiting costs, keeping timelines tight, and adhering to COVID restrictions. The decision taken was to design an **on-line training program**, which would allow for the training of 650 staff members in a few weeks at a fraction of the cost.

You can get access to the online training of the Uganda Micro-scale Irrigation Program by contacting the Ministry of Agriculture in Uganda at ugiftirrigation@agriculture.go.ug or clicking on the following links:

Module 1: Introduction https://bit.ly/3gwuAO8

Module 2: Getting started https://bit.ly/309Nftg

Module 3: Important considerations https://bit.ly/3d7mlja

Module 4: Preparation for Farm visits https://bit.ly/2FddAP2

Module 5a: Farm visit https://bit.ly/3cKhrQk

Module 5b: Farm visit https://bit.ly/3jWqmAI

Useful observations on using this kind of approach:

Self-pacing: On-line format allows staff to decide when to carve out time for training, and reduces conflict with other tasks. However, there is an advantage in having the whole group proceeding at a similar pace; thus, in the case of the Uganda program, the modules were released one at a time, with release of the subsequent module depending on the completion rate of the previous one. Production of a certificate when a module was completed proved to be a powerful tool for allowing the Ministry of Agriculture to track training progress at local government level.

Facilitate exchange and feedback: One perk of having the whole group proceeding at a similar pace was the possibility of fostering discussion about the training material on shared platforms (WhatsApp groups were created in the case of the Uganda Program and managed by the Ministry of Agriculture). When training is delivered on-line it is important to ensure feedback loops (in the form of, for example, feedback forms or exercises). In the case of Uganda, discussions on the exchange group allowed the lack of understanding of certain technical aspects to be identified, which enabled quick response through the production of additional learning material.

Check out the video: https://www.youtube.com/watch?v=jxilqHhsuGA

Ensure accessibility: Aside from needing a certain amount of computer savviness to learn through an on-line platform, there is the need to ensure that staff have adequate devices and are provided with internet data. You need to account for these costs as you design the operation in support to FLID.

Uganda country case – Communication strategy

The communication aspects of an operation in support of FLID should not be underestimated, considering the multiplicity of stakeholders involved, either directly in the implementation or needing to be sensitized, as well as the dispersed nature of the process. As the operation is put together, adequate budget needs to be set aside to this end. Under the Micro-scale Irrigation Program, brochures were found to be a simple but effective medium for information-sharing among key stakeholders (Module 4).

Some pointers on this approach:

1 **Breakdown by stakeholder group:** Brochures were produced for farmers, local leaders and financial institutions. Each brochure remains short and crisp, focusing only on the information needed by the specific stakeholder over a given stage of the Program, and using appropriate language and tone that is accessible to the reader.

2 **Breakdown by phase of the Program:** Particularly when it comes to the farmers, striking the balance between completeness of the information (key in allowing them to remain at the core of the decision-making process) and simplicity (they might be overwhelmed by the amount of information needing to be processed) is tricky. In the case of the Uganda Micro-scale Irrigation Program, breaking down the information in sequential brochures was found to be a good approach. Plus, it allows the Program to adjust the messaging based on the performance results for each step of the Program.

Table 1 Communication outreach materials for the Uganda micro-scale irrigation program

	WHO is targeted?	WHAT kind of information is communicated?	WHAT are the intended outcomes?
Farmer brochure 1	Potential farmers who could benefit from the Program	Explains the objectives and general principles of the Program, with a focus on the co-financing mechanism, farmer's co-payment, eligibility criteria, the main steps of the Program, an indication of by when a farmer who is applying can expect to receive the equipment, supply of requisite form to express interest, contact information, etc.	Gauge interest from farmers in the Program, but also ensure that all farmers have access to the same information (transparency) and guide local government staff in the provision of key information to farmers.
Farmer brochure 2	Farmers who have expressed interest in the Program	Provides the farmers with the detailed steps of the Program, and gives an overview of the questions they will be asked during the farm visit and the documents they will need to produce.	Get farmers prepared for the farm visit. This is important as some of the aspects discussed during the farm visit can be sensitive, such as land tenure or co-payment capacity. The more the farmer is mentally ready for these questions, the more she/he can have an open and constructive discussion with the local government staff.
Farmer brochure 3	Farmers currently undergoing the farm visit	Provides the farmer with the sequential steps for the choice of the most suitable irrigation equipment for their specific situation and financial capacity.	Ensure that the farmer remains solidly in the driver's seat of the irrigation development process by (i) providing them with the tools to make an informed decision on the irrigation technology, and (ii) explaining the financial implications (both in the short and long term) of their choice.
Farmer brochure 4	Farmers who have successfully completed the farm visit	Provides the farmer with the details of the procurement process up to installation.	Ensure that the farmer understands the contractual relationship among the key stakeholders, and how the money flows.
Local leaders	Political leaders, religious leaders, local influencers	Explains the objectives and general principles of the Program with a focus on the co-financing mechanism, the eligibility criteria for a farmer, the main steps of the Program, contact information, and the role that local leaders can play in the success of the Program.	While they might not have an official role in the implementation, local leaders can influence the perception of the farmers. The brochure has the function of increasing their buy-in and outlining the (unofficial) role they can play for the benefit of their community.
Financial institutions	Commercial banks, microfinance institutions and others	Explains the Program and the role that financial institutions can play in the provision of loans to farmers in order for them to cover the co-payment. Provides details on the calculation of the farmer's share and – most important – presents the advantages that financial institutions can get from the Program in terms of increased business volume.	Financial institutions can feel more motivated to lend to smallholder farmers if they feel that they are backed up by a solid program that reduces their risk profile.

Niger country case

Country context

Niger remains one of the poorest countries in the world. Agriculture is a priority sector and accounts for 40% of the country's GDP. Similar to the other Sahel countries, Niger is classified as semi-arid to arid, with only a quarter of its territory exceeding 300 mm of rainfall per year, concentrated in one season. Rainfed crops (millet, sorghum, pulses) form the bulk of the production as staple food. A small but increasing number of farmers are engaged in irrigated agriculture, favoring cash crops. However, these farmers struggle with affordability of agricultural inputs, poor access to credit, limited contract farming with traders, and variable and narrow marketing opportunities for horticultural products, with increasing competition from other countries (Burkina Faso and Senegal) for export of onions. Farmers lack the storage facilities to delay sales and capitalize on better prices, thus resulting in low-value addition to products. Farming conditions are even more challenging for women, with unequal and limited access to means of production (including land, financing, technology and infrastructure).

The Government of Niger aims to achieve food self-sufficiency despite the challenges presented by climatic limitations and hazards. The 2012 government's 3N policy, *"Nigeriens Nourrissent les Nigeriens"* (Nigeriens feed Nigeriens), is the primary policy driver of agriculture. Government considers irrigation instrumental to achieve the 3N goals, through rehabilitation of existing infrastructure as well as irrigation expansion. Today, almost 100 000 ha are irrigated out of a potential of 270 000 ha, of which 11 000 ha are public-led large-scale irrigation schemes, and the remaining are equipped lowland areas (FAO 2016).

Government drove irrigation expansion in the 1980s and early 1990s, pursuing a large-scale irrigation agenda, particularly along the Niger River. Three factors contributed to the rapid expansion of irrigation: (i) the droughts in 1972–73 and again in 1983–84, which put the spotlight on the risk of a rainfed agricultural sector; (ii) the higher yields achievable under irrigated conditions compared to rainfed agriculture, and the consequent increase in revenues (1.5–3 times higher [Abric et al. 2011]); and (iii) the active role of government in driving the irrigation expansion agenda, with the support of various development partners. From the 1990s onwards, the poor performance of large-scale irrigation schemes became increasingly evident. Among the underlying factors was insufficient maintenance (and the difficulty of raising the necessary resources from the farmers to do it); this in turn leading to the need to rehabilitate a fairly large proportion of scheme infrastructure, at costs exceeding USD 15 000 per hectare, in cases where canal lining and the construction of dykes was necessary. The enabling institutional environment was unstable and often insufficient, making it difficult for the national irrigation agency to maintain a quality service. The same struggles and similar attempts to find solutions were sought across the region. Attention started to be given to small-scale schemes and individual irrigation solutions through pilot projects.

In 2013, the **Dakar Declaration on Agricultural Water Management in the Sahel,** adopted by all participating countries, the Economic Community of West African States (ECOWAS), and the Permanent Interstate Committee for Drought Control in the Sahel (CILSS), recommended ensuring "that all hydro-agricultural developments be based on appropriate sectoral policies and strategies, which

are integrated in a value chain approach and based on a rational and sustainable use of available resources". The World Bank support amplified this existing momentum and ensured that the preconditions (sectoral policies and strategies) for a well-performing irrigation sector would be in place. It became clear that improving development and management of irrigation would require some paradigm shifts. Constraints faced by stakeholders were similar across the Sahelian countries and related primarily to "how" planning, design, construction and management was carried out. Addressing these constraints required, firstly, political momentum for reform to allow the necessary institutional changes to be put in place, and secondly, the capacity for scaling up interventions to improve economic efficiency across the value chains. The Dakar Declaration called for a renewed effort to scale up irrigation development and improve irrigation sector performance in six Sahel countries so as to contribute to regional food security within natural resource limits.

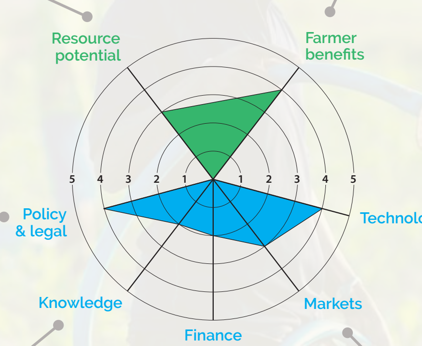
Diagnostic and scoring

Under the renewed impetus provided by the Dakar Declaration, the Government of Niger, with the support of various development partners, in 2016 consolidated the body of knowledge of irrigation development that had been built up over 20 years in regard to small-scale irrigation development.

In terms of water resources, the country has limited surface water, with the exception of the Niger river. However, **Niger is endowed with highly productive aquifers.** Niger has about 2.5 billion m3 of groundwater, of which only 20% is used currently (Merrey and Sally 2014). This endowment of groundwater resources could present an untapped potential to address both water access and agricultural productivity. While groundwater is abundant, the cost to access it – albeit lower in comparison to other countries in the region, thanks to manual drilling mainstreaming – is a constraining factor on irrigation development. In this southern part of Niger (where most of the population is concentrated), groundwater is shallow (less than 7 m) and easily accessible using small pumps.

Farmers could benefit greatly from irrigation to complement low and irregular rainfall, as demonstrated by the fact that private irrigation continues to expand where water mobilization is affordable and markets for high-value crops are accessible.

The challenges limiting farmers to autonomously transition into irrigation include, firstly, the unaffordable cost to mobilize water resources, which essentially translates to the high cost for drilling and pumping. That is why most groundwater irrigation is still based on labor-intensive manual lifting (hand- or foot-powered pumps) and water application (buckets). Labor productivity is low. Additional challenges include limited last mile equipment and technology support to farmers, who are far removed from Niamey, where the technology and equipment vendors are located. Farmers have limited access to finance and are used to full subsidies for irrigation development, such as were provided to the few who benefited from irrigation development projects in the past. Farmers in Niger also have limited access to knowledge on irrigation and other production technologies. For this reason RECA, the network of agricultural chambers of Niger, an institutionalized body, disseminates practical hands-on training on virtually anything that can help farmers perform better in irrigated agriculture (e.g., pest management, pump maintenance, product packaging). The first donor-assisted irrigation projects that targeted small-scale irrigation in Niger in the mid-1990s (Abric et al. 2011) helped farmer organizations endorse a service-provider role. However, while knowledge is theoretically available, it does not necessarily reach the end user.



Large untapped groundwater potential in the southern part of the country where there is shallow groundwater, offering potential for irrigation expansion to hundreds of thousands of smallholder farmers, but constrained by the cost of abstraction (digging well, energy). There is considerable potential for rainwater harvesting using water-spreading weirs.

Compared to rainfed agriculture, irrigation can reduce risk and boost yields over the wet season and introduce a second cropping season for horticulture (onion, tomatoes and peppers) during the dry season. However, cost/benefit is less positive due to the cost of pumping.

The national policy environment supports small-scale irrigation. Smallholders are identified in "SPIN" and are part of capacity-building strategies. There is also a focus on related technical support aspects. The challenge in Niger is that the strategies and policies have not been operationalized. But (in theory) there are no restrictions.

A succession of donor-financed projects since the early 1990s has facilitated the emergence of local irrigation service providers involved in design (of individual schemes, such as borehole, surface pump, hoses/pipes, fencing, etc.) and/or repair of equipment (pumps). Dozens of artisans were trained in manual drilling techniques and business skills so they could establish companies as service providers. The introduction of drip irrigation and training by field agents makes this technology available to farmers. However, high initial costs for pumps remain a prohibitive factor for many. As a result, the technology is inaccessible.

While a considerable body of knowledge on small-scale irrigation is available in the country (RECA has strong production information and outreach systems and materials for use in scaling up in-country knowledge), access to this knowledge among the wider group of potential "beneficiary" farmers is limited.

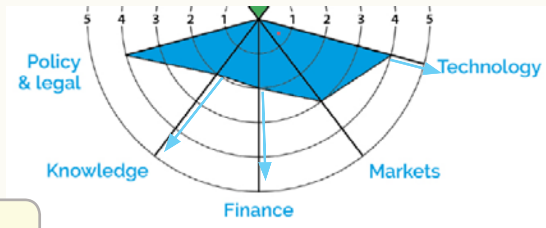
There is reduced appetite among farmers for borrowing for agricultural equipment, due to the fact that government has traditionally subsidized equipment and donors have historically provided free equipment. Exacerbating this is the prohibitive interest rates (>20% per annum).

Established traditional and potential export routes from Niger to Nigeria, Côte d'Ivoire, and other coastal countries exist, thus providing a significant and relatively stable demand. Also, there are donor-supported storage facilities and markets. However, market-price fluctuations are rampant.

Figure 1 Scoring rationale for FLID in Niger

Interventions that address the priority constraints

The assessment of weaknesses in the enabling environment (i.e. the scores) shows that the Government of Niger can catalyze FLID through a set of interventions that minimize the main constraints faced by smallholder farmers. Finance being the major constraint, there is need for **subsidies** to allow farmers to afford irrigation. To overcome the financial constraints, it is estimated that subsidies of up to 95% of irrigation development costs will be needed for small community schemes and 40% subsidy for private developments. Women, having far fewer opportunities for access to financial services, would require much higher subsidy levels, 100% subsidy in the case of the poorest, women and youth. **Multi-stakeholder platforms** are useful for knowledge dissemination and understanding the challenges that farmers face, and also for providing opportunities for information-sharing and exchange. On the technology aspect, dissemination of better adapted solutions could be useful. Introducing more efficient technology – e.g., drip irrigation and semi-Californian systems, abstraction technologies such as solar-based pumping with appropriate delivery models to increase efficiency of production – as well as improving technology support (last mile support) for farmers, could all be a game changer.



Intervention 2:
Dissemination of more appropriate technologies.

Intervention 1:
Establish multi-stakeholder platforms (MSPs) to facilitate knowledge dissemination on appropriate technologies (more efficient on-farm irrigation technology and solar-based pumping).

Intervention 1:
Provision of subsidies.

An overview of the operation to catalyze FLID

1

As a result of this diagnostic process, two outputs were produced:

The national strategy prioritizes small-scale irrigation, ***Strategie de la Petite Irrigation au Niger SPIN*** (SPIN 2015), approved in 2015. The SPIN identified the principles for the development of small-scale irrigation, including principles for the matching grant. Depending on the local geography, small-scale irrigation development can improve food security (collective village level schemes focused on cereals) or offer possibilities for more commercial agriculture for horticulture production. The Government and development partners focused on small village irrigation schemes and built on the long tradition of private, rudimentary, but efficient irrigation centered on the production of onions for markets in coastal countries (Nigeria, Côte d'Ivoire) which created strong and steady demand.

2

The operation to catalyze the FLID process, the ***Sahel Irrigation Initiative Project (SIIP)***, is a World Bank supported regional investment project. The SIIP contributes to the expansion of productive, sustainable irrigation, job creation and food security, aimed at supporting a variety of irrigation models. In Niger, the project focuses on very small-scale irrigation development (from less than 1 ha up to a few ha), by individual farmers or farmer groups wishing to transition to more commercial crops such as vegetables. It also supports water mobilization (such as improved rainwater harvesting with partial water control, lifting groundwater using solar energy, and introduction of efficient irrigation systems such as drip irrigation, semi-Californian and Californian systems) for production of rice, sorghum and vegetables.

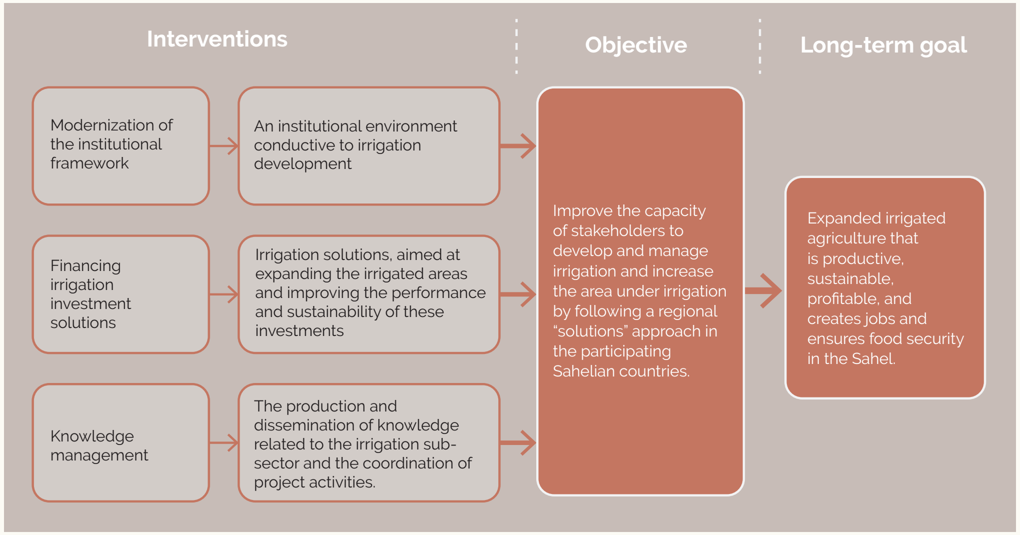


Figure 2 SIIP theory of change

Impacts

Small-scale irrigation in Niger is beginning to show results. Increasing knowledge through demonstrations and improved access to technology has led to increased access to and demand for technology. With irrigation, some farmers successfully grow dry season crops. The use of improved technology (water-efficient application technology such as drip and semi-Californian, and solar pumping with appropriate delivery model) has resulted in revenue increases of more than 50%. SIIPs approach of establishing (social, environmental and economic) viability

of irrigation schemes when selecting sites complements other training programs that are available in Niger, for example, the site diagnostic guidance that is part of the water and irrigation training manuals. Four MSPs have been created in the SIIP intervention zones (Agadez, Dosso, Tahoua, and Tillaberi) to support knowledge sharing and learning. These combined knowledge-sharing interventions as part of the SIIP project have improved farmers' access to irrigation technology and their investment options.

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GWSP
GLOBAL WATER SECURITY & SANITATION PARTNERSHIP

The Farmer-led Irrigation Development Guide

Module

1

Resource Potential

Land and water availability

WORLD BANK GROUP

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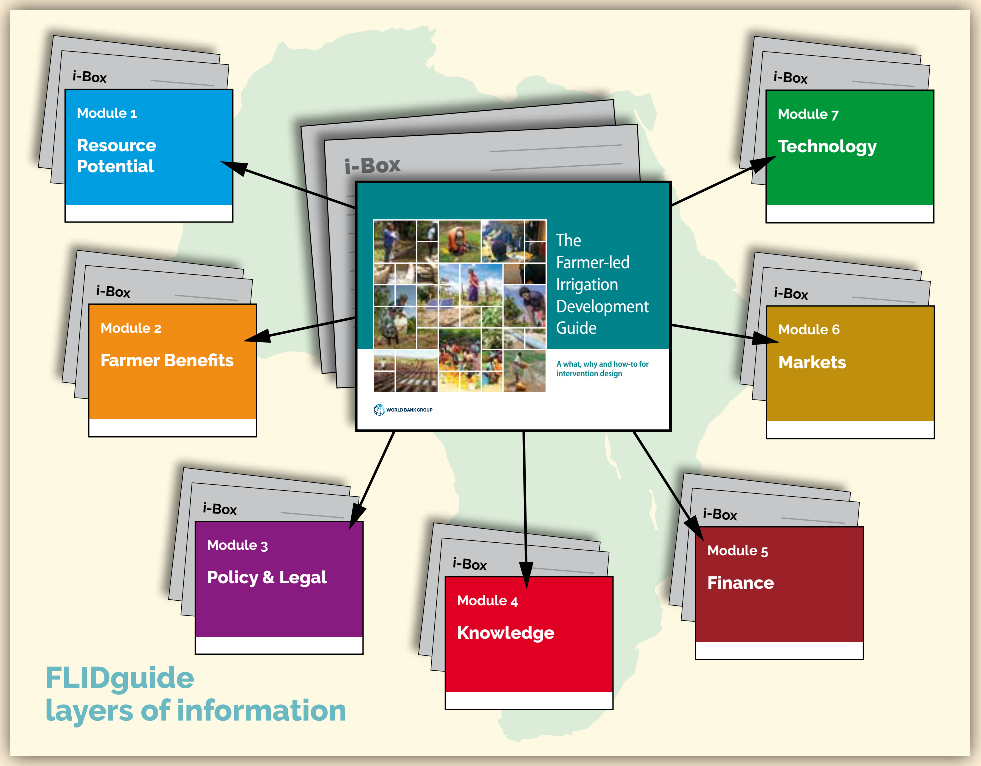
Contents

Abbreviations and acronyms

AGP	Agricultural Growth Program
EIRR	economic internal rate of return
FAO	Food and Agriculture Organization
FLID	farmer-led irrigation development
i-box	information box
IEG	Independent Evaluation Group
IFPRI	International Food Policy Research Institute
IRLADP	Irrigation Rural Livelihoods Agriculture Development Project
LSIS	large-scale irrigation schemes
Mha	million hectare
SSA	Sub-Saharan Africa
SVTP	Shire Valley Transformation Program
SWOT	strengths, weaknesses, opportunities and threats
TOR	Terms of Reference
TRIMING	Transforming Irrigation Management in Nigeria

Using the guide

The main volume of the FLIDguide presents the core body of information that explains FLID and the process of intervention design. Thematic descriptions are included in seven modules. Information boxes (i-boxes) at the back of the Main Guide and each module provide additional detail, and hyperlinks throughout the guide access relevant external publications, websites, animation clips and videos.



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NAVIGATING THE GUIDE

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- open the **View** drop down menu and select them from the **Page Navigation** options.

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- choose **File > Print**, and in the page sizing and handling area or pop-up menu, select **Fit to Printable Area** or **Shrink to Printable Area**.

1 Resource Potential

Land and water availability

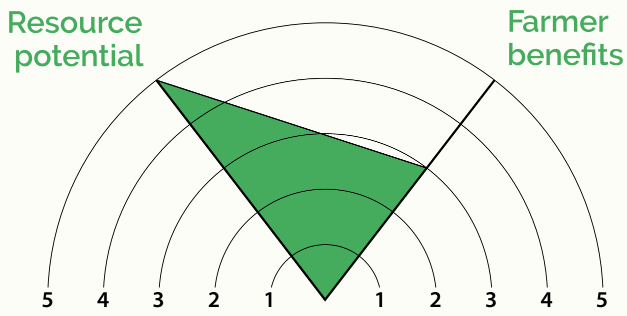
The water and land potential in relation to FLID is described in Module 1. Resource potential is one of the two factors shown at the top of the diagnostic spider plot. The other factor relates to the farmer-benefits as a result of irrigation and together these can be used to assess the "case for FLID". In Module 1, resource potential is shown to comprise attributes of availability (volume of water) and viability (costs of mobilizing the water). The importance of understanding irrigation system scale in relation to resource potential is highlighted and guidance on the diagnostic and scoring of the resource factor is then provided.

1.1 Natural resources and FLID potential

The question "What is the natural resource potential for FLID expansion?" must consider two aspects to inform a decision-making process: the **natural resource base itself**; and the **viability of using that resource** (i.e. the water mobilization cost) in practical terms.

The natural resource base

The resource base is the total suitable land area that could be irrigated with the available water, according to sectoral priorities and allocations. Across Africa, studies point to considerable potential for further expansion of irrigation but also reveal that data on current and potential irrigation areas has high degrees of uncertainty (Giordano et al. 2012; Wiggins and Lankford 2019).



The cultivated area in Africa is estimated at 271 million ha (Mha), but only 18.6 Mha of that area is recorded as being under agricultural water management. This includes all forms of irrigation, water harvesting, and drainage control (Food and Agriculture Organization [FAO] 2016). It is widely accepted that the extent of agricultural water management and irrigation (a subset of agricultural water management), is unreliable due to its reliance on incomplete national databases. These generally only include government schemes, corporate and large private holdings, but exclude FLID and many agricultural practices that are "off the radar" (Beekman, Veldwisch, and Bolding 2014; Woodhouse et al. 2017; Wiggins and Lankford 2019). As such, only broad conclusions can be drawn.

Estimates of total irrigation *potential* that assess the total resource base also vary widely. The lowest reputable figure is 38 Mha (Malabo Montpellier Panel 2018). FAO Aquastat states a figure of 47 Mha, while a detailed resource assessment by Xie et al. (2014) concludes with 81 Mha of potential. The wide variation in irrigation potential results from different assumptions. While water, in the form of runoff, may easily be

quantified and translated into theoretical potential irrigation areas, assessments do not account equally for a set of practical realities. Irrigation in the dry season needs storage, and in many cases, abstractions will have a major impact on downstream users, people and the economy. While irrigation potential may be evaluated to be vast, when realities are taken into account the total will be much lower (Wiggins and Lankford 2019).

The resource potential for irrigation *expansion* is thus affected by combined uncertainties: firstly, the existing total irrigation and agricultural water managed areas are substantially underestimated; and, secondly, the total resource potential is quantified on the basis of different parameters and varies widely. The available irrigation data on equipped areas, based on Aquastat (FAO 2016), together with three estimates of total irrigation potential are shown in Figure 1.1. The figure reflects the major uncertainties and unknowns, and highlights the need for caution in use of such data .

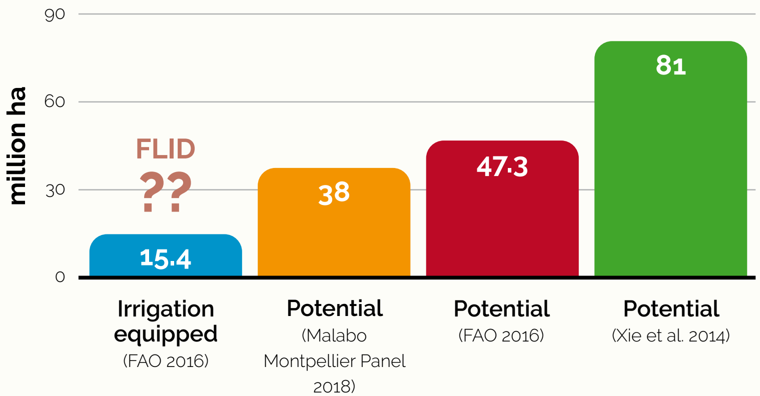


Figure 1.1 Estimated area equipped for irrigation versus two irrigation potential estimates for Africa (FAO 2016; Xie et al. 2014; Malabo Montpellier Panel 2018)

Even though quantification is difficult, it is widely accepted that Africa has substantial irrigation resources that can still be developed. Further, substantial opportunities exist not just for expansion, but also for intensification – i.e. the better use of the available water – through water productivity improvements.

Attention to aspects of storage, sectoral allocations, the seasonal effects of irrigation on basin water balance, and the actual extent of existing irrigation (including FLID) is therefore essential to properly understand the resource potential. The data on the natural resource base provides part of the information needed to understand resource potential as it reflects availability in volumetric terms (cubic meters of water), translated to hectares. The diagnostic activity for this is described in Section 1.2. The cost of mobilizing water for irrigation is the second part of the resource potential assessment. This is affected by the availability of the water resource, proximity to the irrigable land, and the organizational capabilities of farmers, discussed in the next section.

Resource potential and the cost of water mobilization

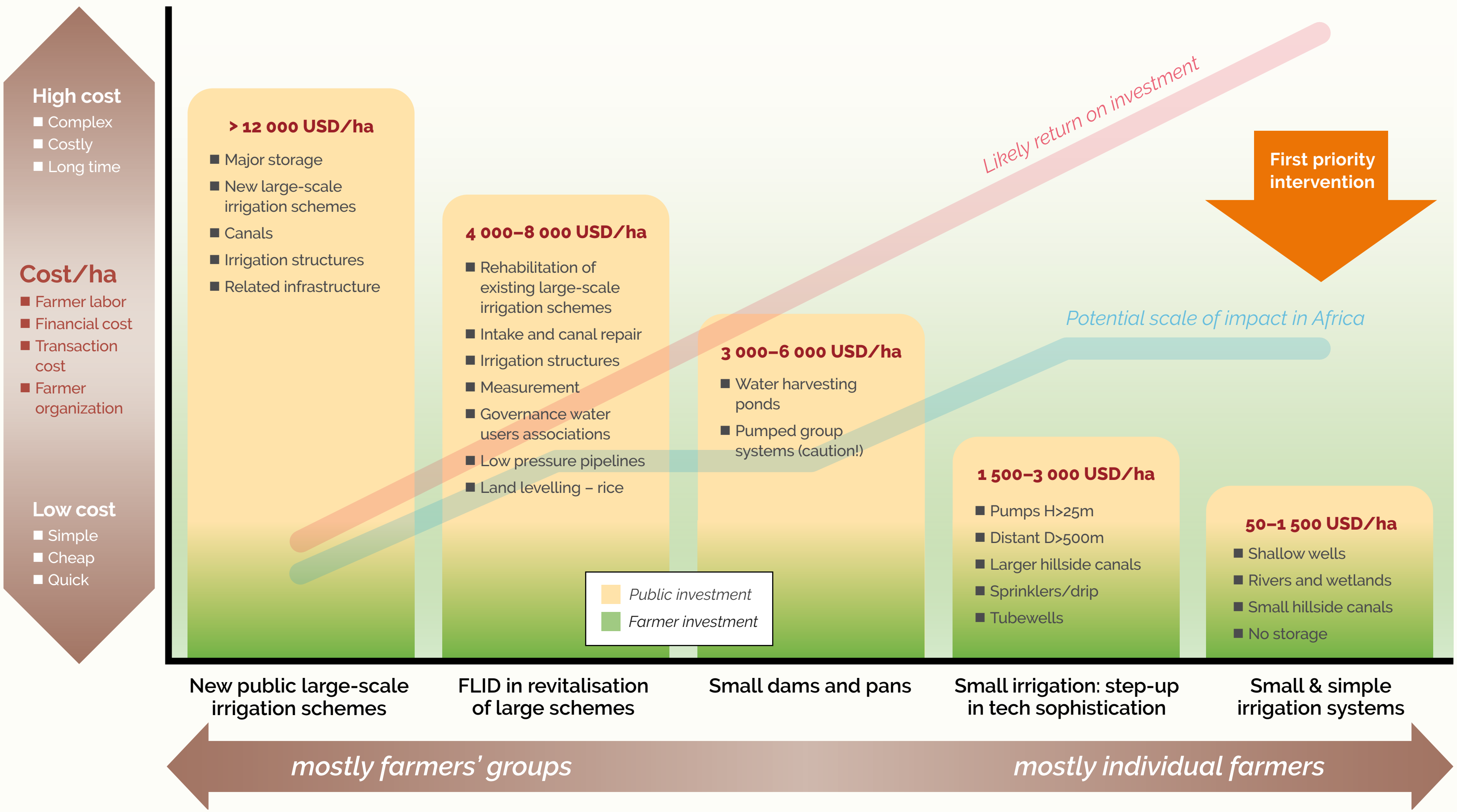
Mobilization costs result from the proximity of water to irrigable lands and the need for storage. Much of the success of FLID has been attributed to the physical situations where farmers can easily and cheaply access water for irrigation (Main Guide Figure 1), *and* where they can grow high value crops and access markets to sell produce (Wiggins and Lankford 2019). Where large bodies of water are close to irrigable land, these can be accessed easily by individuals and small groups of farmers with simple technology at relatively low costs. Where water supply fluctuates seasonally, and is distant from irrigation land, heavy and costly engineering construction for both storage and transmission is needed.

Easy access, in practical terms, means where water is *either* in hillside streams that can be diverted into hand-constructed gravity canals or

through cheap pipelines to the fields, *or* within a few hundred meters from shallow wells, rivers, wetlands, ponds or drains (urban outfalls or agricultural drainage). Where water must be lifted, farmers can readily use bucket-and-ropes, manual or small petrol pumps. Energy costs, whether human labor, fossil fuels, or solar panels, increase proportionally with distance and lifting height, so distance and pumping head are key parameters for "potential".

The progression from highly favorable resource situations, where FLID takes place most easily, to more costly, time-consuming and complex situations, is shown in Figure 1.2.

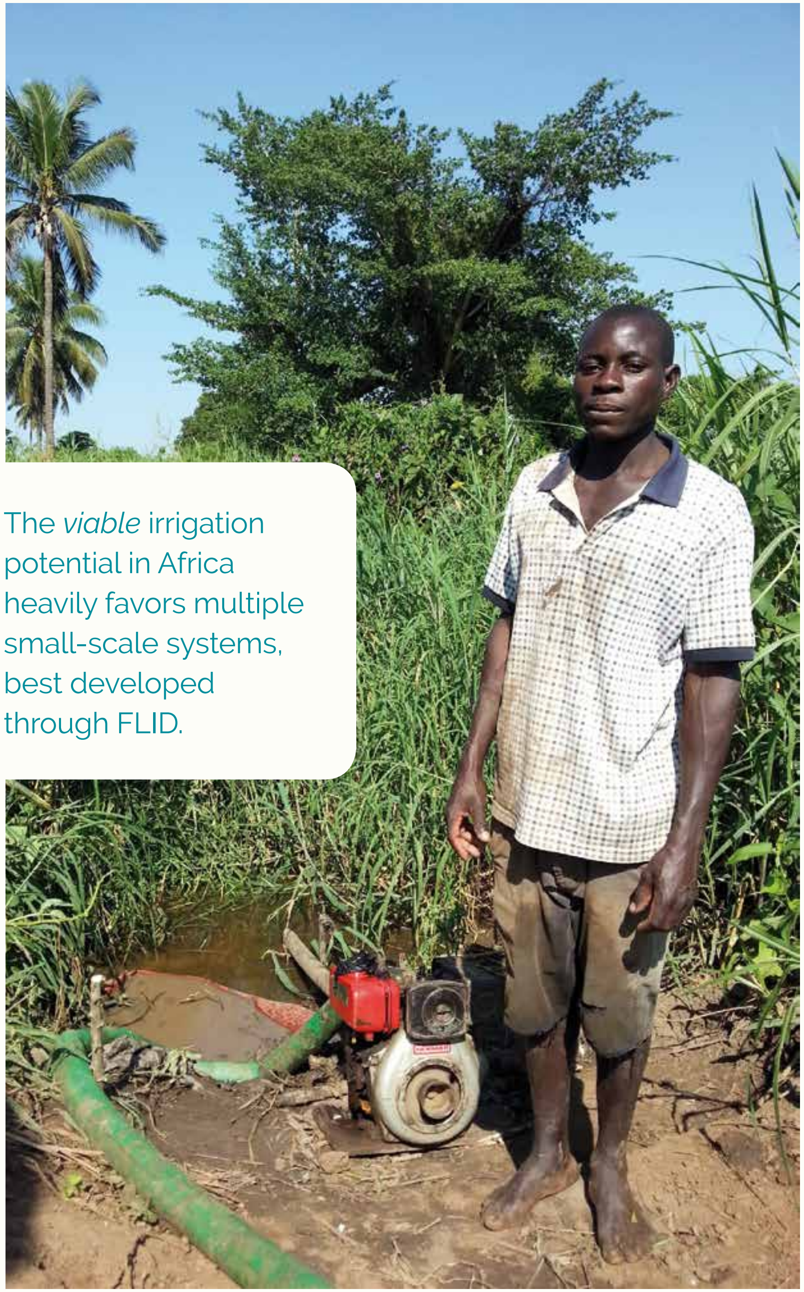
Figure 1.2
Resource potential elements and continuum in relation to optimum FLID opportunities



Where resource potential is high, which is reflected by close proximity to and plentiful supply of water, then **costs and constraints to FLID are low**. Farmers can adopt irrigation, expand and intensify with no or minimal public support. **Where resource potential is low**, meaning water is distant, water supplies are stressed, and/or substantial storage is needed, then **financial and transactional costs and complexity are higher**. The need for public funding to support FLID processes increases as resource potential decreases.

There is another important element that is shown in the Figure, which is the return on public investment. A number of continental assessments of resource potential highlight the importance of water-accessibility (proximity) storage among other defining characteristics, such as soil type and slope (You et al. 2011; Xie et al. 2014; Xie et al. 2018). Different irrigation categories were used in the analysis, in some cases a simplistic separation between "small-scale" and "large-scale" irrigation systems, explained further in i-box 1.1. The evidence shows that not only are "small-scale" systems the most favorable in terms of their rate of return (economic internal rate of return [EIRR]) of 28% versus 6% for large-scale irrigation development), but there is more than double the viable expansion potential in sub-Saharan Africa (You et al. 2010) (i-box 1.2).

Resource potential assessment must go beyond just physical resource availability and also consider: infrastructure development costs; potential to access and augment the resources cost-effectively (e.g. small dams, shallow wells); costs to be borne by farmers; and their organizational abilities. Assessment of the "resource potential" factor must strive to identify the high resource potential contexts where FLID can flourish. Suitability to small-scale irrigation systems, with close proximity to a water source with high water availability, are key parameters. One way that the resource potential can be increased, albeit at public cost, is through small dam and pan construction.



The *viable* irrigation potential in Africa heavily favors multiple small-scale systems, best developed through FLID.

Increasing the potential – small dams and pans can catalyze FLID

Water resources assessments should also take into account the *potential* of new cost-effective public infrastructure that can catalyze FLID. These comprise small dams and pans which are typically less than 5 m in height. They can be built as dams (barriers) in drainage lines or off-channel, on perennial or ephemeral rivers. Where sediment loads are high, sand-dams may be favorable. Water-harvesting arrangements with excavated pans (sometimes lined) can capture overland sheet flow – a technique well suited to Arid and Semi-Arid Land contexts.

These kinds of small water storage structures can add to the water resource potential and trigger FLID by providing additional water resources for the irrigation of adjacent arable lands (De Fraiture et al. 2014). Their potential, based on broad geographic characteristics (rainfall, runoff, slope, proximity of storage sites to land, etc.) needs to be assessed. Due to their size, small embankment dams and excavated pans have the following favorable characteristics:

- They are a **familiar and known feature** in rural areas and provide for multiple water uses: livestock, domestic (non-potable) and micro-irrigation.

- There are often **established social norms and rules of use** that provide a foundation for water governance essential for the sustainable and equitable co-management of similar new constructions.

- They are **technically simple to design**, usually within the capability of local government technical engineering teams in terms of their hydrology assessments, topographic survey, layout planning, and embankment or excavation design.

- Technical **training and support** can be focused on existing technologies, country practices and experiences – not least floodwater and silt management.

- They are **straightforward to construct** with non-specialist and accessible machinery such as that routinely used by road-construction teams (excavators, bulldozers, roller compactors, water-bowsers, trucks etc.).

- They are associated with **small total project costs, easier procurement, limited environmental impacts, and easier regulatory permissions** (storage and abstraction permitting). They have shorter timelines from conception to completion, which are more easily aligned to typical program intervention periods, unlike medium and large water-storage structures.

In the design of small storage structures, runoff-storage hydrology and peak-flood discharges must be assessed rigorously as these present a risk of failure. While important, the assessment is relatively simple in the case of small catchments. Specialist support and input can easily be included in technical training initiatives at the local level as part of operations.

Small aquifer recharge structures are similarly simple, but as in the hydrology aspect of small storage structures, design and siting of recharge structures will require a level of training and expertise to maximize groundwater benefits. Publicly funded water storage and aquifer recharge structures can catalyze FLID and are an important element of the resource potential assessments and subsequent scoring of the factor.

Groundwater and FLID

Groundwater has played an important role in FLID in the past decades (Shah 2018), particularly where shallow aquifers allow access via shallow wells (i-box 1.3). Shallow wells have low construction costs and are associated with simple hand-lifting or pumping technology, though with heavy labour demand and requiring some purchasing power, respectively. The opportunity to expand irrigation based solely on groundwater usage is limited in parts of southern and much of northern Africa, yet groundwater plays an important part in more intensive, sustainable irrigation development through the possibility of conjunctive use (Lefore et al. 2019). Conjunctive use of both groundwater and surface water sources can extend the crop production season, and offset the risks associated with surface water variability and unpredictable over-use by other water users who share the surface resource.

The promotion of groundwater as an irrigation water source is associated with risks of over-abstraction and resultant groundwater depletion and agricultural pollution. The risks depend on agricultural practices, the aquifer characteristics, other demands on the aquifer, and recharge dynamics. In assessing resource potential these risks must be identified in order to evaluate the role that groundwater can play as a viable and sustainable irrigation resource. Shallow groundwater where farmers can most easily carry the development costs of the resource themselves (via shallow well construction) is particularly important. Sustainable groundwater use can be aided by measures included in other modules in the FLIDguide. Regulation, allocation and water governance issues are addressed in Module 3 and technologies that can aid soil-water management, including leachate (and pollution) control, are described in Module 7 i-box 7.2. These management options need to be considered in relation to the status and sensitivity of the groundwater resource during the preparatory studies and in the subsequent formulation of intervention concepts and operational designs.

FLID clusters are pointers to the high potential areas

Studies that identified and mapped actual irrigated areas developed through FLID processes have also shown that farmers often develop irrigation in places not identified in classical irrigation potential studies (Beekman, Veldwisch, and Bolding 2014; De Bont 2018). Insights on FLID-friendly resource potential can be derived from identifying the kind of locations where farmers have already initiated (basic) irrigated agriculture. These practices can be analyzed into a typology based on characteristics of water resource type, agro-ecology, relief characteristics, soil type, market access and/or crop type. In understanding when and where farmers are actually able to develop irrigated agriculture, it can be surmised that other farmers might be able to develop similar irrigation practices in comparable "high-potential" situations.

Thus, rather than starting from identifying the available water and land resources, a FLID potential study would start from farmers' actual agency and abilities. Some areas that are classically seen to have irrigation potential may then fall outside what farmers deem feasible to develop. On the flip side, certain areas that are conventionally seen as unsuitable for irrigation may actually be quite easily developed by farmers. These include, for instance, hillsides (conventionally deemed too steep), river shores (conventionally thought to be too vulnerable) and urban spaces (usually outside the potential search area).

1.2 Diagnostic and scoring of the resource potential factor

Diagnostic

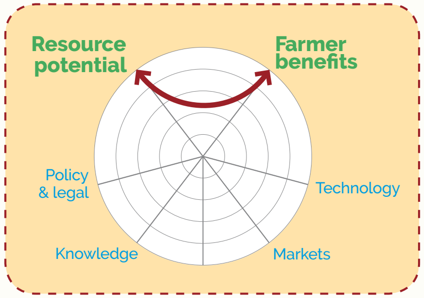
The diagnostic of resource potential would usually be carried out by a specialist consultant and would be informed by the prior discussion on data uncertainty and the broader concept of "potential" that goes beyond just physical resource availability. As irrigated agriculture developed under FLID processes has hitherto been little noticed or quantified, but often covers large (accumulative) areas that influence resource availability, the assignment includes the mapping of existing irrigation. A more detailed outline Terms of Reference (TOR) with a scope of work is included in i-box 1.4.

Scoring

The scoring of the resource potential factor would aim to answer the question, ***"Why and when is FLID favorable?"*** from a resource perspective. The answer to this question would be that FLID is favorable when (1) water is abundant, (cost-effectively and organizationally) accessible by farmers, and of good quality, and (2) when related land resources are suitable for irrigation development by farmers. More detailed guidance on the scoring of the resource factor is provided in i-box 1.5.

1.3 Concluding note

A key driver of FLID is when adequate water is in close proximity to a farmer's field. Systems can be technically simple and costs are relatively low and therefore more affordable. The less accessible water is to farmers, in space and time, the more the need for costly infrastructure development to mobilize the water. In resource-stressed contexts, the social and commercial competition due to water and land scarcity is typically associated with contestation and, often, conflict. In such stressed situations, the political priorities for agricultural water versus other economic sector usage becomes important in the broader considerations. Minimum environmental needs for sustainable resource use must be assessed.



Resource potential is one of the two factors shown at the top of the diagnostic spider plot. The other factor relates to the farmer-benefits from irrigation (Module 2). Together, these two factors can be used to assess the "case for FLID". In planning a FLID operation it makes sense to focus on those resources that require the lowest cost to be mobilized. In these situations, there will be easier access to resources by more farmers and thereby more rapid uptake, assuming that other critical constraints are adequately addressed.

i-Boxes

Understanding "scale" – smallholders, irrigation system size and impact

Terms like "large-scale", "small-scale", and "smallholder" have different meanings to different people and are used freely and sometimes interchangeably. Clarity of meaning is important in regard to farm size, irrigation system size, and development impact.

Farm scale - FLID and farm size: FLID, per se, is not only about smallholders. The process includes any farmer regardless of farm size (or "holding") who takes the lead in developing irrigation, alone or in a group. However, given the broader development goals (see Main Guide), the FLIDguide is explicitly aimed at interventions that would support resource-poor smallholder farmers. These are farmers who are located on farm sizes of less than 10 ha, but most typically in the 0.5 to 2 ha size of irrigation farms.

Irrigation system size and FLID: Irrigation scheme size means the whole area within the irrigated perimeter. System and scheme are used interchangeably in the FLIDguide. Around the world, large-scale irrigation schemes such as Chhatis Mauja in Nepal that covers 3 000 ha, or the Zanjeras in the Philippines covering thousands of hectares, were developed over the centuries through a process of what we now define as FLID (Tang 1992; Meinzen-Dick 2007). While a historical view is helpful, the development of new large-scale irrigation schemes through FLID, in a contemporary global reality, is unlikely. The technical complexity, costs, land-tenure, environmental and water-resource challenges exclude the practical possibility.

A new large-scale irrigation scheme (LSIS) infrastructure project in the FLIDguide context thus means a publicly funded major infrastructure investment involving civil works (such as large dams, major canals and pipelines) and may include smallholders, large individual farmers (>10 ha) and corporate estates. Conversely, in the FLIDguide applications, FLID is associated with smallholder farmers, primarily operating individually or in small groups, and using "small-scale irrigation systems".

FLID has large-scale impact: There should be no confusion about the large scale of FLID extent (in ha) and its related impacts – positive and negative. Impact is reflected most simply in irrigation area (ha) and numbers of farmers, though it has multiple other important social, environmental, and economic indicators. Irrigation in Africa under FLID covers hundreds of thousands, or more likely, millions of hectares – but no one has attempted even to estimate a number (in a publication). What we do know is that new interventions aiming to catalyze FLID will involve tens of thousands of small systems (or more), operated by groups or individuals. The combined irrigation area, and the numbers of farmers involved in a FLID intervention, can thus easily surpass that of a new LSIS operation.

FLID and the revitalization of LSIS

There is a place for FLID processes in the revitalization of existing large-scale irrigation schemes (LSIS). In such situations, farmers would take the lead to expand the irrigation area, to repair existing infrastructure, and reorganize operations and maintenance. Such efforts have been observed in Africa, as on the Kano Irrigation Scheme in Nigeria where 230 ha was independently developed by a farmers' group, but are not thought to be widespread in Africa. One particular challenge relates to the operations and management functions of large-scale infrastructure and related governance arrangements, including asset management (Waalewijn et al. 2020). While FLID on LSIS warrants attention, perhaps more so beyond Africa, this aspect of FLID resource potential has not been included in this first edition of the FLIDguide.

Financial returns on investment at different irrigation scheme and system scales

The benefits (i.e. returns) on irrigation interventions are numerous and extend beyond the financial aspects as described in Module 2 and in the Main Guide. The issue of financial returns is addressed here in more detail. Small-scale irrigation generally has higher economic returns than large-scale irrigation, and there is a much greater resource base in sub-Saharan Africa (SSA), that can be viably developed. The growth trajectory of small-scale irrigation expansion (through FLID) has been the dominant driver of expansion in Africa in the last 20 years, implying it is more easily achieved and has greater benefits than larger, more complex schemes.

Rates of return and successes on investment in small-scale irrigation are higher: While the financial and economic returns for irrigation investments vary widely depending on many engineering, resource, agricultural and economic factors, there is both quantitative and anecdotal evidence that justifies prioritizing small-scale irrigation support, most effectively driven through catalytic FLID interventions.

An expansive International Food Policy Research Institute (IFPRI) study across SSA projected that the average Economic Internal Rate of Returns (EIRRs) for large-scale irrigation development in SSA is 6%, versus 28% for small-scale irrigation (You et al. 2010). The natural resource base for viable small-scale development is similarly much greater (See Table 1).

An internal review of EIRRs of ongoing large-scale irrigation projects, such as the Transforming Irrigation Management in Nigeria (TRIMING) in Nigeria (World Bank 2014) and the Shire Valley Transformation Program (SVTP) in Malawi (World Bank 2017), were found to range from 13 to 18%, while those of small-scale irrigation, such as FADAMA in Nigeria (World Bank, 2016a; 2016b), Irrigation Rural Livelihoods Agriculture Development Project (IRLADP) in Malawi (Independent Evaluation Group [IEG] 2016), and the Agricultural Growth Program (AGP) in Ethiopia (IEG 2017) were considerably higher, ranging from 26 to 40%. This aligns to the large difference in benefit and while more optimistic in the values obtained, confirms the implication of the point above (i.e. small-scale gives better returns).

The above quantitative assessments are supported by one key recommendation from Inocencio et al. (2007) who investigated costs and outcomes of 317 World Bank irrigation projects across the world. They found that the most successful irrigation interventions are those that are developed through large-scale programs driving many small-scale irrigation projects (i.e. a programmatic response that activates FLID expansion).

Small-scale irrigation has greater resource potential for economically viable expansion: An IFPRI study of land and water resource availability identified that in Africa, 16.2 Mha of large-scale expansion and 7.3 Mha of small-scale expansion with better-than-marginal EIRRs was available, with an estimated 93% and 91% respectively being in SSA (You et al. 2010).

However, when a minimum EIRR of 12% was set, the total (for Africa) decreased significantly to 6.1 Mha, and the ratio between

large-scale and small-scale expansion opportunities was inverted. Large-scale irrigation potential was found to be only 1.9 Mha, while small-scale potential was more than double that, at 4.2 Mha (You et al. 2010). While the report did not state what proportion of these viable areas are located in SSA, it is reasonable to assume that it would be greater than 90% as was the case for marginal EIRRs.

The findings summarized in Table 1 affirm the direction taken in the 2009 Africa Country-Infrastructure Diagnosis Study, reported in the World Bank African Action Plan (World Bank 2010). Here, a case was made for public scheme expansion of at least 1.3 Mha, and small-scale (private irrigation) expansion of 5.5 Mha, totaling 6.8 Mha by 2030. This reflects a slightly higher total than the IFPRI study (6.8 versus 6.1 Mha).

When all of the above is taken into account, there is a strong case to be made that intervention support should focus on multiple small-scale systems (4.2 to 5.5 Mha in SSA with high EIRRs) over large-scale irrigation schemes (1.3 to 1.9 Mha with high EIRRs).

Table 1 Irrigation expansion potential in Africa by system scale and rate of return on investment (Source You et al. [2010])

Scale/Type	Resource potential in Africa (Mha)		
	EIRR = marginal	EIRR > 12%	Average EIRR
Large-scale schemes with heavy infrastructure	16.2	1.9	6%
Small-scale systems (moveable, small, relatively simple)	7.3	4.2	28%
TOTAL	23.5	6.1	---

Groundwater development and FLID

Groundwater as a FLID driver

Groundwater remains an essential resource for the expansion of irrigated areas, a priority for many governments in sub-Saharan Africa (SSA), and for continued sustainable irrigation across the continent. The opportunity to expand irrigation based on groundwater usage has been exhausted in parts of southern and much of northern Africa, but access to shallow aquifers and opportunities for conjunctive use are important opportunities to pursue. Conjunctive use brings resilience to the irrigation system, providing backup in times of surface water stress, and extending the irrigation production season (Lefore et al. 2019). There is a strong relationship between FLID expansion and the improvement of drilling techniques (Shah et al. 2018). Each drilling technique facilitates another transformative step in the modernization of farms. The drilling progress is:

- temporary unlined well (manual lifting with bucket)
- lined well (manual lifting with bucket, treadle pump)
- a pump located in the well (motor pump)
- a shallow tube well (treadle pump, motor pump)
- a tube well for intermediate depth (submersible pump/solar)

Sometimes it is not a sophisticated technique. For example, in Sahel thousands of smallholders own lined wells that store a small amount of water in low-yielding aquifers (< 1m^3/hr) that is lifted by hand power. By doubling the amount of water stored in the well and using a solar pump to lift the water, the irrigated area can be doubled. The World Bank-funded Irrigation Rural Livelihoods Agriculture Development Project (IRLADP) in Malawi also supported improvement of shallow wells initiated by farmers. See also De Bont et al. (2019) on groundwater development and FLID in the upper Pangani/lower-Moshi area of Tanzania.

Easily accessed groundwater up to 15 m deep, with related low-cost drilling techniques, represents the biggest potential for FLID. Supporting local manual drilling businesses in the most suitable areas where irrigation is taking place (sand-river/alluvial soils) proved successful in various countries. Manual drilling was rapidly adopted by farmers in Niger and Nigeria because of its low cost (ten times less expensive than machine-drilled and concrete wells) and because it is relatively easy and quick to execute. In Senegal (Niayes region) for around USD 60 a tube-well is drilled into the base of existing concrete wells to increase the yield capacity for motorized pumping.

The existence of feasibility maps for manual drilling for groundwater development for irrigation can help decision-makers to identify suitable areas. In addition, there is a correspondence between the average limiting depth (20 m) for manual drilling and the most promising market segment for affordable solar pumps. UNICEF has already mapped 12 countries in SSA for suitable drinking water, but the feasibility maps can easily be adapted for irrigation.

The real threats of overexploitation through the use of affordable drilling techniques are in areas where the aquifer is shallow (less than 7 m) with high flow rates that can be easily extracted with powerful motor pumps. In Senegal, there are more and more motor pumps connected to two or three shallow tube wells at the same time. The likely direct consequences are the reduction of soil moisture, the disappearance of plant species, and/or enforced changes in farming practices, as well as the premature drying up of ponds and streams.

Groundwater and pollution

The impact of irrigation abstractions and related agricultural pollution on streams, groundwater and lakes is important for sustainable resource use. Groundwater is an enabler of irrigation but is also a risk factor for water quality. While farmers often utilize groundwater for irrigation, those same households also tend to rely on groundwater for domestic uses. Unregulated and uninformed use of pesticides and fertilizers results in these having a high chance of ending up in the groundwater that is used by the household (Sishu et al. 2020).

In working through the diagnostic logic, there are clear trade-offs between gains from irrigation and loss of water quality. Particularly important is whether or not there are national standards and guidelines in place to regulate the use of agro-chemicals. In the Ethiopian case, farmers lacked guidelines in setting a threshold for particular chemicals and also lacked the capacity to test the water, with the result that the pollution was not identified early enough. Most African governments do not know what chemicals are being imported and farmers do not know what they are using (often repackaged for small-scale use without information or warnings). The solutions will require longer-term policy changes, scientific investment and knowledge exchange with farmers to address this significant risk for domestic water sources pollution, triggered by intensified irrigated agriculture such as FLID, and particularly in sub-Saharan Africa.

Outline TOR for the resource potential diagnostic

General Scope of Work

Country-level extent of, and potential for, FLID is established through country-specific diagnostics. A country-level diagnostic comprises mapping using remote sensing techniques, desktop reviews, and field validations, including interviews with key stakeholders. Diagnostics typically take up to 3 months to complete. The diagnostic should be guided by the approaches outlined in i-box 3.4 and 3.5, and in Minh et al. (2021). This information can be attached to the consultant's Terms of Reference (TOR).

The country-level diagnostics will build on existing assessments and focus on identifying gaps and business opportunities for farmer-led irrigation development, as well as the potential in a country. The diagnostics also examine the development of FLID within the limits of natural resources (including water, soil, forests, and other ecosystems).

The specific objectives of the diagnostic studies are to:

a. Describe the extent of FLID in the country in terms of:

- area under FLID
- location (if concentrated in specific areas)
- production (quantitative – absolute and relative) and crops
- economic viability (macro and micro)
- number of farmers engaged in FLID
- typology of FLID farmers, including assets and access to finance
- types of environment (water, proximity of urban centers, etc.)
- land tenure
- technologies, including equipment
- documented cases of existing farmer-led irrigation activities.

b. Assess the above from the angle of constraints, opportunities, and favoring factors.

c. Assess the state of the enabling environment, including existing private sector investments and public sector support.

d. Assess the predominant systems for distribution of agricultural products and financing models available, including various actors in the supply chain and their roles, propose new options, and identify possible gaps.

e. Identify the different farmer-led irrigation technologies and financing mechanisms suitable for the local context and available locally.

f. Distil lessons and make policy and practical recommendations for favoring and fast-tracking of farmer-led irrigation development.

Activities

To achieve the above study objectives, the following set of interrelated activities should be carried out.

Assessment of the current extent of farmer-led Irrigation

- Outline typologies of FLID present in the country smallholders, medium- and large-scale farmers, etc.
- Conduct value chain assessments to the extent it is feasible.
- Determine the role of FLID within the overall country farming system and labor needs, including social and economic aspects.

Assessment of potential for expansion of FLID and reasons for supporting sustainable intensification

- To the extent possible, compile relevant Natural Resources Assessments (with separate sections on water availability and quality, and land availability and suitability).
- Identify the market potential for expansion of FLID.
- Determine the extent of an enabling environment for FLID, including relevant institutional structures.
- Assess the need and scope for advisory services.
- Identify the market potential for expansion of FLID.

Assessment of potential for expansion of FLID and reasons for supporting sustainable intensification

- Challenges and constraints to FLID
- Public sector engagement objectives

Recommendations for implementation

- Conduct a strengths, weaknesses, opportunities and threats (SWOT) analysis on the different alternatives for FLID for the consideration of decision-makers.
- Recommend institutional and policy support needed to support the business and implementation model.

Part 1: Desk review and mapping

- Review available documentation on irrigation in the country. The review should cover studies, reports, research papers, policy, maps, and other documentation related to FLID and associated themes.
- Map the extent of FLID using suitable mapping solutions.
- Consult with stakeholders.
- The report should consider particular important issues such as, but not limited to: gender, generational, access to markets, access to land, etc., according to the consultant's expertise and the particularities of the region.

Part 2: Field visits and interviews

Desk reviews are complemented by field visits and interviews to validate the findings from reports. During the field visits:

- Interview farmers and other stakeholders
- Validate the existence of resources for FLID (water, land)
- Identify constraints – inputs supply chain of equipment, extension services, distance to markets, etc.

Guidance on a rapid resource inventory for diagnostic assessment

The main purpose of the assessment is to answer the question: "What is the current extent of, and potential for, irrigation farming in the country/region/locality?" The assessment would include the following elements:

1 **Natural Resources Assessment** Natural resources assessments serve to identify where resources – primarily water and land – are available and can support FLID. The suitability of an area for FLID depends on many factors, including water resource availability, nearness to a water source, and depth of groundwater. The potential is defined by biophysical suitability, largely water resource and land resources. This suitability is based on rainfall, evapotranspiration, the length of the growing period, temperature regime, elevation, slope, and soil characteristics (texture, drainage, etc.).

The suitability is qualified by other factors, for example proximity to protected areas such as national parks and environmental water requirements. Existing sources of water for FLID would include: harvested runoff, shallow groundwater that can be lifted without the use of pumping equipment, shallow groundwater that can only be lifted with pumps, deep aquifers, and river diversions.

Potential data and information sources for assessing natural resource potential:

Analysis of water resources potential for FLID makes use of a variety of data, including

- Runoff
- Rainfall
- Land cover
- Groundwater depth
- Groundwater recharge
- Aquifer productivity
- Aquifer storage

The parameters above are useful for carrying out a rapid resource inventory necessary to quantify potential based on water resources.

The steps for the assessment are:

1. Identify data sources for the area or country.
2. Estimate water available for irrigation (using [1] surface water [2] groundwater [3] surface water + groundwater), plus other demands (domestic, livestock, environment, etc.) and crop-water requirements.
3. Estimate irrigable area in dry and rainfall season based on water and soil resources.
4. Validate irrigation potential using local information (for example groundwater knowledge based on existing wells and boreholes) for identifiable areas.

FLID potential can be limited by water quality. For example, where water is in abundance but is of poor quality, the potential for FLID is limited. Similarly, where water is available, but land is limiting, the resource potential is reduced.

Data sources for resource assessments include water ministries, publicly available data sources (e.g. The Food and Agriculture Organization [FAO] Aquastat), ministries (land, water, and environment), and local water and land users. Local information from users plays an important role, particularly for validating assessments. Due to unavailability of high-resolution data, for example for groundwater availability, resource potential may be inaccurate at local level but more accurate at national or regional level. Validation of resource potential is therefore required. Use of local information, where available, can improve assessment of resource potential.

2 Best estimate of irrigated extent, in groupings

Three types of irrigation are observed with FLID: first, FLID as supplementary irrigation, where crops are irrigated during dry spells experienced in the cropping season; second, when farmers irrigate to extend the rainfall season, observed when rainfall ceases before the season ends; third, irrigation in the dry season as farmers grow a second crop. The area under FLID in a country is variable because these three components are variable. In particular, the area under FLID to extend production beyond the rainfall season or for supplementary irrigation depends on rainfall variability.

Farmers practice FLID in various environments. These include areas where groundwater is abundant and occurs at shallow levels, areas close to rivers, and areas close to markets with a demand for agricultural products. The extent of FLID can be estimated from volumes of produce traded. It is also more accurately estimated from mapping the area under FLID.

FLID is practised during the dry season when farmers grow additional crops. It is also practised towards the end of the rainfall season, as a way to extend the rainfall season. Irrigated crops include cereals (maize, wheat and rice), and fruits, tomatoes, onions, peppers, cabbages, beans, peas, potatoes, sweet potatoes, sugar cane, and groundnuts. Production costs of these crops are variable, ranging from USD 500 to USD 4 000/ha (Xie et al. 2014). FLID is also evident in areas where there are mid-season droughts during the rainfall season. During these extended dry periods farmers irrigate to mitigate crop failure due to moisture stress. It is also evident in cases where the rainfall season is shorter than normal and additional water is required for crops to mature. In such cases irrigation is used to extend the growing season.

Water sources used in FLID contexts are river water, harvested rainfall and runoff, groundwater, and small reservoirs. Small reservoirs are used for storage and to deliver water to plots using surface canals. Farmers also collect rainwater in dug-out ponds or basins to retain runoff for irrigation. For farmers with landholdings close to rivers or streams, simple river diversions are used to supply water for irrigation. Equipment used in FLID contexts includes buckets, treadle pumps and motor pumps. Small reservoirs, river diversions and tube wells are used to access irrigation water. Energy sources for motor pumps include diesel, petrol and solar, and are used for lifting water from canals, reservoirs and tube wells. Methods for on-farm water application include canals, drip systems, and buckets.

Guidance on scoring the resource potential factor

The parameters to consider when scoring the resource include water availability (quantity), water resource type, distance to the water source, groundwater availability and accessibility.

As water availability and proximity to water are of primary importance, a score for water availability is generated from surface water and groundwater. Where surface water is abundant and reliable it is often more convenient to exploit that than groundwater. Where surface water is limited and/or available only seasonally, groundwater can be included in considerations. Groundwater also has the advantage that it can be developed close to the point of use, thus reducing investment needs for conveyance. The scores of these various parameters are combined to generate a single weighted score for natural resources potential. General guidance is provided in Table 1. The guideline can be adjusted to align with country-specific standards.

For surface water, a high score indicates nearness to the water source (river, reservoir, etc.) as water can then be delivered easily to the plot(s).

For plots farther from the water source farmers will incur investment costs (e.g. for canals or pipes to deliver water to their plots). The water availability and nearness to the water source combined, have a weighted score ranging from highly suitable to unsuitable.

Depth to groundwater and aquifer productivity are used to score groundwater potential. When available at shallow depths and thus easily accessible, groundwater is given a high score. Where groundwater is available at depths up to 7 m, the conditions are highly suitable for developing groundwater for FLID. With easily accessible groundwater farmers can invest in less capital-intensive methods to access water, for example, manual pumps, buckets and ropes. As groundwater depth increases, motorized pumps are required. Such cases would require higher investment but will nonetheless score highly in cases where there are benefits from irrigation. A second element to the groundwater score is the productivity and storage of the aquifer which will lower the water availability score if it is limiting. Two scenarios can be considered: highly suitable groundwater when the aquifer is highly productive, with productivity of greater than 0.5 (see Table 3); and aquifer productivity suitable for small-scale household gardens and community irrigation ranges from 0.5–5 l/s. Lower productivity aquifers are scored unsuitable for irrigation.

Table 1 Natural resources scoring guideline

	Score				
	5 Highly suitable	4 Suitable	3 Moderately suitable	2 Moderately unsuitable	1 Unsuitable
Surface water: distance to water source (m)	<10–250	250–500	500–1 500	1 500–2 500	>2 500
Water availability:	Water is abundant nationally and widely available for irrigation.	Water is widely available for irrigation in numerous sub-regions but there is scarcity in a few sub-regions.	Water is abundant in a few sub-regions, but competition is a common factor in regard to irrigation use.	Water availability for irrigation is nominally constrained; cross-sectoral and localised competition is a feature.	Water availability is heavily constrained, competition and conflict are serious, irrigation abstractions are curtailed.
Groundwater: depth (m)	<7	7–10	10–15	15–30	>30
Groundwater: aquifer productivity (l/s)	>0.5	0.1–0.5	-	-	-
Slope (%)	0–2	2 ≤ 4	4 ≤ 6	6 ≤ 8	>8

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The Farmer-led Irrigation Development Guide

Module 2

Farmer Benefits

The gains from irrigation farming

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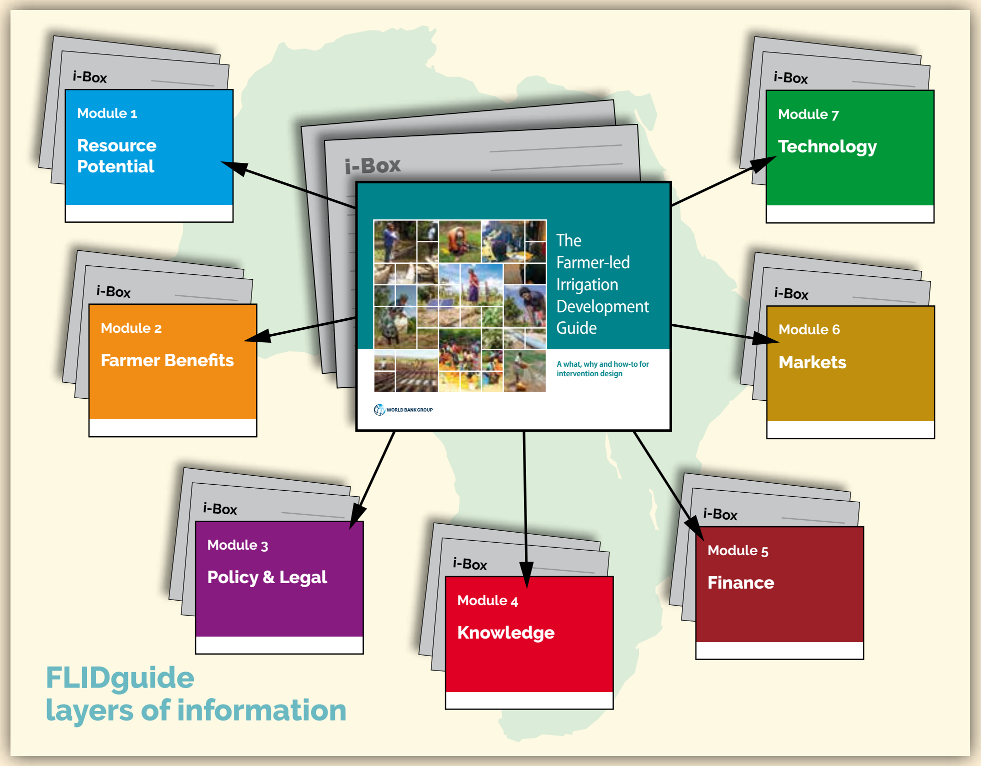
Contents

Abbreviations and acronyms

FLID	farmer-led irrigation development
ha	hectare
i-box	information box
TOR	Terms of Reference

Using the guide

The main volume of the FLIDguide presents the core body of information that explains FLID and the process of intervention design. Thematic descriptions are included in seven modules. Information boxes (i-boxes) at the back of the Main Guide and each module provide additional detail, and hyperlinks throughout the guide access relevant external publications, websites, animation clips and videos.



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- open the **View** drop down menu and select them from the **Page Navigation** options.

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2 Farmer benefits

The gains from irrigation farming

This module answers the question of "Who is the farmer?" and "What are the benefits from irrigation?" We first give attention to the idea of "the farmer" with an emphasis on their diversity. Farmers' aspirations differ substantially as do their needs and their perceptions of what constitutes a benefit. Five fictional farmers are described to help envisage the kinds of people who are involved in FLID processes. Guidance is provided on developing farmer typologies, which are a tool to aid more targeted and effective responses, given farmers' diverse situations.

Irrigation farming has many benefits compared to rainfed farming – it is associated with increased production, better use of resources (i.e. intensification) and increased profitability. Irrigation leads to direct and indirect benefits for both farmers and the wider economy. Examples of quantified irrigation benefits for smallholder farmers in selected countries across Africa is presented. These show that significant cash returns can be achieved. This is followed by an outline of the terms of reference for the diagnostic exercise of farmer benefits and guidance on scoring the farmer benefits axis. When benefits are low, there is no reason to pursue any intervention to support FLID, while the converse is a primary driver of FLID.

Shifts in farming systems enabled by irrigation

- **early planting** before the rainy season, leading to early harvesting with market advantages
- **additional cropping seasons**, thereby increasing benefits from a fixed land resource (i.e. increased land use intensity) and year-round income
- **longer and more frequent growing seasons**, providing year-round incomes
- **greater diversity** in available crops

2.1 Who is "the farmer"?

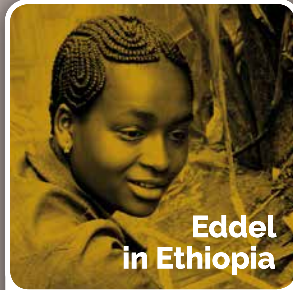
Smallholder farmers are of particular interest because they are more likely to be resource-poor with less financial capacity, and have more difficulty accessing information, inputs and technology. Due to their large numbers, working with this group has good potential to contribute to development goals with large-scale impact.

FLID unfolds in many different physical situations (Main Guide Figure 2), and even in seemingly similar locations, farmers may differ from each other. There will be different technologies, crop choices, marketing strategies and financial capacity, with varied aspirations and experiences. Their rainfed farming, livestock production, off-farm jobs, and other income-generation activities will also be different. These differences must be appreciated to enable effective catalytic responses. To illustrate this point, five "case descriptions" are shown in Figure 2.1. The stories and photos are fictional, but all of the details are drawn from the lives of real farmers in Africa.

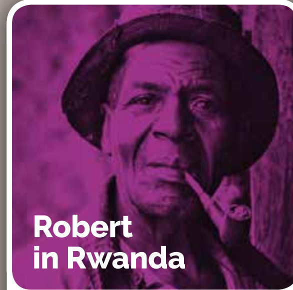
Businesswoman and farmer; farming 2 ha of rice for own consumption with surplus for the local market (wet season) and half that area under tomatoes for a nearby cannery as an outgrower (dry season). Irrigation application methods: basin (rice) and furrow (tomatoes). She is located on customary-held family land. Water is supplied via a small group gravity canal scheme shared with 10 other families.

Traditional herbalist and single mother: farming ½ ha of rainfed maize (wet season) and irrigated vegetables (dry season) for local market sale. Uses a bucket and rope system and a watering can from a hand-dug shallow well to water her vegetables. Reliant on family labor and farming on "borrowed" land near a wetland.

Entrepreneur, part-time DJ, blogger, and farmer for cash; farming ½ ha of cash crops (onions, greens, tomatoes) on a rented peri-urban plot. Employs full-time labor and manages his own informal sales outlets at urban taxi stops. Pumps water from urban outflows, with conjunctive use of a shallow well, with a hose-to-furrow system powered by a "temporary" electric connection to a nearby school.



Agricultural graduate, civil servant and "remote-control" farmer, managing operations daily via Whatsapp; grows high quality green beans and okra for supermarkets on 1 ha of leased land immediately downstream of a major irrigation scheme. Has 2 ha of teff on her family plot, for the local market. Planning to export, she is completing Global Gap registration. Uses supplementary irrigation with sprinklers powered by a petrol pump from a a shallow well.



Shopkeeper, business farmer and traditional leader; farming 10 ha of bananas and vegetables for the local market, and 2 ha of passion fruit on contract for export. Owns the land under a title deed in recently formalized national tenure process. Global Gap registered. Uses both drip (passion fruit) and sprinkler irrigation (bananas) from tube wells, powered with a mixed system using both petrol and solar pumps.

Figure 2.1 Fictional FLID farmers illustrate the diversity of context and farming business (based on true stories)

Farmer profiling and typologies

Simplification of farmer diversity using typologies is needed to enable interventions to be both responsive to diversity yet manageable in practice. Typologies are useful because these characteristic groupings require different kinds of responses, yet share enough commonality within each group so that a targeted response would work for all. This might be a policy, financial, knowledge, marketing, or technical response, or a mix of these.

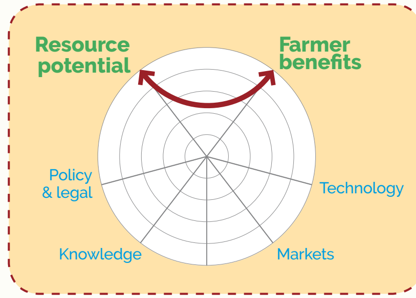
A typology allows for the capturing of meaningful information on anticipated outcomes from the farmers' perspectives (i.e. intended

benefits) which have direct implications for planning in relation to risk appetite, financial means, ways of marketing, scale of farming, and level of sophistication. There are a few ways to develop a typology. When survey resources and sufficient farmer data is available, cluster and other statistical analysis can be used. More pragmatically, a qualitative approach may have to be used. Discussions with farmers, farmer groups, and experienced agricultural officers, combined with targeted field visits and secondary data, can achieve a useful result. Some defining characteristics for smallholder farmer typologies are explained in i-box 2.1.

2.2 Irrigation returns at field level

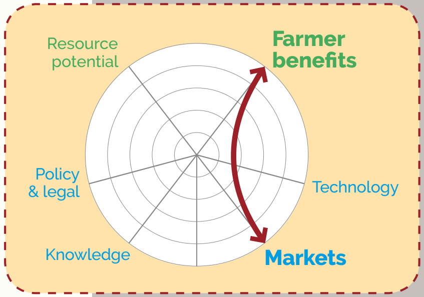
Farmers are different and aim for different results. Some farmers will move from rainfed food-production to irrigation with the aim of securing food supply and marketing some of the produce. Micro-irrigators on very small plots (< 0.2 ha) will have limited volumes for sale after setting aside food for their own provisioning. Others will be driving a fully fledged market agenda at scale to generate cash. In all cases, the additional, or "incremental", benefits result from increased production that is associated with the introduction or expansion of irrigation, from intensification or from improved access to markets.

The financial returns of smallholder irrigation are most readily reflected by gross margins. Gross margins are a common comparable indicator and reflect the monetary net gain from a crop. The gross margin is calculated by taking the gross revenue from crop sales (or equivalent value if the crop is consumed) and all other production costs such as land preparation, seed, fertilizer, chemicals, pumping costs, labor, packaging, equipment, etc. Gross margin assessments exclude fixed costs such as administration and management. The annual net farming income would be calculated from all of the crops that are produced in the year (i.e. the sum of the gross margins). In typical irrigation practice in Africa, between 1.5 and 2.5 crops are grown on a field portion per year – depending on the climate, water availability, farmer interest and market demand.



Gross margins range widely depending on crop, season and marketing strategies. The selected examples below reflect this wide range and also show the significant incomes that can be generated from irrigation farming (Figure 2.2).

In the Eastern Region of Ghana farmers realized gross margins on horticultural crops (tomatoes and peppers) ranging from USD 500 to USD 1 700/ha (Namara et al. 2011). In Uganda, irrigated horticultural crops for local and regional markets gave returns of USD 2 500/ha to USD 3 600/ha (authors' assessment 2020). Peri-urban fresh vegetable production within 2 hrs drive in major cities in Ethiopia recorded gross margins of USD 2 400 to USD 4 000/ha (Wiggins and Lankford 2019), while in Kenya, tomatoes produced for urban fresh produce markets exceeded USD 8 000/ha (Wiggins et al. 2014). In Tanzania an analysis showed a gross margin on irrigated tomatoes from shallow wells of about 700 USD/ha for petty commodity producers and about 4 500 USD/ha for capitalist farmers, the latter reaching over 7 000 USD/ha for irrigated onions (De Bont et al. 2019).



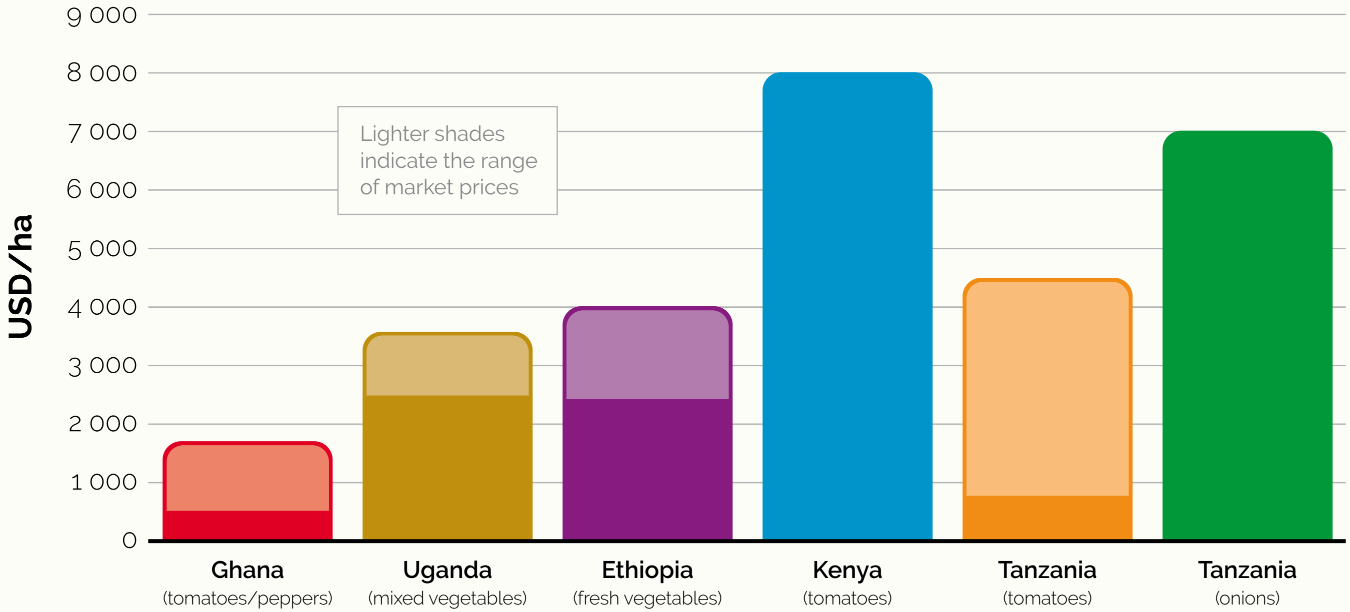


Figure 2.2 Gross margins for irrigated horticultural crops from selected countries in Africa

The financial returns of irrigation vary widely with the crop, season and marketing strategies of smallholder farmers.

Annual and lifetime assessments, particularly comparisons of irrigation and rainfed scenarios, are also useful in understanding farmer benefits. Analysis by the authors in Uganda for mixed horticultural crops (in 2020) showed net irrigation farm incomes averaging USD 5 000 to USD 7 100/ha/annum with double cropping that was enabled by irrigation. Rainfed farming, by comparison, generated a net average farm income of USD 2 300/ha/annum (Figure 2.3).

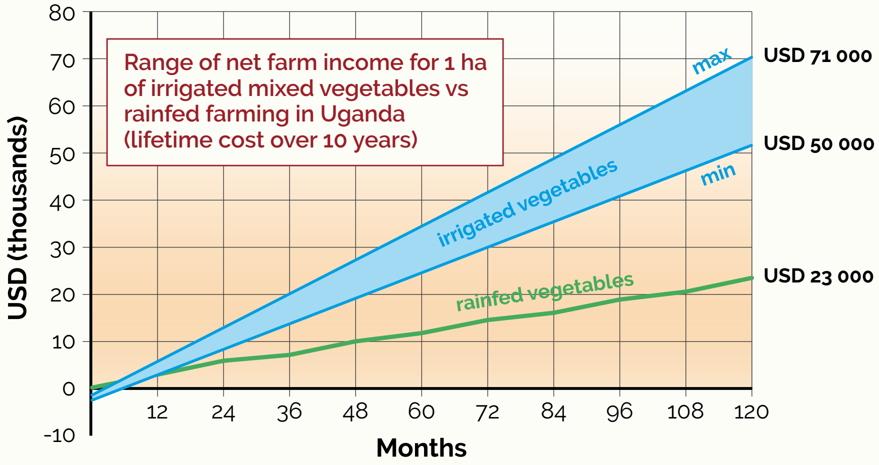


Figure 2.3 Comparison of rainfed and irrigated horticulture farming in a lifecycle assessment in Uganda

Besides the influence of production modalities such as the use of inputs, external labor, etc., the gross margins differ considerably depending on the timing of production (in- or off-season) and the location of selling (e.g. at the farm or in the city). Van den Pol (2012) shows that in Central Mozambique the gross margin for selling tomatoes at the farm is about 2 000 USD/ha while selling in a nearby city amounts to about 3 500 USD/ha. The traders at the farm gate mark up 75% of the farmers' selling price. Seasonal fluctuations are also large. The price for tomatoes ranges between 2 and 7.5 USD/crate, with the low price corresponding to the dry season when tomatoes are easy to grow under irrigation, and the high price reserved for off-season production in the rainy season, when it is particularly difficult to produce tomatoes due to pests and diseases. Understanding and assessing benefits therefore needs attention to these kinds of pricing variables and output market realities (Module 6). While gross margins tell part of the story, it is the incremental benefit compared with rainfed farming that is important and that also has to be evaluated in the diagnostic of the farmer benefits.

2.3 Diagnostic and scoring of the farmer-benefits factor

Diagnostic

The farmer benefits diagnostic requires information of the comparative benefit of irrigation in relation to rainfed farming. It will include for higher yields associated with irrigation (and related production intensification), and production of multiple crops per year (intensity of 200%), and the prevention of crop losses from drought. The diagnostic would usually be carried out by a specialist agricultural economist, and an outline Terms of Reference (TOR) with a scope of work is included in i-box 2.2.

Scoring the farmer benefits

To assess the farmer benefits, you will need to consider the incremental benefit of the gross margins; the benefits from drought-proofing (which itself depends on water availability when droughts occur); the relevance of the broader benefits to the farmer, including food provisioning; and links to the rainfed farming and livestock production systems. Where rainfall is high and droughts are infrequent, then the incremental benefit will be small. Where there is high market demand and rainfall is insufficient and/or unreliable, the incremental benefits to farmers will be high and the rationale for a FLID intervention will be stronger. More guidance on scoring of the farmer benefits is provided in i-box 2.3.

2.4 Concluding note

A high score on the diagnostic spider plot axis for farmer benefits means that irrigation is a game changer for farmers. Farmers can gain financially, be more food secure, and complement other rainfed and livestock farming activities. Investing in irrigation will be attractive to them. The incremental benefits from irrigation are the second part of the equation in understanding the overall rationale for FLID, the first being the resource potential which is described in Module 1. When farmer benefits are minimal, there is no reason to support FLID, regardless of the resource potential. When farmer benefits are significant, the case for FLID is a function of both the factors on the upper half of the plot and is discussed in Section 5 of the Main Guide.

i-Boxes

Farmer typological framework

There are different ways of grouping people. Two are outlined here, the first being a “farmer typology”, the second based on a farming household assessment approach.

Farmer typologies based on enterprise type

International perspectives on typologies of farming-based livelihoods (Green 2008; Van der Ploeg 2008; Scoones 2009; Van Hofwegen 2010) share core characteristics of peasant, entrepreneurial and corporate farming types as described by Van der Ploeg (2008).

These building block concepts are briefly explained below and then modified into a practical typology for use in FLID diagnostic applications in Table 1.

1 Peasant farming is characterized as farming with the primary intention of strengthening the agricultural resource base. Income is only one of several motivations for farming; others include: producing food for own consumption; investment in social linkages; resource reproduction in the long term; and livelihoods resilience. Peasant farmers tend to have a limited appetite for risk and try to reduce their dependence on external markets. Risk and independence are important factors in making farming decisions. The peasant mode of farming does not mean that there is a disconnect from markets, particularly output markets, but rather that such farmers tend to seek out and develop relationships with markets that do not threaten their autonomy (Van der Ploeg 2008).

2 Entrepreneurial farming, as termed by Van der Ploeg (2008), is characterized by full market engagement (input, including labor, and output) with the primary purpose of generating profits. As a result, farming is subject to markets volatility, which represents risk. This kind of farming is the same that which Van Averbeke et al. (2011) called business farming.

3 Corporate farming has the same orientation as entrepreneurial farming but is undertaken by corporate entities. This type of farming is larger in scale and is financed by venture capital, often within a web of interlinked agri-enterprises. Vertical integration across the value chain, including on-farm production, agro-processing, industrial packhouses and transport fleets for national and international distribution, is a feature. Corporate farming has strong potential synergies with FLID, potentially in outgrower relationships, where aggregation and/or processing is vertically integrated. This group has a major impact on smallholder ability to compete due to their large economies of scale, competitive pricing, and high degree of sophistication.

There are two aspects that are not explicit in any of these farmer typologies and which need be considered in relation to FLID: i) the degree of capital investment by the farmer and his/her indebtedness (financial capital); and ii) the degree of risk that is acceptable to farmers. Chipfupa and Wale (2018) developed a farmer typology that included such financial descriptors, as well as a sixth element of psychological capital.

They highlighted the heterogeneity of smallholder farmers in terms of characteristics such as education, age, cautiousness, social-grant dependency and psychological endowment (ie. emotional IQ), along with other livelihoods capital and farming attributes.

They confirmed the importance of access to finance, education and training, and market access as critical to entrepreneurial development, a point underscored in the FLIDguide systems framework. These perspectives are useful and lead to a farmer typology that can be tailored for use in different contexts.

Table 1 Indicative smallholder typology for FLID analysis (amended by the authors, based on Van den Pol [2012]; Manderson [2015]; and Cousins [2014])

Attribute	SMALLHOLDER CATEGORIES			
	Food producers	Market-oriented smallholders in loose value chains	Market-oriented smallholders in tight value chains	Business farmers
Objective of production	Home consumption	Home consumption + cash income	Cash income + home consumption	Profit
Proportion of marketed output	Proportion of marketed output	50% or >	75% or >	100%
Marketing strategy	Selling small amounts to different customers at farm or along roadside	Different traders buying small amounts	One customer/trader per field, after agreeing a price after cellphone negotiation	In contracts to traders or selling directly in the city to wholesalers
Contribution to household income	Reduces expenditure	Variable, from small to significant	Significant	Significant
Labor	Family	Family + some hired	Family + significant numbers hired	Hired
Mechanization	Very low	Low	Medium to high	High
Capital intensity	Very low	Low	Medium to high	High
Access to finance	Absent	Some	Significant	Very significant

Entrepreneurship is an important characteristic of FLID and the final typology provides nuance in the scale, purpose, market proportion and sophistication of the farming strategy. The typology is useful as a basis for defining more locally specific typologies for any situation, thus enabling more targeted planning and design to meet the different needs of the different groups.

Household livelihoods typology

Another approach is to consider the farmer within the context of her/his household, rather than simply the farm enterprise in itself. This can provide additional contextual data to allow segmentation, and then more careful targeting of the intervention responses. Some key criteria that can be used in statistical cluster analysis or similar grouping approaches are listed below (Table 2). Where farmer sample sizes are sufficient, cluster analysis can provide valuable results that reflect the characteristics of the most vulnerable groupings, and facilitate targeting for the most opportune groupings.

Table 2 Useful criteria for defining smallholder farming households (from Anderson, Learch, and Gardner [2016, 6])

Key Criteria	Considerations
Market orientation	Subsistence vs market-oriented vs hybrid
Landholding size	Threshold
Labor input	Family vs hired
Income	Shared income from farming, multiple sources
Farming system	Technology, irrigation
Farm management responsibility	Owner, influence over how to farm
Capacity	Owner, influence over how to farm
Legal aspects	Formal vs informal
Level of organization	Member of group - producer, supply chain, service provider

Additional elements included in a clustering assessment:

- Educational attainment
- Socio-economic status
- Access to emergency funds
- Mobile phone ownership
- Attitudes around work and self-determination
- Incidence of livelihood shocks

An example of a clustering outcome that facilitates intervention targeting is shown in Figure 1.

Descriptive name of household segment	Farming for subsistence	Battling the elements	Diversified and pragmatic	Options for growth	Strategic agricultural entrepreneurship
Key characteristics	Typical quintessential farming household that struggles to support its needs	Persevere through harsh agricultural challenges and remains optimistic about farming	The realities would lead them to diversify out of something they enjoy if given the choice	Stable, optimistic for the future and has options for the future within and outside of farming	Actively engaged in agriculture, and growing agricultural activities
	Stands to gain the most from financial and agricultural support interventions	Financial mechanisms have enabled some of their perseverance	Embody the realism and inner conflict that can characterize households	Could pivot into or out of farming depending on opportunities	Model or "use case" for inspiring growth in other segments

Figure 1 An example of a market segmentation output with characteristic names for each group (Anderson, Learch, and Gardner 2016, 59)

Outline TOR for the farmer benefits diagnostic

Objective of the assignment

The objective of this assignment is to develop typical financial analysis for smallholder farmers developing small-scale irrigation (individually or in small group schemes). The diagnostic is guided by the approaches outlined in i-box 3.4 and 3.5, and in Minh et al. (2021). This information can be attached to the consultant's Terms of Reference (TOR).

Scope of work

The consultant will analyze the following aspects in general:

- A climate analysis (if needed, conducted per region of the country), linked with typical (rainfed) cropping calendars
- Risk analysis of crop failure as a result of dry spells
- Irrigation cropping calendar and typical irrigated crops for irrigation farmers in FLID areas
- A farmer typology (if needed, differentiated per region)
- Gross margin analysis for typical (rainfed) crops, and for FLID farmers' irrigated crops under different types of farming methods (based on farmer typology)

The assessment will include attention to the following detail:

- **Mapping of FLID:** Identify and map the locations in the country where FLID is prevalent. Make a best estimate of the extent of the irrigated area developed through FLID processes, differentiated by farmer typology.
- **Description of smallholder farmers:** Who are the farmers interested in introducing small-scale irrigation in a more independent way? How many are they? How can they be segmented?
- **Crops:** Provide a description of the types of crops grown and the typical crop-combinations. Make a best estimates of the production areas of each.
- **Crop budget:** The consultant will define a realistic range of crop budgets for key crops, notably mixed-horticulture enterprise. The crop budget will consider a range of crop performances in terms of minimum/average/maximum achievable yields. The crop budget will also take into consideration the time and motivation required for the farmer to transition from rainfed to irrigated agriculture, and will reflect a range of access to knowledge in terms of absence/limited/high provision of extension services. The consultant may start to identify the key crops either from the perspective of farmers' own familiarity or from a market segmentation perspective; this should provide for ease of adoption of the key crops.
- **Gross margin:** The consultant should define a realistic farm-typical plot, in terms of combination of crops and with ranges for subsistence vs commercial production. Using pessimistic/optimistic market-price envelopes, the consultant will develop gross margins for typical farms.

- **Cost-benefit analysis:** For the development of the cost-benefit analysis, a range of technologies will be considered and the profitability of investing in irrigation from the point of view of the farmer will be assessed. The consultant will show comparative water cost in the crop budget of capital repayment and operating irrigation tech (solar and petrol) (water total cost as a percentage of Gross Margin is a useful indicator: excellent <10%; affordable 10–20%; difficult 20–30%; unlikely 30–40%). Lifetime horizons should be 5, 10, 15-year on the solar/petrol tech comparison with few sensitivity variables.

In addition, the consultant will analyze the case of gravity-fed systems where these are common.

- **Farmers' capacity to pay:** Based on the above, the consultant will advise on the capacity of typical farmers to pay for irrigation equipment. The assessment will advise on the level of financial contribution that might be needed (in the form of matching grants) to make the irrigation equipment affordable. In addition, the consultant should check the capacity of the farmer to repay a loan (over 6/12/18 months) should the farmer be eligible to access credit for irrigation development, and identify a monthly (micro-loan) repayment amount for the solar option that is similar to a petrol-pumped system (based on 1 acre).

- **Sensitivity analysis (by agro-ecological zone):** The consultant should assess risks of drought (a 10-year timeline, how many of those are going to be hit?).

- **Conclusions (by agro-ecological zones):** The consultant will use the result of the analysis to build the narrative of why FLID is an opportunity for farmers from a benefits perspective (notably, increased productivity vs social stability).

Guidance on the scoring of the farmer-benefit factor

The scoring of the farmer-benefit axis on the diagnostic spider plot is based on a simple ranking from very low to very high, with a score of 1 to 5 respectively. The farmer benefits are high when moving from rainfed to irrigated agriculture (reduction of drought-related crop failure, increased total production, increased yield, increased profit). The farmer benefits are low if introduction of irrigation is of little incremental benefit to farmers (drought failure is not a major issue or cannot be avoided through irrigation, off-season production possibilities are limited, no [accessible] market for irrigated produce).

As farmer-benefit is different depending on how agricultural production is organized at the farm the diagnoses and the scoring need to be done while taking into account the farmer typology, relating to scale, gender, market orientation and other relevant socio-economic and cultural-political aspects. Farmer-benefit also may vary widely from region to region within a country as rainfall seasonality differs.

Farmer-benefit is high when:

- Irrigation can provide a considerable safeguard against crop failure as a result of dry spells.
- There is a clear (and long) dry season in one or more regions in the country where irrigation could offer a possibility for off-season production, and where different types of farmers could increase their cropped area by making use of this possibility.
- Different types of farmers could make a considerably higher gross margin with supplementary irrigation, or by switching from rainfed production to irrigated production.

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GWSP
GLOBAL WATER SECURITY & SANITATION PARTNERSHIP

The Farmer-led Irrigation Development Guide

Module

3

Policy and legal

The rules of the game

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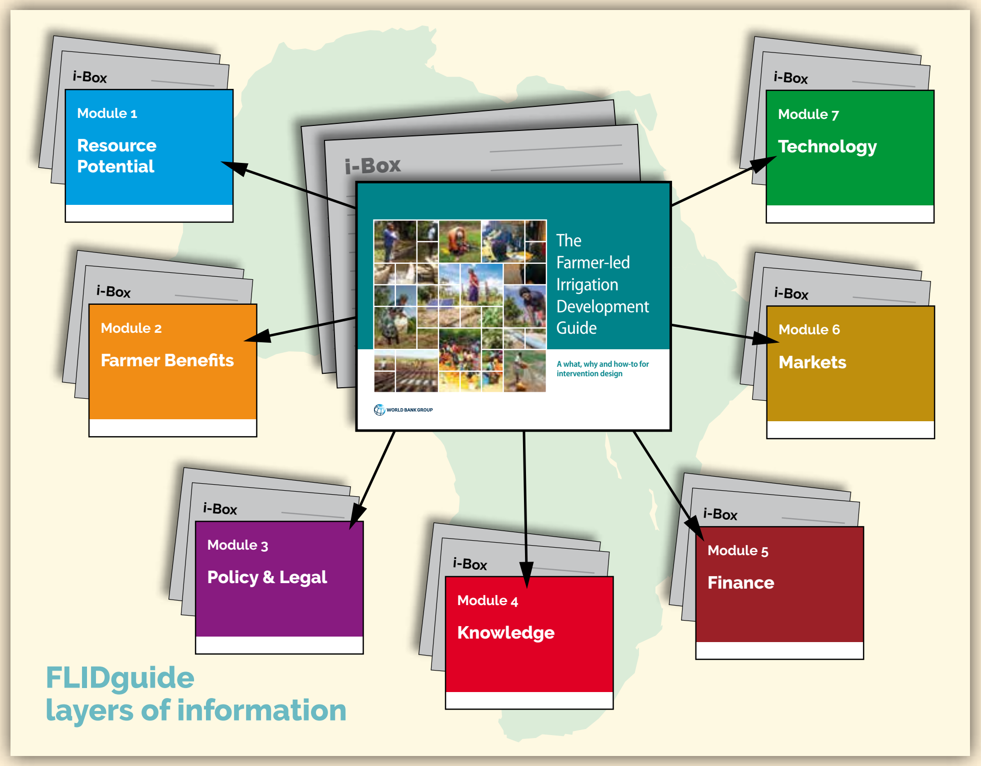
Contents

Abbreviations and acronyms

CAAC	catchment area advisory committee
FAO	Food and Agriculture Organization
FLID	farmer-led irrigation development
ICT	information and communication technology
IWUA	irrigation water user associations
M&E	monitoring and evaluation
O&M	operation and maintenance
TOR	Terms of Reference
WHO	World Health Organization
WRA	water resource authority
WRM	water resources management
WRMA	water resources management authority
WUA	water user association

Using the guide

The main volume of the FLIDguide presents the core body of information that explains FLID and the process of intervention design. Thematic descriptions are included in seven modules. Information boxes (i-boxes) at the back of the Main Guide and each module provide additional detail, and hyperlinks throughout the guide access relevant external publications, websites, animation clips and videos.



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To instal the buttons (in Adobe Reader),

- Right-click anywhere on the toolbar and select them in the **Show Page Navigation Tools** options; or
- open the **View** drop down menu and select them from the **Page Navigation** options.

Alternatively, try using these keyboard shortcuts:
Windows: Press the **ALT** key and ◀ or ▶ arrow
Mac: Press the **COMMAND** key and **[** or **]** square bracket

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- choose **File > Print**, and in the page sizing and handling area or pop-up menu, select **Fit to Printable Area** or **Shrink to Printable Area**.

3 Policy and Legal

The rules of the game

Module 3 covers the diagnostic assessment of policies and laws, with primary attention on water and land. The purpose is to identify how policies and laws enable or constrain FLID, and – when needed – define interventions to overcome constraints. There are other policies and laws that relate to the knowledge, finance, markets and technology factors, which are also important to enable a thriving FLID environment. They are considered and assessed separately in Modules 4, 5, 6 and 7, as they are informed by the content in those chapters.

This module is structured into three sections. The first presents an overview of "things to think about", firstly in relation to water, and then to land – the two primary irrigation resources. It has been observed that secure water or land rights are not always essential conditions for FLID to take place (Woodhouse et al. 2017). Yet, efforts to remove hurdles and reduce the risks associated with insecure water and land tenure can both accelerate FLID and facilitate vulnerable and risk-averse farmers to adopt irrigation practices. When an investment is made on the land for any kind of development, it will affect power relations and impact the tenure governance system. Understanding existing primary and secondary rights, customary norms, and the impact of water and land tenure security, can strengthen the interventions, decrease risks and advance benefits more equitably. The second section provides guidance on the scope of the diagnostic, and also on how to score the "legal and policy" axis of the diagnostic spider plot. In the third and final section, a number of suggestions for water governance and land tenure interventions that can improve the enabling environment for FLID are presented.

An **enabling environment** is when policies, institutions, support services and other conditions create a business setting where irrigation farming enterprises can start easily, develop, and thrive.

Tenure type describes the specific characteristics of the holding arrangements of land or water rights.

Governance is about how the rights are *managed* and influences the reality of who benefits from the resources and related services.

Regulation is about setting *limits*, the *mechanisms* for enforcement, and incentives for sustainable and efficient use.

3.1 Water and land tenure in a FLID context

Tenure – What it means and why it matters

Land and water tenure systems are created by societies to define and regulate how people, as individuals or in association with others (including as families, clans, communities, non-profit organizations, business enterprises and governments), gain access to natural resources. They determine who can use which resources, for how long, and under what conditions. Tenure rights are the main way in which people, the resources, and the conditions of use are connected (Food and Agriculture Organization [FAO] 2017).

For people to derive benefits, tenure rights must be secure, and a sound governance system is needed. Secure tenure can prevail under formal, customary, or informal systems, or a mix of these, as long as all those involved in the use and management of the resources perceive it as legitimate. This means that people understand their rights and obligations concerning the resource, including the conditions under which they can acquire, transfer, or lose their rights. It also means that the social and institutional system of reference guarantees those rights, and a mechanism is in place to address any dispute that could emerge.

Water tenure and FLID

Irrigation expansion resulting from FLID processes is not well defined. FLID is associated with some unique characteristics and problems that are compounded by historical water governance arrangements. One challenge of FLID is that data is generally not included in formal records. This means that balancing the unknown irrigation demand with other water demands in the basin relies on guestimates (if FLID is even acknowledged) and is difficult and inaccurate. A further challenge is that as FLID continues to expand, there will be increasing risks to the water resources sustaining it (see Module 1). Thus, it is important to understand the extent of water resource use (including abstractions for irrigation for smallholder uses) to ensure information sharing, and to identify ways of addressing issues of inequity and potential impacts on other water demands, including downstream irrigators.

Many systems for permitting and enforcement are poorly suited to the FLID context. The permitting of hundreds of thousands of small users with classical approaches of individual permits results in administrative overload and an inability to process and record permits (see history in i-box 3.1). Getting access to rights (through permitting) is time-consuming and complicated for many farmers and, in consequence, regulations are often ignored. Enforcement is also impractical. The system works for modest numbers of medium and large users, but usually fails under the sheer mass of numbers in a FLID reality.

Permitting of hundreds of thousands of individual micro-users is administratively impossible in most settings.

Irrigation growth through FLID processes is organic, making catchment management and equitable allocations difficult. FLID growth is characterized by a flourishing progressive expansion along rivers, on and adjacent to wetlands, around large-scale irrigation schemes and in peri-urban areas (Figure 2). These

conglomerations of smallholder farms have a large-scale effect where water use ratchets steadily upwards, though most often is not registered in the formal administration systems.

There are three main implications of insecure water tenure for smallholder irrigators:

First, the lack of data, stemming from inadequate tenure systems, means that the irrigation abstractions are seldom accounted for in catchment water management plans. The balancing of demands in stressed catchments, and decisions on water allocations across sectors, including for smallholder agricultural use, excludes smallholder irrigation farmers, leaving them at a disadvantage.

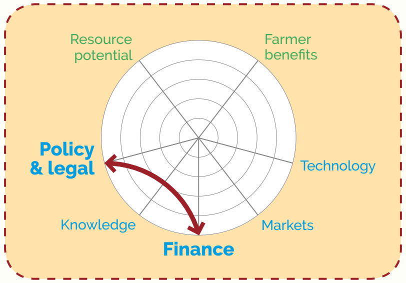
Secondly, water competition is increasingly common and the absence of explicit arrangements, whether formal, customary, or informal, brings uncertainty and increased risk for smallholder irrigation farmers. Uncertainty acts as a disincentive to farmers' investment in irrigated farming, and scarcity increases their vulnerability due to lower production or crop failure.

Thirdly, while some farmers may benefit from a lack of monitoring and enforcement, **the absence of effective regulation is likely to increase inequality.** More powerful individuals are able to capture relatively more of the limited water resource, be it through social pressure, their location relative to the source (proximity), or their ability to purchase more suitable equipment.

Land tenure and FLID

Land tenure is relevant to FLID because the level of tenure security is associated with diminishing risks, incentivizing investment, and promoting inclusion. Where irrigation systems are small and mobile – such as the use of hand-lifting devices, small petrol and solar pumps – the mobility mitigates some of the risk as they can be relocated if necessary. On small group schemes, infrastructure such as intakes, canals, or buried pipelines, is inevitably fixed without the chance of physical relocation, and the risks of insecure tenure are higher. Farm investments, however, go beyond just irrigation infrastructure and equipment, and include soil-fertility improvement, levelling, land preparation, labour and costly agricultural inputs – all potentially constrained by insecure land tenure. When there is *tenure security* on the other hand, farmers invest more readily, leveraging the land and other resources for more sustainable development (i-box 3.2).

Land tenure insecurity has high costs in terms of human and food security, stability, productivity, and long-term sustainability. When tenure is not secure, public interventions to catalyze FLID can easily result in unintended outcomes, thus increasing risks of exclusion. Land becomes a source of conflict, a perpetrator of social inequalities and discrimination, and a factor in the depletion of natural resources.



Tenure risks are amplified when farmers plan to make significant financial and labor investments in irrigation equipment, soil fertility, drainage, or flood protection earthworks. It is self-evident that any irrigation investment would be at risk if the right to use the land and to exclude others (from harvesting the crop or keeping invading animals out) were interrupted – exposing the irrigation farming enterprise to damage. The larger the investments, the longer the duration of secure rights that is needed to derive benefits from those investments. The

longer the duration of secure rights, the more the farmer will be interested and ready to invest in the sustainable use of resources.

Investments, in turn, have an impact on the land and may weaken right-holders' security of tenure. This causal relationship is complex, but it often gravitates around the increased value and competition for land as a result of the investment.

The entry point to understanding the potential impact of land tenure on FLID, during the diagnostic phase, is the assessment of the type and quality of the governance system in place. The assessment will map existing primary and secondary tenure rights holders and the level of tenure security experienced in the target area. A strong tenure system is one that is legitimate, inclusive, accountable, and transparent. The higher the level of tenure security, the higher the chances of FLID sustainability and success. The weaker the system, the lower the level of tenure security, the higher the investment risks – and the greater the chance of unwillingly facilitating or legitimizing land grabbing or land rights dispossession. The tenure governance system assessment determines how much weight should be given to land tenure aspects in the context of FLID to maximize impact and mitigate risks.

A sound land tenure governance system provides tenure security and can become a powerful FLID enabler.

Legal pluralism – A reality and an opportunity

Legal pluralism is when two or more legal systems operate within the same geographical area. This is a reality of life for most smallholder farmers. Local and customary law overlaps, complements, or can even contradict aspects of the formal legal system, also impacted by religious laws and social norms (Figure 3.1).

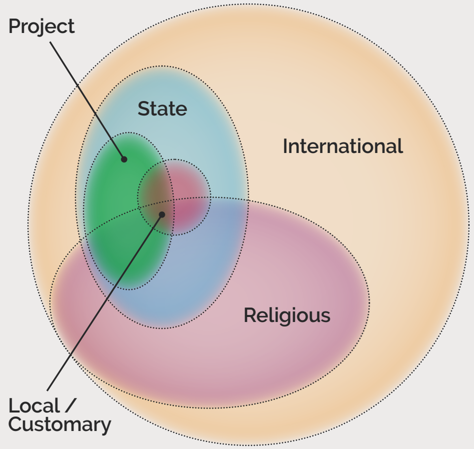


Figure 3.1
Legal pluralism: A foundation of the hybrid law intervention response to the FLID water and land governance challenge

A large percentage of the water and land in Africa is managed and accessed under customary law. While customary land mechanisms are widespread, there are only a few cases where African water legislation recognizes the implications of, or customary/pluralistic arrangements for, improved water management. There is, however, increasing interest in how this issue can be resolved, with ongoing research being conducted, for example, into the customary water regimes of Africa and how to align statutory and customary practices. Studies have already shown that customary laws and institutions can be very effective in resolving local level water use disputes (Ramazzotti 2008; Nkonya 2006).

At the international level, there has been recognition of the importance of customary law for sustainable natural resource management (see, for example, Principle 22 of the Rio Declaration on Environment and Development). Yet statutory water law in Africa has generally failed to address this aspect, so customary water law is largely ignored or overridden by statutory law. Customary law practices in other sectors, such

as land tenure, provide both precedent and lessons to inform a more hybrid practical approach in the water sector.

Legal pluralism (*de facto*) can be translated into practice as hybrid law (*de jure*) and is a valuable instrument in ensuring locally applicable and enforceable rules that harmonize with national legal frameworks (see i-box 3.3). When the water and land tenure and governance arrangements are weak or insecure, the risk and vulnerability for smallholder farmers is high. This is particularly the case when investments are made in irrigation that have the effect of increasing the returns from, and thereby the value of, the available land and water resources. It is essential to understand the full range of laws, rules, and norms that impact on farmers' irrigation practices in order to identify constraints and plan effective responses. New governance arrangements may be needed if FLID processes are to be accelerated and risks adequately managed.

3.2 Diagnostic and scoring

Diagnostic – Collecting and assessing information

The diagnostic involves the collation and analysis of all relevant policy and legal information for both water and land in the context of FLID. The policy and legal review of the other factors is dealt with in their relevant modules, though the process is the same for all (Section 4 of the Main Guide; and checklists in i-boxes 3.4 and 3.5). A more comprehensive approach is described in Minh et al. (2021). The evaluation of policies and laws would also tackle related topics – such as policies for the promotion, assessment, planning or regulation of irrigation; environmental values; water quality; and legal mechanisms beyond tenure for regulating land and water – and explore how FLID can thrive within processes. Attention also needs to be paid to mechanisms for recognizing FLID as a phenomenon (in policies, laws and strategies), and for allowing farmers' voices to be heard in agricultural, land, and water debates. A typical outline Terms of Reference (TOR) with a scope of works for the diagnostic is included in i-box 3.6.

Scoring the enabling environment

Assigning a score aims to reflect the extent of constraints in the policy and legal environment as it relates to the impact of water and land tenure on smallholder irrigation uptake and expansion. Scoring follows from the diagnostic and is as much about the discussion and debate (within your own mind and with your team members) as it is about setting a final ranking.

Deciding on a score must take into account the policy and legal constraints that inhibit natural resource access and use, as well as the impact of constraints on other factors (knowledge, marketing and technical). A set of guiding questions is provided in i-box 3.7. The final score will reflect the extent to which the water and land tenure enabling environment constrains FLID and, consequently, the need for a targeted intervention to help overcome the constraints.

3.3 Examples of interventions

There is good reason to initiate policy and legal reforms where significant constraints are identified in relation to land tenure, water rights, water permitting, and water resource access. Preparation of a "policy note" (an advisory note with recommendations for policy change) can make a valuable contribution to longer-term change. Most often, however, more immediate solutions must be found to deal with weaknesses in the water and land legal framework, in implementation planning and design.

Suggested water tenure interventions

Interventions in water resource management and governance may be needed when the demands on smallholder irrigators for permitting is onerous and when the administration system, compliance and enforcement constrains water access for new irrigation farmers.

> ***Effective regulation*** *supports national economic activity, development, and equity, and promotes efficient and equitable social and environmental policies.* ***Excessive regulation****, especially when non-transparent and arbitrarily enforced, raises transaction costs for the economy as a whole and generates a variety of risks, including corruption.*
>
> – paraphrased from Schiavo-Campo and Sundaram 2000, 25

There are **three critical functions** that governance interventions must strive for in support of FLID processes. These emphasize sustainability, regulation, and monitoring:

1 **Support the sustainable and productive use of water by micro-abstractors,** through legal protection from predation by larger water users.

2 **Strictly regulate the water use of high-impact users,** through the implementation of water use permits and the rigorous enforcement of permit conditions.

3 **Monitor and assess irrigation development** and other water use trends across catchments to identify when and what kind of interventions may be necessary. Monitoring can be done through registration of significant water uses, status monitoring, and remote sensing.

The ability of the state to regulate, allocate, and control water use takes shape with reference to the existing legal frameworks. In an imperfect legal environment, this can be achieved through the process of bricolage, or building with what is at hand. Bricolage, as a practice, is about pragmatism to achieve "whatever works" in the context. It often replicates what is already happening, but in a more structured and explicit way. Bricolage (i-box 3.8) draws on statutory and customary law, *as well as* norms and informal rules, to enable reliable access to water for smallholder irrigation farmers.

> **Bricolage** draws on statutory and customary laws, formal and informal rules, and local and religious norms to arrive at a **hybrid law** outcome.

Hybrid law intervention options (i-box 3.9)

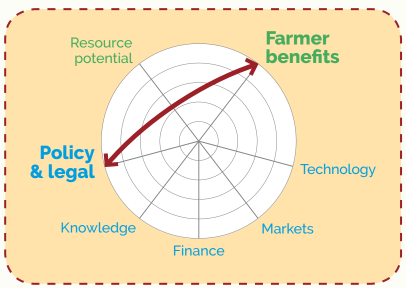
There are five regulatory responses that **can be used alone or in combinations** to ensure that critical water governance functions, and inclusion, are achieved when crafting hybrid law solutions in a FLID context (Figure 3.2). Depending on considerations of practicalities, precedence, political willingness, social acceptability, and the timelines involved, one or more interventions can be selected to achieve the desired functionality.

Figure 3.2
Hybrid law toolkit combining statutory and customary water law

These interventions (in whatever suitable combination) are strongest when they are informed by adaptive management modalities, decentralized governance arrangements, and a system that is gender sensitive and pro-poor:

Adaptive management (i-box 3.10): Enables water managers to track the outcome of implementation of the hybrid water rights system in relation to key indicators (access, environmental impact, conflict etc.), to identify the problems and adjust the system as needed.

Decentralized governance to local levels (i-box 3.11): Decentralization is a strategy to include irrigation farmers who have established themselves outside of the administrative and regulation fold. Water user groups, irrigation organizations, and water user associations are key. Transparency and accountability are incentivized through initiatives that strive for water use efficiency, water productivity, and profitability, and include tech, agronomic and marketing support.



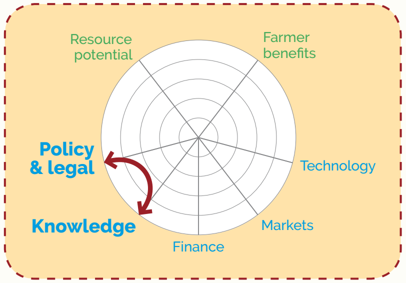
Gender sensitivity (i-box 3.12): Ensuring equitable access to water for all is difficult but important. There is a need to consider how best a hybrid water rights system can facilitate access to water for female smallholder farmers, and avoid entrenching intersecting gender- and class-based forms of injustice.

A pro-poor water rights system should support the water use of smallholder irrigation enterprises to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (i-box 3.13).

Guidance on land governance interventions

Stand-alone land tenure interventions are not included as part of the FLIDguide but FLID has an impact on tenure security. There are risks, described earlier, related to increased investment in irrigation. Mitigation responses in relation to land tenure may therefore be needed as part of other FLID interventions. A **range of strategies that can mitigate FLID risks** are listed below and in i-box 3.14. These must be planned and budgets allocated early in the design phase of the intervention.

Options may range from positive discrimination policies to ensure inclusion of most vulnerable groups in FLID, to the following: **participatory planning processes** to identify strategies to renegotiate and guarantee secondary rights;



empowering the existing tenure governance system to streamline and secure processes for land access; and supporting **processes of land rights documentation** in order to move progressively towards land rights formalization, if appropriate. The approach to be taken will depend on the specific circumstances in each instance and should follow the principle of progressive and context-appropriate strengthening of threatened or insecure land tenure rights.

Inclusion and participation

In order to achieve improved tenure governance and strengthen tenure security, it is critical to recognize and protect all legitimate tenure rights. The key to the success of land tenure interventions at any level is meaningful participation and inclusion of all stakeholders (beneficiaries, rights holders, local authorities, etc.). This may at times require an additional investment in empowering and capacitating those who are traditionally excluded from land governance and decision-making.

Fit-for-purpose

The specific objective pursued in securing tenure rights, and the existing policy, legal and institutional framework, dictate the type of intervention designed; the human, financial and technical costs of the action; and the expected impact in the immediate and long term. Strengthening tenure security is a progressive exercise that can be implemented in phases.

Realistic planning

Investment projects have limited resources and time constraints. It is critical to realistically assess what can be achieved within the given timeline and ensure that targets and budgets are realistic.

Sustainability

Land tenure is a dynamic domain in continuous evolution. Land rights can only be protected when its three critical features (the plot, the right/s and the legitimate rights holder) are clearly identified. If the objective is to secure tenure rights beyond the life of the FLID investment, human and financial capacity must be in place to continually appraise changes.

Ensure sound mechanisms are in place for dispute resolution

Conflict is a natural element of life, and FLID is likely to exacerbate existing conflicts related to secure access to land or create new conflicts because of increased competition and the need for land for expansion. It is critical that a legitimate, accessible and transparent system is in place to address and peacefully resolve emerging conflicts.

3.4 Concluding note

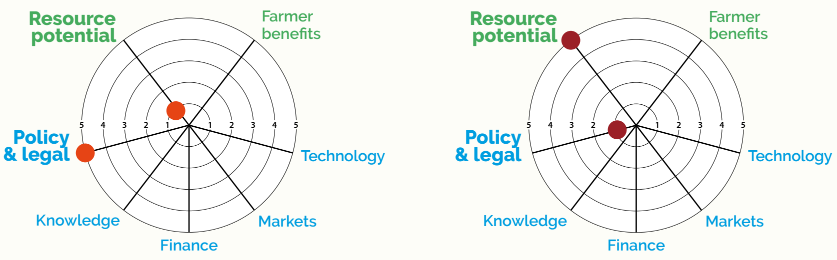
At the end of the policy and legal diagnostic process outlined in this chapter you should have better insight into the land- and water-related factors, and a broadened perspective on tenure strengths and weaknesses in practice. The potential need for catalytic FLID support in relation to tenure inadequacies that may limit the effectiveness of, or bring risks to, an intervention, should be clear.

You should be able to identify strengths in the policy and legal enabling environment that will provide a platform to facilitate faster and easier FLID processes. Where significant constraints have been found, intervention responses may be needed to reduce risks to farmers and ensure more secure and equitable access to water. Land tenure security risks may need to be mitigated. Women, resource-poor farmers, and secondary land rights holders need particular attention. The land and water legal interventions that are informed by the diagnostic assessment should aim to catalyze the FLID process by combining public and private investment and drive inclusive growth while actively pursuing sustainable resource use.

i-Boxes

Water governance – Historical origins and their consequences

The aim of water resources governance (given effectiveness through regulations) is to maximize equitable economic, social and environmental benefits through the sustainable use of limited water resources. Where water is scarce and competition high, water resources regulation becomes more important than in a context of water abundance and includes the need to be able to minimize and address disputes between competing users.



When resource potential is low, i.e. water and land are very stressed, then a strong and enabling policy and legal environment is more important.

Figure 1 Resource potential extremes and the relative importance of an enabling policy and legal environment

Water use permit systems can't cope

Water permit systems are in place across much of Africa, and permits are often a statutory requirement for small and micro irrigation enterprises as well as large enterprises. Research has, however, revealed the general failure of such systems either in protecting the water rights of small scale farmers, or in achieving the objectives of the state in relation to effective water resources management (Schreiner and Van Koppen 2018). The research shows that large numbers of smallholder farmers across Africa operate under customary water (and land) tenure systems.

Permitting of hundreds of thousands of individual micro-users is administratively impossible in most settings.

Small scale water users often mistrust statutory systems and see them as being expensive, cumbersome and lacking in legitimacy. Regulation works most effectively where it is seen as being legitimate and many communities have a preference for informal customary conflict resolution processes around water use. They see these as being more effective and fair, less costly, and carrying more legitimacy than the formal processes which result in a winner and a loser (Sakketa 2018).

The failure of water permit systems in Africa also discriminates against the rural poor. The lack of a water permit means that their water use is, strictly speaking, illegal and they therefore have no legal recourse in the face of competition with other users,

particularly big water users. At the other end of the scale, large water users are equipped to negotiate the formal administrative systems to obtain permits, thus securing legal protection for their water use. Many African governments have put in place statutory water permits systems with the general intention of replacing all other water rights systems, including customary law systems, thus driving inequality rather than ensuring inclusion (Langford and Russell 2017).

Pragmatic focus on the heavy users

Monitoring is the tracking and recording of water use. Regulation is a combination of permitting, compliance monitoring and enforcement, supported by the payment of water-related fees. **The emphasis on who must be monitored and who must be regulated depends on which groupings are using the most water.**

Water use patterns vary from catchment to catchment. There are rural catchments dominated by many micro-abstractors, and others where water use is highly skewed, with most water utilized by a few large users.

Small-scale farmers often operate in the same catchment as towns, hydropower, industry and/or large irrigation farming estates. As an example, in the WamiRuvu basin in Kenya, of the 960 water use permits in the basin, 89% of the water was used by only 30% of the users, while the rest of the 930 permit holders used only 11% of the water. This picture does not include the other small-scale users who were using water in the basin without permits.

In a context of combined skewed water use of this nature and limited state resources, **an effective regulatory system would be focused on regulating (and charging for) the water use of the few large-scale water users and supporting the effective and productive use of water by micro-abstractors**. There is still a need for monitoring more broadly in order to understand and quantify the impact of multiple micro-abstractors, who can, when the numbers are large, have large-scale impacts on the resource.

Water regulation is particularly important where there is competition for limited water resources – whether seasonal, continual, or during drought periods only; a regulatory system must be able to address this issue effectively and, in particular, ensure that the water rights of small-scale farmers are protected in such situations. Adoption of a hybrid or bricolage approach that brings together the best of the various legal systems (statutory and customary) into one effective system is an option that really works on the ground.

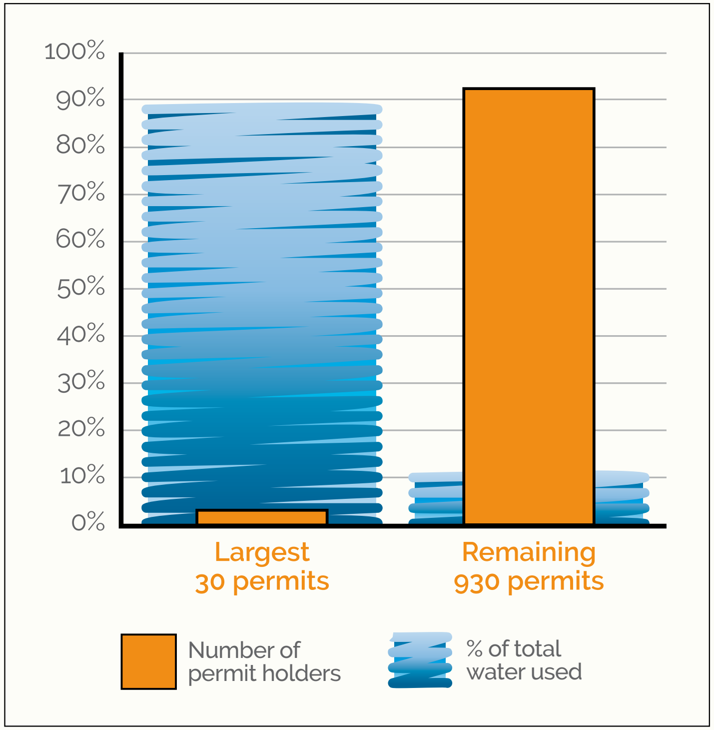


Figure 2 Number of permit holders vs amount of water used in WamiRuvu basin (Sumuni 2016)

Impact of land tenure on FLID

Land tenure in FLID context

Land is much more than a physical or economic asset. Control of land and resources determines power relationships. Across different cultures, land further translates as identity, culture, development, food, shelter and human security.

Secure access to land is indissolubly linked to human development and may determine the success or failure of land-based development. When small-scale irrigation is initiated and developed by the farmers themselves, they gain access to land and secure it through the local land governance system and operate at whatever level of tenure security and legitimacy the system can provide. But when an external investment comes in to support and develop farmer-led irrigation, the cash/technology/knowledge injection will have an impact on local power relations and, in turn, on tenure dynamics.

How does FLID impact tenure in different contexts?

The type and severity of FLID impact on tenure rights are directly related to the quality of the existing tenure governance system and the associated level of tenure security. Effects can be positive or negative, and their intensity can range from *negligible* (which can be addressed within the existing tenure system), to *severe* (the risks are so high that they deter FLID). Most contexts where the impact is identified as negative would fall somewhere in the middle of the ranges, and measures can be taken to mitigate risks. When a positive impact is assessed, land tenure interventions could become an incentive for investment, expansion and sustainability.

Three key elements of land tenure

- **The land parcels** – where is it located, how big is it, what are its physical features, and does it have associated resources.
- **The land rights, claims and encumbrances** – who has the right to do what on the land, and under which conditions.
- **The subjects entitled to those rights** – who are the legitimate rights holders.

What are the potential negative effects of FLID on tenure?

1 **Tenure insecurity.** In instances where the tenure governance system is weak, farmers' security of tenure will be in jeopardy, increasing the investment risks and diminishing the incentives to use natural resources sustainably.

2 **Land grabbing/dispossession.** Participants have no legitimate access to their plots, and the investment empowers infringements on primary or secondary tenure rights.

3 **Benefits sharing.** The initial investment will typically support the purchase of equipment and increase the beneficiaries' capacity, which in turn raises the value of the land. Without a sound tenure governance system in place and understanding of the pre-existing tenure arrangements, there is a chance of elite capture or unfair benefits distribution.

4 **Sustainability.** To ensure that the equipment and capacity are retained and become an integral part of the local socio-economic capital, it is critical to assess whether participants reside and settle in the areas and have legitimate rights to use the land, water and equipment.

How do you assess the potential impact of FLID on land tenure?

The FLID tenure impact assessment aims to identify potential risks and opportunities related to land in the FLID framework, estimate their likelihood, and inform the design of related land tenure measures if appropriate. It determines how much weight should be given to tenure aspects in the context of FLID to maximize impact and mitigate risks. This diagnostic is based on an analysis of the current land tenure governance framework (*de jure* and *de facto*). Table 1 provides an overview of the criteria and a broad indication of the potential impact of FLID on tenure based on the specific circumstances.

Table 1 Criteria for assessing level of tenure security

	Low tenure security	**High tenure security**
Criteria	**High Risks, FLID (potential) negative impact**	**Low risks, FLID (potential) positive impact**
Formal and customary legal, policy and institutional framework	Blended/conflicting and informal systems	Single systems (formal or customary) and harmonized plural systems (blended/ mutually reinforcing)
Tenure governance system	Weak, ad-hoc and inaccessible (land administration services are expensive, far away, unclear, ineffective)	Transparent, sound, legitimate and accessible (land administration services are within reach, affordable and transparent)
Primary and secondary right holders and users	Only partially recognized, and in some instances discriminated against	Known, recognized and protected
Protection and inclusion	Low accountability for, and discrimination against, certain rights holders (women, youth and other vulnerable sectors)	Transparent and inclusive
Grievance-redressing mechanisms	Multiple fora with no hierarchy, no harmonization, and conflicting principles and processes	Legitimate, accessible and empowered to decide and enforce

Normally, where tenure security is high for primary and secondary rights holders, there is a sound land governance system in place and the investment will have higher chances of success and reduced risks of negatively affecting the most vulnerable tenure rights holders.

Tenure systems are dynamic and highly diverse. Therefore, the different criteria must be looked at individually. For example, there is no fixed correlation between the level of formality of the system and the level of tenure security. Formal systems with limited record-keeping and implementation capacity may be weaker than customary systems based on a fully oral tradition with a high degree of local legitimacy.

The assessment of the tenure governance systems is fully context-specific in determining, on a case-by-case basis, how much weight should be given to land tenure aspects in the context of FLID to maximize impact and mitigate risks.

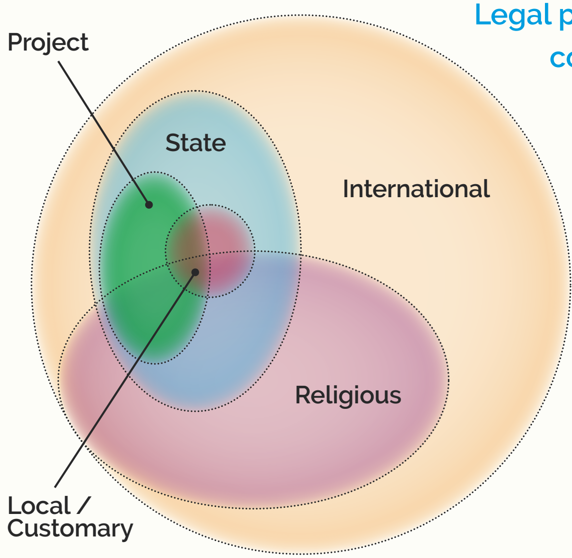
Similarly, there is no guarantee that a system that scores high on one of the criteria will obtain the same score across all criteria. For example, customary systems with a high level of local legitimacy and enforcement capacity may guarantee secure tenure against the external competition for the land, but may not constitute an enabling environment for expansion of irrigated area and risk-free investment. Land transfer is often based on short-term informal agreements (one season or a year), based on crop-share arrangements (you give the land, I farm it, we share the harvest) or informal cash-rental agreements (with a hand-shake, or COVID-era elbow bump). These informal agreements are based on individual negotiations and open to contestation, thus increasing investment risks related to discontinuation of access to the land.

Tenure rights and legal pluralism

What exactly is legal pluralism?

Legal pluralism refers to a context in which two or more *de jure* or *de facto* legal systems operate within the same geographical area. Rather than complicating regulation challenges, it offers important opportunities for devising an approach that can secure water rights for small-scale FLID despite lack of implementation capacity in the state. ***De jure*** legal pluralism recognises multiple legal systems operating within the formal justice system. ***De facto*** legal pluralism indicates that the state does not formally recognize non-state or informal legal systems but may allow their operation in parallel to the formal legal system. Legal pluralism may occur at the same level of governance, or at different levels of governance (Obani and Gupta 2014). In legal pluralism, one may see relationships between the different legal systems based on indifference, competition, accommodation, or mutual support (Obani and Gupta 2014). Understanding legal pluralism enables the development of an appropriate regulatory framework for water rights for small-scale farmers.

National constitutions, legislation (national or state/provincial) and subsidiary regulations include statutory formal law and, in the case of *de jure* legal pluralism, provisions for customary law. However, in many countries in Africa customary land and water tenure practices exist without legal recognition and provide *de facto* governance of large areas of land and water. There is little formal capturing of such systems, and their ability to evolve according to changing conditions has earned them the title of "living customary laws". These laws govern "local communities' water access, use, and control" (Hellum, Kameri-Mbote, and Van Koppen 2015, 7).



Legal pluralism refers to a context in which two or more *de jure* or *de facto* legal systems operate within the same geographical area.

The opportunity is in the current practices

Across Africa (and the world), a large number of people still live in areas where customary law governs land and water tenure. These customary systems operate in parallel with the formal statutory legislation, giving rise to a situation of legal pluralism.

> *"Customary rights" refer to established, traditional patterns of norms that can be observed within a particular socio-cultural setting. Sets of customary rights and obligations may be called customary law. Customary rights exist where there is a consensus of relevant actors considering them to be "law".*
>
> – Thompson (1991)

To date, little has been done to consciously align the statutory and customary rights systems in the water sector. In the land sector many countries in Africa have undertaken policy reforms in the last 10-15 years to harmonize and ensure better synergies between the formal and customary systems. Examples include Kenya, Uganda, Malawi, Namibia, Liberia, Sierra Leone, Ghana, Ivory Coast, Tanzania, Somalia, Mozambique and Madagascar. In some countries customary law is formally recognized, while in others it functions without formal recognition.

Customary law is an unwritten store of legal ideas and knowledge passed down orally from one generation to the next. It is living and adaptable, and thus suited to new applications.

In regard to water, customary law is the reality on the ground that governs the water use of most smallholder irrigators. This has to be contrasted with the implementation of statutory water law, which has been partial at best in many countries, particularly in relation to water use permits. Due to limited state capacity and incentives, very few micro-abstractors, like smallholder irrigation farmers, have water permits, recognize the legitimacy of state systems, or even know that they are expected to have such permits. When dealing with water rights for smallholder irrigators developing their own irrigation systems, it is important to understand the nature of the legal pluralism in the specific country and how it can support access to water for small-scale irrigators.

The ability of the state to regulate, allocate and control water use depends on the existence and nature of an appropriate legal framework. This framework may be captured in a specific water law, often at the national level; provisions in different laws; regulations or subsidiary legislation; customary or traditional law; rulings arising from court cases; and/or constitutional provisions. Such legal frameworks may also specify the different roles of national, provincial/state and local institutions in regulating water use (Salman and Bradlow 2006).

The evolving nature of customary living law creates spaces for change which can be used strategically to improve equality and inclusion from a gender perspective. A good example comes from the Marakwet in Kenya. Historically, male-dominated practices around the design, construction and maintenance of furrows excluded women from decision-making processes. And yet, as younger women are entering into the commercial farming arena, and are developing knowledge and expertise around the furrow system, they are gradually finding a place in water governance. While formal statutory systems often distinguish between water services and water resources, customary systems tend to take a more holistic approach to water generally.

In the face of weak formal systems and the persistence of customary systems, a bricolage or hybrid approach that draws on the best of both can provide the most effective approach to protecting the water rights of smallholder farmers.

Informal rules and practices

The policy and legal diagnostic activity will require the assessment of both the formal and the informal institutions that influence irrigation farmers' decisions and actions. This will include the study of policy, legal, project and other documentation, as well as interviews with stakeholders, both individuals and groups. Institutions, in this sense, means the formal and informal rules which frame the relationships and actions of all stakeholders involved in the irrigation farming business (individuals, informal groups, formal organizations, private sector bodies, government, etc.).

In the diagnostic process it is useful to be alert to the considerations in the checklist below. These are prompts for the enquiry. Understanding the informal *rules* and environment help us to better understand the behaviors and choices that irrigation farmers make and highlight opportunities to strengthen the enabling environment.

Customs, beliefs and traditions:

- Water is often perceived as an open-access common good to be shared by all. This belief can hinder more formalized water allocation and sharing arrangements, compliance with rules, and water-management fee payment arrangements.
- The existence of (shared) infrastructure can be perceived to convey a right of use to those who have access to and benefit from the infrastructure, when the rights of use are more likely a separate requirement.
- Conflict resolution practices and local practice usually involve traditional or religious leaders and awareness of norms can strengthen accessibility, effectiveness and legitimacy of institutional solutions.
- Perceptions around land rights and gender in an irrigation context can hinder access to land, and rights of use.
- Social priorities and beliefs around off-season activities in relation to farming can impact a range of irrigation related activities, both in relation to farming and infrastructure or equipment use and maintenance.
- Societal hierarchies including the roles and duties of different segments of society are different. Understanding the norms in relation to the old, young, women, men, formally educated people, community and religious leaders, can improve how planning and implementation processes can take place most favorably.
- Land ownership traditions and practices impact on access and the perception of threat and tenure insecurity.
- Traditions of collective action can be harnessed for collaborative management, but can also potentially undermine individual action and innovation.

Political and development norms to be considered include:

- The bias towards large-scale or small-scale irrigation schemes
- The cost of irrigation equipment beyond the reach of smallholder farmers
- Should government be the sole provider of irrigation facilities
- The assumption that interventions must necessarily fit into existing farming systems

- The notion that smallholder farmers do not pay back credit
- The assumption that existing farming practices (smallholder farmers) are backward/obsolete
- Corruption (procurement issues, commissions, kickbacks, public relations)
- How informal groups operate (groups of traders, groups of farmers, etc.)

Individual cognition aspects of importance are:

- Experience with new technologies in the past
- People's attitudes towards development projects
- Motives, level of ambition and objectives in embracing FLID
- Level of self confidence in their abilities to innovate (i.e. Confidence in local knowledge can be undermined, intentionally or not, by locals or outsiders and lead to false perceptions that modern is better than local practice simply because it is modern.)

Incentive structures can help catalyze including:

- Level of tenure security and ways to increase it
- Cooperative membership arrangements
- Subsidies for acquisition/operation/maintenance of technology
- Access to inputs, equipment and markets
- Knowledge/access to other levels of the value chain beyond production
- Market prices for produce
- Loans/credit/lease

Types of policies and intervention projects that can inform the diagnostic

The FLID process, and therefore the intention to promote its acceleration, cuts across different policy clusters including: agriculture, water, economic, food security, climate change, poverty reduction and rural development. The policy scoping process should encompass multiple line-ministries to identify as many opportunities and synergies as possible to accelerate FLID.

It is useful to critically assess past and current country programs and interventions led by the government (with or without the support of development partners), non-government organisations (NGOs) and the private sector. The list below provides guidance on the type of interventions that may be of interest and can help identify where to start looking for information.

Government programs and projects include:

- Agricultural development programs
- Water and land development/planning programs
- Agricultural mechanization programs
- Irrigation development programs (smallholder, large-scale)
- Capacity building programs
- Climate change adaptation programs and strategies
- Food security programs
- Commodity-based value chain development programs
- Youth employment programs
- Micro-finance programs
- Land tenure reforms
- Seed money/business development/lease

Private sector interventions include:

- Micro-finance service providers
- Lease programs for agricultural equipment
- Loans for procuring equipment

NGO and development organization interventions include:

- Climate change adaption projects
- Capacity development
- Micro-finance
- Land tenure reform (advocacy)
- Agricultural development
- Social inclusion (gender, marginalized groups)
- Irrigation development projects

Outline TOR for the water and land policy and legal diagnostic

The **policy and legal diagnostic in this module is focused on water and land**, and the policy and legal considerations of the remaining factors are addressed in each of the other modules separately – as they are dependent on the content therein. Some overlap across the FLID factors during a policy and legal review is inevitable as the factors do not exist in silos but are interlinked in reality. The team will have to engage with each other on overlapping issues and resolve differences and gaps. The diagnostic is guided by the approaches outlined in i-box 3.4 and 3.5, and in Minh et al. (2021). These additional information sets can be attached to the consultant's Terms of Reference (TOR).

The main themes of the scope of work in relation to land and water tenure, governance and regulation are outlined below. Remember that the policy and legal review will contribute to understanding the barriers in the enabling environment, and that all of the other factors (potential, benefits, markets, knowledge, finance, and technology) all have policy and legal aspects. These will be diagnosed and scored as part of their respective factor assessments, described separately in each thematic module.

Outline of Scope of Work

The consultant will need to analyze the following aspects in relation to water and land policies and laws:

- **Roles and responsibilities in individual and small-scale irrigation development:** Based on available legislation and other documents, the consultant will analyze what the expected role of farmers is (individually and in groups) vs public institutions in small-scale irrigation development (individual and in group schemes), with reference to: ministries (water and agriculture), ministry of land, irrigation agencies, regional development authorities, and local government (districts or counties, sub-counties or wards or similar). The consultant will also touch upon the role of NGOs and private stakeholders in small-scale irrigation development. The consultant will include reference to policy framework, laws and regulations where these respective roles are spelled out, as well as indicate relevant trends over the past/upcoming decades, notably in regard to the decentralization agenda. More specifically, the consultant will present the organizational structure for small-scale irrigation service delivery (including organization of departments and units as for procurement and extension services, and respective reporting lines to central ministries) at local level. It is recognized that there is ample variability across and within countries, and the consultant will be asked to present a few cases to represent such a variability. The consultant will present reporting lines for small-scale irrigation service delivery, flow of funds, and provide a general sense of the representativeness of technical staff among the various public stakeholders. Finally, the consultant will highlight differences (if any) between theory and practice in the respective mandates.

- What legislation covers issues of access to water? In some countries, for example, access to water under customary law falls under forest and land legislation, rather than under national water legislation.

What does statutory legislation (and subsidiary regulations) require in relation to water use rights for smallholder farmers, **i.e. what are the mandatory legal requirements for legal water use?** In many countries, this may be the need for some form of permit or permission/authorization from the state. In other countries, the requirements may be lighter for small-scale water use.

What institutions are responsible for the administration of the water resources regulatory system, and at what level?

Public incentives and subsidies in regard to land and water: The consultant will present which kind of public support (at central and local level) is available for smallholder farmers (individually and in groups) for small-scale irrigation development. The consultant will present both streamlined approaches as well as projects and program-based approaches and will compare them in terms of the kind of irrigation development fostered and the kind of support provided. Under each approach, the consultant will analyze the process from the expression of interest to the actual irrigation development and provide a judgement on the level of formalization of such a process. Finally, the consultant will critically analyze how the current avenues available to farmers to request support are aligned to the roles and responsibilities of the various stakeholders as analyzed in the previous point.

Water licensing/permitting: The consultant will investigate and assess the policy and legal requirements for water abstraction for small-scale irrigation development (individually and in groups), the stakeholders involved (including at basin level), and will highlight the difference (if any) between theoretical requirements and practice. An analysis of the documentation required, and of the cost associated with the permitting will be included. The consultant will elaborate on the role of the water resource authority, agency or similar body, within the context of the Water Act. Finally, the consultant will summarize how the aspect of water permitting in irrigation development has been tackled in on-going irrigation development projects and programs.

The words *authorization, permit* and *license* are often used interchangeably but sometimes are intended to be distinct from each other. Attention to meaning is needed for each country.

In Kenya, for example, you need a *permit* to abstract water, *and* in addition, an irrigation *license* to do so, from two different authorities.

In South Africa, a general *authorization* allows irrigation abstraction below certain thresholds (maximum flow-rates and total volume/day). The water users simply have to inform government (to allow monitoring), but do not have to obtain permission for their usage. Irrigators above that threshold, however, have to apply for a water-use *license* to abstract for irrigation (among other uses).

Land registration and land administration: The diagnosis looks at the tenure governance system with the main intention of understanding the level of tenure security it grants to primary and secondary right holders (those leasing or using the land of others). The aim is not to make the land issue onerous, but to understand the land tenure context on the ground in relation to FLID and identify and mitigate risks. The transparency, strength and legitimacy of the system define the level of tenure security of

the smallholder irrigation farmers and secondary rights holders. The consultant will elaborate on:

1 **The type of tenure governance system** – whether it is formal (dictated and enforced by statutory authorities); customary (dictated and enforced by customary authorities); plural (regulated by parallel systems which may be harmonized and mutually reinforcing, or conflicting); or informal (regulated by temporary rules agreed among occupants in a legal and physical space that is beyond the scope or enforcement capacity of formal and customary systems in place). There is no fixed correlation between the level of formality of a tenure system and the level of tenure security but understanding the type of tenure allows security of tenure then to be assessed. Instead, single systems (formal or customary) and harmonized plural systems (blended/mutually reinforcing) tend to guarantee a higher level of tenure security than blended/conflicting and informal systems. In contexts where plural systems coexist and the quality of governance is sound, the highest level of tenure security is typically granted by blended/mutually reinforcing (hybrid) systems.

2 **The quality of tenure governance – the diagnostic must** evaluate to what degree the system(s) in place cater for all existing primary and secondary right holders; set transparent rules and safeguards for acquisition and transfer of land; have the capacity to address disputes and enforce decisions on the ground; and be understood and perceived as legitimate by all stakeholders. The quality criteria are not always directly related. For example, a system may be perceived as highly legitimate and have the capacity for management and enforcement of rights, yet still discriminate against vulnerable groups. It may not allow for owners to sell their land, while still granting users a very high level of security.

Farmers groups: The consultant will investigate and assess the policy and legal requirements for farmers' groups for small-scale irrigation development. Consultant will identify the legal framework mix that would facilitate compliance with obligations set in agreements between farmers and private and public entities in irrigation development and contract farming, and the enforcement mechanisms, without jeopardizing their rights.

Monitoring and evaluation (M&E): The consultant will analyze the available tools used by the public stakeholders supporting small-scale irrigation development for M&E.

Conclusion: Following the analysis of these key elements, the consultants will propose necessary support mechanisms for further development of support processes of farmers leading the development of irrigated agriculture.

Guidance on scoring the policy and legal factor

Specific questions regarding water policies and laws

It is important to understand the status of customary land and water law within the same area. This helps to identify what the immediate options are in terms of securing water rights. It requires an understanding of the possibility that there may be plural legal systems operating in the area (statutory law, formal and informal customary norms, and human rights principles) that may provide both opportunities and/or constraints in relation to access to water rights for FLID. This analysis may also give rise to the recognition that there is a need for legislative amendment to better protect the water rights of small-scale farmers. Particular considerations in regard to water regulations should include:

What are the constraints to implementation of the legislation? Can these be addressed with some level of support, or are they more fundamental challenges that cannot easily be addressed?

What is the status of implementation of legislation on the ground? In a number of countries, implementation of regulatory instruments such as permits is only partial/weak, and this may have implications with regards to securing water rights for large numbers of smallholder farmers.

What is the actual practice in the country with regards to water rights for smallholder farmers? The options may include requiring permits or permissions for small-scale farmers; recognition (formal or otherwise) of customary law for small-scale farmers in selected areas; collective permits; and/or *de facto* "turning a blind eye" to unauthorized water use by small-scale users.

Are smallholder irrigators acknowledged in policy, such that their water use is prioritized, given their contribution to improved livelihoods, increased rural stability and food security, and their economic contribution?

Do smallholders have difficulty in accessing and using water sources in practice, or are they constrained by permitting requirements and the enforcement thereof? Regulations may waiver the need for a permit when the abstraction volume is below a certain volumetric threshold – such as when provided for in a general authorization for small users. It is common that onerous requirements for licenses, and environmental and water resource authorizations, apply to any irrigator (even the smallest) who is not farming purely for subsistence purposes. The presence of a pump, regardless of size, typically triggers the formal requirement for an irrigation license and/or a water permit. These demanding legal provisions potentially present a constraint to farmers using water in practice, especially when water resources are stressed.

> The presence of a pump, regardless of size, typically triggers the need for an irrigation license or a water permit.

Does the law make provision for different kinds of permits (refer to i-box 3.5), either collective or targeted? Collective permits are when allocation of water is afforded through a permit to a water user association or similar local body, which then allocates the water to individual irrigators. Targeted permits prioritize permitting, monitoring, and compliance for the largest users, but this is not applied equally for large and small users.

Bricolage – pragmatic institution-building process

> *"Institutional bricolage" is a process by which people draw on a range of existing practices to create institutions that are a dynamic "mix of the 'modern' and 'traditional', 'formal' and 'informal'".*
>
> – Cleaver (2001, 26)

Supporting FLID calls for a regulatory system that meets the needs of both the regulator and the water users. Access to water rights for FLID is dependent on the formal regulatory system (legislation and regulations), as well as the status of implementation of the law in the particular country/catchment. In many contexts, implementation of legislation is extremely poor.

Water resources management is not an end in itself, but a mechanism to enable the use of water to support the attainment of local and national development objectives. An effective regulatory system is one that can be implemented within existing human, technical and financial resource constraints in a way that best achieves the desired outcome. Such a system must also protect those that are most vulnerable in the face of market failure: poor/small-scale water users and the environment. Appropriate hybrid approaches can reduce transaction costs for both individual and enterprise level water users (Schreiner and Van Koppen 2018). In the context of FLID, such a system must be able to support and promote the agency of smallholder farmers in accessing and using water to enhance productivity.

A hybrid water use rights system might, for example, see the use of strictly enforced permits for high-impact users, while other instruments are used to enable the legal water uses of small-scale users, which could include: legal recognition of customary law; collective permits administered through local water management institutions; or exemptions of domestic and small-scale productive uses of water with prioritized legal status. Development of such an approach is highly dependent on the context in each country, including the legal and regulatory system(s), the socio-economic context, and water resources availability.

This approach supports the development of institutions, including regulatory approaches, that are directly relevant to the context on the ground, rather than the importing of apparent "best practice" which may not work well in the local context.

Hybrid water law

Where the diagnostic assessment identifies that legal weaknesses can constrain an intervention – particularly when there is water stress – a hybrid water law approach is the best response. A hybrid law system that combines statutory and customary water law can provide a strong framework, particularly in a context of limited state capacity for implementing water permit systems. In building a hybrid water rights system there are a number of tactical elements or practices that can be used to arrive at a workable composite system. The key practices are listed here and detailed below.

1. Targeted use of permits and/or categorization of permits by level of impact
2. Recognition of customary law with equal legal standing
3. Prioritization of water use for smallholder irrigators
4. Exemptions from permit applications with a raised threshold
5. Collective permits

1 Targeted use of permits and/or categorization of permits by level of impact

In many parts of the developing world, and extensively in Africa, water use permits have been incorporated into water legislation as a tool for controlling water use. However, as has been examined, implementation of these permit systems has been partial at best in most countries, and many of the water permit systems currently in place neither protect nor effectively address the water use of smallholder farmers. This calls for a more nuanced approach to "regulating" small-scale water use for irrigation.

Permits can be an extremely useful water regulation tool if applied appropriately. However, the use of permits requires sufficient technical, administrative and financial capacity to assess permit applications, issue permits with appropriate conditions, and enforce adherence to the conditions. If this cycle is not completed, the simple issuing of permits is not an effective regulatory approach.

In the context of limited state resources the application of a differentiated approach to regulation would enable those resources to be focused on regulating and controlling the (generally) small number of large water users, enabling the state to complete the cycle described above and, through this, to regulate the highest

impact water use. At the other end of the scale, in order to support poverty eradication through local economic development (and, in this case, farmer-led irrigation development), the state should focus on supporting and enabling the use of water by smallholder farmers and encouraging local level regulation based, where appropriate, on customary living law. This would enable the most effective use of limited state resources in achieving sustainable use of water resources while supporting local economic development and poverty eradication. Developing such a differentiated approach needs to take into account that, in many cases, a dual legal system (statutory and customary) is often already operating.

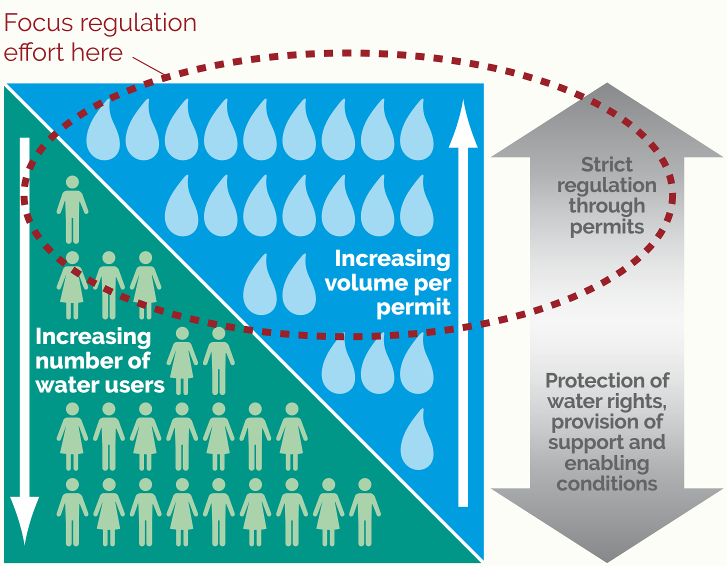


Figure 1 Regulation of high water use through permits vs protection of large numbers of small-scale irrigation farmers (Schreiner and Van Koppen 2018)

The use of permits to regulate high-impact users requires consideration of the threshold for which a permit is needed, or, as in the Kenyan case, a series of thresholds for differing levels of water use. Setting the threshold too high may lead to over-use of water in some areas, while setting it too low will continue to criminalise the water use of small-scale users. Determination of the threshold also requires a consideration of the capacity of the state to implement a water use permit system across a large number of users. The lower the threshold, the higher the number of permits that must be assessed, issued, monitored and enforced.

In addition, while the categorisation of permits is an extremely useful tool, having too many categories becomes administratively cumbersome and confusing to water users, while too few categories undermines the purpose. It should be recognized that it is also often possible, within the water legislation, to have different requirements per catchment, which also allows efforts to be focused on those areas where competition is particularly severe, rather than on catchments where there is still an abundance of water. In closing basins or ecologically sensitive areas, the category thresholds might be lower than in unstressed catchments. If such an approach is not permitted under existing legislation, a legislative amendment may be required.

2 Recognition of customary law with equal legal standing

"The greater recognition of the customary is also an element of the social: a recognition and acceptance of the norms by which the rural poor live their lives can only be of benefit to the whole society."

– McAuslan (2006, vii)

As has been discussed, a large percentage of the land in Africa is managed and accessed under customary law, and yet little of the water legislation in African countries recognizes the implications or potential of this for improved water management. There is, however, increasing interest in how this issue can be resolved, with ongoing research being conducted into the customary water regimes of Africa and how to align statutory and customary practices. Studies have already shown that customary laws and institutions can be very effective in resolving local level water use disputes (Ramazzotti 2008; Nkonya 2006).

At the international level, there has been recognition of the importance of customary law for sustainable natural resource management (see, for example, Principle 22 of the Rio Declaration on Environment and Development). However, statutory water law in Africa has generally failed to address this, so that customary water law is largely ignored or overridden by statutory law. Customary law has been more widely recognized in other sectors, such as land tenure, and there are lessons that can be learned from these approaches to inform an approach in the water sector.

The challenge is to give customary water law a role in water management equal to statutory rights. The benefits of doing so are straightforward: customary law is already in place on the ground across most of Africa, and operates with local legitimacy on a daily basis; statutory water law has not reached many of those governed under customary law due to the financial and human capacity constraints of the state. Harnessing the power of customary law to govern water for small-scale irrigation can, therefore, address both the benefits of local legitimacy and agency and the limitations of the state. It is a win-win situation. It also responds to the lived reality of Africans – surveys conducted in 15 African countries show that people living in contexts of legal pluralism recognise that they function in a bricolage of traditional, democratic and statutory systems (Logan 2009).

Government officials, on the other hand, are often faced with a mismatch between the statutory tools and capacity at hand, and the lived reality on the ground – statutory water law seldom provides guidance to them on how to respond to customary water law practices. Constitutional and statutory law in Africa shows varied responses to customary law, ranging from equal standing with statutory law (usually somewhat generically at the Constitutional level and without specific reference to water law) through to provisions that apply to customary land tenure, or to a specific ethnic group. In general, however, water law in Africa has failed to grapple effectively with the implications and potential of customary water law.

As an example, the Malawi Water Resources Act (2013) requires that the issuing of a water permit must be subject to "the protection of the environment and water resource from which the abstraction is made, the stream flow regime, and other existing and potential use of the water resource, including uses by virtue of customary use rights and practices." (s43b). It does not, however, explicitly give customary water rights equal status to statutory water rights.

In the Tanzania Water Resources Management Act (2009, section 52), customary water rights "held by any person or community in a watercourse shall be recognized and [are] in every aspect of equal status and effect to a granted right". This is an important step forward, but these rights are essentially weakened by the requirement that such rights must be recorded through the permit application procedures within two years from the promulgation of the Act. The poor capacity of the state and the lack of information

provided to communities on this matter means that these rights have largely been eroded in legal terms, although the water use continues on the ground.

Formal recognition of customary water law and rights is an important step in supporting and enabling the water use of small-scale irrigators across Africa. Its recognition can enable water rights derived from customary law to be of equal legal status to those derived under statutory law and permits. This can be a blanket approach for the whole country, or specific to geographical areas or identified communities. There may be other customary law regimes (e.g. land tenure or forestry tenure) which may serve as a basis for this approach. It is important, however, that customary water law be applicable only to communities that are truly governed by such law and does not open a door for external opportunists to claim water under a system that does not apply to them.

To prevent potential abuse of the system by outsiders, or by community members wanting to use significantly high volumes that might impact negatively on other users, it may be appropriate to set a limit of abstraction above which customary law would not apply. The challenge is to set a limit that is sufficiently high to support small-scale irrigation without enabling water-grabbing by those with sufficient resources to do so.

If customary water law is not formally or sufficiently recognised in statutory law, this may require policy and legislative amendments. Where it is recognised, the development of regulations or subsidiary legislation that clearly define the water rights and responsibilities may enable better protection of the rights for small-scale farmers and a better understanding, on the part of government officials and other water users, of the nature and extent of such rights.

Benefits	Limitations
Already in place across large parts of Africa	Formal recognition may require legislative amendment, which can take time
Reduced administrative burden on the state for authorizing water use	No written record of water use rights is provided to the user for use in raising finance with formal banking institutions
Affordable, accessible and carries legitimacy among smallholder farmers, including for dispute resolution	May be weak in addressing issues of gender and other traditionally marginalized groups

3 Prioritization of water use for smallholder farmers

Prioritization of water use for small-scale irrigators can provide significant protection for their water use, particularly in times of water shortage. Currently, most of the water legislation in Africa allows for some degree of prioritization of water use – whether as an absolute priority, or a priority that is to be used in times of water shortage to inform curtailment options.

Most of the current legislation grants the highest priorities to water for ecological functioning (environmental flows) and water for basic human needs. The latter is usually defined in relation to the human right to water, and is seen as water for drinking, cooking and hygiene. According to the World Health Organization (WHO), this amounts to 50–100 liters per person per day. Beyond this, prioritization is generally according to broad water use categories. One of these categories is often agricultural water use or irrigation. The gathering of all types of irrigation under one category has made the targeted protection of small-scale irrigators' water use difficult.

The need to prioritize the water use of smallholder irrigators is driven by the fact that they are generally highly vulnerable to water constraints, having limited financial resources or insurance capacity to fall back on in times of water shortage. Since smallholder irrigation in Africa plays a huge role in meeting the human right to food security and nutrition of millions of rural households, it can be argued strongly that their water use should be accorded a high priority (Hellum, Kameri-Mbote, and Van Koppen 2015).

Priorities of water use established under statutory water law should inform the allocation of water rights and be called on in dispute resolution issues. Critically, they should play a role in the determination of curtailments imposed on water use during droughts and other water shortages.

Thus, in order to support small-scale irrigation, in the prioritization of water-use sectors, smallholder and large commercial irrigation should be treated differently. A higher priority should be given to smallholder irrigation, since such users are economically vulnerable should they lose their access to water for even one season, and because of the critical importance of their water use in meeting household and national food security needs. The rules for curtailment of water use during water shortages may also need to be reviewed to protect the water use of smallholder irrigators during times of water shortage.

Benefits

- Little to no administrative burden on the state
- Easy to introduce
- Protects the water rights of smallholder irrigators, including in times of drought

4 Exemptions from permit applications with a raised threshold

The exemption of a certain level of water use from permit requirements is contained in most of the water legislation across sub-Saharan Africa. Often referred to as water for primary purposes, this generally covers little other than a very small amount for domestic water use, domestic food gardening and the watering of livestock for domestic purposes. It does not include abstraction for smallholder irrigation. A relatively easy approach to enabling the water use of smallholder irrigators is to raise the threshold of such exempted water use.

Based on a requirement of 2 500 m^3 per annum to irrigate one hectare of land (this amount varies according to crop, number of rotations and rainfall, but is a conservative estimate), large numbers of small-scale farmers are currently required by law to apply for a permit (or, in Kenya, permission to use water and, in South Africa, a general authorisation to use water). Exemption thresholds could be raised significantly – for example, to not less than 5 000 m^3 per annum, and preferably closer to 12 500 m^3 per annum. To support such water abstractions, it may be necessary in some areas to construct water-storage facilities or curtail to some degree the water use of commercial farms, large industry and urban areas.

However, it must be recognized that the exemption of small-scale irrigation from the requirement to apply for a permit does not necessarily protect this water use in times of water shortages, unless accompanied by the prioritization of smallholder irrigation referred to in the section above, and/or formally given the same status as permitted water use. Category A water use in Kenya, for example, which does not require a permit, is formally recognized as having the same legal standing as water use under a permit.

Benefits

- Easy to put in place
- Minimal administrative burden on the state
- Gives rural smallholders protected rights to use water if accompanied by prioritization of small-scale irrigation

Example of Kenya permit categories

In Kenya, exemptions from permit or permission requirements cover water for domestic purposes only. In terms of permits/permissions, there are four categories, A–D.

Category A water use is defined as "water use activity deemed by virtue of its scale to have a low risk of impacting the water resource. Applications in this category will be determined by the [Water Resources Management Authority (WRMA)] Regional Offices" (WRMA 2007a, 67). This category of water use does not require a permit but does require that the water user makes an application to the WRMA regional office, thus allowing the water use to be registered with the state. Should the water use meet the criteria for Category A, a letter of permission to use the water is issued. This still imposes an administrative burden on the state, although less of a burden than the issuing of a permit. It also provides the water user with a written authorization, which is of equal legal standing to a permit. In this sense, it gives legal protection to the small-scale water user (WRMA 2007b).

Category B is defined as "water use activity deemed by virtue of its scale to have the potential to make a significant impact on the water resource. Permit applications in this category are handled by the [WRMA] Regional Office" (WRMA 2007a, 67).

Category C is defined as "water use activity deemed by virtue of its scale to have a measurable impact on the water resource. Permit applications in this category will be determined by Regional Offices in consultation with the Catchment Area Committees [CAACs]" (WRMA 2007a, 67).

Category D covers "water use activity which involves either international waters, two different catchment areas or is of a large scale or complexity and which is deemed by virtue of its scale to have a measurable impact on the water resource. Permit applications in this category will be determined by [WRMA] Regional Offices in consultation with the Catchment Area Advisory Committees and approval by [Water Resources Management] Authority Headquarters" (WRMA 2007a, 67).

The **thresholds** for each of these categories were determined according to three principles:

- The need for flexibility so that different thresholds can be applied to different regions and sub-catchments in response to resource availability and the state of the resource
- The need to manage the task of issuing permits – so that permit applications for complex situations, over-stressed or over-polluted sub-catchments or aquifers can receive adequate scrutiny and simple permit applications can be approved quickly and easily
- The extent to which the permit conditions need to be enforced (WRMA 2007b).

Example of General Authorizations: South Africa

In South Africa, the National Water Act (1998) enables the use of General Authorizations which can specify volumes of water that can be used in defined areas without the need for a permit. Registration of water use above a certain quantity is still required, and in recent years the requirement has been put in place that users apply for a General Authorization as with Category A water use in Kenya. The conditions under which water may be used can be specified in the General Authorization.

Originally, the General Authorization was intended to be used as an enabling tool that could reduce the administrative burden imposed on the state by water use permits. However, due to the high levels of water competition in South Africa, the levels have been set so low that it has become a restrictive, rather than enabling tool. Nonetheless, it has the potential to be used as a tool to support the water rights of small-scale irrigators. It can be targeted to support specific water use, specific groups of people using water, or particular geographical areas of water use (Anderson et al. 2007).

This has the potential to be a powerful tool, which could even be used to give legal status to customary water use. Despite this, it is not widely present in African water law, so that, in most countries, amendment of the national legislation would be required to introduce it.

5 Collective permits

Collective permits are fairly widely used in the irrigation sector, often through the allocation of water through a permit to a local water management body, such as a water user association. The local body then allocates the water to individual irrigators (Ramazzotti 2008; FAO 2016). In such cases, the use of collective permits is dependent on there being a local institution that is able to hold such a permit, allocate water among members and handle dispute resolution. Collective permits can be used to support allocation of water to smallholder irrigators, including those using water under customary law. Not all legislation specifically allows for the use of collective permits, but it may be possible to use this approach even where it is not specifically referred to as such.

Example of collective permits

The **Water Resources Act of Malawi (2013)** allows for the specific use of collective permits, stating:

131.(1) An association of water users [...] may be established by the agreement of the simple majority of a group of water users, at their initiative or also at the initiative of the Authority, for one or a combination of the following purposes:

(a) to manage, distribute and conserve water from a source used jointly by the members of the association;

(b) to acquire and operate an abstraction licence or a discharge permit under this Act;

(c) to resolve conflicts between members of the association related to the joint use of a water resource.

Research into the nature of effective local water management institutions suggests that the bricolage approach, where people *"consciously and unconsciously draw on existing social and cultural arrangements to shape institutions in response to changing situations"* (Cleaver 2002) creates strong and effective institutions that draw on the best of different formal and informal traditions. Effective functioning of local institutions is also supported by clear roles and responsibilities, and local legitimacy. Such local structures are important in local water management and in the application of collective permits. In Tanzania, for example, River Committees allocate water from a specific stretch of river and are mandated to resolve conflicts over water use, including by smallholder irrigators, commercial farmers and municipalities (Komakech and Van der Zaag 2011).

Benefits	Limitations
Limited administrative burden on the state	Requires water users to be organized into a formal structure of some form, such as a water user association
Relatively affordable and accessible for organized rural smallholders	Does not accord formal individual rights to farmers
Supports local management and dispute resolution over local water resources	Membership may fail to be inclusive of all users of the same source

Adaptive management

The introduction of a hybrid water rights system is best done within a framework of adaptive management. Adaptive management, or learning by doing, ensures a structured approach to learning – with managers, technical experts, and stakeholders – in order to continually improve the functioning of the system (Figure 1).

Adaptive management enables water managers to track the outcome of implementation of the hybrid water rights system in relation to key indicators – such as access to water, impact on environmental flows, or levels of conflict over water – to identify the problems and adjust the system as needed. Adaptive management intentionally and systematically facilitates ongoing minor adjustments to the entire management system – or, where significant challenges arise, major adjustments. The changes might require the introduction of a different tool, or configuration of tools, available from the toolbox (i-box 3.9).

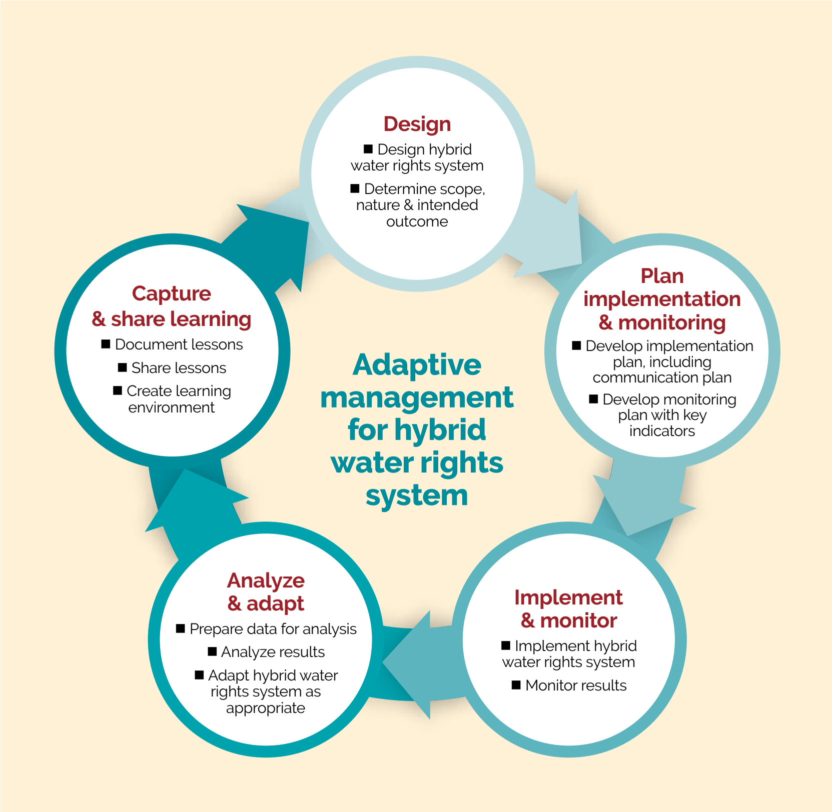


Figure 1 Steps in adaptive management applied to hybrid water rights

Decentralizing governance to local levels

Overview

The institutional and regulatory arrangements established at basin, sub-catchment and local levels have to be able to respond effectively to changing resource availability and environmental conditions. Users have to be involved and informed, and their abstractions adjusted, monitored and managed.

A key tactic in achieving transparency, accountability and inclusion of irrigation farmers who have established themselves outside of the administrative and regulation fold is through decentralizing governance to the lowest appropriate level. This means establishing or supporting water user groups, irrigation organizations and water user associations

Involving irrigation farmers in decentralization and regulation processes

Many irrigation farmers who have developed their own systems, and participate where farm sizes are smaller, do not have permits even when legally required. Inclusion into the regulatory system means both restrictions on their water access and an increased financial burden in the form of fees. These disincentives need to be actively countered in an intervention design so that the net benefit of being in a regulatory arrangement is positive. If irrigation farmers are going to be included in decentralized water management with tighter regulation and enforcement processes, their abstractions will be constrained at some point. To participate willingly, they have to derive greater benefits from being part of the process, and most likely with less water. Benefits arise in the form of increased profitability and reliability of water supply (i.e. reduced risks, because they plan and invest with greater confidence). To achieve these benefits, a set of parallel measures is needed:

Participation in rule-making and in designing monitoring systems: Farmers should participate in the formulation of rules, monitoring and communication arrangements, and be supported with organizational capacity development for local water monitoring. Flow monitoring and communication instruments, ensuring transparency, need to be linked to basin institutions.

Agronomic and marketing efforts: Increase enterprise profitability through increased production and strengthened market linkages.

Technical energy and irrigation innovations: Increase water productivity (both crop and financial water productivity) through improved on-farm soil-water management and lower-cost pumps as well as on-farm application systems that use less water.

Local water governance interventions: Reduce risks of water supply failure through localized water governance arrangements, explicit rules for when the resource is low, and simple, transparent monitoring infrastructure so farmers in a locality are aware of other farmers' water uses. Information and communication technology (ICT) can be highly enabling in this regard.

Guidance on water governance processes and intervention principles is provided elsewhere in this Guide. Through a combination of transparent decentralization of regulation roles and functions, and by ensuring net gains in profitability at the same time, more inclusive, sustainable and equitable water resources management in a FLID context is possible in practice.

Basin institutions – an overview of roles and responsibilities

The river basin, or catchment, is the hydrological unit for managing water resources. River basin boundaries overlap with administrative boundaries, with basin institutions falling within two or more administrative areas. As such, responsibilities for water resources management institutions and decision-making span multiple groups with overlapping boundaries.

Basin institutions

Basin institutions, also referred to as water resources management (WRM) institutions, are those institutions that share the responsibilities for water resources management in a river basin. They include water authorities, catchment authorities (referred to in some countries as catchment councils), sub-catchment councils, and water user associations. The hierarchical presentation of WRM institutions in a river basin is shown in Figure 1.

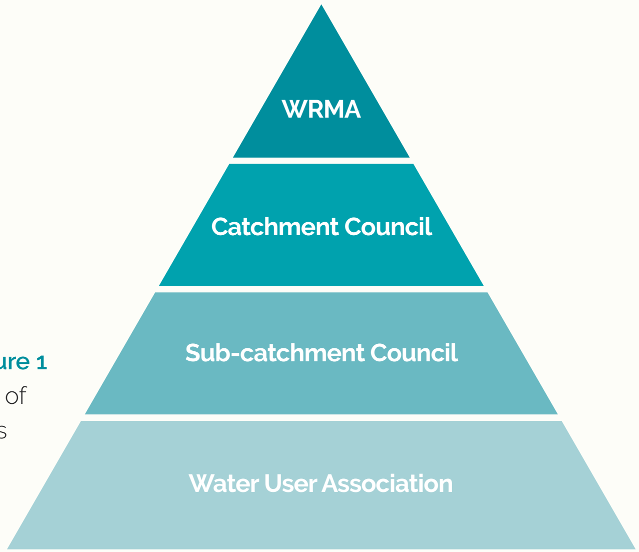


Figure 1
Hierarchy of WRM institutions

The sharing of responsibilities among institutions varies by country. Also, the configurations of responsibilities vary depending on the country. At times, basin institution administrative boundaries do not coincide with hydrological or basin boundaries, resulting in governance challenges. An example is where a basin traverses two or more administrative boundaries, as is the case with sub-catchments of the Orange-Senqu River basin.

Water user associations

The configurations of responsibilities (and nomenclature) of basin institutions vary with the country. In some countries, such as South Africa, Uganda, Zambia and Tanzania, a Water User Association (WUA) has broad responsibility for water resources planning and water use monitoring and coordination. In these countries, separate entities of irrigation organizations (on irrigation schemes) and water user groups (collectives of individual small abstractors) would be the first level of involvement of irrigation farmers. In other countries, such as in draft water legislation in Nigeria, and more widely globally, water user associations are specifically dedicated to irrigation scheme water management functions. They have no wider mandate for sub-catchment planning, monitoring and coordination.

The legal responsibilities of a Water User Association varies significantly in different countries. It is important to confirm their irrigation management versus sub-catchment mandate roles to avoid miscommunications and wrong assumptions.

The composition of a water user association includes individual or private irrigators, irrigation organizations, rural and urban water

users, and any other water users in the catchment. Representation in a typical WUA is shown in Figure 2. Irrigation farmers who have established themselves through FLID processes would fall under this fourth tier of WRM institutions, the WUAs, and likely be organized in water user groups around a shared river (bank), or aquifer in a limited locality (within a few kilometers of each other).

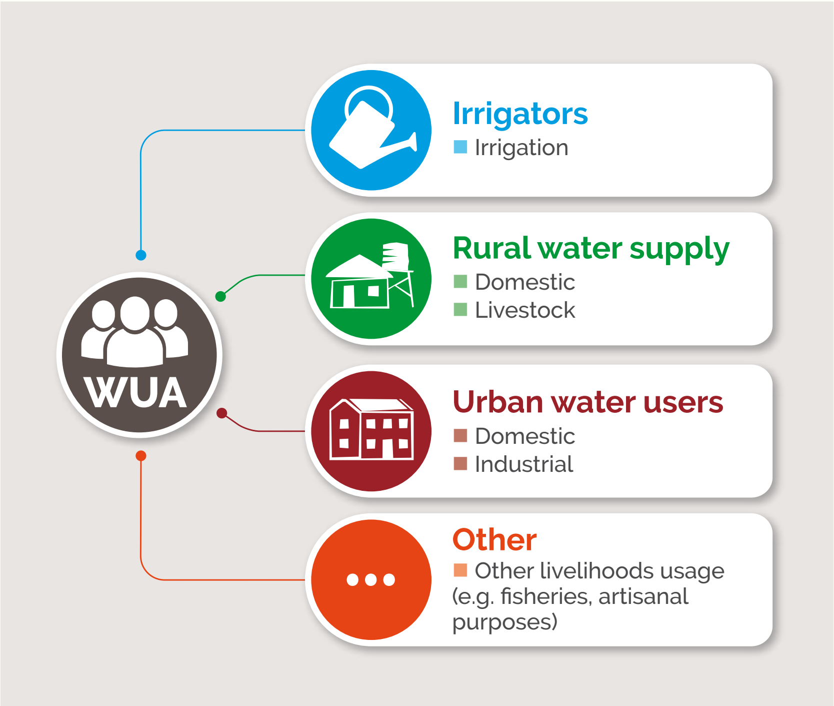


Figure 2 WUA composition when there is a sub-catchment mandate in law

Where WUAs have a more limited irrigation scheme mandate, their main functions include water allocation, and operation and maintenance (O&M) of the irrigation system itself. Responsibilities also include the collection and management of user fees from members of the WUA to cover O&M costs (Aarnoudse, Closas and Lefore 2018). In some countries revenue collection is the responsibility of the catchment council, whereas in others it falls under the WUA. As such, water user associations need to have capacity for revenue collection and management.

Farmers or irrigators are part of water user associations (WUAs).

In some cases, for example in Ethiopia, separate WUAs for irrigation, known as Irrigation Water User Associations (IWUA), also exist.

IWUAs are more focused on irrigation-related functions. For example, in Ethiopia, the tasks of IWUAs are strictly limited to the management, operation, maintenance of an irrigation and drainage system, and watershed management and protection. (Lempériere et al. 2014)

In some countries, for example Kenya, the Water Resources Authority (WRA) is responsible for the national water strategy, regulation and use, policy, permits, and collection of water fees.

Gender sensitivity and hybrid water rights

Land is much more than a physical or economic asset. Control of land and resources determines power relationships. Across different cultures, land further translates as identity, culture, development, food, shelter and human security.

In practice, female farmers often experience intersecting marginalization that takes place on the basis of gender, race, ethnicity, geography and income.

Where there is increasing demand for limited water resources, poor and elderly women are most disadvantaged in access to water, and permit systems have failed to address this issue. Indeed, studies have shown that permit systems tend to strengthen the water access of larger water users relative to smaller and poorer users (Hellum, Kameri-Mbote, and Van Koppen 2015).

Female farmers (and other marginalised groups) often face difficulties in effectively participating in decision-making processes and operate under unfair laws and practices, not least around the ownership of land. Since water permits are often tied to land, women's constrained access to land ownership simultaneously constrains their access to water.

Most female farmers in Africa either own small pieces of land or do not own land at all. They also struggle to access finance, credit and information. Extension services often fail to meet the needs of female farmers. Water governance interventions must proactively respond to the needs of female smallholder farmers and to achieve this, an inclusive process is needed. The implications for water reform actions require attention to the steps of design, implementation, monitoring and adaptation of land and water rights (see Figure 1). These actions are likely to be most responsive to the needs of women when have the enabling characteristics described in (i-box 3.11).

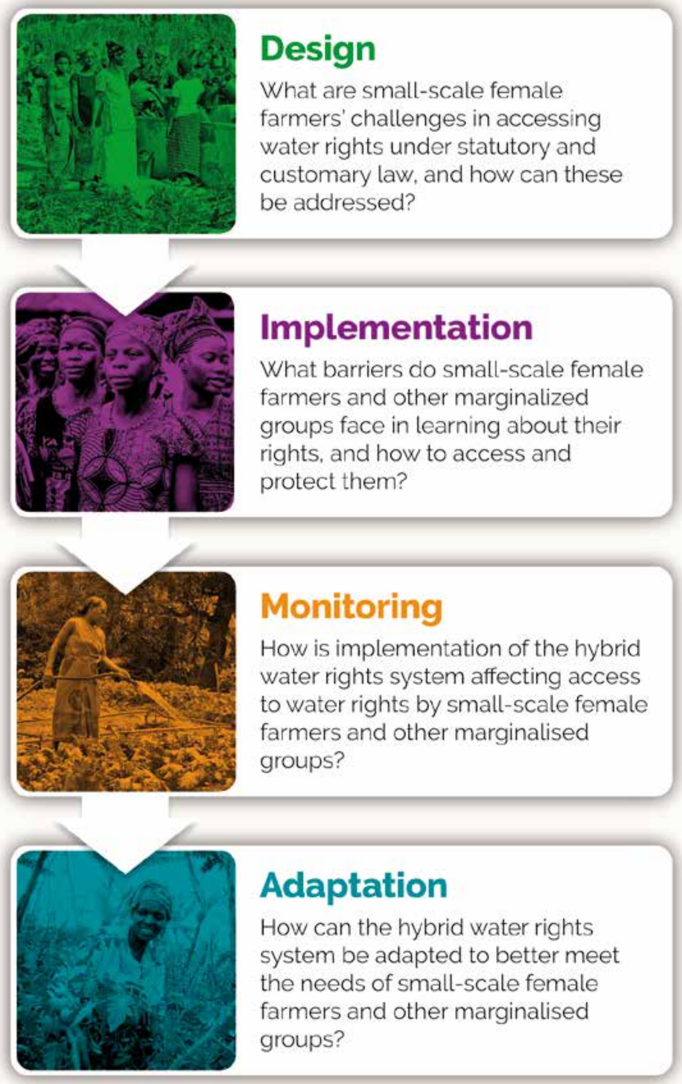


Figure 1 Responding to the needs of female farmers through their active involvement in the water institutions reform process (Schreiner and Van Koppen 2019)

Ten characteristics of water regulation to support FLID processes

The intended outcome of integrated water resources management is the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. To achieve these ends, an effective water use rights system is one with the following elements:

– Schreiner and Van Koppen (2018)

1 It supports sustainable and productive water use in the public interest

A water use rights system should support the productive use and development of water in the public interest and in support of national development goals, while ensuring that such water use remains within ecologically sustainable boundaries.

2 It provides legal protection for low-impact water users

In striving to support rural development and the growth of smallholder agriculture for poverty eradication and improved food security, a water use rights system must provide at least equal legal protection for the water use of low-impact users. These include those who use small volumes of water through collective or communal systems, relative to large water users. There is reason even to prioritize the water use of small abstractors above that of large users, particularly in times of drought, as has been done in some countries in Latin America.

3 It regulates and controls high impact users

Not all water users have the same potential impact on other water users and on water resources. Some water users have particularly significant impacts, either due to the volume of water abstracted or to the potential level of pollution from their activities. These users can be classified as high-impact users, and it is particularly important that their water use is strictly regulated and that requirements of water legislation such as prior notification and consultation are enforced.

4 It protects ecological functioning of aquatic ecosystems

The need to protect the ecological functioning of aquatic ecosystems is very well recognized in water policy and legislation in Sub-Saharan Africa. Any water use rights system needs to be able to ensure that the ecological functioning of water resources is sufficiently protected, such as through the determination of an ecological reserve.

5 It is cost-effective, efficient, and makes optimal use of limited state resources

The water use rights system should strive for maximum efficiency and cost-effectiveness both for the state and for the water users, aiming to minimize financial and administrative burdens on both – and particularly on small abstractors and poor water users – while still retaining the core effectiveness of the water use rights system. This also requires that where the water use rights system is used as the basis for revenue generation for the water authority, rigorous assessments ensure that the internal processes of the state are efficient, and also that the revenue generated from users exceeds the cost of collecting the revenue. An efficient water use rights system ensures that limited state resources can be used for

maximum developmental impact, rather than being consumed by unwieldy and difficult to implement regulatory requirements.

6 It is administratively fair

Fairness does not imply a one-size-fits-all water rights regime. On the contrary, a differentiated system is required to ensure administrative fairness in the context of significant economic inequalities. A water use rights system should be responsive to the different administrative, educational and financial capabilities of users, as well as requiring an appropriate level of effort from users dependent on the likely level of impact arising from their planned water use. This means that, for example, the system should provide easy application procedures for small abstractors, particularly those in outlying areas and without access to the Internet, with much higher demands of information and investigation for users with planned large-scale or high-impact water uses.

7 It serves to reduce conflict between water users and support effective conflict resolution where necessary

Where there is competition over water, the water use rights system should reduce potential conflict by setting clear boundaries for water use by different water users, as well as clear rules for constraining water use during times of water shortage. Where conflict over water does arise, the water use rights system should provide a strong reference point for resolving the conflict. This should include, where possible, priorities among different types of uses or users, or considerations for calculating such priorities. The system should also ensure that adequate dispute resolution mechanisms are accessible to the poor and to those in outlying rural areas, such as providing legal recognition for local or customary dispute resolution mechanisms as first instance avenues for conflict resolution.

8 It is equitable, inclusive and gender sensitive

The water use rights system must sufficiently address the water use needs and priorities of all water users and must be designed to recognise and support the differentiated and often overlooked water use needs and priorities of women, who constitute a large percentage of smallholder farmers and the majority of domestic water users in Sub-Saharan Africa.

9 It makes optimal use of polycentric and multi-level governance

Climate variability and change, regulation of water use in outlying areas, and limited state resources poses challenges and uncertainties. It makes good sense that a water use rights system should be polycentric (i.e. there should be multiple centres of control), both within the state and other, non-state systems such as local water management institutions and local customary law systems. Decentralized yet nested systems of water governance that have mechanisms for coordination across levels of governance (local to national) and among various sectors are necessary to respond to the increasing levels of ongoing change in water availability and quality that is becoming the new normal across the region.

10 It is participatory

Affected parties, particularly water users, should be able to participate in management of water resources, including co-decision-making with managers, and could even administer elements of the water use rights system, particularly through local level institutions (Bhaduri et al 2014). This must include meaningful mechanisms for including traditionally marginalized water users.

Mitigating potential negative impact on land tenure

The key to mitigating the potential negative impact of irrigation development initiated by farmers when the diagnostic scores low on the land tenure enabling environment is *tenure security*. Increasing tenure security is the one solution that can help address most tenure-related challenges. All tenure-related activities should be guided by the principles of *inclusion and participation, fit-for-purpose, realistic planning, sustainability* and *sound land disputes resolution.*

Depending on the context, the type of challenges, the specific objectives pursued in securing tenure rights, and the type of investment, a range of interventions may be considered with different associated costs in terms of time, technical capacity, and financial and human resources.

If there is a need for structural changes in the land rights framework to achieve long-term tenure security (i.e. if rights are not recognized or protected by the current system, and this is considered to be an insurmountable obstacle to the development of farmer-led irrigation), there may be scope for a *land policy reform process* or a *tenure governance reform process*, including land and water. These lengthy processes require high investments in terms of human, financial and time resources, but are the only avenue to achieve long-lasting systemic changes.

If the existing framework does provide space to further secure tenure rights, *capacity development* targeting land service providers (statutory or customary) can effectively empower the existing tenure governance system to streamline and secure processes for land access and protection of tenure rights. These processes require a high investment in terms of technical backstopping and human resources, a variable investment in terms of time and limited financial investment.

If the priority is to identify and clarify rights, *mapping and documentation of existing land tenure rights* may be the most appropriate option. In the last few decades, technology developers and project managers have joined forces to explore how to secure tenure rights through recording, inventory and mapping them efficiently and effectively. The costs of mapping, as well as the expected impact on tenure security, are variable and will depend on what has to be mapped and the specific objective pursued. A community-driven exercise aiming primarily at clarifying rights and resolving internal disputes will not require many resources. If the aim is to strengthen the right through formal recognition, costs will be higher. The effects of mapping on tenure security may differ if resilience and strength are variable, but they are usually immediate.

If the priority is to create space for recognition and protection of secondary rights and right holders within a sound tenure governance system, local processes such as *awareness raising, facilitation and mediation* of local dialogue, or *participatory planning*, may be an appropriate option. They are locally driven, generate a high sense of ownership and are affordable.

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The Farmer-led Irrigation Development Guide

Module

4

Knowledge

FLID actors and their information networks

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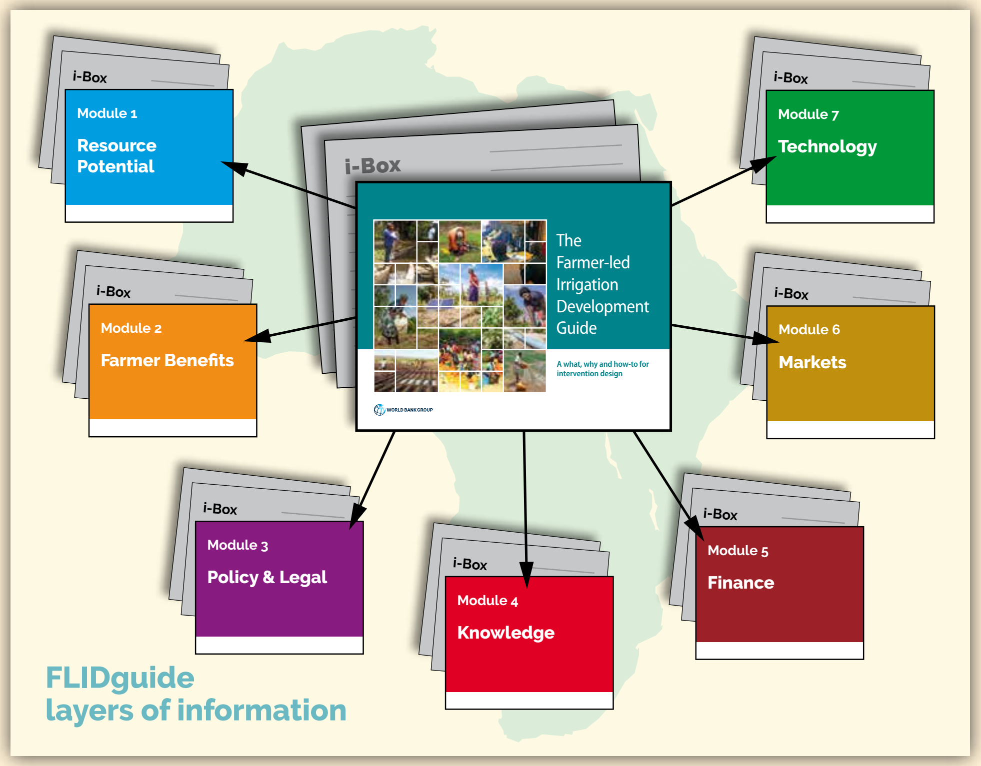
Contents

Abbreviations and acronyms

AEAS	Agricultural Extension and Advisory Service
CGIAR	Consultative Group on International Agricultural Research
CIG	common interest group
CPD	continuing professional development
FAO	Food and Agriculture Organization
FFS	farmer field school
FLID	farmer-led irrigation development
i-box	information box
IAP	irrigation acceleration platform
ICT	information and communication technology
MSP	multi-stakeholder platform
O&M	operation and maintenance
PO	producer organization
SACCO	savings and credit cooperative
SWS	smart water solutions
TOR	Terms of Reference
WUA	water users association

Using the guide

The main volume of the FLIDguide presents the core body of information that explains FLID and the process of intervention design. Thematic descriptions are included in seven modules. Information boxes (i-boxes) at the back of the Main Guide and each module provide additional detail, and hyperlinks throughout the guide access relevant external publications, websites, animation clips and videos.



FLIDguide layers of information

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- choose **File > Print**, and in the page sizing and handling area or pop-up menu, select **Fit to Printable Area** or **Shrink to Printable Area**.

4 Knowledge

FLID actors and their information networks

The FLID knowledge environment is conducive when key stakeholders systematically align their efforts to respond to farmers' real needs.

Knowledge and innovation processes are strongly intertwined. Knowledge comes from experience and education – formal or informal. In a FLID context, knowledge comprises the facts, information, and skills about irrigation farming business where farmers are in the lead. Innovation is the process of creating new knowledge where novel ideas are put into practice, usually involving other actors.

FLID farmers must be able to analyse their own situations, draw on their knowledge and proactively ask for new and relevant information, and then co-shape the technologies, methods, and services they need to reach their goals (Blum, Cofini, and Sulaiman 2020).

Across Africa, FLID farmers learn from each other by observation and informal discussions, and they innovate constantly. These innovations travel by word of mouth, or with migrating farmers who bring new knowledge and practices to their resettled locations. Farmers also gather new information from outsiders: via private sector input (technology suppliers, aggregators), from extension officers and research institutions, and from the internet. In all cases, making new ideas work in their specific farming business and agro-ecological context requires farmers to experiment, observe and make adaptations.

This module focuses on **the process of innovation**, involving the exchange of useful information, and adaptation of knowledge to new situations. Particular innovations around access to finance, market relations and irrigation technologies are discussed in Modules 5, 6 and 7, respectively. The module first identifies the many different stakeholders who have relevant knowledge for farmers and describes their often overlapping roles. The different ways in which farmers acquire knowledge, and how the process and content suit their different needs, is then outlined. The second part of the module provides guidance on the diagnostic and scoring of the knowledge factor. The final section describes examples of public interventions that can catalyze FLID through accelerated knowledge exchange, by fostering multi-stakeholder platforms, farmer learning, and information dissemination through media outreach. Information and communication technology (ICT) opportunities to support knowledge and innovation dissemination are also outlined in this module, and further addressed in subsequent modules.

4.1 Irrigation actors and knowledge systems

Stakeholders and the roles they play

The provision of irrigation services to smallholder farmers involves many different stakeholders, across the technology, agronomy, marketing, information, and financial sectors. Stakeholders generating and sharing knowledge include the farmers themselves, financial service providers, irrigation equipment suppliers, market offtakers, input suppliers, universities, and government institutions. A full list of stakeholders is included in i-box 4.1.

Few of these stakeholders, other than farmers themselves, are aware of the nature and extent of FLID processes and how they, as service providers, could respond to the demands and wishes of a diverse range of farmers. **Many farmers experience gaps in service provision. There are notable exceptions where service providers engage responsively across some or all related sectors** and improve the range and performance of their core products. More commonly, however, the *modus operandi* aims to convince farmers of the suitability of existing agronomic, technical, or financial solutions. These are most often developed in offices or laboratories where there is little understanding of the day-to-day realities of FLID. These marketplace actors often emphasize the need for heavy investment in technology, marketing and training, based on what *they* know and think, rather than what farmers need. A shift to a learning attitude, based on farmer feedback, is called for – one where efforts are made to redesign products in response to farmers' expressed needs and varied circumstances.

Mixed roles and multiple motivations

Knowledge and services are needed across the multiple sectors in order to catalyze FLID effectively. Gaps in the FLID services ecosystem can be debilitating for farmers, and to the value chain actors who rely on successful farming to generate sales. Where effective knowledge and innovation networks lag, supply chain actors often go beyond their core functions to fill these knowledge gaps.

Development and national financing institutions, suppliers, and agri-business take on multiple roles to provide packaged solutions. They extend their range of services beyond their core service to include elements that farmers are missing because of service gaps. Suppliers and agri-business offtakers often provide three critical services: financing, agri-business support services, and technology. The mixed roles and the overlapping services are illustrated in Table 4.1.

Irrigation equipment suppliers often see their sales constrained by lack of credit and, sometimes, also agronomic knowledge related to irrigated production. Consequently, *they* must fill the gap in credit provision and agricultural advice even though many would prefer to avoid the risks and transaction costs. Yet, there is little choice if their sales are to be increased. Agronomy and marketing support are also provided to increase farm profitability, and thereby reduce their clients' risk of default.

Agri-business and market offtakers need consistent volumes of quality produce, so they finance inputs and agronomy, and sometimes provide irrigation technology for farmers to secure their bulk produce supplies. Outgrower or contract farming arrangements, in which agricultural inputs and services are provided on credit, are common in high value export crops (such as vegetables, fruit and coffee).

Table 4.1
Overlapping roles of actors across financing, agri-business support and technology services

		SERVICES								
		Financing			Agri-business			Irrigation equipment		
		Agri loans	Tech loans	Pay-as-you-go	Agronomy	Financial literacy	Marketing	Sales and supply	Advisory support	Warranty
STAKEHOLDERS	Financing institutions	core service	core service			sometimes				
	Agri-business offtakers	sometimes			core service		core service	sometimes		
	Irrigation equipment suppliers		sometimes	sometimes	sometimes		sometimes	core service	sometimes	core service

Financing institutions sometimes provide financial literacy services in addition to credit or link financial services to agronomic assessment and advice, mainly as a mechanism to reduce the risk of defaults.

Their different core businesses, and motivations to move beyond their core services, influence the nature of the knowledge and information services that are provided. It is generally relatively large and commercial farmers who are reached through these services, but in outgrower arrangements, and in some irrigation equipment initiatives (such as solar pump suppliers [Thottoli, Zevenbergen, and Van Veldhuizen 2019]), smaller scale farmers are increasingly included in these combined service packages.

The prevalence of these mixed services reflects the gap in access to credit, and in reliable information for smallholder farmers. The commonality in the responses highlights the strong links between the factors. While each of these value chain actors can play a different role in a pluralistic knowledge landscape, it requires effective coordination to minimize transaction costs, and to amplify the complementary benefits.

Knowledge and innovation networks

Innovation and local adaptation do not depend on individual actors, their capacities and strategies, but on the interactions in open innovation networks. It is therefore crucial to understand the collaborations and alignments between actors in a FLID ecosystem. In places where processes of interaction, knowledge exchange and social learning become effective, it is often because of knowledge brokers. Sometimes actors within these networks naturally assume such roles, but they can also be facilitated externally. This is particularly important around complex issues such as irrigation development and because new trends call for reflection on appropriate responses.

Agricultural knowledge systems are increasingly pluralistic (i.e. involving mixed public and private actors), more decentralized – with ICT and remote information access a key dynamic – and tending to operate less hierarchically. There is also more of a partnership modality with farmers and farmer organizations, driven by market forces (Blum, Cofini, and Sulaiman 2020). The reason for this is that product sales will increase when farming activities are successful – thus, where gaps in knowledge and support services are evident, it is in the commercial interests of service providers to address these more directly.

> *"Pluralistic advisory service systems are characterized by the coexistence of multiple public, private, and civil society service providers, offering various types of service; have diverse financial resources; and use multiple sources of knowledge, technologies, know-how and information."*
>
> – Blum, Cofini, and Sulaiman (2020, 20)

It is important to understand the networks of knowledge and innovation exchange, and their strengths and weaknesses, to promote improved knowledge flows. Figure 4.1 depicts the relations in an "open innovation network" around smallholder irrigated agriculture. The relations and collaborations between these actors is what makes innovation and local knowledge adaptation work.

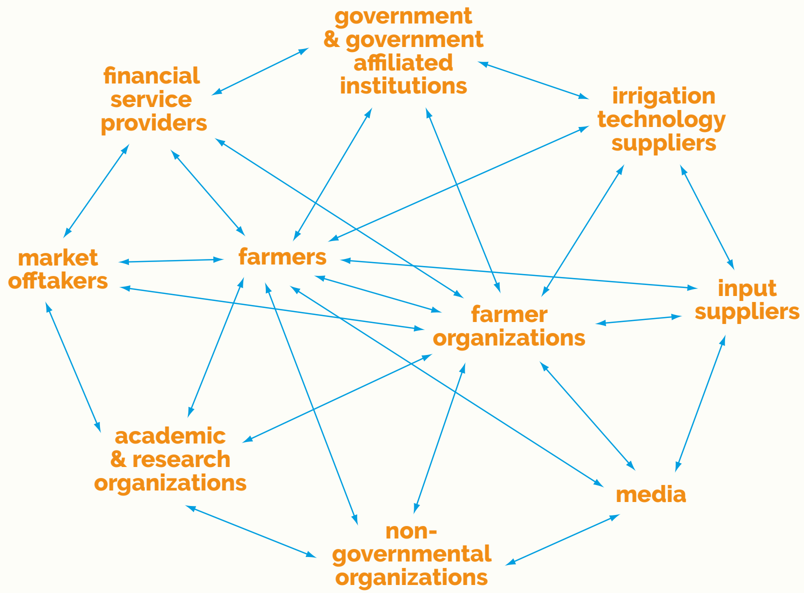


Figure 4.1

Network of irrigation stakeholders

Farmers are diverse and acquire knowledge in different ways

Smallholder farmers are diverse in a variety of ways, which affects their agricultural knowledge needs and interests. For instance, they have different education levels, contrasting scales of enterprise, and are involved in the production of crops with

dissimilar requirements. They are also tied into value chains in myriad ways. This farmer diversity is illustrated in Module 2, Figure 2.1.

The smaller and poorer farmers are, the less likely they are to have access to quality agricultural advice services (Bitzer et al. 2016). Women and youth are also considerably constrained in their access to innovation processes and to useful knowledge. The future of (irrigated) agriculture depends on engaging with young people, and it is therefore of great importance to cater for the particular needs and interests of youth – both rural girls and boys and young women and men. Important topics would include how to gain access to land and water, credit, market information, and training (Blum, Cofini, and Sulaiman 2020). Poor access to knowledge intersects with low literacy, which – given the close correlation between women and lower literacy levels – makes access to knowledge strongly gendered. Attention given to reaching non-literate and low-literate farmers, limiting reliance on written texts and using local languages, can contribute to broadening the base of farmers able to access useful knowledge on irrigation.

Farmers have different information and support requirements, often aligned with their education level, scale of enterprise, cropping systems, socio-economic characteristics, and the way they are tied into value chains.

People are different and acquire knowledge differently. It is well known that facts will not convince those who refuse to consider evidence because of their belief systems, prior education, (limited) experiences, or preconceptions. Yet if the same useful information is provided by someone they trust or respect, they are more likely to accept it. This reality of having "faith in the messenger" poses both a risk and an opportunity. The risk is that farmers may believe an authority such as a teacher, preacher, or specialist such as an engineer, even when the information is wrong for their situation, and contradicts their lived experience and rational logic. They may defer to such people on principle because the attributes of the messenger – such as education level, social status, vestiges of modernization, or material wealth – are perceived to be good reasons for deference. Alternatively and strategically, finding the right messengers for a particular audience can be a valuable tool for effective knowledge exchange.

The multi-faceted nature of farming also complicates knowledge uptake. Problems and poor outcomes may be attributed to "irrigation" but could result from agronomic practices, soil fertility, or lack of plant protection information, etc. Experimentation and adaptation in multiple subsystems are needed to make cropping systems perform optimally. There is thus no simple right or wrong answer to most challenges that farmers face. In the end, farmers have to be provided with sound information in different ways, from sources they believe, and be encouraged to adapt and experiment themselves to find the best solutions for their situations.

The power dynamics of knowledge exchange must be considered. Engagements should be strategically facilitated to maximize relevant knowledge uptake between all stakeholders, including farmers.

4.2 Diagnostic and scoring

Diagnostic – collecting and assessing information

In diagnosing the knowledge factors that enable FLID processes, the central question is whether farmers of different scales, gender, and socio-economic status can access appropriate knowledge, and use it to their benefit. In the diagnostic of the knowledge factor you should not only assess differentiated farmers and their access to knowledge, but also the wider pluralistic knowledge environment and how it is organized and governed at both national and sub-national levels.

A consultant would usually be assigned to undertake the diagnostic, and a typical scope of work is included in an outline Terms of Reference (TOR) in i-box 4.2. The diagnostic also includes the policy and legal aspects of the knowledge environment. This part of the diagnostic is informed by the approach described in Section 4 of the Main Guide and guided by details in i-boxes 3.4 and 3.5. These details can be appended to the consultant's TOR.

Scoring the knowledge factor

The knowledge factor is constrained when the types of farmers who are chosen as the focus of a potential FLID intervention have limited or no access to essential knowledge. If the focus includes smaller enterprises, or female and younger farmers, these farmers are more at risk of poor access to knowledge. Knowledge gaps can include irrigation practices and equipment, agronomy and the business side of running a profitable irrigated agricultural enterprise. The score of the knowledge axis should reflect the *extent of access to useful knowledge by farmers*. This access by farmers is mediated by the knowledge environment, and the assessment of the environment is thus taken into consideration when scoring the knowledge factor.

The knowledge environment is weak when it is characterized by (1) a public sector that has limited or no understanding of irrigation engineering, agronomy and FLID processes, or fails to operationalize support for FLID; (2) private sector service providers that are non-responsive to the real needs of different types of farmers and tend to promote their own envisaged solutions; (3) significant gaps in services and approaches between actors in the FLID ecosystem; and (4) poor quality or non-existent formal professional education and training of a technical irrigation cadre.

The assigned score is not definitive but is a best assessment, based on team discussion and debate, to guide intervention decision-making. More detailed guidance on scoring the knowledge environment is provided in i-box 4.3. When the knowledge-related constraints are assessed to be severe, then the score is a low 1 (very weak) or 2 (weak) and interventions may be needed to address the critical issues to catalyze FLID.

4.3 Examples of interventions

When the diagnostic and scoring processes lead to the conclusion that the knowledge domain is one of the crucial areas to strengthen, this would merit interventions. Public interventions aiming to support FLID processes must take stock of the multiple activities of stakeholders, and understand their motivations and views on their roles. Where service providers are simply purveyors of pre-defined products, they need to be challenged and motivated to become responsive to farmers' real needs. Such responsiveness can be promoted in various interventions. It can be achieved, for

example, through the targeted monitoring of technical preferences during implementation, through funding for applied research, and by purposefully facilitating farmer feedback in interventions, such as multi-stakeholder platforms and farmer field schools.

This section proposes four public interventions to strengthen the FLID knowledge environment: (1) Facilitated stakeholder collaboration; (2) Farmer empowerment and demand-led service provision; (3) Mass media and communication outreach; and (4) Formal education reform and investment.

Example intervention 1

Facilitated stakeholder collaboration and multi-stakeholder platforms

The FLID knowledge environment is often rich in actors but poor in alignment, leaving considerable gaps in service provision and opportunities for collaboration unexplored. Knowledge networks can become more effective when knowledge brokers contribute to coordination, identifying gaps and avoiding unnecessary competition and repetition. **Public interventions are well suited to take a lead in aligning key stakeholders in the FLID ecosystem.** This can take the form of a loosely organized process, or be more formalized and institutionalized into multi-stakeholder platforms (MSP) focused around smallholder irrigation development. Public actors can lead the process of initiating MSPs and contribute staff time and funding, but should take care not to control the platform, as it should function as a place of interaction between a wide variety of stakeholders. MSPs can be hosted, for instance, by NGOs, universities or network organizations. **MSP facilitators need to be locally based, widely trusted organizations that can facilitate the collaboration of different stakeholders and lead the platform.** A longer list of functions of the MSP host organization can be found in i-box 4.4.

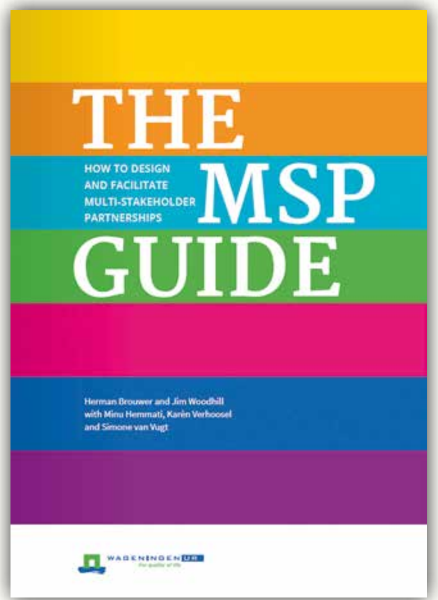
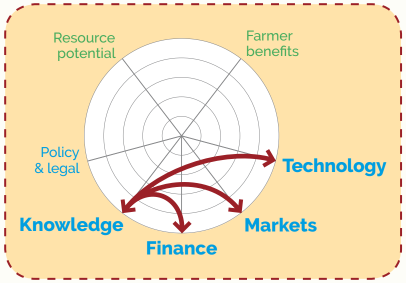


Figure 4.2 *The MSP Guide*, by Brouwer et al. (2015), is a rich source book for practical information on MSPs, their establishment, functioning and possible role in innovation processes and development policies.

MSPs have also been referred to as Innovation Platforms or, in the case of FLID processes in Kenya, as irrigation acceleration platforms (IAPs). The IAPs in Kenya were initiated by the Smart Water for Agriculture project. They bring together various stakeholders and facilitate interactions between them to achieve effective joint actions to improve FLID processes (Thottoli, Zevenbergen, and Van Veldhuizen 2019). Platforms are created at the local level (district, county or irrigation cluster) for coordination of concrete implementation activities with farmers, and at national level for alignment of policies and strategic collaborations. Farmers, public actors, and a variety of value chain actors jointly assess and prioritize challenges and opportunities related to FLID processes in order to find the best response strategies (i-box 4.5).

Platforms allow for sharing of information, knowledge, and experience related to irrigation practices. Platforms also jointly mobilize resources and facilitate effective support services around promising financial and technological



products. IAPs can become the organizing entity for field days, demonstrations, farmer training, pilots and tests. They can also assist with farmer exchange visits and participate in trade fairs and exhibitions.

Experience has demonstrated that MSPs need to be carefully designed to maximize their effectiveness in achieving the intended outcomes. The MSP process model (Brouwer et al. 2015) emphasizes that every MSP process is unique and will follow its own path and logic, but there are common process considerations with four main phases (i-box 4.6).

The process model of MSPs fits well with the understanding that change processes are iterative and are best served by collaboration between complementary partners.

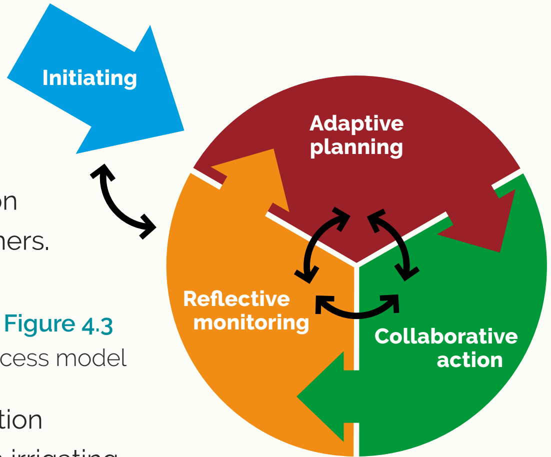


Figure 4.3
MSP process model

In Tanzania, agricultural innovation platforms that were set up with irrigating communities created synergies between a variety of knowledge actors. They linked up several knowledge and innovation entities not previously working in the area, thus broadening the group of farmers that could benefit from them. Equally important, the platforms became engines for capacity building and empowerment of farmers, who strengthened their ability to mobilize knowledge and innovation actors (Mdemu et al. 2020). Experience with MSPs for FLID processes have led to ten main lessons, summarized in i-box 4.7.

Example intervention 2

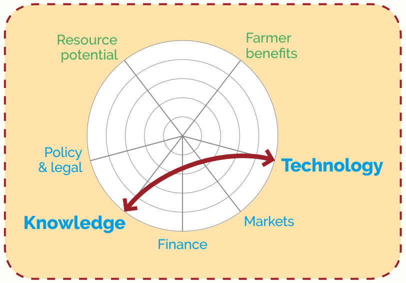
Farmer empowerment and demand-led service provision

FLID processes are characterized by farmers being central to developing their own irrigation practices. Enabling and strengthening FLID requires that farmers keep that leading role, and demand knowledge and innovations that fit their particular needs. At the same time, enabling FLID requires service providers in both public and private sectors to be responsive to the specific wishes of farmers. To assist both public and private actors, FLID interventions initiated by the government could include elements in the design such as the examples that follow.

1 Strengthen farmers' problem-solving and innovation capacities

Participatory approaches to farmer-learning and innovation strengthen farmers' problem-solving capacities. Farmer field schools (FFS) are one of the most effective approaches. They focus on the empowerment of farmers by developing their capabilities to make well-informed decisions – about cropping, irrigating and marketing. Farmers are thereby enabled to select the types of technologies they want. The process of farmer learning in FFS *encourages and facilitates them to conduct their own on-farm observations and research*, and to come up with their own localized and applicable solutions (Blum, Cofini, and Sulaiman 2020).

The FFS methodology is well elaborated and tested. The Food and Agriculture Organization (FAO) operates a Global Farmer Field School Platform with resources on how to organize FFS and integrate them into public and private agricultural extension services. See i-box 4.8 for a

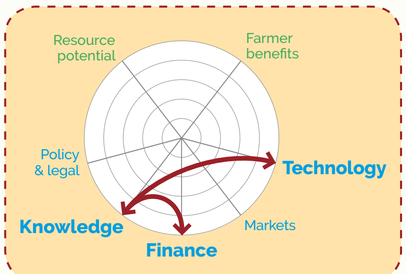


quick overview of principles of FFS and benefits for both farmers and development organizations. Farmer field schools that are oriented to irrigation practices could make use of instruments like the Chameleon card readers and the wetting front detector (discussed in Module 7). The FFS approach involving this kind of technology facilitates learning about soil-water management and soil fertility, both crucial for successful irrigation agronomy.

Farmer-to-farmer approaches can contribute to strengthening local innovation and knowledge-sharing processes that keep farmers at the center of developing irrigated agriculture. MSPs can also be encouraged to work with these farmer-to-farmer networks through partners within the platform, either from the public or private sector.

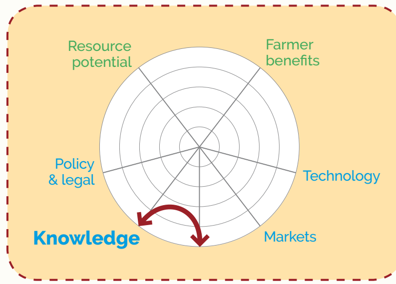
2 "Demand-responsiveness" as a selection criterion for partnerships and subsidies

Knowledge systems can only be responsive to farmer demands when farmers know what they need, and are able to express it confidently. On the other hand, service providers have to pay heed to farmers' preferences and be responsive in what they offer and how they design and redesign their services and products. This holds true also for credit institutions, public extension officers, agronomic advisory services and irrigation technology providers. Far too often, these service providers push their "solutions" without taking heed of farmers' wishes. A public-sector-led FLID intervention can stimulate service providers to work more demand-responsively, for instance, by making demand-responsiveness an explicit selection criterion for partnerships and subsidies. **Government programs can choose to partner with service providers that take farmers' wishes seriously and that have procedures in place to use farmers' feedback to improve their products.**



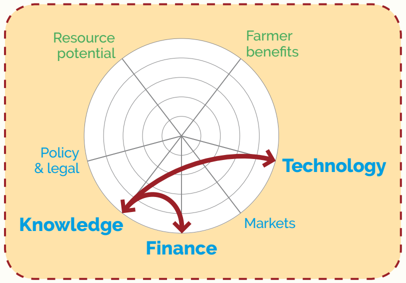
3 Make service providers financially accountable to farmers

FLID interventions aim for an outcome where service providers remain accountable to farmers beyond the life of the intervention. Where service providers operate in free and competitive markets and generate profits purely from farmer payments, this is to a large extent already the case. Yet, in practice, where there is heavy reliance on subsidies (by governments and development organizations), there is a risk that companies, NGOs, and non-profit enterprises may continue to promote and market products and services that farmers have not asked for. **Demand-side financing of agricultural services, where farmers receive money to pay for services, is one way to make agricultural service financially accountable to farmers** (see i-box 4.9). Experiences with financing mechanisms to stimulate demand-led service provision in both the private and public sector can be found in Module 5 of Blum, Cofini, and Sulaiman (2020). A public-sector-led FLID intervention could seek to align with ongoing reforms or experiments with demand-led agricultural service provision.



4 Give farmers control over innovation funds

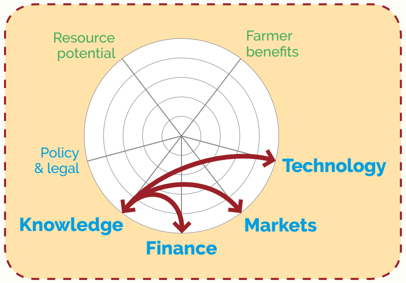
A final mechanism to empower farmers, and make service providers and their products more demand-responsive is to assign farmers, through their representatives, a role in allocating innovation funds. FLID interventions can set aside substantial funds to subsidise the development of promising technologies and other innovations. Farmer-managed innovation funds tend to respond better to farmer needs (Waters-Bayer et al. 2011). It is crucial that farmer representatives in such positions reflect the diversity of irrigation farmers that the FLID support programme aims to support.



Example intervention 3

Mass media, ICTs and communication outreach

Knowledge and innovation processes, by definition, require adaptations to fit new locations as well as existing farming practices. Where the aim is to promote uptake at scale, the broadcasting of these new ideas and related information – by word-of-mouth, print, or internet-based media – is pivotal. Activities could include direct outreach to farmers, but also aim to reach other actors in the FLID domain. An example of information materials targeting different stakeholders is included in i-box 4.10. Traditional media broadcasting through television, radio and the print media is increasingly tied into internet-based platforms and apps. While the potential is undoubtedly huge, there is need for realism (see box on the right). In the context of FLID support programmes, ICT initiatives cut across the FLID factors that are further discussed in Modules 5, 6 and 7 on finance, marketing and technology, respectively.



Be realistic about ICT options

Though ICTs have the potential to reach high numbers of farmers in remote areas, in practice there are important limitations: content is of limited relevance in many local contexts; ICT initiatives in project contexts are often unsustained after project closure; and a digital divide (inequitable access to smartphones, computers, and internet connectivity) leads to a gap in access, use and impact along lines of poverty and gender. (Blum, Cofini, and Sulaiman 2020)

ICT interventions can be publicly funded or existing platforms can be used. One example of public funding is the multi-purpose **IrriTrack** app that combines stepwise practical project implementation support to field personnel, with essential technical and financial information for farmers. The information generated by the app, based on site specifics and farmer preferences, enables farmers to be better informed and make personalised choices based on their needs and means (see Main Guide i-box K).

Existing platforms, programmes, and apps can also be used to share content on FLID processes and particular innovations. They can contribute to attitudinal change towards farmers' initiatives in developing their own irrigation, and to raising farmers' awareness of service providers that they could approach for support in their local contexts. Broadcasting information and success stories on particular irrigation practices and technologies needs to consider the many stakeholders and their differentiated contexts (i-box 4.1), and emphasize the

need for local adaptation of technologies and ideas. Collaboration between farmers, technology providers and agronomic advisory services, among others, is a key part of knowledge development and dissemination, expanded further in Modules 5, 6 and 7.

Example intervention 4

Formal education reform and investment

In order to support irrigation farmers and the irrigation sector more broadly, a country needs a sufficient number of trained irrigation experts at different levels (university, polytechnic, vocational). Irrigation skills are needed in different disciplines (engineering, agronomy, extension, economics, sociology, etc.). If a country does not have a body of irrigation experts working at national and local levels, and does not have corresponding education programs, a FLID support program could invest in setting up such programs or sponsoring students to follow existing programs. Through using these various educational interventions, a skilled and suitably trained technical cadre can have both immediate and long-lasting positive effects on FLID in a country.

FLID-sensitive technical and multi-disciplinary training

Responsiveness to FLID opportunities requires more than just numbers of experts. The domination by engineers with a technically dominant mindset also has to be tackled (De Bont et al. 2019; Liebrand 2019; De Bont and Veldwisch 2020). Irrigation is multi-faceted and FLID is essentially people-centred. If technical personnel are effectively to support FLID processes they must be able to work in interdisciplinary teams and be sensitized beyond their core disciplines. Examples of people-centred educational interventions (expanded in i-box 4.11) include:

- Curricula revision and development to ensure an interdisciplinary and farmer-centered emphasis
- Re-orientation of educators
- Continuing professional development (CPD).

Research partners in FLID interventions

Besides acting as knowledge- and capacity-building partners, universities can also be involved as research partners. A sponsored PhD program can contribute to consolidating academic and educational practice on interdisciplinary irrigation studies, while establishing new foundational knowledge in a country. Regular student programs (like Young Professional programs) can conduct internships and field research in collaboration with project implementation activities. This can strengthen the practical orientation of educational programs, encourage critical and independent thinking among young academics and technicians, and add person power to field activities. PhD programs can also link to international research organizations such as the Consultative Group on International Agricultural Research (CGIAR) and international universities, strengthening relevance, profile and excellence.

i-Boxes

Stakeholders in the FLID ecosystem

Stakeholder	Role and importance in the FLID process
Farmers	Irrigation practices spread when smallholder farmers adopt them. Their views on what is feasible and relevant are crucial. The success of unsupported FLID processes has largely depended on farmers spreading knowledge amongst each other. Farmers must be a central part of any demonstration, testing, or research activity that aims to reproduce such processes.
Farmer organizations	Farmer organizations play a fundamental role in advancing collective interests – usually in relation to shared irrigation systems or increasing marketing power through their numbers. Farmer organizations can be formal or informal groups and include: common interest groups (CIGs) for organizing local initiatives; producer organizations (POs) with a commodity-based marketing focus; Irrigation Organizations (managing group schemes); Water Users Associations (WUAs) (either managing schemes or involved in wider watershed activities) and cooperatives that often take on multiple roles of marketing and/or water management (though less suited to the latter [Waalewijn et al. 2020]).
Financial service providers	Commercial and retail banks, microfinance institutions, mobile money platforms, insurance providers, Savings and Credit Cooperatives (SACCOs), investors, etc. provide credit for supporting FLID. Informal credit provision is an important link in unsupported FLID processes. Informal credit provision is an important link in unsupported FLID processes.
Irrigation technology suppliers	Irrigation technology supply companies are increasingly offering products on credit. They are important drivers for change in farmer irrigation practices, providing the smart water technology as well as spreading the required knowledge. This category also includes distributors, retailers of irrigation technologies, hardware stores and other such suppliers, who are usually the first port of call for farmers for their irrigation needs.
Market offtakers	FLID is heavily influenced by farmers' access to guaranteed markets. Market offtakers – including processors, exporters, brokers and traders – are critical stakeholders to engage in credit provision interventions.
Government and government- affiliated institutions	Various government departments and agencies spearhead the development of irrigation – through setting policies, regulations and standards. They are important at both the national and local government levels, especially for program rollout and extension services.
Input suppliers	Improving on-farm agriculture and irrigation practices needs a holistic approach. It is therefore important to involve suppliers of seeds, fertilizers, pesticides, etc. – manufacturers, distributors as well as local sales outlets.
Academic and research organizations	Research and extension organizations provide agricultural and water information and knowledge. They support testing and development of new irrigation technologies as well as information for establishing standards.

Stakeholder	Role and importance in the FLID process
Non-government organizations	Local, national and international NGOs provide a range of business development services. They are often locally trusted players, especially with youth and women farmers, and can support implementation or program pilots.
Media	Radio/TV, social media and ICT platforms can spread knowledge on irrigation solutions, farmer-to-farmer learning, and influence uptake and usage.

Knowledge diagnostic TOR – example scope of work

A consultant will usually conduct the knowledge diagnostic and analyze the implications for individual farmers, those on group irrigation schemes, and other stakeholders in the FLID ecosystem. The diagnostic of the knowledge component focuses on: (1) the **organization of the FLID ecosystem** and the alignment and coordination of services between the stakeholders; and (2) the **access to and use of suitable knowledge** and innovations for different types of farmers.

The diagnostic process should address the six elements described below and draw conclusions based on their strengths and weaknesses. For two of these elements, the diagnostic process will build on data gathered on the basis of the Terms of References (TORs) in other modules. Element 2 will build on information drawn from the farmer surveys and farmer typology compiled for the farmer profitability assessment. Element 4 will build on input from interviews with service providers conducted on the basis of the TORs in Modules 5, 6 and 7 (Finance, Marketing and Technology). Data for elements 3, 5 and 6 (below) will be gathered by a contracted consultant or the team implementing the diagnostic process for the knowledge component. The elements of the diagnostic are expanded below.

Element 1

Policy and legal aspects of agricultural knowledge and extension.

Policy and legal aspects of the agricultural knowledge systems, including enabling or constraining provisions in relation to information and communication technology (ICT) as a knowledge tool, and the agricultural education environment. The policy and legal review is guided by the approaches outlined in i-box 3.4 and 3.5, and in Minh et al. (2021). This information can be attached to the consultant's TOR.

Element 2

Farmers' access to and use of suitable knowledge and innovations in (and not limited to) the following domains.

a. Accessing water sources (pumps, diversions, etc.)

b. Water transportation methods (pipes, canals, hoses, etc.)

c. Field water application methods and timing

d. Costs, benefits and profit margins of irrigated production

e. Agronomy of irrigated crops, including pest and disease management, and soil fertility management

Both the **suitability** of knowledge and innovations, and the **access** to them are highly differentiated for different types of farmers. The diagnosis under Element 1 thus needs to be differentiated for scale, gender, market orientation and other relevant socio-economic and cultural-political aspects.

The diagnostic analysis of this element will be done by the knowledge consultant on the basis of data gathered by the consultant for the Farmer Profitability axis and the draft Farmer Typology constructed by that consultant (Module 2).

Element 3

Knowledge on irrigation engineering, irrigation agronomy and FLID processes present and operationalized in the public sector.

This entails the knowledge of (1) how FLID processes evolve; (2) awareness of the extent of irrigated areas developed by farmers; and (3) the acknowledgement of the importance of FLID-based agricultural production for food security, farmer income and the (local) economy. These factors can be assessed in different branches of government, both at national and local government levels, as well as in different line ministries of government (e.g. agriculture, irrigation, water resources management). The consultant should establish the existence and use of irrigation development guidelines at national and sub-national levels. She/he should investigate the extent to which farmers' irrigation experience and knowledge contributes to and influences irrigation design and planning processes, and whether their views are heeded. The number of formally trained irrigation engineers and agronomy experts employed by the government (national and sub-national) should be established, along with the awareness of FLID processes and the ability to support them.

The knowledge consultant will gather the data needed for the diagnostic analysis of this element and analyze the data.

Element 4

Demand-responsiveness of the private sector service providers and their servicing to different types of farmers.

This relates to the willingness and ability of service providers (in providing advice on agronomy irrigation technologies and finance) to understand, appreciate and respond to farmers' differentiated demands. Questions to be answered include: How do service providers differentiate their products to farmers of different scale, gender, market orientation and other relevant socio-economic and cultural-political aspects? How have service providers arranged for feedback from farmers to influence their products, design and redesign processes?

The diagnostic analysis of this element will be done by the knowledge consultant on the basis of data gathered by the consultants for the Finance, Markets and Technology axes (Modules 5, 6 and 7).

Element 5

The collaboration, coordination and alignment of services and approaches between actors in the FLID ecosystem.

This concerns a variety of both public and private actors in the FLID domain (i-box 4.1), both at national and local government levels. Questions to be answered include: Are different parties aware of the activities, objectives and constraint of other parties? Are there platforms and procedures to exchange experiences and explore synergies, and are these actively being used and facilitated?

The knowledge consultant will gather the data needed for the diagnostic analysis of this element and analyze the data.

Element 6

Formal professional education and training available at national level.

Data will be collected and collated to answer the following questions: At the national level, what programs exist to train irrigation engineers and agricultural experts and to what extent is supporting FLID processes part of the curriculum? How is irrigation knowledge incorporated in the training programs of agricultural extension officers? Are universities, polytechnics and practical training institutes offering professional (short) courses on irrigation and supporting FLID? To what extent are they participating and making their knowledge available in partnerships and knowledge-brokering processes with other public and private actors in the FLID domain?

The knowledge consultant will gather the data needed for the diagnostic analysis of this element and analyze the data.

Guidance on scoring the knowledge factor

The scoring of the knowledge axis on the diagnostic spider plot is based on a simple ranking from very weak to very strong, with a score of 1–5 respectively. The knowledge factor is constrained when several types of farmers (particularly small enterprises, young and women farmers) have no or poor access to useful knowledge on irrigation practices, irrigation technologies, irrigation agronomy and running a profitable irrigated agricultural enterprise.

Access by farmers is mediated by the knowledge environment, which is poor when it is characterized by: (1) a public sector that has limited or no understanding of irrigation engineering, irrigation agronomy and FLID processes and fails to operationalize support for FLID processes; (2) private sector service providers that are non-responsive to the real needs of different types of farmers and rather push their own envisaged solutions; (3) important gaps in services and approaches between actors in the FLID ecosystem; and (4) formal professional education and training that is of poor quality or non-existent.

- Quality of the knowledge of how FLID processes evolve
- Extent of awareness of the irrigated areas developed by farmers
- Acknowledgement of the importance of its production for both food security, farmer income and the (local) economy
- Existence and use of irrigation development guidelines, including participatory methods and methodology to support FLID processes
- Extent to which farmers' irrigation experience and knowledge contributes to, and influences irrigation design and planning processes
- Presence of formally trained irrigation engineers and irrigation agronomy experts in government institutions and their awareness of FLID processes and ability to support them

1 Demand-responsiveness of the private sector service providers and their servicing to different types of farmers (Element 4 of the diagnostic):

- The willingness and ability of service providers (providing advice on agronomy irrigation technologies, and finance) to understand, appreciate and respond to farmers' differentiated demands
- The degree to which service providers differentiate their products to farmers of different scale, gender, market orientation and other relevant socio-economic and cultural-political aspects
- The extent to which service providers have arranged feed-back from farmers to influence their products, design and redesign processes

2 The collaboration, coordination and alignment of services and approaches between actors in the FLID ecosystem (element 5 of the diagnostic):

- The degree to which both public and private actors in the FLID domain (see i-box 4.1) are aware of the activities, objectives, constraints, etc. of other parties
- The degree to which stakeholders in the FLID knowledge domain are communicating, collaborating

3 Knowledge on irrigation engineering, irrigation agronomy and FLID processes present and operationalized in the public sector (element 3 of the diagnostic):

- Partnering both for particular purposes and for strategic, longer-term alignment
- Are there platforms and procedures to exchange experiences and explore synergies and are these actively being used and facilitated?

4 Formal professional education and training available at national level (element 6 of the diagnostic):

- The extent to which graduates of irrigation programs (engineers, agronomists, interdisciplinary actors) are able to supporting FLID processes, both in numbers and in qualities
- The possibilities for professionals to follow (short) courses on irrigation and supporting FLID at universities, polytechnics and practical training institutes
- The extent to which universities, polytechnics and practical training institutes are participating and making their knowledge available in partnerships and knowledge brokering processes with other public and private actors in the FLID domain.

Key functions of a multi-stakeholder platform (MSP) host

Performance area	To be achieved	Assessment
Facilitation and brokering	Facilitating interactions between stakeholders towards the common objective	Number of stakeholder groups represented and actively participating in platform meetings
	Establishing trust, establishing working procedures, fostering learning, motivating, and managing conflict.	Quality and interactivity of meetings
	Brokering connections between actors that benefit from each other's services or roles; bringing multiple actors together informally, more formally or bilaterally	Bi/multi-lateral agreements (formal/informal) between different actors.
Building networks	Scanning, scoping, filtering and matchmaking partners with complementary resources, including matching information or product demand and supply	Number and diversity of stakeholder groups represented in the irrigation acceleration platform (IAP)
Clarifying key issues	Helping to define main challenges and opportunities that the IAP will address	Challenges and opportunities identified and activities developed accordingly
	Soliciting further studies if needed to deepen understanding	
	Keeping IAP focused on priority tasks agreed by members	
Mobilising external support	Promoting the platform to ensure support and buy-in into the network by individuals and organizations that matter	Quality of support provided by non-platform members.
	Lobbying essential stakeholders to join and contribute resources to the platform	Resources committed to the IAP activities
	Representing the IAP and its members at higher levels	Participation in external meetings, networks and fora
Problem solving and mediation	Identifying, proposing and providing practical solutions to address bottlenecks hindering progress of multi-stakeholder action	Technical advice provided and accepted by platform members
	Undertaking conflict resolution and preventing (hidden) power struggles	Number of conflicts addressed successfully

Performance area	To be achieved	Assessment
Capacity building	Monitoring and identifying capacity gaps for implementing smart water solutions (SWS) and helping to find ways to develop the capacity required	Timeliness and quality of planning and reporting docs
Management	Regular planning and reporting of flows (narrative, financial) from stakeholders, across the IAP and to the intervention team	Timeliness and quality of planning and reporting docs
Documentation	Ensuring that process and results of meetings and activities are well captured so that they can be shared more broadly	Main findings and lessons learnt, captured in well-organized and accessible documents

Source: Thottoli, Zevenbergen, and Van Veldhuizen (2019, 14)

Stakeholder categories involved in MSPs for FLID

Stakeholder category	Role in, and benefit of, a multi-stakeholder platform (MSP)	
1. Facilitation and brokering	The actual implementation of irrigation practices is by farmers, and their access to services and innovations can be mediated through an MSP. Farmers' views on what is feasible and relevant are crucial in the development of innovations.	Farmers are part of any demonstration, testing, or research activity. Organizations joining the MSP can be formal or informal groups, water users' associations, cooperatives, etc.
2. Irrigation technology and agro-input suppliers	These can be important carriers of change when they make technologies and support services available in response to farmer-demand. They see MSPs as an important medium to access potential clients	and can find partners among, for example, finance institutions and market offtakers.
3. Market offtakers	Businesses acting as traders or direct exporters play an important role in securing farmer income. Through coordinated activities of MSPs they can benefit from building relations with reliable	producers and avoid having to provide credits and irrigation technologies themselves.
4. Private and public agricultural service providers	Research and extension organizations provide agricultural and water knowledge and support SWS testing and development.	Other organizations, including NGOs, provide managerial and business development services.
5. Financing institutions, banks, savings and credit cooperatives and microfinance institutions	Formal credit providers can align with technology suppliers and/or market offtakers to offer irrigation-specific financial products to reliable farmer (groups).	
6. Policy and regulatory bodies	Though funding for MSPs and their activities can come through public-sector led interventions, government actors should not use these to push their specific agendas or take over coordinating roles. For public organizations, working with a	variety of private sector actors in an MSP may be an efficient and effective strategy for private sector investments to align with (parts of) their policy objectives.

Source: Thottoli, Zevenbergen, and Van Veldhuizen (2019, 14)

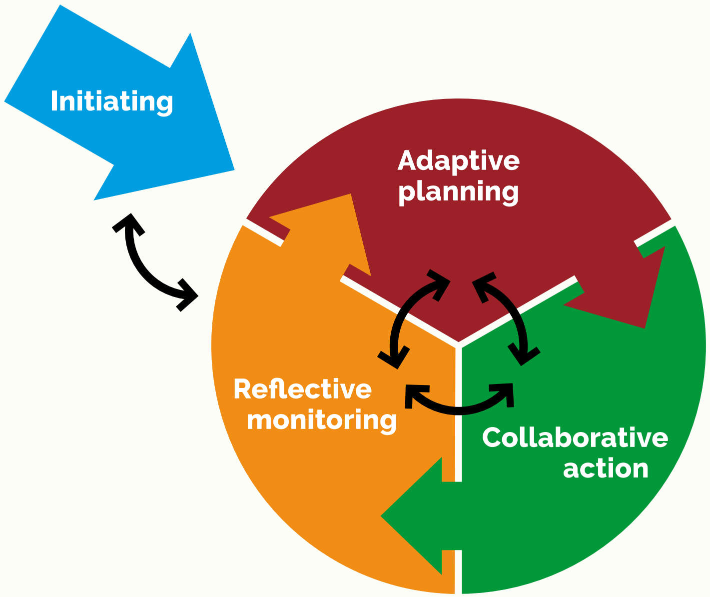
Multi-stakeholder platform (MSP) process model

1. Initiating

- Clarify reasons for an MSP
- Undertake initial situation analysis
(stakeholders, issues institutions, power and politics)
- Establish interim steering body
- Build stakeholder support
- Establish scope and mandate
- Outline the process

2. Adaptive planning

- Deepen understanding and trust
- Examine future scenarios
- Generate visions for the future
- Identify issues and opportunities
- Agree on strategies for change
- Identify actions and responsibilities
- Communicate outcomes



3. Reflective monitoring

- Create a learning culture and environment
- Define success criteria and indicators
- Develop and implement monitoring mechanism
- Review progress and generous lessons
- Use lessons for improvement

4. Collaborative action

- Develop detailed action plans
- Secure resources and support
- Develop capacities for action
- Establish management structure
- Manage implementation
- Maintain stakeholder commitment

Source: Brouwer et al. (2015, 29)

Ten establishment lessons for FLID multi-stakeholder platforms (MSP)

1 The MSP host organization. Local organizations such as non-government organizations (NGOs) or universities that typically are good at facilitating an MSP often also have their operational challenges, and interventions need to carefully monitor and logistically support the host organizations.

2 The facilitator. As success of MSPs depends largely on the effort and motivation of the individual facilitators, it is important to carefully select individuals with the complex set of qualities and attitudes required. Interventions should aim to support the host in this.

3 Organizing and managing the platform. Local platforms should be given space to develop their organization and management structures in line with what is preferred between partners in the platform. MSP hosts should take care to share responsibilities and delegate tasks. Periodic work plans can be helpful.

4 Representation. All major stakeholder groups need to be represented and actively participate in key activities. Experience shows that farmers, in particular, should not miss sessions, as this hampers the transmission of knowledge to farmers, as well as critical feedback from farmers on the services and technologies that are promoted by other stakeholders.

5 Clarity of MSP objectives and roles. Provide adequate time and space to discuss, clarify and negotiate the platform's central objectives and roles with all stakeholders. Monitor the MSP regularly and facilitate interaction and discussion to address emerging frustrations regarding the way objectives and roles are given shape.

6 Implementation of activities. MSPs need time to experiment with various innovations and types of activities; this involves a process of trial and error to understand what works in their respective areas. Even if this process takes considerable time, it is recommended over providing an "institutional fix" from the project intervention side, as it also contributes to maturation of the platform.

7 Communication and documentation. Training on communication planning and tools needs to be provided so that MSPs can be effective in communicating with their members through SMSs, WhatsApp groups, radio, printed brochures, emails or newsletters. This is particularly important in relation to information on upcoming events and facilitates good participation in the events.

8 Ownership of the platform. Generally, MSP hosts and co-facilitators must take ownership of this platform. Particular effort may need to be made with farmers, who tend to have weaker ownership of the platform and its objectives. Sharing responsibilities and paying more attention to the process of establishment could aid farmer-ownership. The name chosen for the endeavor is important. Words like "Irrigation Acceleration Platform" are seen as project jargon and the choice of a local name in the vernacular language, by the members, can help to strengthen ownership perceptions.

9 **Project support to MSPs.** If MSPs depend on project finance it is critical to streamline the planning, budgeting and fund-release process between the project and the platform members. To prevent conflicts around financial resource allocation among the MSP members, it is important for the MSP host to be transparent about the budget allocations, and standardize any allowances to members.

10 **Sustainability.** If MSPs want to continue after project closure their long-term financial sustainability should be on the agenda from the onset. Members should be trained and assisted to develop and implement a financial strategy that makes them independent of the project that initiated them. This includes raising funds from the private sector for activity-based funding or through writing proposals to donors.

Source: Thottoli, Zevenbergen, and Van Veldhuizen (2019)

Farmer Field School (FFS) highlights

Farmer-to-farmer approaches strengthen local innovation. "Farmer-to-farmer approaches engage farmers on a voluntary basis in providing advice and training to other peer farmers. Farmer advisers are usually individuals with little formal education, who receive initial training on technical themes, facilitation and communication skills. Through a process of experimentation, learning and practice, they increase their knowledge and become capable of sharing it with others [...]. Farmer advisers are empowered to become change agents, promoting rural development processes and improving livelihood in their communities. [...] Farmer advisers are also in a better position to respond to locally identified priorities of the communities and to determine, and change, the course of their development. In enhancing demand drive, farmer-to-farmer approaches have the potential to improve feedback from farmers [...]. Farmer-to-farmer approaches are also very suited for engaging with women, youth, and the poor, thus making their voices heard" (Blum, Cofini, and Sulaiman 2020, 40).

Principles of Farmer Field Schools

- The field is the learning place
- Facilitation, not teaching
- Hands-on and discovery-based learning
- The farmer as expert
- Equity and no hierarchy
- Integrated and learner-defined curriculum
- Comparative experiments
- Agro-ecosystem analysis
- Special topics, e.g. irrigation methods
- Team building and social animation
- Participatory monitoring and evaluation

Benefits for farmers

- Strengthening observation capability and increasing knowledge ownership through discovery-based learning
- Building self-confidence and enhancing decision-making capacity
- Minimizing risks in experimenting with new practices
- Changing deep-rooted beliefs and practices
- Developing problem-solving capabilities

How does FFS help government and development agencies?

- Structured implementation process
- Facilitating inter-sectoral collaboration
- Empowering extension officers
- Expanding results effectively
- Joining the global FFS network

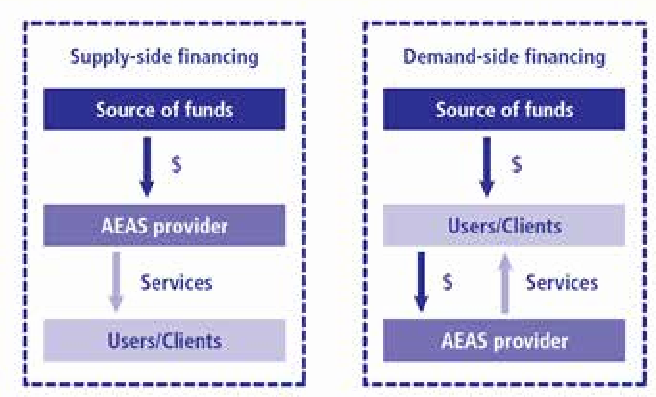
Challenges of FFS?

- FFS requires having a group of experienced FFS facilitators
- Appropriate fund-release mechanism and effective logistics
- Quality Control
- Cost
- Monitoring of FFS

Source: Hagiwara et al. (2011)

Supply-side financing versus demand-side financing

Demand-side financing of agricultural services, where farmers receive money to pay for services, is one way to make agricultural service financially accountable to farmers. Experiences with financing mechanisms to stimulate demand-led service provision in both the private and public sectors can be found in Module 5 of Blum, Cofini, and Sulaiman (2020). A public-sector-led FLID intervention could seek to align with ongoing reforms or experiments with demand-led agricultural service provision.



AEAS = Agricultural Extension and Advisory Service

Source: *Blum, Cofini, and Sulaiman (2020, 77)*

Example of an information outreach and training strategy targeting different stakeholders

Different stakeholders need different information content. The delivery style and choice of platform needs to match their capabilities and allow easy access to new information. Short and targeted messaging with essential information for a particular group is more useful than comprehensive descriptions covering many groups to avoid information overload and reduce meaning and impact.

An example of a targeted message from the Uganda Micro-scale Irrigation Program is shown in Main Guide i-box N Table 1. The messaging was split into discrete segments and targeted key stakeholders *(farmers, local leaders, and financing institutions)* with the specific information that they needed to know.

Communications outreach to government personnel was far more comprehensive. This took the form of a multi-module awareness-raising online training program involving 650 personnel, trained during the peak of the 2020 pandemic. The outreach included details on the program context, extensive attention to the rollout processes, the technical elements of field assessments, and data management.

Links to the training modules and videos can be found in the Main Guide i-box M. A description of the brochure with links can be found in Main Guide i-box N Table 1.

Main elements of a FLID-sensitive education focus

Scope of learning: curricula

FLID-sensitive irrigation curricula content should aim at multi-disciplinary training of socio-technical engineers, agronomists and irrigation managers. Technical knowledge and skills need to include basic aspects of:

- hydrology
- crop water requirement
- irrigation engineering in a FLID context (Module 7 Technology)
- field application methods (Module 7 - Technology)
- permitting and water law (Module 3 - Policy and Legal)

In addition, curricula should also aim at the development of socially aware technicians and engineers by including subjects such as:

- Social and managerial knowledge
- The history, problems and potential of irrigation and extension services in the country and continent.
- Operation, maintenance and organizational needs of smallholder irrigation schemes
- Economic aspects of irrigation, related to operation and maintenance (O&M), inputs and outputs, marketing and producer organizations
- Gender issues in agriculture and, more specifically, how gender relations affect the functioning of smallholder irrigation as well as equity and sustainability of irrigation systems, and its implication for the designs and participatory processes involving smallholder

Re-orientation of educators

Few staff at agricultural and irrigation training institutes currently have the capacity and appropriate qualifications to offer the courses with the envisaged curriculum content. A review and development of curriculum can be accompanied by a teacher training trajectory in four steps:

- Joint review of current curricula with key training staff
- Joint development of new training material and training curricula
- Teacher training provided "on-the-job", in the shape of staff development workshops.
- Special attention to development of field practical exercises and internships, as these will form an essential part of the new curricula.

Continuing professional development (CPD)

The newly developed curricula and teacher skills at the supported polytechnics and universities may be opened up for mid- and advanced career specialists through the offering of short courses. These individuals may thus update their knowledge while interacting over policy and strategy questions related to supporting FLID processes. A FLID support program could offer to sponsor short courses at partner institutes, thus contributing to both capacity and team building at the same time. Curricula developed at the practical training institutes can also double, in shortened form, as refresher and specialization courses for extension workers in both public and private extension services.

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The Farmer-led Irrigation Development Guide

Module 5

Finance

Implications and options for FLID financing

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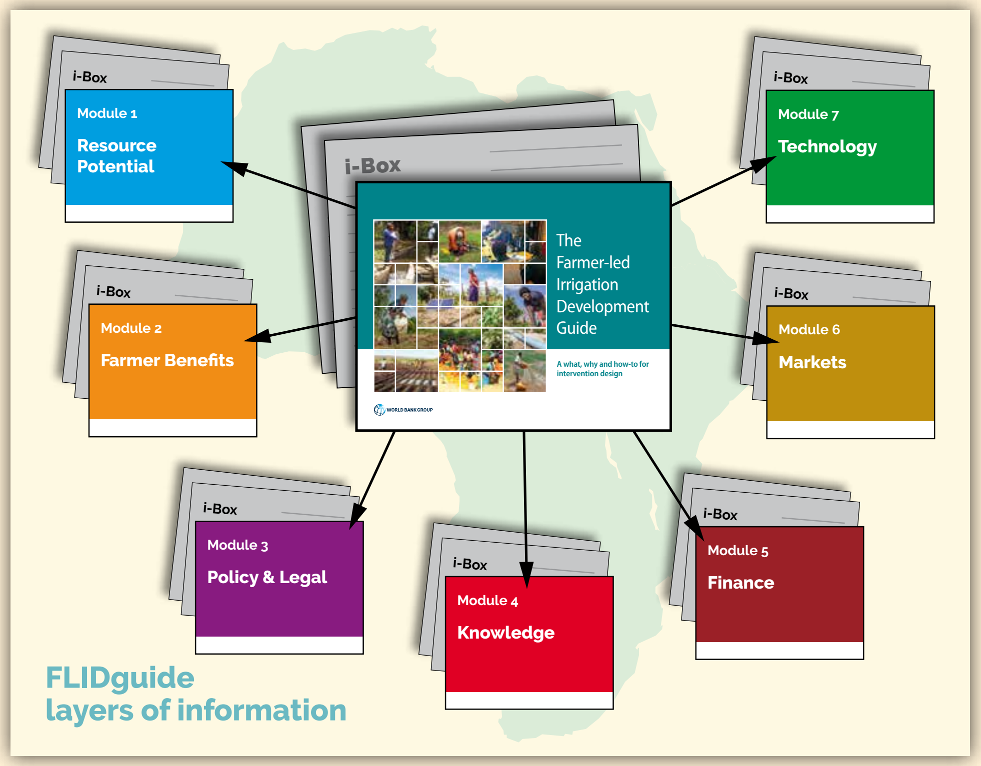
Contents

Abbreviations and acronyms

DFI	development finance institution
FLID	farmer-led irrigation development
GHG	greenhouse gas
GoR	Government of Rwanda
GSM	global system for mobile communications
i-box	information box
IAP	irrigation acceleration platform
ICT	information and communication technology
MFI	micro-finance institution
PAYG	pay-as-you-go
RAB	Rwanda Agriculture and Animal Resources Development Board
R&D	research and development
SACCO	savings and credit cooperative
SME	small and medium-sized enterprise
SSA	sub-Saharan Africa
SSI	Small-scale Irrigation
SSIT	Small-scale Irrigation Technologies
TOR	Terms of Reference
VAT	Value Added Tax

Using the guide

The main volume of the FLIDguide presents the core body of information that explains FLID and the process of intervention design. Thematic descriptions are included in seven modules. Information boxes (i-boxes) at the back of the Main Guide and each module provide additional detail, and hyperlinks throughout the guide access relevant external publications, websites, animation clips and videos.



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5 Finance

Implications and options for FLID financing

Financing responses help farmers to bridge the irrigation affordability gap.

Where individuals or small groups of farmers want to move beyond rudimentary irrigation practices, they will need equipment. Indicative benefits of suitable technologies are assessed for selected situations (Module 2). In a farmer-led process, farmers own the equipment and infrastructure and are the ones who pay for it.

However, affordability is often a major constraint. Irrigation technology (Module 7) that is common in FLID contexts (Main Guide Figure 1) includes petrol and solar pumps with plastic pipelines, storage tanks, and a range of on-farm irrigation technologies (hoses, sprinklers, and drip systems). On gravity schemes, usually involving groups of farmers, infrastructure includes diversion weirs and canals. Costs per hectare range widely depending on the country, system type, and quality. In rudimentary systems such as hand-dug wells with bucket-and-ropes, or simple gravity earth-canal schemes, high labor requirement can offset the equipment cost. Cheap, low-quality petrol pumps can be bought for a few hundred dollars, while high-quality, fully equipped installations will cost many thousands of dollars per hectare (i-boxes 7.5 and 7.7). Even when costs are on the lower side of the scale, the financial hurdle for establishment and acquisition can keep the technology that farmers need far out of their reach. Financing responses such as access to credit, and subsidies, can provide a critical bridge across the affordability gap and are the focus of this module.

More is at stake, however, than just accelerating the uptake of equipment for irrigation expansion and intensification. In the absence of affordable credit and equipment, interventions to support FLID run the risk of perpetuating current trends, with better-off male farmers progressing because they have the financial means, or the social capital to borrow informally, while women and resource-poor farmers are left behind. Financing interventions must address access and inclusion at the same time.

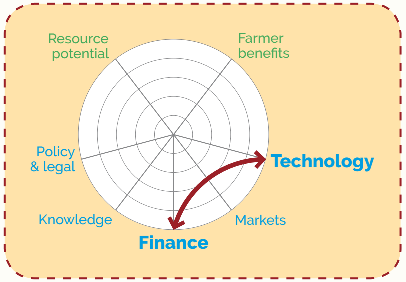
Module 5 unravels some of these complications to make irrigation systems affordable and find solutions that work for farmers. These go beyond the market-driven responses typically provided by financing institutions that tend to remain out of reach for most who need them. The module follows on directly from Module 4 – Knowledge, with the section on stakeholders being important preparatory reading. The first section of this module describes credit and financial service provision in a FLID context; these are the things to think about when assessing the financing environment. The second section provides guidance on the diagnostic and scoring of the financial enabling environment. This is followed by an outline of possible intervention responses that address affordability, credit availability and financial services constraints. Four examples of interventions are outlined, with ideas on how information and communication technology (ICT) can catalyze financial service provision at scale.

5.1 Affordable financing in a FLID context

Globally, agricultural finance is associated with strong positive impacts such as **increasing poor farmers' wealth**, **reducing poverty**, and **raising expenditure levels**. Much experience has been consolidated through the rapid expansion and application of various development programs since the 1980s. Important lessons have been learnt about limitations and opportunities. This section highlights a few considerations in relation to financing in a FLID context. Challenges and lessons of experience are outlined to provide insight into the financing dynamics, and the potential constraints that a financing intervention would need to address.

Equipment financing triple-jump

Most agricultural financing is focused on short-term credit for seasonal inputs (fertilizer, seed, chemicals), which is repaid at the end of one season. The relatively high cost of irrigation equipment needs longer-term capital, and there are three financial hurdles to consider in any assessment:



1 The down payment required to purchase equipment is probably the strongest limitation to acquisition for farmers other than those relatively well-off. Financing support may be needed to ensure inclusiveness, as upfront costs can extend to thousands of dollars per hectare.

2 The loan repayment installments usually extend between 12 and 36 months, and their timing and spread can have important impact on monthly cash flows for both farmers and suppliers. Loan repayments compound the financial stress of crop establishment and having to pay for husbandry costs up front, with revenue only generated after marketing.

3 The life-cycle cost-benefit reflects the net returns over the long term (typically a 10-year period for smallholder farms and equipment). The time taken to the break even point, where the net benefits accrued are greater than would have been obtained without irrigation (see Module 2), is an important parameter.

When tackling the affordability challenge, all three of these elements need to be considered, particularly from the perspective of the farmers – their ability to pay up front, the farm cash flow, and their appetite for risk. The financing solutions that are pursued – whether credit services, subsidies, or both – should enable a farmer to clear each of these three jumps comfortably.

Many players in the financing game

There are many stakeholders involved in credit provision for smallholder farmers across the finance, agricultural services, agro-processing and equipment supply sectors. There is a bewildering variety of possible financing solutions involving credit and subsidies, alone or combined. These are often tied into other agricultural and technical support services to maximize the chance of profitable farming, and thereby loan repayment.

Understanding the different stakeholders and the roles they play is essential, along with foundational information in order to understand the financing landscape, and for assessing strengths, weaknesses, and opportunities.

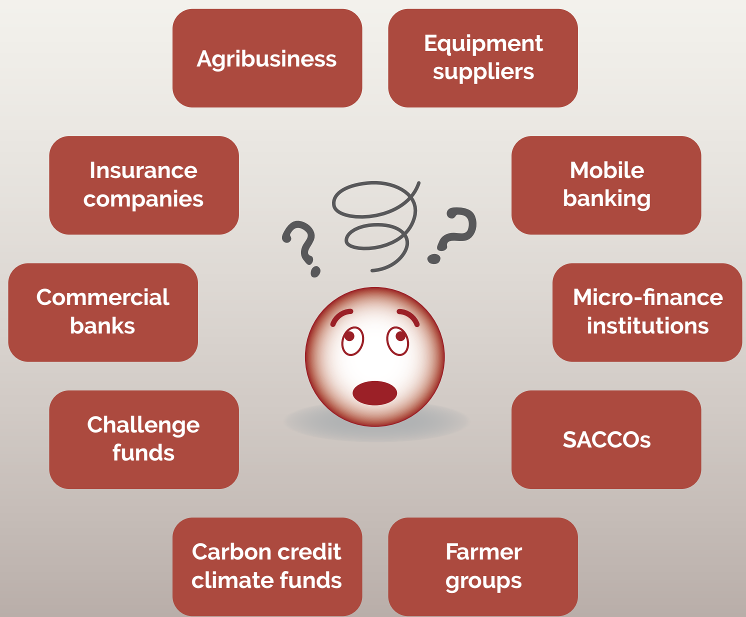


Figure 5.1 Credit provision stakeholders

Formal and informal partnerships, alliances, and innovation platforms are increasingly used as a way of engaging stakeholders as well as a mechanism for coordination and networking, and to create linkages with farmers. Through these platforms, farmers interact with various market actors for advice, knowledge, input and output markets, as well as other services, such as access to financing solutions. The stakeholders and examples of innovation platforms are described in Module 4.

Formal and informal financing

Smallholder farmers who develop irrigation by themselves rely mainly on informal networks for financing their production systems and for marketing their produce. Informal money-borrowing systems include group saving schemes, rotating credit schemes and moneylenders, usually located within the community. One attractive arrangement, often with people outside of the community, is pre-financing of the cropping season by informal traders. They provide the financing on the promise that the crop will be sold to them, thus solving the farmer's finance and market challenges all at once. The risk of fluctuating market prices is typically shared between the farmer and the trader.

While informal arrangements are the dominant FLID financing mechanism, they can be risky. Farmers might not achieve the expected harvest in terms of quantity and quality, or the market cash returns may be less than anticipated, making loan repayment difficult, with no formal recourse, and potential impact on social relations. Despite the risks, however, informal financing relations are generally much easier to navigate than formal loans at finance institutions. Key characteristics of informal and formal financing arrangements are compared in the box below.

Comparative financing constraints

Informal

Informal lending from relatives, friends, moneylenders, and informal traders are the dominant financial force behind the FLID phenomena. While they constitute a key FLID driver, their weaknesses include:

- **Interest rates** from short-term informal lenders are often even higher than formal financing.
- **Short repayment periods** can place heavy cash-flow stress on farmers.
- Limitations in **loan amounts** constrain choices on quality and suitability, and can undermine reliability, profitability and enterprise resilience when things break down.
- Those with less social capital tend to be **excluded** from the lending channels.
- Farmers **cannot build credit history and financial records** for future formal loans.

Formal

Formal credit systems are poorly adapted to the FLID context. Farmers are typically autonomous, operating small enterprises, and have minimal recordkeeping. These characteristics do not **match the expectations** of conventional financing institutions:

- Structured business plans, written marketing contracts, farm **financial records** and collateral are usually absent. Irrigation assets are generally not accepted as collateral.
- Often land is held in customary tenure, or farmers are tenants, thus excluding the possibility of **land as collateral**.
- **Financing packages tend to be inflexible**, and therefore limited in their usefulness – **minimum loans** are often much higher than farmers' need.
- **Interest rates** can be prohibitively high.

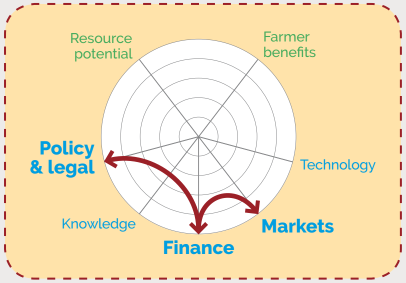
The two forms of financing can also be complementary, and easy-to-access short-term financing can bridge an important gap – if relatively small. Despite the prevalence and relative ease of access, the risks and costs of informal credit remain high, and more structured finance interventions are often needed to catalyze FLID.

High interest rates slow FLID down

High interest rates push up costs and constitute a barrier both for smallholder farmers buying equipment and for suppliers who are keen to sell or rent out equipment. Interest rates from informal sources, including offtakers, are generally higher than official or commercial rates (Chokkakula and Giordano 2013; Fuglie et al. 2020). In Ghana, for example, interest rates can be as high as 45% per annum. Monthly rates as high as 20–30% have been reported in Southern Africa. Such sky-high rates make equipment acquisition very costly.

This situation is partly explained by the tendency for higher charges on short-term loans because of the fact that smallholder farmers are thought to be a risky business proposition; and by the high transaction fees – the costs of client acquisition – due to many and widely dispersed farmers taking small loans. These factors combine to seriously constrain credit affordability (Chipfupa and Wale 2018; Mutambara 2016).

A few countries have policies and set national guidelines which have lower interest rates to support several sectors, including agriculture. However, while these rate caps apply to banks, they may not necessarily apply to micro-finance institutions (MFIs) or financial cooperatives. In Kenya and Ethiopia, for example, MFIs and savings and credit cooperatives (SACCOs) are either not regulated or are subject to different rules.



Interest rate regulations are also not watertight and have gaps that can be exploited. Lower interest rates, for example, can be offset with higher transaction fees, or exposure can be limited through loan caps that are below the likely cost of irrigation equipment. Another downside is that regulated (low) rates tend to disincentivize commercial lending. Rural banks and MFIs generate their revenue through interest rates and related fees. The rate caps may be unattractive, resulting in disinterest in providing credit to farmers and agribusiness who are keen to invest in equipment. Farmers who have potential are then excluded from gaining the substantial benefits of irrigation.

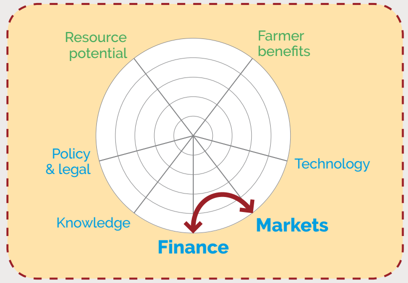
Inclusion

Younger, better-off male farmers tend to benefit most from FLID across Africa. Women and resource-poor farmers, while constituting the majority, are particularly disadvantaged in the FLID process. The two main reasons for this are the high upfront costs of equipment and the difficulty in accessing credit – even informal credit. Other reasons relate to the agricultural production cycle, including: inadequate information on irrigation farming; difficulty in accessing seed and fertilizer; lower labor availability; weak land rights; and poor market integration (Lefore et al. 2019).

The combination of more constrained credit access and exclusion from important agricultural system factors leads to widened inequality and more wealth in fewer hands. **Addressing the limitations that women and resource-poor farmers face in accessing affordable credit is therefore essential** to enable more equitable outcomes.

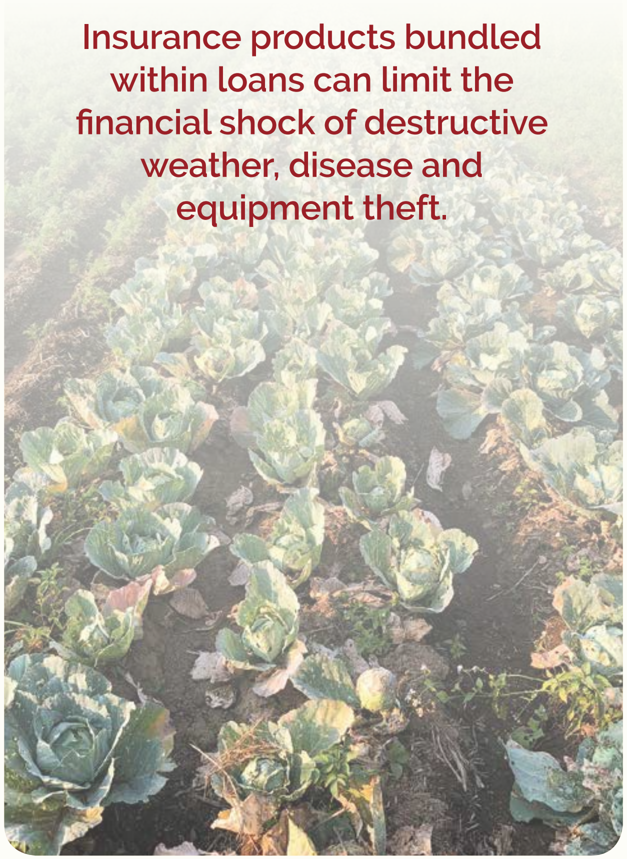
Markets drive FLID

There is a strong message emerging from case experiences that **the market for high-value irrigated produce is a primary driver of FLID**. Evidence from Kenya, Tanzania, Mozambique, Mali and Burkina Faso – as well as beyond the continent (e.g. South Asia) – suggests that a strong market "pull" factor is associated with profitable and expanded FLID. Clusters of irrigators tend to be built around growth in value chains, particularly where there is demand for high-value irrigated produce (Muturi et al. 2019; Nkoka, Veldwisch, and Bolding 2014; Abric et al. 2011; De Fraiture and Giordano 2014). These markets are growing, particularly as sub-Saharan Africa (SSA) urbanizes and consumer habits and diets shift (Tschirley et al. 2015). Markets are addressed in more detail in Module 6 but are highlighted here because of **the strong link between the market players and how financing arrangements are envisioned**.



Crop and equipment insurance for risk reduction

Limiting risk through insurance is part of an integrated financing response. Weather shocks, disease, and the loss of equipment due to vandalism or theft can lead to production losses or failure, with resulting loss of profit. While irrigation itself is "insurance" against water scarcity risks, the use of financial insurance products bundled within loan products can help mitigate these hazards. There are two main types of insurance: *group-yield index* and *multi-peril insurance* (i-box 5.1).



In SSA, it is notable that while these products are available, uptake is low due to high costs and poor understanding of the benefits of the products. Some insurance products are still not sufficiently tailored to the needs of the farmers, particularly smallholder irrigation producers. The prevalence, strength, and extent of uptake of insurance have a bearing on the diagnostic scoring of the financial factor because insurance impacts risk, and risk is one key determinant of the cost of finance.

5.2 Diagnostic and scoring

The purpose of the diagnostic and scoring exercise is to reflect the severity of the financial constraints that are faced by smallholder farmers when they want to build their own systems (materials, machinery, labor), or purchase irrigation equipment. An intervention is needed where significant constraints are identified and the score for the financial factor is low.

Diagnostic – collecting and assessing information

The diagnostic requires information on the category of the farmers targeted in the intervention, the type and quality of financial services and credit provision arrangements, *and* the broader set of financial services that are available to smallholder farmers. This includes accessible banking, accounting, e-commerce, digital money etc., as credit provision is but one service in the suite of financial services provided by the financial sector. The diagnostic would also cover the policy and legal aspects of the financial environment informed by Section 4 of the Main Guide and guided by the approach in i-boxes 3.4 and 3.5. This information can also be included in the consultants' Terms of Reference (TOR). The information collected under the financial theme will require information-sharing by team members and will feed into scoring deliberations, as described in the next section. A consultant would usually be assigned to undertake this task and a typical scope of works of a TOR for the diagnostic is included in i-box 5.2.

Scoring the financial environment

To assess how limiting or enabling the financial environment is for a farmer attempting to access financial support, you have to consider financial policies and laws; the range of financial and credit services that are available to smallholders; and the accessibility of those services across the country. We know that better-off farmers tend to find ways to finance irrigation equipment through savings and informal or formal borrowing.

In assessing the score we must ask: What is the category of farmers targeted in the intervention? And can they accept the risks and afford the cost of the equipment they

need? Where the cost of credit is high, or financial products are poorly suited to smallholders' needs, or the accessibility of services is so weak as to limit targeted farmers from acquiring equipment; then the score for the finance factor will be low. In turn, this means that a financing or subsidy intervention is needed to catalyze FLID. More detailed guidance on the issues that inform the scoring assessment is provided in i-box 5.3.

5.3 Examples of interventions

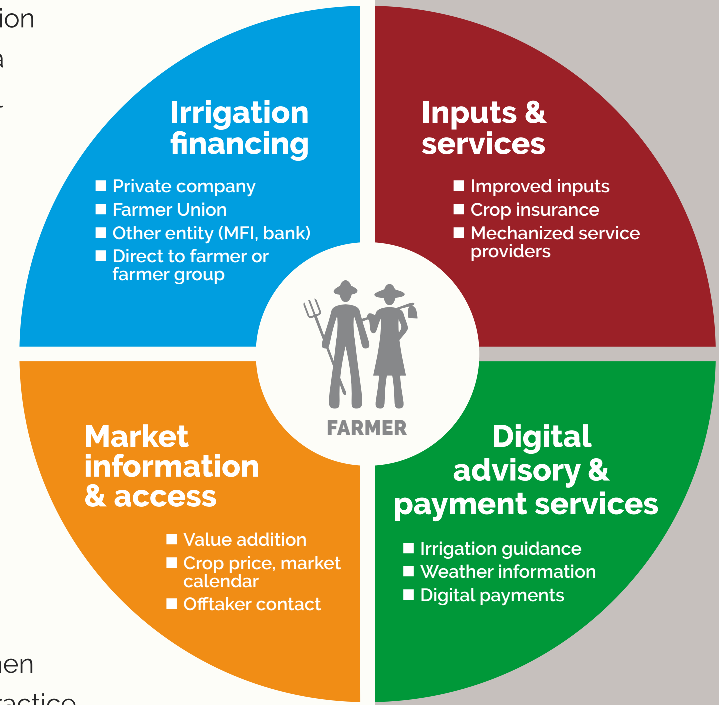
There are many different finance interventions that can be used singly or together. It is inevitable that a solution that is responsive to the constraints in any context would involve a mix of the intervention examples presented next. The choice of intervention(s) is informed by the diagnostic, and complemented with information from the diagnostics on knowledge, markets and technologies.

While financing is the focus, the linkages across factors are strong. Though financing can play an important role in lifting farmers and their enterprises to new levels of production and financial vitality, **a sole emphasis on financing equipment should be avoided**. Financing institutions, aggregators, and irrigation equipment suppliers who offer credit have identified strong linkages to output markets as a critical factor to reduce the risk of farmers' defaulting on their loans. Strengthening financial services may enable farmers to purchase equipment, but on its own is unlikely to be enough to ensure loan repayment that depends on sustainable irrigation enterprises (Merrey and Lefore 2018). This means that effective access to markets, as well as support and advisory services, are needed in an integrated financing approach (Figure 5.2).

The first two financial models strive to **catalyze private sector activity** based on an integrated irrigation financing approach. These include stakeholders in loan finance, agronomy, markets, and technology sales and service provision. **The other two models target affordability more directly**, by reducing direct costs through matching grants, or facilitating hire-purchase-type arrangements.

There are other **catalytic opportunities that extend across all of the financing options**, such as the use of insurance, ICT and financial technology, and the mobilization of green or climate funds. These potentially transformative complementary interventions are addressed at the end of the section. Combinations of solutions can markedly strengthen financial access, inclusion and affordability, but make implementation more complex in practice. The risks from additional complexity versus the benefits to farmers must be assessed and rationalized.

Figure 5.2
Elements of integrated irrigation financing



Example intervention 1

Facilitating linkages between existing actors (i-box 5.4)

This intervention recognizes that there is willingness and demand from all actors in the irrigated agriculture value chain but identifies that the linkages are weak and their expectations misaligned. The intervention builds on stakeholder networking approaches that are described in Module 4. It is often a weak financing environment that calls for this approach. It is based on the observation, in many situations, that:

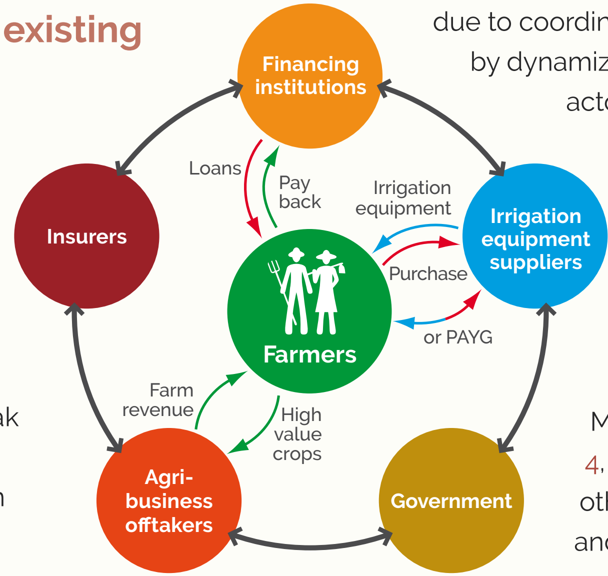


Figure 5.3 Facilitating linkages between farmers and market players

1 **Farmers** are technically ready to adopt new irrigation technology but cannot afford it.

2 **Financing institutions** (agricultural and development banks) face high transaction costs in identifying farmers who are investment-ready.

3 **Aggregators** and agro-processors have unmet demand for consistent and reliable supply of produce for processing.

4 **Suppliers** of irrigation equipment are often established (even if in major and not in minor centers) and have suitable technology solutions, but cannot carry the risks and transaction costs of financing.

5 **Government** is often looking for private sector partners to leverage private financing and achieve more integrated and sustainable development.

Where these common interests are present, albeit misaligned due to coordination weaknesses, FLID can then be accelerated by dynamizing the linkages between the interested actors. Change can be catalyzed by facilitating farmer business plans; resolving gaps in financing criteria; identifying holistic finance, equipment, marketing and extension packages for farmers; mitigating financing risks by engaging insurers; and motivating public sector finance for roads, water permits, and other agricultural value chain investments. Multi-stakeholder platforms, described in Module 4, can play a valuable role in this process, as can other forms of networking such as media outreach and digital connection platforms.

Example intervention 2

Credit guarantee and risk-sharing arrangements (i-box 5.5)

Credit guarantee arrangements to finance irrigation can work well because they bring all parties together and **transfer the risk from private to public sector**. There are numerous variations of the approach in terms of how funds flow, but they share the same strategy. A development finance institution (DFI) provides a guarantee to national financing institutions, to suppliers, or to agribusiness companies. They provide credit to farmers to access equipment without carrying the risk of default. Three variations are listed below, and expanded in i-box 5.5.

Variation A – **DFI guarantees a financing institution**, such as an agricultural or development bank. They in turn guarantee credit to selected (proven) MFIs, who act as agents during an intervention rollout and lend to farmers directly.

Variation B – **DFI guarantees a supplier**, which then provides credit to individual farmers, as a conventional loan or with a pay-as-you-go (PAYG) financing arrangement (discussed later).

Variation C – **DFI guarantees an agribusiness company**, such as a cannery, bulk aggregator/exporter or processor, which in turn finances the irrigation equipment of outgrowers.

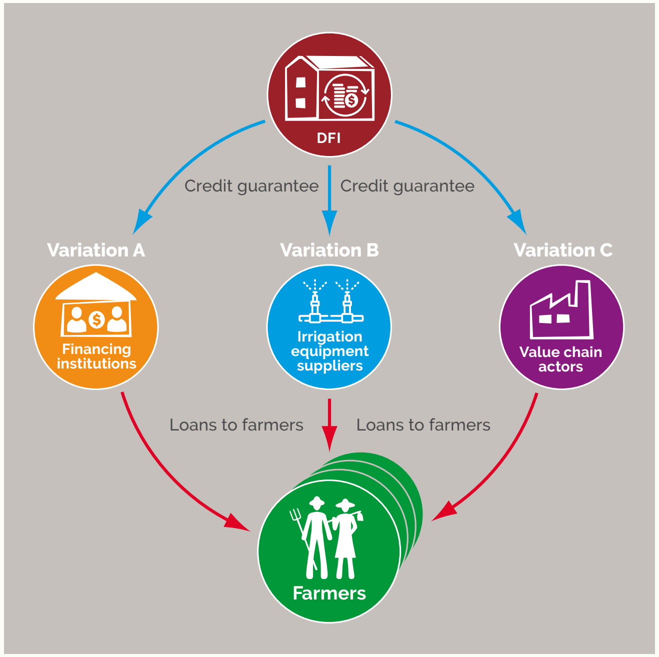


Figure 5.4 Credit guarantee variations

In the variations of the credit guarantee model, the intervention would require engagement with private sector entities, commerce groupings, and multiple government line ministries. Selection criteria and application modalities for eligible financing institutions and MFIs would have to be established, along with funds management, disbursement procedures and financial safeguards. Involvement of financial management and agricultural financing specialists is essential. Collaboration with co-financing institutions focused on the private sector could be advantageous.

Example intervention 3

Pay-as-you-go (PAYG) (i-box 5.6)

PAYG are financial products for *end consumers (farmers)*. These are different from the credit guarantee and other models that target higher-level financial institutions, equipment suppliers, and produce offtakers, but still for the farmer's benefit. The PAYG model is most common with solar pump arrangements that have a relatively high capital cost. They are similar to hire-purchase agreements, where a down payment is followed by installments over 12 to 36 months, with payment often facilitated by mobile money. Sometimes equipment is global system for mobile communications (GSM) enabled, so it operates as and when payments are made.

Equipment companies have developed these financial products for credit, as they are among the few ways that the companies can increase the sales of their products when affordability is low and the finance environment is weak. The PAYG financial products readily complement, but do not replace, other financing interventions.

The public sector can promote PAYG by increasing knowledge about this modality among irrigation equipment suppliers, supporting digitally enabled equipment (such as GSM-equipped pumps) , and adding PAYG capabilities to risk-sharing interventions (such as example intervention 2).

Pay-as-you-go rental and irrigation service provision models have real advantages:

- **They enable women and other resource-poor farmers** to bypass social ownership barriers and remove the financial burden of the down payment
- **Existing MFIs or SACCOs are often able to provide adequate short-term credit** to cover pump rental or irrigation services
- **The irrigation service provision model fills a niche market** of smallholders who cannot purchase pumps, while engaging small and medium-sized enterprises (SMEs) in irrigated value chains.

Variations of PAYG include one where payments lead to equipment ownership (effectively a hire-purchase setup) and another which is a simpler rental arrangement for water services provision. The latter has evolved rapidly with a surprising footprint across Africa, with studies suggesting that an estimated 25% of irrigators in many countries are being served in this way (De Fraiture and Clayton 2012). There is real potential to increase irrigation market density with this "uber for irrigation" approach, especially when combined with ICT platforms.

Example intervention 4

Subsidies (i-box 5.7)

It might happen that even with a conducive credit system, smallholder farmers still cannot afford the development of irrigation, as costs are prohibitive given their resources. When farmer affordability is low, subsidies are a key instrument for accelerating irrigation equipment uptake, to support intensification and expansion. Subsidies can strengthen supply networks, improve agricultural and technical knowledge, and related services and support. When successful, these lead to lower prices, with cascading farm-financial and wider economic benefits. When used inappropriately, they can also distort competition, weaken value chains, undermine other useful technologies, or skew demand and prices.

To ensure that farmers remain in the lead of the irrigation development process, subsidies should be partial, aiming solely at bridging the affordability gap of the smallholder farmer and nothing more. Subsidies are administered through either matching grants or revolving funds. In a matching grant, the public subsidy reduces the capital cost for the farmer and is blended into the equipment-purchasing financing arrangements. Farmers contribute a part of the cost. Matching grants promote ownership, increase affordability, encourage sales, and strengthen supplier networks and product knowledge by increasing turnover and technology penetration. In setting the farmers' contributions, attention needs to be given to realistic affordability levels; the impact of the grant on market costs, broader awareness and knowledge; and the government's ability to finance its portion.

In a revolving fund, the subsidy is used to capitalize a loan fund, which is then administered by an entity that could be a farmers' or savings group, a SACCO, or similar. The group has a reserve of money (the Fund) which is used to lend to borrowers from the group. Over a set period of time, the borrower is expected to repay the original sum that restocks the fund, and then others get access to loans in subsequent rounds.

Subsidies, through matching grants or revolving funds, can be effective in bridging the affordability gap when the financing environment is weak. Caution, however, is warranted, and the potential downsides – such as negative impact on markets, the setting of precedents and promoting dependency etc. – must be carefully assessed.

Cross-cutting intervention – ICT (i-box 5.8)

ICT tools can catalyze and facilitate all manner of interventions, and opportunities for ICT to improve efficiencies and accelerate the pace of rollout should be sought in all of the above intervention examples. ICT reduces the costs and risks associated with offering financial products, and also helps to close the gap in both equipment and produce markets. In public interventions, ICT innovations can be accounted for as directly funded services, as well as included in pre-qualification specifications and/or tendering criteria. The use of ICT tools can be identified at multiple steps in the financing process, as illustrated in Figure 5.5.

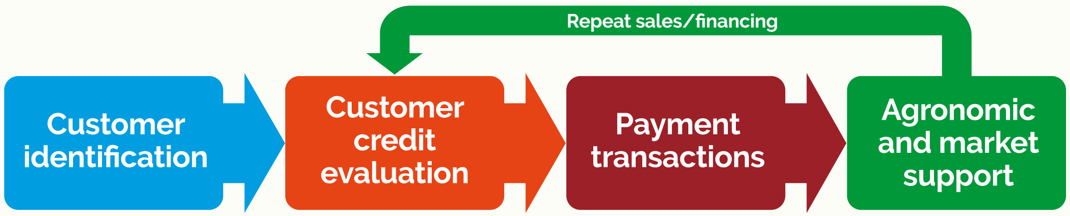


Figure 5.5 Steps in the FLID financing process

Widely used and accessible ICT solutions can be integrated with the interventions, and are expanded in i-box 5.8 and 5.9. These include:

- Mobile money and e-wallets
- Remote sensing and remote monitoring of use of pumps
- Credit scoring tools
- Apps to link irrigation customers to produce buyers
- Data services for credit and inputs, and e-Voucher systems for subsidies.

5.4 Concluding note

Irrigation technology is usually costly for farmers to acquire, partly explaining why FLID is dominated by the relatively better-off, mostly younger men. Low levels of affordability, when combined with expensive or inaccessible financing options, form a serious constraint to rapid technology uptake that has the potential to trigger intensification, profitability and greater inclusion.

Informal financing currently drives FLID, and assessment of the informal environment can help highlight weaknesses, leading to the design of intervention responses where informal financing bridges a smaller and more manageable gap. Solutions that are financially enabling will be varied and context specific; subsidies will be informed by political priorities and the national fiscus; while networking solutions will be informed by the status of financial, agribusiness and technology supply actors. Interventions will most likely comprise a mix of approaches outlined in this module. ICT is a potential game changer in extending information services, linking farmers and catalyzing access to, and beneficial outcomes of, financial services.

i-Boxes

Crop and equipment insurance

The most commonly used insurance products are indemnity-based crop insurance, where an insured farmer receives compensation for the verifiable loss or damage at the end of the growing season, and weather index insurance, where the farmer makes claim payments based on the realization of an objectively measured weather variable (e.g. rainfall) that is correlated with production losses. Some of the other variations made within insurance products to incentivize uptake of irrigation equipment include:

- **Group yield index** – uses a combination of weather index and group dynamics to estimate potential loss or damage of product. Upon loss of production yields, the insurance firms evaluate the loss based on the weather conditions first, and in addition use yield data collected from the farmer group to assess any additional loss or damage outside of the weather conditions. This product is mostly applicable in situations where farmers are organized in groups, have structured offtake contracts, are provided with inputs and/or equipment, and target yields set at the beginning of the offtake contract.

- **Multi-peril insurance** – provides a cover for several agreed-upon losses, such as loss of production due to weather conditions, pests or diseases. Insurance firms use satellite weather data to verify this. However, this is not a preferred option as it calls for multiple physical inspections (planting, production and harvest seasons), the costs of which are usually borne by the farmers. This insurance product has to be bundled together with irrigation equipment insurance, which provides cover against loss due to fire, vandalism or theft, to promote uptake of irrigation equipment and also mitigate perceived risks by the financial institutions.

Insurance companies partner with commercial banks, offtakers and equipment suppliers to design credit products whereby insurance premiums are bundled into the loan products when lending to farmers. The insurance covers the cost of production and potential income lost and is mostly tailored to a specific crop. The premiums cost ranges between 5% to 10% of the overall production cost for weather and pest insurance policies and 2% to 5% of the equipment cost for irrigation equipment insurance.

Outline TOR for the finance diagnostic

The consultant will analyze the following aspects in relation to subsidy and financing aspects as they impact on individual and group schemes in small-scale irrigation development:

With reference to policy and legal aspects of financing: The diagnostic will cover the policy and legal aspects of the financial environment informed by Main Guide Section 4 and guided by the approaches outlined in i-box 3.4 and 3.5, and in Minh et al. (2021). This information can be attached to the consultant's Outline TOR for the finance diagnostic. The assessment of the policy and legal environment will feed into the diagnostic and subsequent scoring of the legal and policy factor.

With reference to existing government programs (not related to donor-funded projects)

1 Assessment of the current public financing structures within the national government and county government for provision of subsidies and loans to individual farmers and groups of farmers for small-scale irrigation development. Among the aspects to be assessed is whether there are any procedures for farmers to express interest in applying for subsidies.

2 Assessment of the current procurement structures within the national and local government for procurement of irrigation equipment from suppliers on behalf of individual farmers and groups of farmers for small-scale irrigation development.

3 Description of the flow of funds for irrigation service delivery in the following areas:

- Within the national government structures
- Within the local government structures (from local government headquarters down to the lowest level of local government administration) for irrigation service delivery.
- Between the national government and local government structures

4 The consultant will be required to focus on the public financing and procurement aspects noting that a *separate assignment regarding policy, institutional and legal environment* is being undertaken with a focus on roles and responsibilities of the different institutions and departments relevant for small-scale irrigation development. This assignment will complement that *separate legal and policy review* with a particular focus on subsidies, loan structures and procedures currently in use for procurement.

With reference to donor-funded projects: the consultant will be expected to analyze these in relation to individual and group schemes for small-scale irrigation development, taking into consideration how these models and value chain actors could complement public support.

- Analysis of financing models used in small-scale irrigation projects and examples or case studies of how other agricultural inputs have been disbursed to farmers (either individually or in groups).
- Analysis of the role of value chain actors in provision of financial products and market linkages (e.g contract farming) in relation to financial institutions (commercial banks, savings and credit cooperatives (SACCOs), micro-finance institutions (MFIs), digital money platforms) and other non-state actors (e.g. NGOs).

Proposals: Following the analysis of these key elements, the consultant will provide suggestions on suitable financing models or mechanisms for further development of FLID.

1 **With reference to private finance:** the consultant will be expected to analyze the following areas in relation to how private finance providers support farmers to invest in irrigation:

- Identify and assess the experience of financial institutions, their respective market reach or presence in countries and their financial products offered (loans, collateral required, credit assessments, risk mitigation structures) for small-scale and individual irrigation equipment;
- Analyze the *capacity of financial institutions* to provide loans and make recommendations on public action necessary to scale up FLID;
- Analyze the *experience and financial products key value chain actors and traders* involved in the financing of small-scale and individual irrigation farmers. This will include the mapping of their experience, respective value chains, offtake models and types of financial products, market linkages and related constraints. The study will include contract farming arrangements involving financial institutions (such as commercial banks, SACCOs, micro-finance institutions, and digital money platforms) and other non-state actors (NGOs).

2 **With reference to donor-funded projects:** the consultant will be expected to analyze:

- Financial arrangements in relation to individual and group schemes for small-scale irrigation development, taking into consideration how these financing mechanisms and models could complement public finance interventions aiming to increase access to affordable financing for smallholder farmers;
- The range of financial loan products currently used for individual irrigators, related financing models used in small-scale irrigation projects, and examples or case studies of how donor funded projects have supported farmers to access irrigation equipment and other agricultural inputs and methods of disbursement (either individually or in groups)[1].

Proposals: Working closely with the public finance specialist (TOR attached), the consultant will be required to analyze these key elements, and provide concrete suggestions on suitable financing models or mechanisms and levels of subsidy for further development of FLID in a report and short power point presentation

[1] The consultant will be required to refer to the recent work done by Stichting Nederlandse Vrijwilligers (Netherlands Development Organization) (SNV) on assessment of FLID in Kenya and constraints and barriers to smallhold farmers investing in irrigation. The consultant is expected to review the financial models identified and explore their applicability to achieve scale with consideration of use of public finances.

Guidance on scoring the financial factor

The scoring of the financial axis on the diagnostic spider plot is based on a simple ranking from very weak to very strong, with a score of 1 to 5 respectively. Characteristics of a weak financial environment describe a general situation that constrains smallholders' access to finance, and might include:

Financial policies and regulations that are unsuitable for irrigation equipment markets and irrigated value chain development

- Interest rate policies are not in place for agriculture and climate-smart technologies.
- Tariffs, including exemptions, are implemented haphazardly and inconsistently for equipment and related products, such as solar systems, batteries, and parts.
- Foreign exchange is in short supply, and foreign exchange rates are unstable.
- Equipment suppliers are unable legally to offer products on credit – e.g. pay-as-you-go (PAYG), asset finance models.

Appropriate financial products (for smallholder farmers) are limited in the formal credit market

- Longer-term credit, seasonal repayment and affordable annual interest rates are unavailable.
- Insurance for producers and other actors in irrigation value chains is costly or difficult to access.

Laws and regulations related to finance pay little attention to equal access; women and other recognizable groups (e.g. those based on religion or ethnicity) are constrained in accessing credit

- Women are required by cultural or religious rules to get the permission of male relatives to access credit .
- Women and other recognizable groups are barred by laws or regulations from accessing credit.
- Women and other recognizable groups face unreasonable bureaucratic barriers by financial institutions to accessing credit, e.g. literacy or education requirements, excessive information demands, complexity of forms, the need for signatures, or the presence of male relatives, among others.

Information and communication technology (ICT) systems are underdeveloped, with few opportunities to reduce transaction costs of credit provision and risks of default for borrowers

- Money mobile is unaffordable, inaccessible, and not widely used by companies and farmers.
- Internet access is expensive and generally inaccessible in rural areas.
- Apps are seldom used to link equipment suppliers, offtakers and post-harvest agribusinesses (aggregators, processors etc.) with each other and with individual producers and farmers' organizations.
- Information services, such as weather, market and agronomic advice, are unavailable.
- There are weak linkages and networking opportunities for different actors across agricultural, finance and technology sectors in the irrigation space, enabled by ICT.

Facilitating linkages between existing actors

The market system in most developing countries is loose and lacks integration, a fact which, some argue, is a major cause of earlier failures to build a market for irrigated supply chains. The lack of linkages between actors creates poor information flows, reduces trust between actors, and discourages innovation – all of which contribute to high risks of failure. The intervention aims to build bridges between these actors based on an integrated irrigation financing approach. It is based on the following:

1 **Farmers** are technically ready and financially able to adopt new irrigation technology. They are, however, unable to develop the kinds of business plans and financing proposals that formal financing institutions – such as agricultural banks or national development banks – require. Where farmers are organized in groups, their institutional establishment is often weak, without bank accounts, administrative records or clear organizational roles and responsibilities.

2 **Financing institutions** (agricultural and development banks) face high transaction costs in identifying farmers who are investment-ready, and in supporting the coherent package of agricultural services and inputs that farmers need. This package usually includes not only loans for equipment, but also access to quality seed, fertilizer, extension support and secure markets. Access to the whole package – and potentially to insurance in addition – increases the chance of farming success and reduces loan default risks. Financing institutions may have interest but cannot carry the costs of establishing these linkages.

3 **Aggregators and agro-processors** have unmet demand for consistent and reliable supply of produce for processing (e.g. tomato canneries, mango juicing) or pack houses for export. Outgrower arrangements that are centered on aggregators are well established and widely successful, but usually include only input supply (seed, fertilizer) and extension support. Side selling is widespread despite contracts, with related risks of not recouping input loans provided in advance. Equipment costs are higher than inputs and repayment timelines are longer. The equipment financing risks are excessive for most aggregators, pointing to a need for other financing modalities.

When there is a clear failure in coordination between multiple willing and interested actors in the value chain, interventions can bridge these gaps.

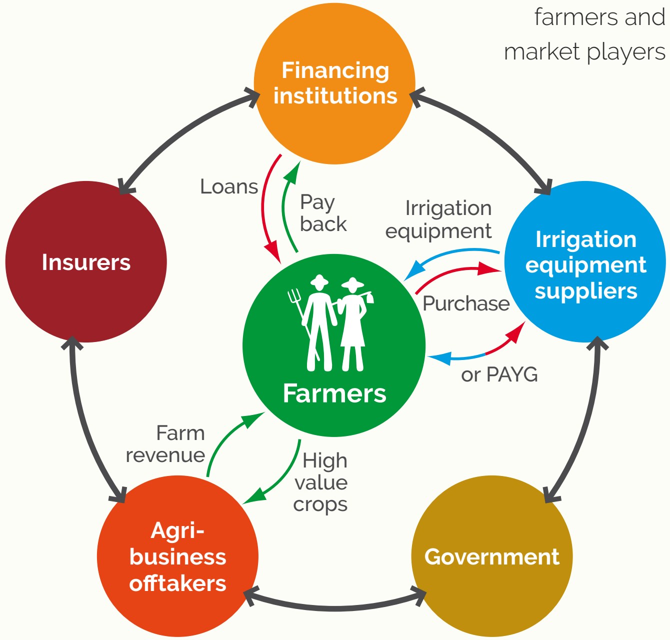
4 **Suppliers of irrigation equipment** are usually established in major centers, if not decentralized to small centers. In general, they either already have or are able to get suitable technology solutions needed by farmers. Their business motivation is to increase equipment sales but, as in the case of aggregators and financing institutions, they cannot carry the heavy transaction costs of facilitating the linkages – even if they had the expertise and capacity to do so.

5 **Government** is often looking for private sector partners to leverage private financing and achieve more integrated and sustainable development, with opportunities in collaboration with river basin or catchment management agencies, regional and district development funds, climate and green funds, and local infrastructure investments.

Where these aligned interests are present, though separated by a failure in coordination, then FLID can be accelerated by dynamizing the linkages between the financial institutions and other interested actors. Brokering engagement can bridge such information gaps and, importantly, develop trust between actors. Knowledge brokers should aim to ensure incentives for different types of actors to remain engaged. In addition, brokering engagement often works best if it is nested at multiple scales (local, regional and national), with information moving across scales. Different types of knowledge exchange and innovation platforms are described in Module 4 and can be used to activate this kind of intervention. They catalyze change by:

- **Facilitating financing** with the advantage of reducing the cost of customer acquisition for financing institutions and equipment suppliers.
- **Offering business advice** and capacity development to farmers who are technically ready to invest in new farming practices, and need support to develop business plans and financing proposals.
- **Identifying and bringing together a coherent package of technologies** that require financing to enhance success across the system: irrigation, greenhouses, seeds, agro-chemicals, extension support and post-harvest storage.
- **Creating linkages to mitigate financing risk**, often through assurance of good market opportunities, thus opening opportunities for formal offtake agreements with agribusinesses.
- **Enabling private sector actors to access data and market intelligence** that are not easily available, contribute to finance innovations, and identify priority information on opportunities for co-investment and risk sharing (Minh et al. 2020).
- **Bringing attention to the need for financing key public sector services** (such as access roads and bulk water supply, as well as the necessary land and water rights), and for financial policy.

Figure 1 Facilitating linkages between farmers and market players



Irrigation acceleration platforms (IAPs) can be limited by the role that government wants to play, and by the preferences of other types of actors, such as private companies and external stakeholders, in leading such networking initiatives. Platforms are also often difficult to maintain after a specific project closes – though they may play an important role in the short term, by bridging initial market and knowledge gaps so that sufficient momentum is obtained.

Credit guarantee arrangements

Credit guarantee arrangements to finance irrigation can work well because they bring all parties together and **transfer the risk from private to public sector**. There are numerous variations of the approach in terms of how funds flow but they share the same strategy. A development finance institution (DFI) provides a guarantee to national financing institutions, to suppliers, or to agribusiness companies. They provide credit to farmers to access equipment without carrying the risk of default.

Variation A – A DFI guarantees a financing institution, such as an agricultural or development bank. They, in turn, guarantee credit to selected (proven) micro-finance institutions (MFIs), which act as agents during an intervention rollout and lend directly to farmers.

Variation B – A DFI guarantees a supplier, who then provides credit to individual farmers, as a conventional loan, or with a pay-as-you-go (PAYG) financing arrangement (i-box 5.6).

Variation C – A DFI guarantees an agribusiness company, such as a cannery, bulk aggregator/ exporter or processor, which in turn finances the irrigation equipment of outgrowers.

Variation A

– A DFI guarantees the financing institution and, in turn, the MFIs, who lend to farmers

The basic arrangement is that a DFI provides a credit guarantee to a commercial bank or irrigation fund, and the credit guarantee then cascades down to selected MFIs or savings and credit cooperatives (SACCOs – i.e. a local financing institution). The MFIs or SACCOs then provide credit to individual farmers or small groups, who purchase irrigation equipment from a supplier. The purchase can be either in cash, or through PAYG, a form of hire-purchase explained in i-box 5.6.

The farmers sell produce at local, distant or contract markets, generate profit and repay the loans to the MFIs. The risk of loan default is effectively carried by the DFI.

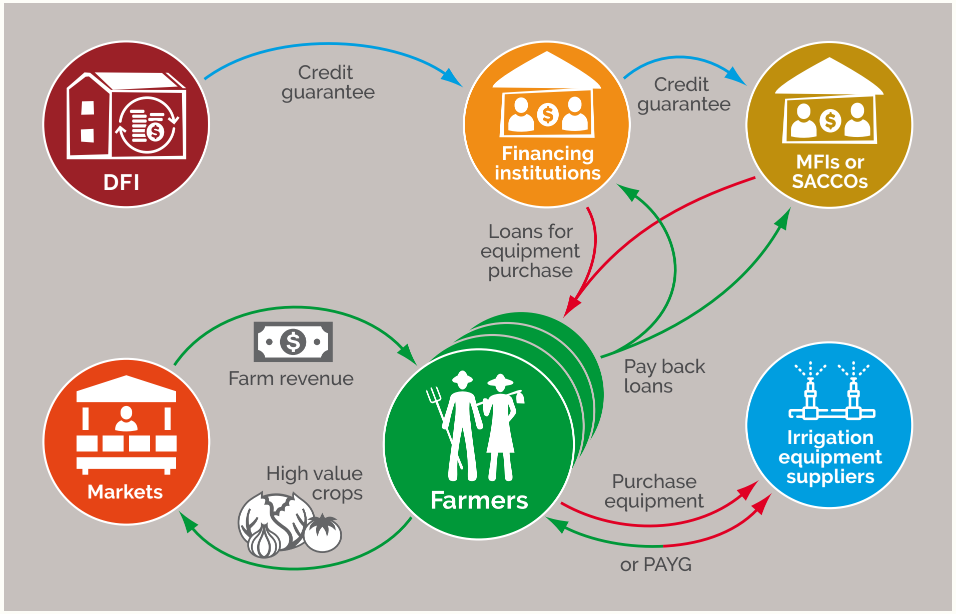


Figure 1 Financing institutions, MFIs or SACCOs as credit providers

Variation B

– A financing institution guarantees the irrigation equipment suppliers

The credit guarantee is provided from the DFI to the financing institution, and cascades onwards to the irrigation technology suppliers. The suppliers facilitate the credit services, either as a direct loan or under a PAYG arrangement.

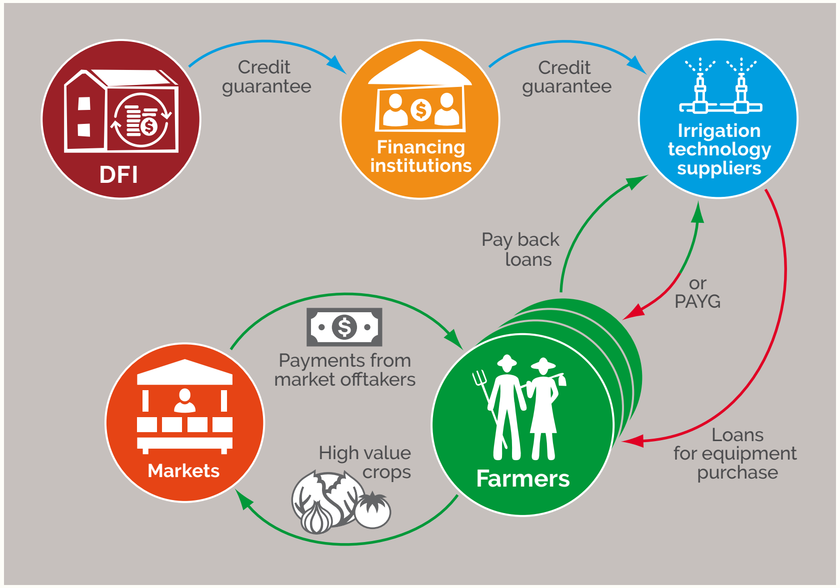


Figure 2 Irrigation equipment suppliers as credit providers

Variation C

– A financing institution guarantees the agribusiness/offtaker

The credit guarantee is provided to the agribusiness entity, such as a cannery, mill, packaging, or processing facility. A critical element of this variation is that the agribusiness company will have a **supply contract with the farmer for the produce**. This approach is routinely used to provide inputs (seed and fertilizer) and chemicals, but less often for equipment, because of reasons explained earlier (default risk, theft, crop failure, etc.).

Figure 3 Agribusiness companies as credit providers

Pay-as-you-go

Pay-as-you-go (PAYG) in overview

These are financial products for *end consumers (farmers),* which are different from the credit guarantee and other models that target higher level financial institutions, equipment suppliers or produce offtakers. Equipment companies have developed these financial products for credit, as it is one of the few ways in which they can increase the sales of their products when affordability is low and the finance environment weak.

This finance model is often referred to as PAYG because the equipment may include global system for mobile communications (GSM) shut-off switches to block use for non-payment (made with mobile money such as m-pesa, e-bucks, etc.). PAYG is primarily available for solar pumps, which have higher up-front costs than petrol pumps (although solar pumps have much better returns over ten years when interest is not unreasonably high [see Module 7 i-box 7.6]).

The PAYG model has been driven by a few private equipment developers and manufacturers and is cascaded down through their distributors as a financial option provided to farmers. It has generally relied upon support from blended sources, particularly private equity sources, including company research and development (R&D), crowdsourcing and private investment firms, as well as through climate or energy funds, and credit guarantees. Development funds and social enterprise funds have enabled piloting and strengthening of this finance model. Accountable to investors, the companies providing PAYG often pursue parallel approaches to reduce risk, such as using ***ICT tools and information*** or ***marketing partnerships*** that can improve farm profitability and reduce client default.

The PAYG financial products are increasingly more available to irrigation farmers and can complement other financing interventions, by being nested within them. On their own, they do not replace the other financing responses which extend equipment access by providing higher level financial muscle to financing institutions, suppliers and aggregators.

Country experiences

One barrier to asset-based financing is the requirement and management of the down payment, usually 25% to 50% of the equipment price. Matching grant payments or subsidies to cover part of the costs from public or development funds have had mixed results. In one case, in Ghana, that predated remote shut-off systems, farmers did not make any payments after the publicly sponsored deposit because they lacked incentives in the absence of a robust compliance system.

In other countries, such as Uganda, where matching grants for irrigation equipment have been used, the public procurement systems and norms have excluded the possibility of farmers engaging in a PAYG arrangement with the supplier. This constraint has eliminated the chance of using PAYG to reduce the upfront cost, thus potentially excluding farmers with lower affordability levels who otherwise would have been accommodated.

PAYG to ownership

Some equipment developers and suppliers have begun to offer pumps on a consumer finance model, effectively using the irrigation equipment for asset-based finance akin to hire-purchase arrangements. These models often include warranties and service packages that ensure product quality during the payment period, which is typically a down payment followed by regular payments over 18 to 36 months.

PAYG rentals and service provision

Another version of PAYG falls under equipment rental and irrigation services. Evidence points to a significant rental market for pump users (*AgWater Solutions* and *ILSSI* sources) serving more than 25% of irrigators across multiple countries in sub-Saharan Africa (SSA). Additional studies point to a pathway from rental to eventual ownership. This highlights the potential for pump rental and irrigation service as a PAYG irrigation business and to increase the irrigation market density. The market size is sufficient to explore development of ICT platforms for this type of "uber for irrigation" service to reach more farmers. As most pump renters and irrigation service providers are individual entrepreneurs, the source of finance for their investment in equipment has been individual savings and remittances.

Pay-as-you-go rental and irrigation service provision models have some real advantages:

- The arrangement enables **women and other resource-poor farmers** to bypass social ownership barriers and removes the financial burden of the down payment.

- Existing **micro-finance institutions (MFIs) or savings and credit cooperatives (SACCOs) are often able to provide short-term credit** of an adequate amount to cover pump rental or irrigation services.

- The irrigation service provision model **fills a niche market of smallholders** who cannot purchase pumps, while engaging small and medium-sized enterprises (SMEs) in irrigated value chains.

More information can be found at:

http://documents1.worldbank.org/curated/en/387931552667416907/pdf/135340-WP-P165652-PUBLIC-15-3-2019-11-41-29-WeBook.pdf

https://www.pv-magazine.com/2019/12/18/a-solar-powered-irrigation-pump-with-pay-as-you-go-option/

https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jul/IRENA_Pay-as-you-go_models_2020.pdf?la=en&hash=7A2E7A7FF8B5BAB7748670876667628A39DE40D5 (focused on the solar energy sector – not irrigation per se, but offering useful information on PAYG models)

Subsidies

Subsidies have the benefit of strengthening the overall market system for irrigation, prompting growth and benefits. They are used when markets alone do not deliver the best outcomes for farmers or for national development priorities. However, subsidies can have negative effects. They can distort competition, undermine the perceived value of products, and weaken the value chain when used inappropriately. Subsidy programs can also inadvertently undermine other (similar) useful technologies that may be well established and still relevant, skewing demand and prices. They can also promote some types of firms over others, or entrench unrealistic perspectives about the true value of the technology being subsidized. More sweepingly, subsidies can distort allocation of resources and shift markets across the economy, prompting technology use or production that was not anticipated or part of the initial subsidy objectives. Yet, subsidies remain a powerful instrument when demand and supply networks are weak, and farmer-affordability is low.

Subsidies are often blended into equipment purchase financing arrangements using matching grant arrangements. These are a form of subsidy, where farmers contribute some of their own capital, thereby strengthening ownership and leveraging private sector investment (in this case individuals and small groups of smallholder farmers). A percentage of the equipment purchase (perhaps 25% to 75%) is funded by the state, to increase affordability, encourage sales and uptake by farmers, and strengthen supplier networks and product knowledge. Subsidies can also take an indirect form through down payments on equipment for farmers through projects implemented by NGOs or corporate social responsibility programs.

What to consider when setting subsidies and matching grant amounts

What can the farmer afford? The sub-grouping of farmers who would benefit, or, conversely, those who would be excluded from the benefits, depends on the size of the subsidy and how much farmers can afford. Factors to consider would include the socio-economic standing of the group of interest, size of farm, crop mix, and profitability of the farm enterprise in comparison with the anticipated capital contribution. It is useful to compare the probable farmer contribution with other common assets (such as motorbikes) to get a sense of what farmers are likely to afford from their own resources and savings. Affordability surveys can also be helpful.

How much is the funding reality going to change over time? It is possible to set a high initial public contribution for the purchase of irrigation equipment, with the intention of reducing the subsidy once there is momentum and wider uptake. The subsidy intervention could prompt a much broader awareness of the benefits of irrigation, and encourage individual action because farmers would observe others in their locality who are benefitting. Short-term fertilizer subsidies have been shown to trigger this effect when the issue in question is not only affordability but also the fact of farmers not having had the opportunity to see the advantages of irrigation for themselves. In such instances, the subsidy accelerates knowledge around the benefits and can be steadily reduced.

What is the state's fiscal capacity to finance subsidies? The government financial resources have to be taken into account and balanced with the numbers and types of farmers who would likely be beneficiaries of the subsidy. Political appetite is key.

What kinds of items are being subsidized? If the support is for a short-term investment (like fertilizer), it differs from a long-term investment (irrigation equipment). In the case of a short-term investment, the relative amount is smaller, and the benefits are accrued in a season. In a longer-term, larger investment there can be ongoing dependency on the subsidy, because even with the appreciation of the benefits and positive impact of irrigation, affordability may not always be there.

Country examples in summary

Uganda micro-scale irrigation program

The program supported irrigation farmers on less than 1 ha to gain access to a range of irrigation equipment. Solar pumps were heavily subsidized, in view of the positive impact on greenhouse gas (GHG) emissions and the lifetime cost advantages (twice the net returns, over ten years, of using petrol pumps for mixed vegetables).

- Subsidies were capped differently, so that the simplest irrigation arrangement had a similar down payment for both solar and petrol systems.
- Suppliers were prequalified, and designed different systems according to each farmer's specific needs.
- Government paid suppliers in two installments, and farmers paid their matching contribution via the district offices.

Rwanda small-scale irrigation technology subsidy program

The program supported irrigation farmers on 2 to 10 ha to accelerate and promote the widespread use of sustainable, demand-driven, affordable, farmer-led and -owned irrigation systems. Technology included motorized, solar powered and treadle pumps.

- Subsidies were fixed across the full range of technologies, whether solar, petrol or manual systems.
- Suppliers were prequalified and provided predesigned irrigation kits from which farmers could select those most suited to their specific requirements.
- Government paid suppliers the subsidy up front, and farmers paid their matching contribution directly to suppliers when the installation was completed.

Country example: Micro-scale Irrigation Program in Uganda

In the Micro-scale Irrigation Program the farmer and the local government co-financed the purchase of irrigation equipment. Solar-powered and petrol-powered systems were supported with different levels of subsidy in order to encourage the uptake of climate-smart and more profitable solar-power. Solar-powered systems have a higher purchase cost than petrol or diesel pumps, though they have higher returns in a comparative lifetime assessment. While the initial cost of petrol is lower, the high cost of fuel makes these more costly overall in the long run. **The subsidy was structured so that the initial purchase cost to farmers was similar**, thereby triggering climate-related and long-term financial benefits for farmers. The co-purchased equipment was owned, operated, and maintained by the farmer. The subsidy level depended on the irrigation technology chosen by the farmer and was capped at a maximum of 1 ha per farmer.

The **local government procured the irrigation equipment** on behalf of the farmer **after collecting the farmer co-payment**. Where farmers finance their contribution through loans, formal or informal, the substantial increase in profits resulting from irrigation enables repayments of the loans. In the solar and solar pump examples, the farmer would be able to pay back the investment cost of the equipment after 6 to 12 months. The farmer with solar would pay back more quickly because they would make approximately double the net profit compared to the petrol-powered system, due to the continuous high costs of petrol.

Experiences informing the Uganda case

Why a subsidy and not just access to financial services? It might happen that, even with conducive credit arrangements, many smallholder farmers will still not be able to afford the initial development cost of an irrigation system. The requirement for down payments, or the monthly repayments while waiting for their crops to grow and generate profits, may be prohibitive. Equipment subsidies are also useful beyond helping those who would otherwise never be able to acquire equipment. Subsidies can also strengthen supply networks, improve agricultural and technical knowledge and related services and support. Used carefully, the effect of subsidies can lead to lower prices with cascading farm-financial and wider economic benefits. Used inappropriately, they can distort competition, weaken value chains, undermine other useful technologies, or skew demand and prices.

Farmers in the lead and matching grants: Subsidies are a quick and effective way of achieving affordability when the financing environment is weak, but caution is warranted, and the potential downside must be carefully assessed. In order to ensure that farmers stay in the lead of the irrigation development process, subsidies should only be partial. The subsidy should aim to bridge the *affordability gap* that is faced by smallholder farmers. Matching grants, where farmers contribute part of the costs, promote ownership and increase affordability. In setting the farmers' contributions, attention needs to be given to: realistic affordability levels; the impact of the grant on market costs and broader awareness of equipment; related knowledge over time; and the government ability to finance.

Country example: Small-Scale Irrigation Technology Subsidy Program in Rwanda

1 Why the subsidy? The Irrigation Policy endorsed by the Government of Rwanda (GoR) in July 2014, identified several challenges limiting the growth of the irrigation sub sector in Rwanda. The foremost challenge is the high cost of irrigation equipment primarily as a result of Rwanda's hilly extensive topography. Pumped irrigation schemes that occur on the hillside require relatively bigger pumping systems which must be imported at a significant cost. The high cost of irrigation development is also related to the lengthy procurement process associated with governmental procurement policies and the related transaction and financial costs that are incurred as a result.

This high investment cost has tended to deter individual farmers from participating in irrigation development, leaving the government as the sole investor. The scenario, in which the government is carrying the entire burden of the costs of irrigation development, is unsustainable.

In light of these challenges the GoR adopted the farmer-led small-scale irrigation technology subsidy program using small-scale irrigation technologies (SSIT) in 2014. The farmer-based approach aimed to promote widespread use of demand driven, affordable and locally assembled SSI equipment. It was expected that the SSIT subsidy program would support Rwandan smallholder farmers with simple and cheap irrigation technology systems to increase their crop productivity and improve the sustainability of irrigation development through a farmer-led approach.

2 What farm elements are subsidized.
The SSIT program targets the use of portable diesel/petrol water pumps and/or treadle pumps, solar pump driven irrigation units, delivery pipes, and dam-sheet technology to irrigate relatively small plots/farms ranging from 0.1 ha to 10 ha. Fabrication and assembly of some of the SSIT equipment is done locally through strategic partners. This would drastically reduce the cost of irrigation development to around USD 1 500/ha.

3 How it works – the operational mechanisms themselves
The Rwanda Agriculture and Animal Resources Development Board (RAB) works with the administrative districts in order to encourage uptake of the SSIT equipment at district, sector or village levels. They also work together to select strategic private service providers who will be asked to set up service shops and sales of the SSIT equipment in the district in the following steps.

- The districts also receive an annual budget to cover the SSIT subsidies, which can go up to 50% of the equipment cost.
- Interested farmers are required to approach the service providers with a proposal for SSIT.
- The service provider will check the feasibility of a farmer's proposal and provide a quotation for the SSIT equipment to be supplied and installed.
- The proposal with quotation is then submitted to RAB for further verification before a final recommendation for a subsidy is made.
- If successful, the farmer will take the approved proposal to the service provider and pay 50% of the SSIT equipment cost.
- The service provider will receive the balance of payment from a RAB enabled guarantee fund at an appointed financial institution and will be obliged to install the SSIT with a warranty.

4 Experiences – enabling factors, what worked and what could be done differently

What worked well:

- **SSIT decentralization and budget:** To facilitate accessibility of the SSI equipment, the GoR decided to decentralize the program and its operational budget at district level. This could even be leveraged to sector level.

- **Government incentives:** Due to high cost of imported irrigation equipment, the GoR (in addition to SSIT subsidy of up to 50%) approved some tax exemptions such as duty free and Value Added Tax (VAT) on imported irrigation equipment.

- **SSIT equipment suppliers:** Starting from 2014 to date, the list of eligible SSIT service providers has been growing, and their performance in selling, supplying and distributing SSIT equipment has also improved.

What could be done better:

- **Expand list of subsidy-eligible SSIT:** Although RAB has approved a long list of SSIT equipment eligible for subsidy, it is important to *include a wide range of small-scale irrigation technologies that qualify for subsidies*, particularly more sustainable technologies such as ones that use solar power and are more water efficient.

- **Value chains:** Integrating the produce resulting from SSIT into value chain systems need to be prioritized since SSIT farmers show a preference for producing high value crops like vegetables.

- **Capacity building:** There is a need for increased farmer capacity in the operation and maintenance of SSIT equipment. This could be part of the SSIT subsidy package offered by the SSIT service providers.

- **Access to finance:** To facilitate the farmers' taking advantage of the 50% subsidy, attention needs to be directed towards creating an enabling environment for the farmers to secure financial loans for the other 50%.

Sources: Ministry of Agriculture and Animal Resources, Rwanda [MINAGRI] (2014a); MINAGRI (2014b); Nzeyimana (2018); Rwanda Agriculture and Animal Resources Board [RAB] (2018).

ICT and financial interventions

Relevance across the process

Information and communication technology (ICT) tools can reduce the costs and risks associated with offering financial products, and also help to close the gap in both equipment and produce markets. The use of ICT tools can be identified at multiple steps in the financing process, as illustrated in Figure 1.

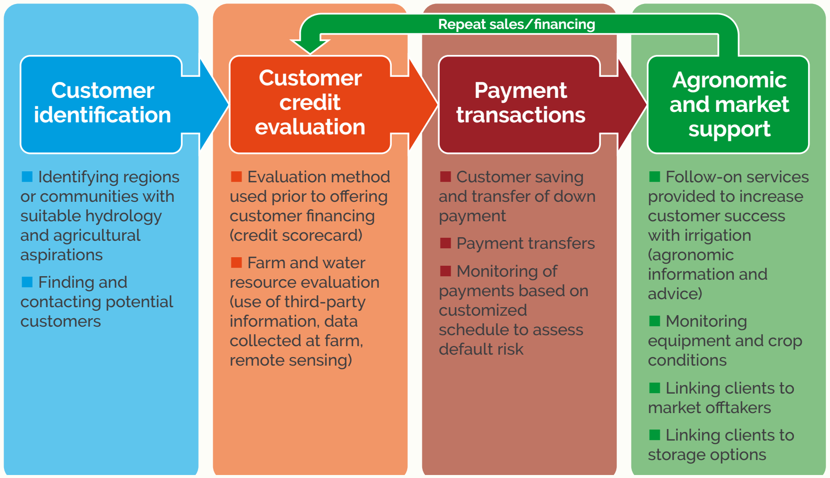


Figure 1 Steps in the FLID financing process

Examples of ICT tools

The effectiveness of ICT tools to compensate for gaps in market systems is highly dependent on the level of market development and, particularly, access to reliable and affordable internet/ smartphone use. In case studies, the ICT tools appear to work best when multiple tools and irrigation equipment are bundled.

Mobile money and e-wallets

Mobile money use in Africa is mostly person-to-person and is growing. Mobile money makes it easier for individual farmers or groups of farmers to make payments for inputs such as pumps. E-money also facilitates withholding of pump payments from produce revenue, such as through produce offtakers. Mobile money companies are also motivated to support the increased use in agriculture; they are creating financial profiles of clients for the finance industry. More creative uses are also being found to overcome barriers to credit. One project in Zambia, for example, is exploring how e-wallets can be used by women's groups to jointly save for down payments on pumps, which increases transparency and protects group savings. However, some countries impose regulations on person-to-company transactions, reducing the opportunity to market operators and entrepreneurs. The level of mobile money expansion and the regulations on use vary for each country.

Remote sensing and remote monitoring of the usage of pumps

Remote sensing, farm level moisture sensors, and sensors on pumps are all being used to assess farmer irrigation practices, to alert credit providers to the risk of loan default and to build up data for future credit assessments. Remote sensing and satellite data analytics of irrigated areas and water resource use is being used to identify where and how to support farmers to improve irrigated practices, from basin to farm level. In Kenya, information provision to farmers based on remote sensing data is emerging as a commercial service, while in most countries remote sensing remains a public or donor investment, because of the high costs. At present, tools and equipment are being fitted to transmit data on farm water use. Solar pump suppliers are fitting pumps with

bluetooth and water use sensors, which enable the companies to monitor use. Soil moisture sensors, such as the Chameleon sensor, are also bluetooth enabled to monitor on-field water use. Data is analyzed regarding location and timing of pump use as well as abstraction rates, which can flag inappropriate use and indicate risk of default on pumps. This enables pump suppliers to know if clients need in-person field visits or phone-based push messaging in order to improve agronomic practices. Efforts are underway to combine various data sources and apply machine learning that can support credit-worthiness assessments and reduce risks of default. One project in Uganda provided farmers with smartphones to enable bluetooth upload of information from pumps, while also providing an opportunity to push out agronomic and market advice.

Uganda country example: IrriTrack - a FLID intervention-support App

IrriTrack was developed for the Government of Uganda as part of a World Bank-supported FLID intervention in the country (Uganda Intergovernmental Fiscal Transfers Reform Program) Further case study details in Main Guide i-box L.

How can digital drive down irrigation costs?

The local government carries out the farm visit, collecting farm data through a Program-dedicated App – IrriTrack. Through a monitoring and information system (MIS) – which also allows central monitoring by Ministry of Agriculture – farmers' data is shared with irrigation equipment suppliers, who submit a bid for each farmer. This allows public extension officers to provide advisory services to smallholder farmers on the opportunity (or lack thereof) of introducing irrigation in their specific farm context. The App makes possible an indicative estimate of

prices specific to farm context, thus giving farmers a tool for making informed decisions. In addition, it allows increasing competition among suppliers. The dispersed nature of FLID farmers, coupled with their small farm size and the limited presence of suppliers beyond major cities, means that suppliers have high transaction costs in carrying out farm visits, and would prefer to lose a prospective client rather than incur the cost of a farm visit without the certainty of getting the contract. Data collection by local government allows transaction costs to be reduced. Over time, as suppliers establish presence in the countryside, this public support will be less and less needed.

IrriTrack is downloadable from Google PlayStore and is one example of an ICT intervention that not only supports the practical field exercise within an operation, but further collates all farmer information for onward transfer to suppliers (for tendering purposes) and to micro-finance institutions. This information exchange maximizes linkages and opportunities for financial support, as well as competition for equipment supply. In so doing, the ICT intervention aims to support the whole intervention process to arrive at the best solution for farmers based on their site-specific physical conditions, their farm vision, and their affordability status.

Credit scoring tools

Equipment suppliers and financial service providers employ a wide range of criteria to score credit worthiness in markets where smallholders lack credit history. Tools include quantitative data-driven analytics, satellite data analytics, qualitative information assessment, local references and social capital, and a combination of all these methods. The lessons from tool development and pilots should be heeded, particularly as credit scoring tools can be biased against the poorest and women farmers.

Apps to link irrigation customers to produce buyers

Apps are being piloted and used commercially to link producers, storage and other post-harvest services, as well as produce buyers. While some successes are noted, evidence suggests that the apps do not compensate for lack of markets or infrastructure in general, and are limited in areas with low ICT access.

Data services for accessing credit and inputs

Entrepreneurs are emerging as information service providers to develop and operate ICT tools that enable farmers' greater access to credit and inputs on credit. For example, data service providers gather data on farmers for financial service providers to assess credit worthiness, such as FarmDrive. Another service, MyAgro, enables smallholders to build up savings on a lay-away format, and then access inputs.

Other resources for ICT tools

World Bank 2017. ICT in Agriculture: Connecting Smallholders to Knowledge, Networks, and Institutions. Updated Edition. Washington, DC: World Bank.

E-voucher subsidies

Overview

E-voucher programs improve access and productive use of agricultural inputs by beneficiary farmers and build a sustainable demand for inputs from smallholder farmers as well as further the development of the private sector input supply. For smallholder farmers, access to productivity-enhancing inputs through input subsidy programs (ISPs) allow them to improve the quality and quantity of their farm output and increase their incomes. Throughout the 1990s and until 2005, agricultural input subsidy programs (ISPs) had been largely phased out in sub-Saharan Africa as evidence emerged that these programs were largely ineffective in promoting African governments' development goals, thus contributing little to agricultural productivity growth, food security, or poverty reduction while placing a major fiscal burden on treasuries.[1] Starting in 2005 the landscape changed profoundly as large-scale ISPs became the centerpiece of many African governments' agricultural development programs primarily driven by the 'Malawi miracle'.[2] The Malawi case had an important effect on policy discourse on the continent, convincing numerous governments to undertake similar targeted input subsidy programs.

There are many ways of formulating E-voucher models but in general they all provide greater involvement of both private individuals and financial institutions. The status of the financial enabling environment is key to formulating e-voucher interventions. Where it is mature and developed with strong participation from the private sector, the use of mobile banking tools (such as e-money) easily and quickly facilitates farmers' adoption of e-vouchers. In other cases, e-voucher scheme may have to deliver farm inputs to farmers through messaging to their mobile phones. Development partners experiences and ongoing operations can also be used to gain momentum quickly with an e-voucher initiative.

Guidance on e-voucher design

A set of key learnings from ongoing programs in Africa is summarized below. These are important for the adoption and sustainability of e-voucher initiatives, and could be useful when designing interventions.

1 **Enabling policy environment and ecosystem** are critical for the sustainability of e-voucher programs. E-vouchers, as an instrument, have the potential to deliver pluralistic extension and advisory services that could bring transformation in smallholder agriculture. E-voucher programs, when supported by a strong policy environment, can play a critical role in the way subsidies are administered and can trigger a cascade of positive changes to the agricultural services sector (i.e. with business benefits to local input suppliers, strengthened distribution channels, etc.). A supportive policy environment will include provisions for easier adoption of e-vouchers by farmers, strong ownership at all administrative levels of governments, supportive policies for voucher agencies, etc. Some of the aspects of the policy environment could be embedded in the project design while others are more gradual to follow.

2 **Client capacity** is a critical element in mainstreaming an innovative electronic public policy instrument such as e-vouchers. Skilled human resources or a higher order of government capacity is critical

1 Kherallah et al. 2002; Morris et al. 2007; World Bank 2008

2 Smart Subsidies, Reaping Richer Returns: http://documents1.worldbank.org/curated/en/720751489776752023/122290272_201800290000052/additional/113592-PUB-PUBLIC.pdf

for implementation. Capacity building must be embedded in the intervention and could be in the form of a separate subcomponent within the project design.

3 **Capacity of non-state actors including farmer** organizations/cooperatives is another critical element especially because these actors could make up for the weak capacity of the public sector. The non-state actors include those along the commodity value chain where their capacity is dependent upon the maturity of the value chain. Farmer organizations (FOs) and cooperatives are other key actors. They are building blocks of the e-voucher programs as the beneficiary farmers are often required to be members of cooperatives to be eligible. The FO or cooperative organizational infrastructure helps the program to connect with a large set of beneficiary farmers easily. The capacity building activities for farmer organizations/cooperatives could also be included in the project design. The capacity of equipment and agro-dealers at the local level is also key for implementation. Insufficiently developed local markets will lead to delays in the supply of goods and services that the e-voucher system is intended to provide. The presence of e-vouchers does not necessarily translate into supporting or developing the re-establishment of equipment supplier and dealer networks at the local level but could stimulate the establishment of their operations up to the 'last mile'.

4 **Last-mile infrastructure and digital connectivity** are the key necessary conditions of a reliable e-voucher system. Where connectivity is unstable this can lead to partial redemptions, lack of SMS notifications, and a breakdown of information flows that undermine the achievement of impact at scale. The digital connectivity and last-mile infrastructure should be considered for geographical targeting.

5 **A mature fintech sector or mobile money banking** environment is one of the key enablers for the smooth implementation of an e-voucher program. Fintech includes mobile money, digital payment systems, and other electronic payment systems, etc. Countries with established fintech ecosystems will be the first to tap into the potential of the e-voucher system for agriculture.

6 **Early identification and selection of the voucher management agency and other associated technical providers** is foundational to success. Electronic cards and associated mobile payment system should be procured from a competent technical provider through a competitive selection process. Some eligibility requirements to assess the competences of a potential voucher management agency (vendor) are listed below:

- Having the legal and systematic infrastructure recognized in the country to process mobile (and digital) transactions
- Experience with electronic cards and provision of point-of-sale devices at outlets
- Ability to work seamlessly with other stakeholders of the e-voucher system. e.g., national ID authority, national statistical services, Government e-Payment Gateway, etc.
- Ability to manage an information system that can produce management reports with the required information (i.e., input type, quantity, unit price, amount per farmer, name of agro-dealer).

- The existence of local branches and kiosks in project target areas is plus

- Ability to provide technical trainings to project implementation staff, agro-dealers, and other partners on: (i) the mobile transaction system; (ii) irrigation equipment; and (iii) agricultural inputs to be redeemed.

- Shortest possible time to set up the system in order to ensure quick implementation.

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GWSP
GLOBAL WATER
SECURITY & SANITATION
PARTNERSHIP

The Farmer-led Irrigation Development Guide

Module

6

Output Markets

Strengthening output value chains

WORLD BANK GROUP

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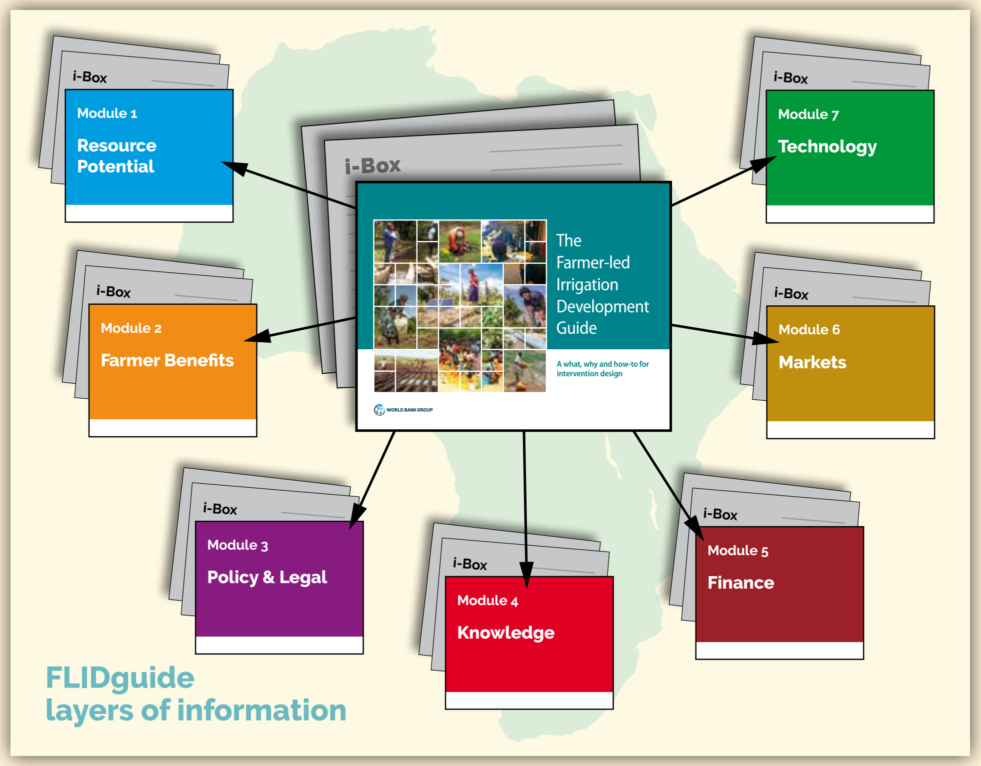
Contents

Abbreviations and acronyms

4P	public-private-producer partnerships
comex	commodity exchange
CTA	Technical Centre for Agricultural and Rural Cooperation
D4Ag	Digitalization for Agriculture
FLID	farmer-led irrigation development
FMCG	fast-moving consumer goods
FPO	farmer producer organization
FSP	financial service provider
GAP	Good Agricultural Practice
IFC	International Financing Corporation
IOT	Internet of Things
ITC	International Trade Centre
KPI	key performance indicator
M&E	monitoring and evaluation
MFN	Mastercard Farmers Network
MMP	mobile money provider
NRA	net rate of assistance
P2P	person-to-person
PAYG	pay-as-you-go
PDCRE	Smallholder Cash and Export Crops Development Project (Rwanda)
SSA	sub-Saharan Africa
TOR	Terms of Reference
VODP	Vegetable Oil Development Project (Uganda)
WRS	warehouse receipt systems

Using the guide

The main volume of the FLIDguide presents the core body of information that explains FLID and the process of intervention design. Thematic descriptions are included in seven modules. Information boxes (i-boxes) at the back of the Main Guide and each module provide additional detail, and hyperlinks throughout the guide access relevant external publications, websites, animation clips and videos.



Tips

NAVIGATING THE GUIDE

To move quickly and easily between the interlinked information, set up your PDF reader so that the **PREVIOUS VIEW** and **NEXT VIEW** buttons (as distinct from PREVIOUS PAGE and NEXT PAGE) are instaled on the toolbar at the top of your screen. **You may then freely explore the document using the navigation pane on the left of your reader or the many hyperlinks provided in the text, and backtrack to the start by repeatedly hitting the button.**

To instal the buttons (in Adobe Reader),

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- open the **View** drop down menu and select them from the **Page Navigation** options.

Alternatively, try using these keyboard shortcuts:
Windows: Press the **ALT** key and ◀ or ▶ arrow
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PRINTING

Office desktop printers cannot print to the edge of the paper. To print pages of this document without losing any content,

- choose **File > Print**, and in the page sizing and handling area or pop-up menu, select **Fit to Printable Area** or **Shrink to Printable Area**.

6 Output Markets

Strengthening output value chains

FLID is characterized by market-oriented farming – farmers' livelihoods depend on lively markets!

This module elaborates on the importance of access to agricultural output markets for farmers developing their own irrigation systems; how they benefit from it; and the enabling environment that facilitates easy and equitable market access. Farmers' ability to expand, intensify and increase profit from irrigated agriculture is not only mediated by access to finance (Module 5) and technology (Module 7), but also by their engagement with agricultural output markets. Market-oriented farming is one of the defining characteristics of farmers who lead the way in developing irrigation, which includes farmers at all scales. Among these, smallholder farmers, who are the focus of the FLIDguide, often struggle to make the best use of input and output markets, thus constraining their enterprise productivity and profitability. Understanding the different market systems in relation to crop types, demand and supply, market services, the different actors involved, and the constraints and opportunities in the market system, is essential for planning an intervention for supporting FLID processes.

Effective market participation can provide farmers with the incentive and capability, in terms of income, to adopt and expand irrigation activities. In turn, investments in irrigation allow farmers to engage in crop commercialization and intensification, resulting in higher farm incomes. Improved linkages between farmers and agricultural output markets have multiplier effects across the rural economy, raising the demand for labor and farm inputs, creating more downstream jobs in processing, trading, transport and storage, and increasing local consumption. Module 6 is focused on the link between FLID processes and agricultural output markets, providing insights on the **enabling environment** needed for smallholder farmers to make their irrigated farming more profitable.

The first section of this module describes market systems, different types of output markets, and the main factors that govern the level of market participation by smallholders. It highlights factors that restrict or limit smallholder access to markets, and opportunities to facilitate better access. In the second section, the key points of enquiry when assessing output markets are outlined and expanded in a scope of works for a market diagnostic. A set of guiding questions is provided to assist with the scoring of the markets factor. The third and final section describes example interventions that can strengthen individual farmers' agency and access to markets, including agricultural-tech platforms, aggregation models, electronic markets, and certifications. The module content overlaps with and complements the Knowledge (Module 4) and Finance (Module 5) modules.

6.1 Market systems and FLID

Market access as a catalyst

Globally, ease of market access for smallholders has shown a positive correlation between increased incomes and increased investment into improving farming practices. Most smallholder farmers in Africa are, however, poorly linked to markets for several reasons – remoteness, low production, low farmgate prices, and lack of information. Further, farmers' levels of participation in markets is dependent on the nature of the commodity (food/cash/niche crops), gross margins, market requirements (quality, safety, certifications, customer preferences), and risks involved (price volatility, trade embargo, erratic weather conditions, climate change).

If small-scale farmers – the majority of Africa's farmers – are to take advantage of opportunities in markets, then additional action needs to be taken to improve their access to inputs (credit, financial services, technical advice) and to output markets, especially those with growing demand and favorable prices. There is mounting evidence that smallholder farmers developing their own irrigation practices make significant investments in developing irrigation, both at household and aggregate levels – to enter irrigation farming with markets in mind (rainfed farmers), to upscale production with a strong business orientation (small and rudimentary irrigation enterprises), or to intensify production and sophistication to increase profitability (established business irrigation farmers) (see the Main Guide).

The market environment varies from place to place, informed by two key parameters: the **rural investment climate** that is conducive to investment and innovations by farmers and other players in the supply chain; and **public investment in rural public goods**, including roads, warehouses and other physical infrastructure (Wiggins and Keats 2013).

While these two parameters that make output markets more accessible and inclusive for smallholders "are necessary conditions, they are not always sufficient conditions" (Wiggins and Keats 2013, viii). This section explores a few considerations in relation to market access in a FLID context. Key constraints and lessons of experience are outlined to provide insight into the market dynamics.

Market systems

An agriculture market system consists of farmers who grow crops for sale, buyers who purchase crops, and other value chain actors who participate in the trade of a given crop. Broadly, a market system has three components – **core market, supporting functions, and enabling environment** (Figure 6.1).

Factors such as commodity, production systems, farming traditions, and the level of development in a country differentiate one market or marketing system from another. There are different types of markets based on location and proximity to farmers – **primary markets** (rural and assembly)**, secondary markets** (wholesale and semi-wholesale)**, and terminal markets** (processor, retail or export). For more information on market systems, marketing channels and agricultural marketing see Smallholder Agriculture and Market Participation (Poole 2017).

There are many stakeholders in a value chain, which include farm input suppliers, storage operators, processors, wholesalers,

Core market

Direct market players

- **Producers:** Farmers – small, medium and large – growing rice for sale in the markets.
- **Buyers:** Market intermediaries – such as collection agents, traders, wholesalers, millers, processors etc. – who buy and sell rice in the markets before it reaches the end-consumers.
- **Consumers:** People who purchase rice from supermarkets and grocery stores for own consumption.

Supporting functions

Suppliers of supporting goods and services

- **Input suppliers:** Dealers and companies that sell seeds, fertilisers, pesticides and other inputs to rice farmers.
- **Equipment suppliers:** Dealer and companies that provide specialised equipment such as farming tools, irrigation pumps, tractors, dehuskers, moisture meters, solar dryers, etc. to rice farmers.
- **Warehousing companies:** Harvested rice needs to be stored under controlled environmental conditions to protect it from moisture, fungal infections, and rodents. Private sector players provide professional warehousing services to store rice for long durations.
- **Logistics operators:** Transporters that facilitate collection, aggregations, and transportation of rice from farm to off-takers and end-consumers.
- **Certification agencies:** Companies that provide quality testing and certifications services required by certain market segments, especially export markets.
- **Banks and financial institutions:** Institutional credit lenders such as banks, micro-finance institutions, agri-financing companies that extend loan facilities to rice farmers.
- **Digital platforms:** Companies and startups that provide a suite of digital services such as weather forecast, market prices, and extension services through mobile and IOT based platforms.

Enabling environment

- **Government:** Market regulations, trade rules, export/import policies, food safety laws, support prices, public procurement, quality & grading standards, crop-related subsidy and other government actions that regulate activities and behavior of all market players.
- **Infrastructure providers:** Roads, electricity, telephone services, public warehouses, agricultural markets, and mobile technologies that are needed for the market system to function.
- **Industry associations:** Associations (farmer/trader/transporter/processors/retailer association) that advocate or lobby for favorable industry policies, bring investment, and promote collective branding and advertising.

Figure 6.1 Three main elements of a market system

exporters, and retailers (Module 4). Depending on the offtaker, market requirement, level of formalization, and scale of operation, smallholder farmers participate in arrangements that can be summarized into four market-access models (illustrated in Figure 6.2):

Model 1 – Aggregator-back model

Intermediaries, traders and wholesalers purchase, aggregate and transport agricultural produce from farmers to offtakers and add margins on top of the farmgate prices offered to farmers. Smallholders rely on sales via intermediaries to meet their daily cash requirements, but due to lack of market information and price discovery channels, they often have to sell crops at lower farmgate prices.

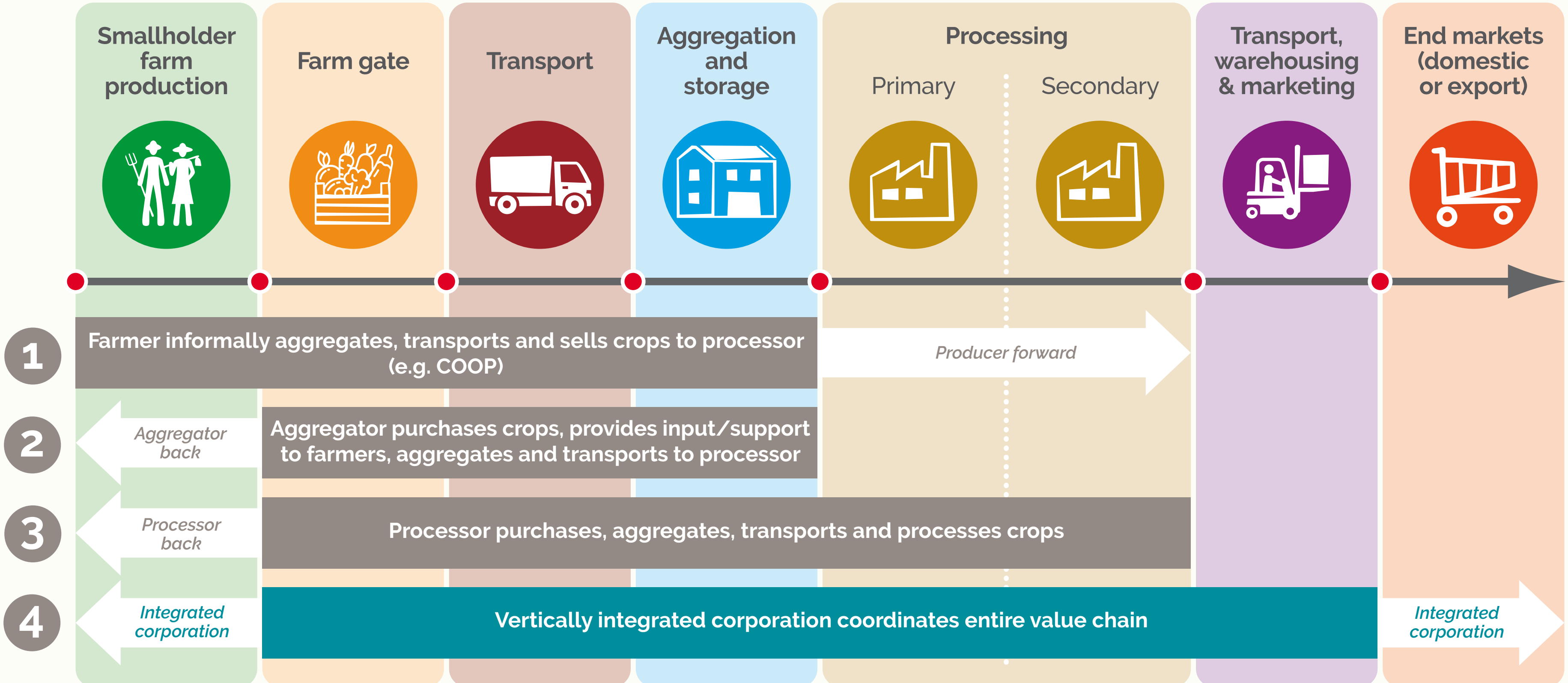
Model 2 – Producer-forward model

Farmers form groups (informal groups, producer organizations, cooperatives) to aggregate and transport agricultural produce at large-scale to end-buyers. Due to economies of scale, farmers get cost benefits, higher farmgate prices, and improved negotiating power in trade transactions. However, weak governance structures and lack of processes and mechanisms that ensure accountability can lead to management inefficiencies, corruption, and political interference, all undermining individual farmers' agency within such models.

Model 3 – Processor-back model

Farmers engage with processors through pre-harvest contracts to deliver a specified commodity as per the quality and quantity requirements of the buyer for an agreed price in advance. In some interlinked contracts, in addition to agreement on sales and quality of the produce, the processor also supplies inputs, finance and technical assistance in advance to the smallholder on the promise of sales, with the costs of these deducted from payment.

Figure 6.2
Common types of market-linkage models
(Infographic developed on the basis of Tam and Mitchell [2020])



Such market linkages provide assured markets and better farmgate prices to smallholders and help in curbing fire-sales of crops at discounted prices to intermediaries. However, when contract prices are way off the current market prices at the time of crop delivery, either farmers or processors tend to default on contract obligations.

Model 4 – Vertically integrated model

Large-scale corporations, beverage manufacturers, fast-moving consumer goods (FMCG) companies, and others integrate a large number of smallholder farmers into their supply chains by leveraging contract farming. The corporations provide high-quality inputs, irrigation, storage, transport and extension services to smallholders in a particular region in order to grow high-value export crops and "buy back" the final produce at an agreed market price. Since farmers are locked into the supply chain of the offtaker, they sometimes lose their negotiating powers.

Appreciation of the different models and market linkage services provided by the stakeholders within each model are key to understanding the market access landscape, and to assess constraints and opportunities for interventions to support FLID processes.

Smallholders and informal markets

Informal trade and traditional market structures are dominant in many parts of Africa (Vorley, Del Pozo-Vergnes, and Barnett 2012). Despite their limitations, such as lack of traceability and food safety, traditional markets have linked farmers and consumers effectively. Informal transactions between smallholder farmers and local traders are most often the first links, even in the "modern" food supply chains. The growth of formal markets has not replaced the traditional informal markets and the latter continue to be the dominant structure of trade in Africa across many value chains, especially for perishables and staples. As a result, business models trying to integrate smallholder farmers into modern supply chains are including informal trade as part of the overall model. These changes highlight the fact that informal and formal markets can not only co-exist but also be mutually beneficial to each other. Informal markets play a pivotal role in smallholder farmers' pursuit of diversified avenues of income, mainly because in many cases informal markets are easier to access and more profitable. Moreover, buyers in traditional markets are better placed to meet urgent needs of smallholder farmers – such as cash or informal credit. Acknowledging the importance of informal markets, many governments and development institutions are actively supporting traditional markets by addressing key bottlenecks such as price fluctuations and power disparities between buyers and sellers. Better understanding of informal markets and supply chains can help governments in formulating more inclusive policies to facilitate smallholder farmers and low-income consumers to realize the full potential of these markets.

Limitations of informal markets: While informal markets provide easy access and flexibility in trade to smallholder farmers, they are also vested with some major bottlenecks, including poor traceability, lack of food safety systems, monopolies and crop cartels. Further, smallholder farmers who only trade in informal markets and fail to integrate into formal markets are unable to build the critical mass essential for influencing markets and government policies.

Drawbacks of formal markets: Many smallholder farmers do not participate in formal and high-value markets because of high entry barriers set up by formal buyers with respect to extensive quality requirements. And while formal buyers demand high-quality produce, they do not always give farmers competitive prices, making formal markets less profitable for smallholders. Formal buying arrangements between companies and smallholders, such as contract farming, often restrict farmers from selling produce to other companies. Moreover, the tradition of on-the-spot payments and easy access to informal credit from local traders against future harvests makes informal markets more lucrative for smallholder farmers. For more information on informal markets see Vorley, Del Pozo-Vergnes, and Barnett (2012).

Smallholder farming markets – lessons of experience

The experiences of governments, donors, NGOs and private companies in linking smallholders to markets have generated seven prominent lessons that need to be considered in relation to the diagnostic, both in scoring of the market factor and in the subsequent planning of interventions as required (summary based on Wiggins and Keats [2013]).

1 **Informal markets** impose few market-entry constraints with respect to quality and standards and hence play a pivotal role in small-scale farmers' livelihoods.

2 **Domestic and regional markets** are characteristically larger, more stable and have lower demands with regard to product quality and safety in comparison to export markets. Export markets are accessible only to a small proportion of smallholder farmers; for the majority of smallholders, it is more pragmatic to focus on products traded in large volumes in domestic and regional markets.

3 **Grouping smallholder farmers into producer organizations or cooperatives** helps to achieve economies of scale, thereby reducing the high transaction costs incurred by individual farmers while trading with value chain actors.

4 **Farmer organizations should be cautious in diversifying their portfolio of services.** While producer organizations and cooperatives can reduce transaction costs, leading to better farmgate prices and cheaper inputs for members, there are other value chain activities such as warehousing services, micro-financing, packaging, etc. which are done more efficiently and effectively by the private sector.

5 **Value chain actors can make supply chains more effective and efficient** through investments in new business models. Such initiatives are likely to work when there is a clear business opportunity and the value chain actor does not extract undue rents.

6 Market linkage initiatives at farm or supply chain level should **focus on business objectives and prioritize returns on investments**. Social objectives of reaching the most poor and vulnerable farmers are not always feasible or economically viable.

7 Private sector and government agency efforts to link farmers to supply chains and markets should **concentrate on developing processes rather than imposing standard models**. These outside agencies should foster trust between farmers and other value chain actors, build up local competencies, and resist "too much change too quickly" in order to meet project targets and budget constraints.

6.2 Diagnostic and scoring

Diagnostic

The diagnostic requires critical enquiry into access to markets and information on the strength of the enabling environment. This would include assessment of agricultural trade policies; the regulatory environment; public and private marketing infrastructure; the range of supporting services available to smallholders; and the accessibility of those services across the country. Guidance on policy and legal aspects of the diagnostic are included in Module 3 (also in i-box 3.4 and 3.5). More detailed information on a diagnostic approach is available in Minh et al. (2021). The diagnostic would typically be carried out by a specialist market consultant, informed by the scoping Terms of Reference in i-box 6.1.

Scoring the market factors

Efficient access to markets underpins a strong business case and provides the impetus for smallholders to invest in irrigation systems. The purpose of the scoring exercise is to reflect the severity of the market access constraints that are faced by smallholder farmers in accessing different kinds of output markets. Key elements of the scoring would include consideration of the categories of farmers that could be targeted in the intervention; the rural investment climate; state of supporting infrastructure; regulatory and compliance systems; and access to market intelligence. Guidance on the scoring of the market factor is provided in i-box 6.2.

If the constraints to market access are high and the enabling environment is poorly suited to smallholders' needs, then the score of the market factor will be low. In turn, this means that a market-systems-based approach may be needed to catalyze FLID.

6.3 Market access intervention examples

Example intervention 1

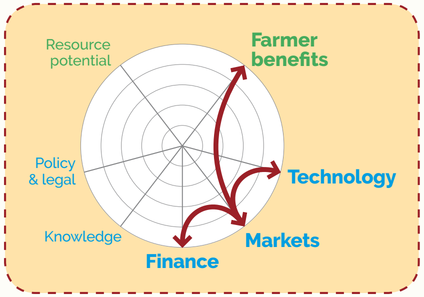
Farmer producer organizations

Smallholder farmers can organize themselves into formal legal structures – producer organizations, cooperatives, associations – to exert their collective economic agency and power in formal markets. Farmer producer organizations (FPOs) allow smallholder farmers to gain more bargaining power in formal markets and reduce transaction costs, thereby delivering on their expectations: **higher farmgate prices, more stable markets** and **access to affordable credit** (Vorley, Del Pozo-Vergnes, and Barnett 2012).

Key factors that make farmers' groups powerful and sustainable

1. Farmer producer organizations (FPOs) are formed with a clear agenda and the farmers with common interest take membership voluntarily.
2. FPOs' management is skilled and demonstrates adaptability in line with the needs of its members and market requirements.
3. They are recognized as legitimate and credible institutions within policy circles, practise evidence-based advocacy, negotiate effectively, and implement agreements and laws.
4. They demonstrate the ability to change, innovate, and evolve as per the demands of market systems.

Source: Vorley, Del Pozo-Vergnes, and Barnett (2012, 40)



FPOs, often set up by an external agency (government or NGO) can deliver value for smallholder farmers by leveraging economies of scale, facilitating access to technology and inputs at lower costs, and integrating farmers into high-value markets which are usually out of their reach.

Example intervention 2

Public-private-producer partnerships

Private-sector companies can play a crucial role in addressing market failures in dysfunctional agricultural markets. Especially when government budgets for agriculture are limited, private-sector expertise, investment capital, and efficiencies can complement the public-sector efforts to improve incomes and livelihoods of smallholder farmers in Africa. Moreover, private-sector firms offer a multitude of services to smallholder farmers, such as access to inputs and working capital, raw material procurement, specialized technical assistance, market intelligence, and investment in community assets such as warehouses, transportation and processing facilities (Table 4.1 and i-box 4.1).

> *"4Ps involve cooperation between a government, business agents and small-scale producers, who agree to work together to reach a common goal or carry out a specific task while jointly assuming risks and responsibilities, and sharing benefits, resources and competencies."*
>
> – Baumgartner (2016, 3)

Public interventions can directly initiate, facilitate or support existing linkages between small-scale producers and private companies. The multi-stakeholder platforms and farmer field school approaches, described in Module 4 Section 4.3, are useful modalities to establish and promote these partnership outcomes.

A public-private-producer partnership (4P) model is an innovative approach that can help private-sector companies expand their business with smallholder farmers and which provides an opportunity for governments to attract private-sector investment in the agricultural sector (Baumgartner 2016). Moreover, a 4P model offers an equitable partnership arrangement in which smallholder producers are respected partners and not relegated to a secondary role, where they suffer because of the asymmetries in the balance of power between them and private actors. The 4P model ensures farmers' agency in price-setting mechanisms, enforcement of contracts, payment modalities, ownership, and coordination. In a typical 4P the private-sector partner is selected through a competitive process and producers are actively engaged in negotiations, partnership arrangements and overall monitoring.

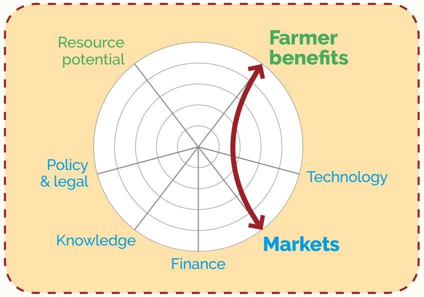
Example intervention 3

Agricultural commodity exchanges

An agricultural commodity exchange (comex) is an organized and regulated market in which registered buyers and sellers trade **standardized contracts*** (spot, future, forwards,

* a trading contract that stipulates standard quantity, standard quality, minimum price, and delivery specifications (date, place, payment mode) of a commodity traded on the exchange between a buyer and a seller.

derivatives) of agricultural commodities (maize, rice, wheat, etc.) based on the exchange's trading rules and procedures (Songwe 2016). The success of various comex in Africa has shown that commodity exchanges can "play an important role in connecting rural areas to the urban centers as well as linking small farmers to major buyers" (Songwe 2016, 3). A centralized trading process via commodity exchanges tends to have a discernable positive impact on agricultural markets – in the form of improved market transparency, better price discovery, reduced transaction costs, higher returns for market participants, and tighter control over price fluctuations. Moreover, comex helps in defining better quality standards, accelerating product standardization, and making the overall market more fair, robust and competitive.



Enabling conditions for well-functioning commodity exchanges can be broadly categorized into four types as outlined by Songwe (2016):

Commodity-related requirements: Availability of the specified commodity, grades and standards, spot market with large number of participants and value, robust warehouse network, price flexibility for futures exchanges, local-currency denominated contracts, etc.

Contract-related requirements: Attractive contracts for market participants (producers, hedgers, speculators, etc.); contracts that are not biased towards some market participants over others; contracts usable as collateral in the banking system; predictable interest rates; warehousing costs, transportation costs, etc.

Institutional requirements: A robust regulatory framework with clear rules and terms for market participation; a trusted dispute resolution process; an inclusive brokerage network; robust institutional ownership and governance arrangements; a functional technology platform; and multiple channels to disseminate market information.

Legal and policy framework: Communication, storage and transportation infrastructure; efficient flow of information; a developed financial system; an appropriate legal and compliance system; effective policies for fiscal and monetary management; and foreign trade.

Example intervention 4

Warehouse receipt systems

Warehouse receipt systems (WRSs) are an innovative financing mechanism that allows farmers, farmer groups, traders, exporters and other value chain actors to store agricultural commodities (grains, coffee, etc.) in an accredited and certified warehouse in exchange for a warehouse receipt (International Trade Centre [ITC] 2007). Issued by the warehouse operator, the receipt specifies the quantity, quality and location of the stored commodity and is used by the receipt holder as collateral to access credit from financial institutions. WRS plays a crucial role in curbing "fire-selling" by smallholder farmers immediately after harvest when market prices are normally low, since it provides an option to store a crop, monitor market conditions, and sell when prices are favorable – often resulting in a 35–40% increase in price (International Financing Corporation [IFC] 2015). Moreover, WRS helps in drastically reducing post-harvest losses since the stored crop is managed by certified warehouse operators equipped with proper

facilities and expertise. Broadly, two types of warehouse receipt systems exist: unregulated WRS, in which trade partners are bound by contractual laws; and regulated WRS, in which trade is managed by an independent government or private regulatory agency.

WRSs are considered a viable FLID financing mechanism for smallholder farmers in Africa to access capital to invest in irrigation equipment against the stored commodity in a warehouse. As WRS mainly concerns non-perishables, specifically staples, in the context of FLID processes this usually entails rice.

Example intervention 5

Digitalization for agriculture (D4Ag)

Digitally-enabled market linkage solutions have a critical role to play in connecting smallholder farmers to high-quality farm inputs, agriculture machines and mechanization services, offtake markets, and local or international end-customers. By introducing efficiency and transparency into the informal agriculture value chains, digital market linkage solutions allow smallholder farmers to lower their production costs through access to inputs, finance, irrigation and mechanization products and services, and increase their incomes through reducing the costs and risks of finding and transacting with buyers. At the same time, these solutions help agribusinesses across the value chains to reduce their operating costs and grow their markets and businesses.

Four major clusters of **digital market linkage models** currently stand out in the sub-Saharan African (SSA) region: digitally-enabled value chain integrators; mechanization access solutions; agri-input and food e-commerce solutions; and agriculture e-marketplaces. For more information on the digitalization of African agriculture see report from the Technical Centre for Agricultural and Rural Cooperation (CTA).

1 **Digitally-enabled value chain integrators** are D4Ag solutions that use digital tools that link agricultural markets to smallholder farmers. These solutions enable agents of the market offtakers to aggregate produce from a larger number of smallholder farmers, bringing efficiencies to the operations of the offtakers and increasing margins for both farmers and offtakers. Twiga Foods and Digifarm are leading digital offtake market integration solution providers in Kenya.

2 **D4Ag mechanization access solutions** use digital tools and channels to link smallholders to farm machinery or farm mechanization services, reducing the farmers' need to purchase expensive technologies for farming or irrigation. The best established example is Lagos-based Hello Tractor which now has operations across multiple SSA countries, and Sunculture which provides pay-as-you-go (PAYG) services in East Africa.

3 **Agri-input and food e-commerce solutions** are online retailers of agricultural produce for urban consumers or agricultural inputs for smallholder farmers. They rely on online order fulfilment for aggregating demand, and offline shipping and logistics for ensuring that the products reach the end-customers. These solutions have seen an increase in demand during the COVID lockdown periods. Examples of such direct-to-consumer local produce e-commerce enterprises include FarmFresh in Gambia, Get It Rwanda in Rwanda, and KwikBasket in Kenya.

4 **Agriculture e-marketplaces** are D4Ag market linkage solutions that bring individual buyers and sellers of inputs and produce together, through a virtual trading marketplace. Mastercard Farmers Network (MFN), active in Uganda, is an example of an e-market place.

Apart from the market linkage solutions, there are also **supply chain management solutions** that are designed to make agribusiness operations more efficient and profitable. These solutions are already providing tangible results in well-established, tight smallholder value chains such as tea, coffee and high-value horticulture crops, and showcasing their ability to scale into loose value chains. SourceTrace, CropIn and E-prod are examples of existing supply chain management solutions in Africa.

6.4 Concluding note

Market-oriented farming is one of the defining characteristics of farmers who take the lead in developing irrigation. Different categories of farmers will likely face different kinds of constraints, including the rural investment climate, state of supporting infrastructure, regulatory and compliance systems, and access to market intelligence.

A range of interventions can overcome these constraints, such as smallholder farmers organizing themselves into formal legal structures to exert collective economic agency in formal markets; public-private-producer partnerships, where the private sector companies, enabled by public finances, can support and expand the businesses of smallholder farmers; agricultural commodity exchanges, playing an important role in linking small farmers to major buyers, and bridging the rural-urban divide; warehouse receipt systems, as an innovative financing mechanism that enables efficient storing and trading of agricultural commodities; and digitally-enabled market linkage solutions, introducing efficiency and transparency into informal agriculture value chains through access to inputs, finance, irrigation and mechanization products, thus reducing transaction costs and risks.

Farmers' ability to expand, intensify and increase profit from irrigated agriculture is heavily dependent on markets. Enabling their efficient access to, and effective engagement with, agricultural output markets, along with the necessary knowledge, finance and technology, is key to facilitating farmers' business success.

i-Boxes

Outline TOR for the market diagnostic

To assess how limiting or enabling the market environment is for a farmer attempting to access different types of markets, one has to consider agricultural trade policies and regulations; the range of supporting services that are available to smallholders; and the accessibility of those services across the country. The diagnostic is guided by the approaches outlined in i-box 3.4 and 3.5, and in Minh et al. (2021). This information can be attached to the consultant's Terms of Reference (TOR).

The consultant will provide an overview of the general market characteristics and include the following metrics:

- Labor availability
- Energy availability
- Domestic market (projected demand for irrigated crops, population trend, income growth, etc.)
- Export markets

More specifically, in order to understand smallholders' access to output markets, four categories will be investigated. The extent to which each of these four categories (Wiggins and Keats 2013, 25–28) is responsible for low market involvement by smallholders will be analyzed, based on the information collected in the diagnostic. Data needs to be collected on the following:

1 **Research and development; technology dissemination and uptake; cost drivers; and overall economics** – relates to crop yields, vulnerability to pests, labor costs, input costs, value of outputs, etc., and the effect of crop gross margins for a range of crops. Based on the data, assess if it makes sense, economically and technologically, for farmers to engage in a particular market. Do these factors change the ratio of benefits to costs at farm-gate level and suppress the value of outputs, thereby disincentivizing farmers from participating in some markets?

2 **Macro-economic instability, lack of risk mitigation options, and insecure property rights** – pertains to stability of government policies on trade, price controls, subsidies, exchange rates and the incidence and risks related to bad weather. The impact of property rights and/or the absence of formal land titles on cropping, financial inclusion and the insurance sector should be taken into account (see Module 3). Based on the information, assess if these factors create an enabling environment or if they deter farmers and private sector from participating actively in markets and/or investing in farms and supply chains.

3 **Market failures due to high costs of information** – transaction costs[1] incurred in gaining information required to make trade deals, negotiate contracts and monitor implementation of contracts; ease of access to information on market prices and extension knowledge sought by farmers; farmer's competence, collateral and credit history required by banks; supply-demand information sought by inputs and equipment dealers; raw material supply required by processors, wholesalers and retailers in order to make investment in processing plants, warehouses and storage facilities. Based on data on transaction costs incurred by different market players, assess whether they would increase or suppress

1 Costs borne by market participants in accessing information on prices, quantity, quality, and other characteristics of an agricultural product, in order to buy or sell it in the marketplace, lend credit, make investment decisions, etc.

overall investment at farm and supply chain level and prevent farmers from engaging actively in markets.

4 **State of monopoly and competition in rural markets** – local traders, input dealers, and informal lenders have power to extract rents (unearned profits) by charging higher prices owing to lack of competition in the market. Gather information on net margins earned by different market intermediaries from farm-gate to retail and assess the impact of these margins on farmers' participation in certain value chains and markets.

The marketing assessment will be informed by the development of farmer typologies that are outlined in Module 2, and would be developed as part of the separate TOR described there.

Guidance on scoring

Guidance on the issues that inform a scoring assessment is provided below. As with all of the thematic factors in the FLID system, the scoring of the market axis on the diagnostic spider plot is based on a simple ranking from very weak to very strong, with a score of 1 to 5 respectively. Characteristics of a weak market environment (Wiggins and Keats 2013) describe a general situation that constrains smallholders' access to markets, and might include:

1 A rural investment climate provided by the government that is inappropriate for development of market linkages.

- **Macro-economic stability** is not strong enough to enable investment and innovation in agricultural output markets.
- **Net rate of assistance (NRA) to agriculture** i.e. government taxes and public spending does not favor agriculture.
- **Trade policies** are inconsistent and unfavorable for smallholder farmers to access national, regional, and export markets.
- **Foreign exchange** is in short supply and foreign exchange rates are unstable, unpredictable or non-competitive.
- **Taxation** on agriculture is high with tax not reinvested in public goods, agricultural institutions & research, and agricultural markets.
- **Land property laws** are weak and property rights are not recognized.

2 Insufficient spending on rural public goods that is vital for production, agro-processing and export of high- value produce.

- **Physical infrastructure** such as reliable roads, power, water supplies & drainage, and warehouses & cold chains vital for agricultural produce, agro-processing, and export of high value produce is weak or under-developed.
- **Communication infrastructure** such as mobile connectivity and internet access lacks scale, penetration, and sophistication (2G & 3G networks), limiting smallholder farmers' direct access to digital agricultural solutions.
- **Agricultural research and extension services** systems do not adequately address the productivity, crop protection, pest control and post-harvest management issues of smallholder farmers, due to poor reach and knowledge gap.

3 Lack of regulatory and compliance systems that restrict farmers' participation in domestic, regional, and export markets.

- **Food safety laws, standards and regulations** are not in place; do not address harmonization among domestic, regional or international market requirements; lack compliance, audit and certification systems; or the cost of compliance leads to exclusion of smallholder farmers from markets and policy discourse.

■ **Organic certifications** systems are unavailable, costly or difficult to access.

■ **Legal system for drafting, negotiating and enforcing farming contracts** between farmers and buyers under different market-linkage models either do not exist or are weak in regard to dispute resolution.

■ **Traceability systems** to identify agricultural product origin and subsequent movements throughout a supply chain, as well as track adoption and implementation of good agricultural practices (GAPs), social and environmental practices, food safety and payments, do not exist.

4 Poor level of digitization of value chains with few opportunities to access market intelligence and reduce transaction costs.

■ **Internet access** is expensive and generally inaccessible in rural areas.

■ **Digital commodity markets** do not exist and the preconditions, such as rules and bylaws, contract specifications, quality standards, warehousing systems, brokerage networks, technology infrastructure, and reliable financial settlement systems are absent or weak.

■ **Mobile money providers (MMPs)** and financial service providers (FSPs) are unable to provide a combination of digital payments services legally – e.g. airtime top-up, person-to-person (P2P) remittance, bill payments, merchant payments, agricultural credit, and insurance products are nonexistent, expensive, or not accessible to smallholder farmers.

5 Laws and regulations related to marketing of agricultural produce that do not ensure equitable access to markets for women and youth.

■ Women and youth face unreasonable bureaucratic barriers to form producer groups or cooperatives.

■ Women and youth face cultural or systemic exclusion by market intermediaries or value chain actors and institutions from the management and marketing of agricultural produce.

Building blocks of a successful public-private-producer partnership

Designing an effective and equitable multi-stakeholder partnership is a big challenge. It requires a diligent and meticulous analysis of interests, motivations and priorities of all stakeholders involved in order to make the partnership successful, results-oriented, and sustainable. Finding answers to the set of guiding questions below (Baumgartner 2016, 6–8) can help to achieve the desired outcomes of a public-private-producer partnership (4P) model:

1 **Define a clear rationale for adopting the 4P model:** nature of problem (opportunities and challenges), need for a partnership, alignment of common interests, stakeholder incentives, overall goals and objectives.

2 **Select the 4P partners:** selection process through competitive bidding or due diligence; identifying the capacity-building needs of partners, especially farmers.

3 **Develop a business case for a 4P model:** negotiate and develop a viable business model and bind producers, private companies and government into a partnership based on the type of business model chosen, e.g. contract farming, out-grower model, joint-venture, etc.

4 **Ensure long-term financial viability of the 4P model:** identify the funding sources – public goods, semi-public assets, private sector investments, producer assets – required for making a 4P partnership successful.

5 **Define roles and responsibilities of partners:** for each partner, negotiate roles and responsibilities, agree on the share of risks and benefits, and identify strengths and weaknesses.

6 **Develop a 4P governance mechanism:** establish internal rules, regulations and mechanisms for conflict-resolution, risk-mitigation, decision-making and stakeholder communication.

7 **Develop a 4P monitoring and evaluation (M&E) process:** follow a robust M&E process that helps stakeholders track and monitor the project's key performance indicators (KPIs) and alerts them of deviation from KPIs.

The responses to the questions above constitute the "**building blocks**" of a successful 4P model.

Figure 1 Building blocks of a private-producer-partnership (4P)-based market intervention (reproduced from Baumgartner [2016, 7] with minor amendments)

There are different value chain development models that are adopted by the private sector to link smallholder farmers to the output markets. The type of model depends on the nature of the product (perishable, bulk commodity, differentiated, etc.), the list of partners (producers, buyers, processors, exporters, etc.), and end-market.

The different public-private-producer partnership models are (Baumgartner 2016):

1 Horizontal business models

In such models, the partnership between producers and private companies is **informal** in nature, **not based on any written contracts or agreements**. The model requires farmers to be organized into groups, cooperatives or associations with the capacity and bargaining power to supply agricultural commodities to one or more private players (e.g. traders, processors, retailers). An example of this model in Africa comes from Ghana where farmer producer organizations and district value chain committees linked smallholder maize farmers to markets and enabled access to training, inputs and technology via a cashless credit system.

2 Vertically integrated models

These business models are based on a formal, written contract between farmers or farmer organizations and a private company. The contracts can range from seasonal contracts to fully integrated outgrower schemes and depend on the private company, country, agricultural commodity and other factors. Vegetable Oil Development Project (VODP) in Uganda falls in this category of business model in which an oil processor established a nucleus estate and negotiated **direct contracts** with local farmers to source raw material.

3 Joint-venture models

In a joint-venture business model, farmers are not only suppliers of agricultural commodities but shareholders in a joint venture between them and the private company or investor. Unlike the previous two models, this model gives more power to smallholder farmers in decision-making, facilitates their ownership of assets and has implication for sharing of benefits and risks within the 4P. In Rwanda, the government purchased 30% and 15% shares in two tea-leaf processing factories on behalf of tea-producer cooperatives as part of the Smallholder Cash and Export Crops Development Project (PDCRE) to encourage farmers' ownership and create opportunity for them to get dividends.

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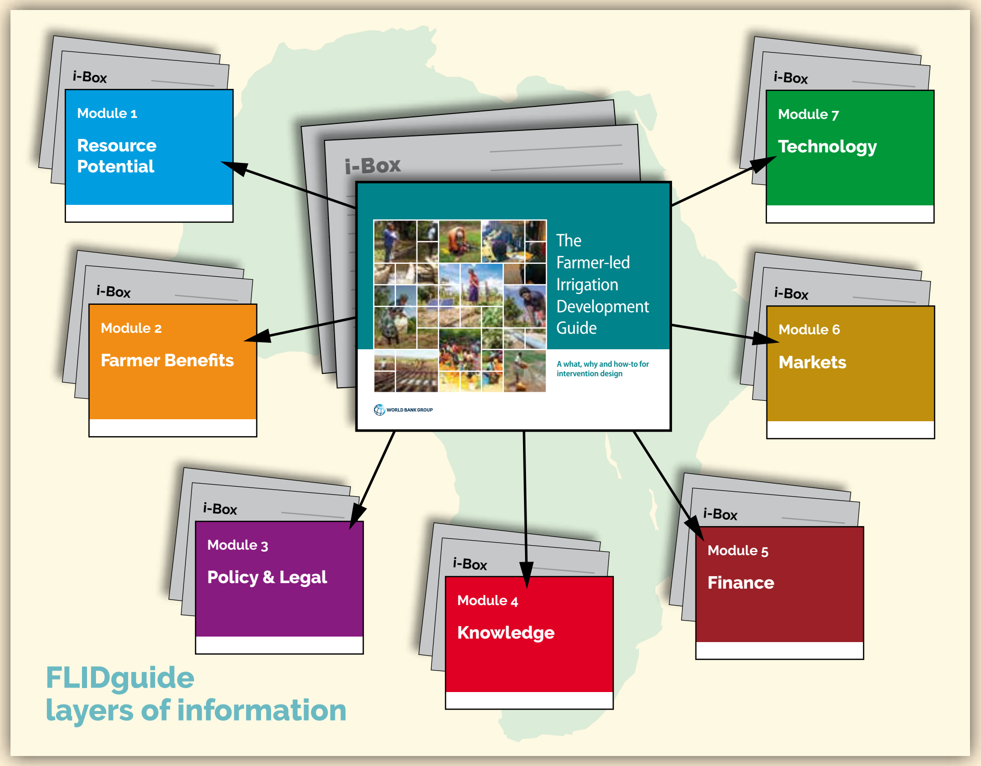
Contents

Abbreviations and acronyms

CSIRO	Commonwealth Scientific and Industrial Research Organisation
D4Ag	Digitalisation of African Agriculture
ESMAP	Energy Sector Management Assistance Program
FAO	Food and Agriculture Organization
FLID	farmer-led irrigation development
GHG	greenhouse gas
GPS	global positioning system
GSM	global system for mobile communications
GSWI	Global Solar and Water Initiative
HP	horsepower
i-box	information box
IFC	International Financing Corporation
M&E	monitoring and evaluation
PAYG	pay-as-you-go
RMS	remote monitoring systems
STEPS	Social, Technological and Environmental Pathways to Sustainability
TDH	total dynamic head
TOR	Terms of Reference
VIA	Virtual Irrigation Academy
WFD	Wetting Front Detector
WHO	World Health Organization
WP	water productivity

Using the guide

The main volume of the FLIDguide presents the core body of information that explains FLID and the process of intervention design. Thematic descriptions are included in seven modules. Information boxes (i-boxes) at the back of the Main Guide and each module provide additional detail, and hyperlinks throughout the guide access relevant external publications, websites, animation clips and videos.



Tips

NAVIGATING THE GUIDE

To move quickly and easily between the interlinked information, set up your PDF reader so that the **PREVIOUS VIEW** and **NEXT VIEW** buttons (as distinct from PREVIOUS PAGE and NEXT PAGE) are instaled on the toolbar at the top of your screen. **You may then freely explore the document using the navigation pane on the left of your reader or the many hyperlinks provided in the text, and backtrack to the start by repeatedly hitting the button.**

To instal the buttons (in Adobe Reader),

- Right-click anywhere on the toolbar and select them in the **Show Page Navigation Tools** options; or
- open the **View** drop down menu and select them from the **Page Navigation** options.

Alternatively, try using these keyboard shortcuts:
Windows: Press the **ALT** key and ◀ or ▶ arrow
Mac: Press the **COMMAND** key and [or] square bracket

PRINTING

Office desktop printers cannot print to the edge of the paper. To print pages of this document without losing any content,

- choose **File > Print**, and in the page sizing and handling area or pop-up menu, select **Fit to Printable Area** or **Shrink to Printable Area**.

7 Technology

FLID technologies and their social implications

This module addresses technologies and the role they can play in farmer-led irrigation expansion, intensification, and profitability. The contents are not a comprehensive description of technical irrigation options – which are extensive and widely available in the public domain – but guidance on how technologies might be better incorporated in a FLID intervention plan.

The first part of the module draws attention to the reality that technology is not a dislocated object but has a powerful social dimension. The idea of "transformative technologies" is routinely part of FLID intervention discussions. While its use can be justified, the phrase risks missing the critically important aspect of context. Technology must be assessed in relation to the farmer's particular situation, either as an individual or within a group using an irrigation system. It is this context that defines which technology is transformative, and which is not. Two prominent technology examples that frequently feature in FLID interventions are used to highlight this point: the choice of pumping energy (solar vs petrol), and a range of field application methods that are often misunderstood. The second part of the module provides guidance on the diagnostic and scoring of the technology environment in a country. The final part of the module describes a set of principles that inform the process of technology selection. These need to be taken into consideration when knowledge and finance interventions are designed (as per Modules 4 and 5).

Co-constructing technical solutions is an iterative process, with farmers at the center.

7.1 Technology and the farmer

The socio-technical dimension

The introduction of any technology triggers some measure of social and behavioral change. It can dramatically improve the farming business by reducing labor and overall production costs, increasing crop and water productivity (i-box 7.1), and improving the quality of agricultural produce. Less evident, perhaps, are the deterministic effects that technology has on behaviors, farming practices, gender roles, and social relations. Some of these effects are outlined below.

Irrigation technologies must fit the social, organizational, financial, and agricultural realities to function effectively.

Knowledge and role changes

Changes in technology often require different sets of technical, irrigation and agronomic skills, and can shift the timing and alter the workloads of women and men. There are essential conditions for technology to perform well, and there is an implicit assumption, in the technical design itself, that the irrigation technologies are relevant to a set of physical, financial and operational realities. Understanding those implicit

assumptions (particularly for equipment maintenance and water-application), and linking them functionally to the technology at hand, is therefore important to achieve the intended results.

Impact on local customs

Technology choices can impose changes on farming households, farmers' groups, and the surrounding community, and can be inadvertently disruptive. Alternatively, choices can institutionalize new practices that are aligned to changing customs. Notably, roles for water management on group schemes, and for irrigated production on individual farms, may be more flexible where irrigation is relatively new and agriculture has traditionally been rainfed. Roles are also reshaped continually based on new incentives emerging from changing social and economic conditions. One common example of such change occurs with migration: if men or women migrate seasonally out of a community to seek off-farm cash income, spouses "left behind" often take up roles in domestic water management, farming, and marketing which may not have been the norm under previous customs, particularly if they cannot afford, or find, labor to hire for those tasks.

The wider impact of technology change must be informed by customs and norms.

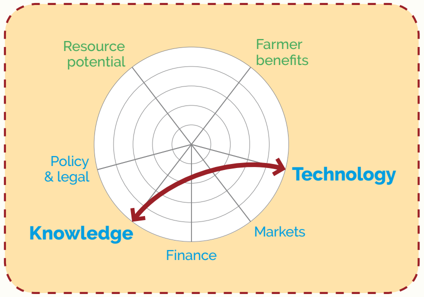
Inclusion

Technology processes and choices can strengthen inclusion (Main Guide i-box H). Roles in farming, and the distribution of benefits from agriculture production, are both gendered and generational. Women, men, youth and the elderly have different roles in farming and food value chains that vary even within communities. Women and youth typically undertake specific tasks in production, harvesting, processing and the marketing of farm outputs. At the same time, both women and men may control decision-making – and undertake different tasks – on their separate plots, while still adhering to customary norms on joint or household plots. Understanding customs and norms is important to anticipate the wider impacts of intentional technology changes.

Best-fit technology

FLID is characterized by diverse personalized practices (Module 2 Figure 2.1) with a wide range of technical solutions that are used successfully (i-box 7.2). These include solutions that are locally developed based on years of experience, and those that are freshly invented or modified from what farmers have observed in other settings. This personalized character of technical solutions in FLID is somewhat different from technology-centered interventions that are imagined to be 'silver bullet' solutions. These are often promoted as if they will solve all of the challenges that farmers struggle with daily. They assume that all farmers will need the same solutions and respond in

the same way. Even though such technologies may not be the best-fit choices, they typically have an image of modernity and are frequently favored by policymakers, engineers, and farmers, alike (De Bont and Veldwisch 2020; Beekman and Veldwisch 2016; Venot et al. 2014).



A *fit-for-purpose* strategy that allows farmers to develop and/or choose solutions for themselves – complemented by knowledge that allows them to do so – is needed to drive technology change in programs aiming to achieve meaningful outcomes.

FLID is technologically balanced

A characteristic of FLID is that farmers find a balance between their choice of technology and their context. Even where farmers may have more advanced options available, many often prefer labor- and knowledge-intensive, or locally available solutions. These include simple stream diversions with earth furrows; bucket-and-rope methods drawing from shallow wells; or hand-dug ditches to control drainage. Others may find a balance with more capital intensive technology – like small petrol pumps, popular because they are widely available, affordable, mobile, and easily serviced.

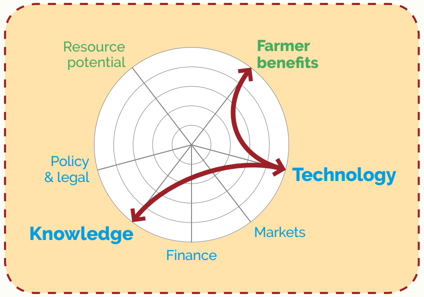
Irrigation ***practices*** must be the focus – they include knowledge and the whole technology mix, not just a single technology on its own.

Integrated practice counts

The *practice* of irrigation – meaning how knowledge informs the use of the technology – plays a big part in determining the outcomes from a given technology. There are few right or wrong technical solutions, but rather preferences and practices that determine the best choice. Preferences are informed by many factors that include: experience, crop type, affordability, other existing technology on the farm (pumps and tanks), labor availability, access to spares, water quality and security, social and family commitments, and costs in general.

Technology, in turn, can promote better practice. An inspired example is where water productivity can be greatly improved by the use of cost-effective *soil-water measurement instruments* (Figure 7.1 and i-box 7.3). Adaptive irrigation scheduling is not practiced by most smallholders because they lack the *equipment and knowledge* to understand the status of water in the root-zone soil profile. It is also almost impossible for farmers to know whether they are retaining fertilizer in their soil or leaching it out. Soil-water monitoring equipment can help farmers manage water and nutrients in the root zone more effectively, whether in simple furrows or sophisticated drip systems. The benefits of managing soil-water are substantial in terms of labor, fertilizer and pumping cost savings –

Figure 7.1 Using a soil-water monitor in Mozambique



translating to increased water productivity (i-box 7.4) and financial returns. A doubling and tripling of yields, and of gross margins, is recorded in multiple countries and farming contexts across Africa (i-box 7.4).

There is also a process of evolution regarding technical choices. Technical advancement in FLID often takes place in small steps, rather than a technological "big-bang". Farmers at different stages of irrigation introduction, expansion or intensification will have different technology needs, risk appetite, and financial capacity. A petrol pump and hose-pipe setup may be chosen to start irrigation farming because it is affordable, even though a solar pump, sprinklers or a drip system may have been preferred at the time. As farmers become more financially established and gain more experience, they might choose more sophisticated technologies, like drip irrigation and fertigation. These are more complicated, require different skills, and better spares backup to sustain functionality over time (Figure 7.2).

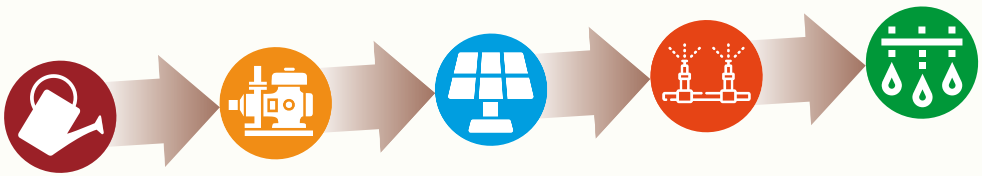


Figure 7.2 Farmers have different technology needs that vary over time

There are many examples of "silver-bullet" thinking about a single technology. Two stand out in relation to FLID: solar-pumping systems as better than petrol pumps; and the promotion of drip irrigation as better than, for example, hosepipe or short-furrow irrigation. While solar-pumped and drip systems undoubtedly have transformative potential in certain situations, they will not suit all farmers. These points are elaborated further in the section that follows, with detail in the i-boxes to demonstrate that it is a *combination of established and new technologies* that can dramatically change the lives of many, rather than one technology alone that solves all of a farmer's or farmer group's problems.

Solar is the future, but petrol has its place

Small petrol pumps for irrigation are widely used, readily available, and cheap to purchase in Africa (i-box 7.5). They are mostly used by individuals, but sometimes shared within small groups. Their affordability, mobility and simplicity explain their widespread presence, but they do have their drawbacks – in the form of very high operational costs (fuel, oil and spares), negative environmental impact, and short lifespans. Solar pumps, though far less prevalent in Africa, are increasingly popular for a range of reasons:

1 The financial case to be made for solar-energy-pumped systems on a lifetime assessment, when comparing purchase, operations and maintenance costs, can be significantly positive. Assessments show that net financial returns are between two and three times better with solar than petrol, with payback periods of between one and three years (i-box 7.6) (World Bank 2018; Food and Agricultural Organization [FAO] 2018; Global Solar and Water Initiative [GSWI] 2018).

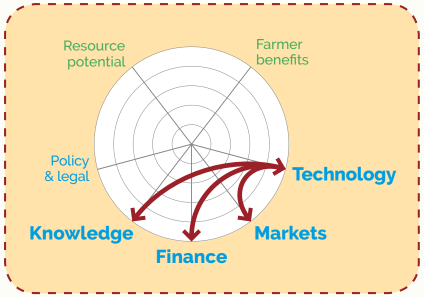
2 Solar pumps offer a more environmentally responsible alternative to petrol pumps. Life-cycle assessments ("cradle to grave") indicate a potential reduction in greenhouse gas (GHG) emissions of 97 percent compared with diesel pumps (FAO 2018). In many lowland areas across Africa, thousands of small petrol pumps are found in close proximity, with cumulative and significant negative impacts at scale that can be offset by solar.

3 There is a major opportunity for suppliers to meet farmers' demand for affordable solar pumping solutions. The International Financing Corporation (IFC) has estimated the value of the market that could benefit from solar pumping as 3.5 billion USD in Africa in the next five years. The value of the market that could *afford* solar pumps in Africa was assessed to be 456 million USD (IFC 2019). Even if the numbers are subject to debate, the potential for sectoral growth is clearly at a massive scale, with corresponding large-scale multiple benefits including cost savings and reduced environmental impact.

Despite these advantages, the uptake of solar pumping remains low in Africa. One reason is that there is limited knowledge of solar-pump technology among both farmers and suppliers. Another, and probably the main, reason is that although lifetime costs are advantageous, the upfront cost of solar is much higher than petrol. This upfront cost is the first of the financing triple-jump that has to be cleared by farmers (Module 5 Section 5.1), and clearing this hurdle is difficult because affordable financing is generally limited in Africa.

So, while solar pumps have clear advantages in the lifetime cost comparison, successful uptake at scale depends on some enabling conditions. These include access to affordable finance and/or subsidies on solar-pumping equipment, as well as knowledge interventions for farmers, equipment suppliers and financing institutions. General guidance on the selection criteria and applications of solar pumps are included in i-box 7.7 and i-box 7.8.

Petrol pumps, by contrast, do not depend on any of these factors for uptake at scale. They are widely known, cheap, highly mobile, and easily maintained locally (e.g. by motorcycle mechanics). Petrol pumps can also be used easily in pump-rental arrangements due to their mobility (easily transportable on a motorbike), and their relatively high flow rates compared to solar pumps. It is important then, before potentially transformative technical solutions are prioritized, that rigorous country-specific analyses are carried out to quantify the comparative benefits of solar versus petrol pumps. The need for, and practicalities of, parallel interventions (such as affordable financial access, subsidies, knowledge, market development) must be fully assessed to ensure that selected technologies will be "transformative" in a specific context.



Suitable on-farm irrigation application methods

Irrigation application technologies, and their efficiencies in particular, are a classic focus point for irrigation engineers. In a FLID context, however, there is a need to revisit conventional knowledge to enable farmers to select the best-fit solutions. While sophisticated technologies have their place, there are many low-cost, reasonably efficient and robust technologies that may suit farmers better than more sophisticated options. Good management can ensure that all of these irrigation technologies are effective in practice.

A popular and robust irrigation option is the use of flexible hose pipes for water application, either with spray nozzles or in combination with short furrows. **Hoses have the advantage of being low-cost, portable (easier to protect from theft), and simple to maintain.** In the watering activity, farmers pay close attention to crop health and are more attuned to volumes of water applied than in the case of mechanized field methods (when no soil-water management instruments are used).

The lack of water efficiency in these relatively rudimentary methods is often raised as a reason for objection to them, but contrary to popular engineering perception, **the *irrigation application efficiency* of short furrows in a smallholder setting can be greater than 80%** (Reinders 2011). The short-furrow practice is completely different from the

long-furrows method, from where the well-known low efficiencies originate. The reasons why short-furrow irrigation is widely used by smallholders in water-scarce settings are: furrows are short and level so there is no percolation gradient; irrigation is more hands-on and farmers are attentive to applied volumes; pumping energy to lift water is costly for smallholders, and is used only judiciously as a result.

Other practical and efficient methods (i-box 7.9) include the "California system" and low-cost "spray tubes". **While these simpler technologies tend to require additional labor, they also have their advantages: costs are low, water application is more visible, and maintenance is relatively simple.** Crop husbandry (weeding, inspection, protection) takes place at the same time.

Drip irrigation is widely promoted, given the high application efficiencies that can be achieved, and the reduced pumping costs that result from lower water demand. It is also **particularly well-suited to solar pumps which have relatively low flow rates (and with longer daily pumping hours)**. Drip systems are popular because they are seen to be modern by funders, politicians, and farmers alike.

Yet there are nonetheless **significant challenges in practice** and drip systems have had limited widespread successful uptake in smallholder farming in Africa. The high unit costs; the need for continued and effective maintenance; the unsuitability to high silt loads, or iron/calcium solutes in water; and costliness and low availability of spares are some of the reasons for this (i-box 7.10). It is also significant, particularly given the essential character of FLID that this guide aims to catalyze, that there are very few spontaneous adoptions of drip systems despite the numerous attempts to introduce the technology (Venot et al. 2014; Abric et al. 2019).

7.2 Diagnostic and scoring

Diagnostic

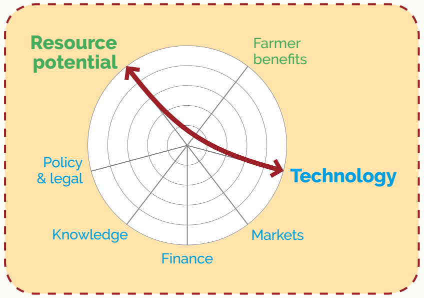
The technology and equipment diagnostic requires information on the kind of smallholder farmers who have the most potential (Module 2) and might be targeted in an intervention. It will take cognizance of the range of water and land resource contexts, and the farming types that are characterized by scale, markets, and technology. Information on technical system availability, system costs, quality variability, and national standards, is needed. This information is important for affordability assessment. The diagnostic would usually be carried out by a specialist consultant, and an outline Terms of Reference (TOR) with a scope of work is included in i-box 7.11.

Scoring the technical environment

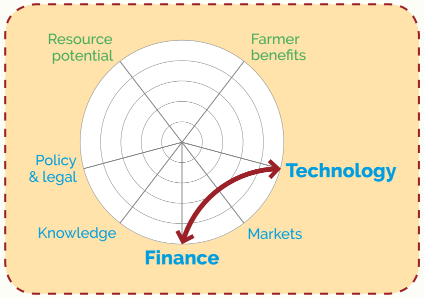
To assess the strength of the technical enabling environment, you first have to understand what type of equipment is preferred and used by farmers, what is available on the market, and what the market demand is (from the diagnostic process above). Attention must be given to technology gaps in the country, and to technologies that can fill these gaps, informed by wider regional and global experiences. Key parameters for assessment of the environment are: the degree of physical access, quality and costs of the needed (known) and potentially useful (not widely known) equipment. A weak technical environment is scored low and is where technical solutions of sufficient quality are not locally available at a reasonable price. More detailed guidance on scoring of the technology factor can be found in i-box 7.11.

7.3 Guidance on intervention planning

In countries, or parts of countries, where resources are abundant and benefits are significant, irrigation expansion can be promoted through public interventions that make irrigation equipment accessible and affordable. The type of equipment to be promoted depends on the physical characteristics of the resource base (see FLID contexts in the Main Guide Figure 1) and the kinds of farmers who are likely to be prioritized. This information is gathered in the diagnostic described in Module 2.



The possible technologies that are identified are not interventions in themselves but are the subject of interventions that are detailed in the Knowledge and Finance Modules of the FLIDguide. Two groupings of intervention principles are described: those that pertain to the financing of technology; and those that involve knowledge-exchange about technology. In all cases, best-fit technical solutions are based on consultative planning, with farmers in the lead. The best-fit technologies are then used in the intervention design process described in the Main Guide Section 6.



Intervention principle 1
Technology and finance

Foundations of a technical approach

Farmers at the center of decision-making: Interventions must take account of the full range of considerations *from the farmers' perspective* when introducing, promoting, or packaging technical solutions. Farmers' representatives need to be included in the team and farmers themselves more widely consulted. In regard to pumping technology, while GHG emission imperatives and the long-term financial advantages of solar pumps arguably justify heavy subsidies, pumping interventions will likely include both solar and fossil-fuel options to meet diverse needs. A FLID intervention also needs flexibility to allow farmers to choose their on-farm water application system from among those best suited to their physical, financial and technical realities, and their personal experience.

Awareness and balance: When farmers make technology choices, they balance their knowledge and capability set, their financial situation, and their willingness to take risks. The key, then, is to identify those technologies that are likely to **match a farmer's needs *and* ways of working, when providing information and options**. Remote monitoring systems, for example, can facilitate affordable financing through pay-as-you-go (PAYG) arrangements (i-boxes 7.8 and 7.13) while providing opportunities for the monitoring of abstractions for better water governance (Module 3). The technologies that suit farmers best will both minimize their dependence on external parties and improve their farming outcomes.

Co-dependency between tech choices and implementation realities

Technology availability, farm financial returns, financing availability, and related affordability of technology

are a critical nexus for implementation design. The type and mix of technical options to be included in an intervention, and the costs thereof, impact heavily on how the intervention will be rolled out at scale. In turn, the practical rollout realities and limitations will impact on the type and mix of technical solutions that can be included. What is easily done in a pilot project is often not possible in a rollout at scale because the human resource, physical support (vehicles, survey instruments, digital tablets, global positioning systems [GPS] etc.), and the financial absorption capacity of government administration, is simply not available.

When assessing technology options that warrant inclusion in the scope of a program, the following must be considered:

- **The diversity of farming contexts,** and whether packaging of technology into kits of some sort is warranted. Kits simplify implementation but compromise responsiveness to individual needs and preferences.

- **The capital and operational costs** over the lifetime of the equipment.

- **The experience, distribution and capability** of technology suppliers; their assessment of risks; and their willingness to engage in government-funded initiatives.

- **The capability of local government teams** who will inevitably be at the forefront of technical discussions and of driving administration and knowledge exchange with farmers.

- **Procurement realities** (at national and local government level).

Irrigation kits versus tailored solutions – implications for rollout

Technology choices must fit social realities and farmers' means. At the same time, implementation realities have limits. The decision on what kind of tech is best included in an intervention, and how it will be packaged and procured, is impacted directly by a number of factors. The wider the range of technology options supported, the more the intervention will respond to individual farmers' needs, *but* the more difficult it will be to assess individual farm suitability, to process farmers' applications in administration systems, and to procure, supply, and instal systems when implementing at scale.

Implementation using a matching grant mechanism of *a single irrigation kit* (say, targeting vegetables on a half-hectare farm located close to water) is relatively straightforward. This might comprise a solar-powered pump with a plastic transmission pipeline and a hosepipe. Perhaps a soil-water monitoring instrument is included. While such a solution would be perfect for some farmers, the kit will certainly fail to meet the diverse needs in different situations. The kit may be rejected, or part thereof will be redundant for many. This means that real opportunities will be missed, and program resources may be wasted.

On the other hand, assessment of every farmer's site-specific physical and farming preferences, with tailored technical solutions, is close to impossible due to technical capacity limitations. It requires sophisticated data processing and administration, and has complex procurement issues at scale due to many small, different systems.

Wherever public finances support technology uptake, a balance has to be found between the number and type of technical options, and the capacity of the staff and administrative systems involved.

The political willingness and fiscal strength of the country in relation to the public component of matching grants, and government experience in similar arrangements.

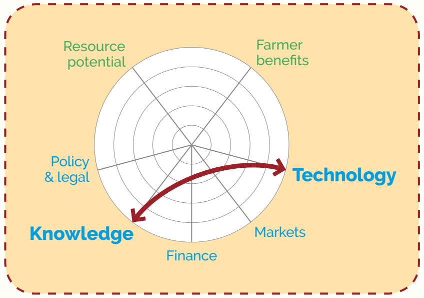
The suitability for individuals, as well as for small groups, and the subsequent irrigation water management and organizational implications that then have to be included.

The process of deciding on which technologies should be included in FLID initiatives is inevitably iterative. The implications of seemingly simple choices only emerge as the implementation processes are defined and detailed. Funding availability, affordability, legal and administrative procurement realities, and other essential rollout elements (media, on-line training, digital data collection tools, apps, etc.) will influence the technical character of interventions. Thinking ahead, assessing what is reasonable, even with program financing, support and training, and adjusting tech options and targets accordingly, is vital to success.

Understanding the range of irrigation contexts, the possible tech options and the lifetime costs is essential for implementation planning.

Intervention principle 2

Technology and knowledge



Promote farmers' own technology development

Farmers – by virtue of their need for urgent practical solutions on a daily basis, coupled with the reality of the resources available to them – are natural design innovators, practical problem solvers, and technical inventors. It would be beneficial, in intervention planning and design, to give thought to allocating resources (financial and technical backstopping where needed) for farmers to be provided with materials, and/or small construction equipment, in order to implement their own best-fit solutions. This could apply, as an example, to groups of farmers sharing their own water system (gravity canals or pumped), so that they can improve and expand their system as they see fit, based on their experience. Cost-efficient support can then be provided from intervention funds.

Co-constructed solutions

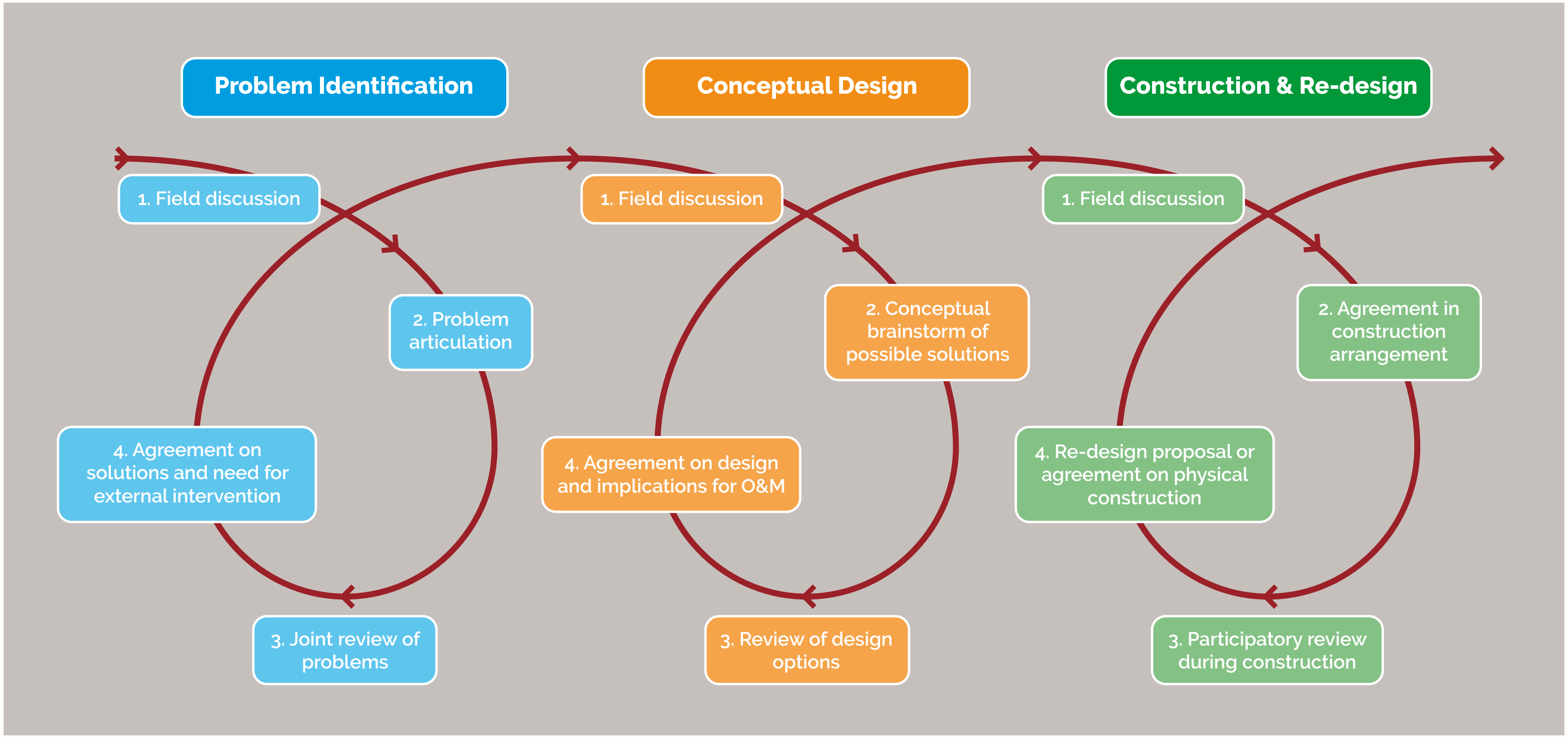
It is widely accepted that development outcomes are rarely sustained when external organizations impose technologies in developing contexts. When working with farmer groups, social heterogeneity means that poorer farmers can easily be left out, so attention to inclusion is essential. Elite capture of natural and financial resources risks worsening conditions for the resource poor. In planning interventions, it is important that solutions are co-created with representative farmers and local stakeholders (Ostrom 2007).

Projects need to budget time and resources to co-design activities that aim to increase equity in access to, or benefits from, irrigation. An

Where technical solutions involve the supply of irrigation equipment, the best results are achieved when **farmers are centrally involved in all steps of the process**: problem identification, the formulation of options, and the final setting of performance requirements.

important first step is to understand the social and economic context, such as who is excluded and why. A next step is to engage producers and local stakeholders in the co-design process to identify joint solutions that will work in their context. Producers, like other stakeholders, have specific insights and may suggest, for example, intervention sites, storage options, marketing support, appropriate financial products, or equipment adaptations. Additional participatory steps could include facilitation of input from farmer-based organizations for water monitoring and management, and from marketing groups and cooperatives, in designing indicators for monitoring and evaluation (M&E). The co-construction process is iterative, with farmers at the center, and is illustrated in Figure 7.3.

Figure 7.3 The iterative co-construction cycle (*Source:* Beekman and Veldwisch 2016)



Participatory intervention design involving farmer-based organizations that aims to reach men, women, youth and resource-poor producers effectively can also benefit from an "institutional bricolage" approach (Merrey and Cook 2012) (Module 3 i-box 3.8). Bricolage is effective in water and land governance and can also be applied to other organizational aspects of farmer-led irrigation. Another useful resource on facilitating participatory processes with agricultural communities is the Social, Technological and Environmental Pathways to Sustainability (STEPS) Center, which offers methods and tools for working with farmers.

7.4 Concluding note

The aim, in regard to the technology aspects of intervention planning, is to identify the missing or difficult-to-access technology solutions that can speed up farmer-led irrigation, while promoting farmer initiatives and investments. In this module, technologies that impact on FLID have been highlighted, and the importance of understanding how knowledge informs practice, and the outcomes from technology use, has been emphasized. Assessment of the environment that enables inclusive access to technologies and related constraints are identified from the diagnostic assessment. The strength of the technology environment is thereby scored. Best-fit technology selection for interventions must match local preferences and be informed by the benefits that can be derived in the cropping enterprises they are intended to improve.

When farmers contribute to solutions that work for their particular needs and preferred practices, they are more likely to continue using and improving those technologies. Interventions must allocate time and resources for farmer and supplier engagement in the co-construction of solutions. In this way, self-organization of the technology supply chains can be nurtured and can catalyze FLID far beyond the timelines of the intervention cycle.

i-Boxes

Water productivity

1 Increased output for the same evapotranspiration

Water productivity is about getting more output from the same amount of water used for crop production. It becomes more important at farm-level when water stress increases both at farm level and within the wider catchment. If a farmer's water supply is limited, either by physical resource availability or regulatory curtailment, that can drive him/her to find more sophisticated ways of maximizing output with the same volume of water. Stress at farm level can prompt farmers to climb up the sophistication ladder in terms of their technical system efficiency, their crop and cultivar selection, and their irrigation farming knowledge. Better agronomy and irrigation practices can significantly increase the harvestable fraction of the crop yield per unit of water. It has been shown, for example, that yields for the same evapotranspiration can vary by as much as up to five times in wheat, for example, through a range of improved agricultural practices (Giordano et al. 2017).

2 Water productivity does not equate to less water being used in the locality

While farmers may respond to water stress with sophistication in their irrigation system and their agronomic choices, increased water productivity does not mean that they will use less water. Behavioral factors come into play. It is well established that increased technical system efficiency, and increased water productivity, do not necessarily lead to reduced abstraction by farmers from the available resource (if physically available) but often leads to the opposite (Perry and Steduto 2017; Optsal et al. 2020). The reason for this is that greater water productivity means that the unit cost of water is lower per unit of crop produced. The consequence of the lower cost of water is that, unless regulation and compliance measures are effectively in place, then the increased water productivity tends to incentivize more production. It is relatively cheaper for a farmer to pump more water to expand or intensify their output. The introduction of more sophisticated application technology, such as drip irrigation, with higher efficiencies, is associated with a similar behavioral trend (Perry and Steduto 2017).

3 Real savings need combined agronomic, technical and governance interventions

To achieve real water savings through increased water productivity, beyond the boundary of the irrigation farm itself, intervention design needs to focus on three elements together (Opstal et al. 2020).

1. **Invest in irrigation agronomy** to increase the harvestable yield for the same water-use (better varieties, reduce weed growth, better fertilization and disease management, reduced water stress through soil-water management, and strategic planting times). Farmer field schools can play an important role in this aspect (Module 4).

2. **Make sure that abstraction measurement, control and enforcement** (through both technical and water governance

interventions) are part of interventions where water is stressed (Module 3).

3. **Reduce the non-recoverable fraction of return flows** by minimizing open water evaporation (ie. get tailwater on the farm back into the streams). This can be achieved through better technical design practices and inclusion of these aspects in knowledge interventions.

Summary of technologies

Farmers' technology preferences are informed by many factors that include: their experience, crop type, capital cost, operating cost, other existing technology on the farm (pumps and tanks), labor availability, access to spares, water quality, security, cultural norms and social/family commitments. There are few technology solutions that will be applicable to every farmer's situation. Not only do their needs differ widely, but they change over time. Some famers may progress from rudimentary technology to more complicated systems as their enterprise grows in size and sophistication; others may choose to stay with a (basic) technology that works for them and their farming strategies. A summary of common technologies is presented in Table 1 and further technical details and indicative costs are included in the Module 7 i-boxes that follow.

Table 1 Summary of common smallholder irrigation technologies and challenges

Technology type		Applications and advantages	Challenges
Water-lifting	Buckets, watering cans	■ Can be started with little cost and risk. ■ Water source close to the field. ■ Portable. ■ Smallest of micro-scale irrigation options (10 – 100 m²)	■ Labor need for applying water is high but there is no maintenance. ■ At peak crop-water requirement, work is intense, and farmers may not be able to keep up with demand. ■ Often used with low-yield water sources which may not be enough when shared by multiple farmers.
	Rope and washer pumps	■ Usually installed as a community facility for household supplies but can be used for irrigation by farmers who have a suitable water source nearby their field. ■ Suited for borehole or well applications when lifting water from less than 30m depth. ■ Fixed position pump. ■ Small-scale irrigation, depending upon power source and depth of 100–1 000 m².	■ Labor requirement is high if the pump is human powered. However, they can be powered by motors (solar or fossil fuel) and by animal use. ■ The water source needs to be close to the field unless a gravity pipe system can be used to transfer the water to the field. ■ Needs regular maintenance. ■ Parts (usually the valves) may not be locally available.
	Hand pumps (lever action)	■ Usually installed as a community facility for household supplies, but the water can be used for irrigation by farmers who have small plots around their homes. ■ A fixed-position pump that typically draws from boreholes or wells of less than 80m depth. ■ Smallest of micro-scale irrigation (10–100 m²)	■ If a communal pump, irrigation use is unlikely due to competition with household water users. ■ Heavy labor requirement. ■ Unlikely to be specifically installed by a single farmer for irrigation use. ■ Maintenance with associated technical skills is needed and parts may not be locally available.

Technology type		Applications and advantages	Challenges
Water-lifting	Treadle and hip pumps	■ Foot- or hand-operated pump specifically designed for irrigation where the movement is ergonomically designed and makes it easy to pump for prolonged periods. ■ Can only be used with surface water supplies but produces pressure that can be used with a pipeline to the field and/or sprinklers. ■ Portable pump. ■ Low cost. ■ Medium-scale irrigation 1 000–10 000 m^2.	■ Labor requirement is intense. ■ Easy to repair, minimal seasonal maintenance.
	Petrol pumps	■ Widely known, cheap, highly mobile. ■ Easily serviced and easily maintained locally by motorcycle mechanics. ■ Can also be used easily in a rental mode due to their mobility. ■ Easily transportable on a motorbike. ■ High flow rates and can irrigate large areas 1–5 ha. ■ Mixed ownership arrangements are possible – can be one farmer, shared or rented. ■ Can only be used when water is close to the surface (max 7 m below ground).	■ Regular (monthly) maintenance required. ■ High fuel costs. ■ High operational costs (fuel, oil and spares). ■ Short lifespans (1–2 years). Environmental pollution.
	Diesel pumps	■ Same function as petrol pumps but more expensive to purchase. ■ Less expensive to maintain than petrol (spares), use less fuel and are more robust than petrol pumps.	■ High operational costs (fuel and oil). ■ Environmental pollution.
	Solar pumps	■ Minimal maintenance and running costs, seals and minor electronics replacement needed after a few years. ■ Assessments show that net financial returns are between two and three times better with solar than petrol, with payback periods of between one and three years. ■ Very attractive where petrol/diesel is expensive and/or difficult to access. ■ Smaller systems (<0.5 ha) are portable and trolly arrangments are made for slightly larger systems. ■ Electricity can be multiple use – to run cellphone chargers, lights in off-season etc. ■ Can be either surface water or borehole/well pumps. ■ Medium-scale irrigation 1 000–10 000 m^2	■ Can only operate during full sunlight i.e. 6–7 hours/day so there is less flexibility in terms of irrigation activities. ■ There is limited knowledge of solar-pump technology among both farmers and suppliers. Leads to less supply/marketing and farmers need more training than with petrol pumps. ■ Although lifetime costs are advantageous, the upfront cost of solar is much higher than petrol.

Technology type		Applications and advantages	Challenges
Irrigation application	Watering can	■ Low cost and easy to use. ■ Associated with growing high value crops like vegetables and often used in communal gardens. ■ The water source needs to be very close (edge of the field/garden) to reduce the labour. The water can be in ponds or from a supply pipe. Water is usually not over-applied due to the labor required.	■ High labor requirement. ■ During peak crop-water demand the water source may not be enough when shared by multiple farmers. ■ Some of the lowest value crops may be abandoned in peak demand times though with experience farmers work out how to balance supply and demand.
	Short furrow	■ Short furrows are 5 to 10 m long and are level. They are effective as long as they are not on steep land or very sandy soils. ■ High application efficiencies (> 80%) when there is experience and good water application management. ■ Furrows are low cost – mainly labor only (though can be mechanized) – and can easily be rearranged for different crops. ■ Best used with gravity-fed systems that can sustain high flow rates. ■ In the watering activity, farmers pay close attention to crop health. ■ Well suited to petrol and diesel pumps.	■ Considerable skill is required in the layout and operation of short furrows to get effective watering over short time periods. ■ More labor required than for sprinklers or drip systems. ■ Crops can easily be waterlogged leading to poor root development and fertilizer leaching. ■ Use on land that is too steep or on sandy soils leads to ineffective irrigation.
	Hosepipe	■ Very good entry point technology for farmers. ■ Can be used on varying slopes and soil types more easily than furrows. ■ Hoses are low-cost and portable so avoiding theft or vandalism problems that can occur with sprinkler and drip. ■ Similar time requirement as for irrigation with furrows, though less arduous. ■ In the watering activity, farmers pay attention to crop health and are more attuned to volumes of water applied than with sprinklers and drip. ■ Can be used with solar and petrol pumps.	■ Maintenance cost is minimal, but more labor is needed than with sprinklers or drip systems, ■ Under or over watering can easily occur. ■ Tendency to wet foliage which can lead to fungal and other problems.
	Sprinklers (5–15 m Radius)	■ These classical conventional sprinklers are usually in small sets (2–5) and are moved around the field in a weekly or bi-weekly cycle depending on the soils, crop and crop water demand. ■ Reduced labor compared to hosepipe or furrows, but fuel costs are comparable. ■ Can be used with solar and petrol pumps, but better suited to petrol pumps that typically have higher flow rates.	■ Poor coverage of water where farmers do not understand the wetting pattern and spacing requirements properly. ■ Wetting of leaves can lead to fungal diseases. ■ Breakages and thefts lead to reduced capacity systems.

Technology type		Applications and advantages	Challenges
Irrigation application	Rain-gun (30 m Radius)	■ Large capacity single sprinklers can cover a greater land area with a lower capital cost and less labor than smaller sprinkler sets. ■ Suitable for more robust crops that will not be affected by large droplet sizes and mud-splash on leaves.	■ Reduced labor compared to the smaller sprinkler sets but higher fuel costs due to higher operating pressures. ■ Poor coverage of water due to farmers not understanding the wetting pattern. ■ Poor performance in windy conditions. ■ Wetting of leaves can lead to fungal diseases. Can degrade soils due to large droplet sizes and high water application rates. ■ Not suitable, in practical terms, for solar pumps.
	Spray tubes/ lines & microsprinklers	■ These systems are set in place with main and lateral pipes. ■ They are suitable for well-established farmers who have an established layout of crops, especially permanent or semi-permanent crops like strawberries and trees. ■ Labor requirement is minimal. ■ Can be used with solar and petrol pumps.	■ Damage to the spray and micro sprinklers by animals or blockage due to particles in the water or by ants. ■ Replacement costs of plastic pipelines every five years can be high.
	Drip	■ Most suitable for farmers with experience of irrigation. The farmer needs good experience of irrigation, crop agronomy and the financial stability to purchase and maintain. ■ Reduced pumping costs result from lower water demand. ■ Particularly well-suited to solar pumps which have relatively low flow rates and longer daily pumping hours. ■ Labor is minimal and efficient. ■ Can be used with petrol and diesel pumps.	■ Sophisticated understanding of the technology, and substantial skill is needed to operate and maintain successfully. ■ Requires substantial training and back-up to get the full potential benefits of use as not only water but also fertiliser (fertigation) should be applied to optimize investment in the system. ■ Equipment needs careful handling and maintenance and replacement after 5 years. ■ Spares are often not available at local level. ■ Irreparable damage often occurs due to: 1) animals chewing the drip lines 2) drip lines becoming blocked with soil or other particulates due to inadequate filtration 3) drip lines becoming blocked due to chemical precipitates 4) removing and storing the driplines to allow for tillage

Technology type		Applications and advantages	Challenges
Irrigation application	Wetting front detector	Helps farmers to manage water and nutrients. Devices inform the farmer about fertilizer retention in soil, or whether it is being leached out. Water management in the root zone can be effectively managed – whether in simple furrows or sophisticated drip systems. ■ Cheap and affordable with benefits quickly evident ■ Cross-learning between farmers on both the system's operational use and on water management practices is rapid. ■ Major benefits in terms of labor savings, lower fertilizer use, reduced pumping costs and reduced agricultural pollution (less deep percolation). ■ A doubling and tripling of yields, and of gross margins, is recorded in multiple countries and farming contexts across Africa.	■ Farmers need training and have to plan and allocate time to take measurements. ■ Purchase of ongoing nitrate measurement kits is needed for fertilizer management, and availability may be limited.
Soil-water management	Soil-water sensors	In practice, farmers often irrigate with fixed amounts, or at a constant intervals, with little regard for variability in weather conditions and actual crop-water requirements. The generalized observation is the tendency to over-irrigate in the early and late stages of crop growth but under-irrigate in mid stages. The benefits of managing soil water are substantial in water, productivity and financial terms. These benefits result from: ■ Reduced fuel consumption and costs when using petrol/diesel pumps ■ Reduced wastage of fertilizer through deep percolation ■ Reduced labor requirements by irrigating less frequently and only when needed ■ Increased crop productivity and yields ■ Increased profitability through reduced costs and increased production.	■ Farmers need training and have to plan and allocate time to take measurements for the systems to yield benefits. ■ The main reasons for non-adoption of technologies include the difficulty and high cost of using older generation tensiometers, and the perception that scheduling provides little benefit. New generation instruments have overcome this limitation.
	Remote sensing tools	Estimates of crop-water status and health can be made by remote sensing. This is undertaken remotely from the farm and information is delivered to the farmer about when to irrigate or fertilize. ■ Needs good communication, i.e. smartphone and high level of understanding by farmer and supplier. ■ No burden on the farmer but the service has to be paid for by the farmer or NGO/government.	■ Only suitable for farmers with large contiguous blocks of single crops, e.g. minimum 1 ha of a single crop in a single field. ■ The farming style and the technology are not compatible and the communication between farmer and information supplier is ineffective.

Soil-water management technology examples

Examples of robust, cost-effective and simple monitoring instruments are those developed by Australian scientists at the Commonwealth Scientific and Industrial Research Organization (CSIRO): the Chameleon soil water sensor and the Wetting Front Detector (WFD). Information below is provided by the Virtual Irrigation Academy (VIA).

What is the Chameleon Card starter kit?

The Chameleon Card measures soil sensors using colored lights to tell you when to irrigate. The Chameleon Card starter kit (shown in Figure 1) lets you know how hard the plants must work to extract water from the soil. The kit consists of a reader, that looks like a credit card, plus three sensors. The reader on the Chameleon Card has a light (see Figure 2) which changes color in response to the soil water status.

- Blue means the soil is wet (do not irrigate).
- Green means the soil is moist (get ready to irrigate).
- Red means the soil is dry (plant experiencing water stress).

The sensors can be buried in three different fields, or at different depths in one location. Simply touch the wires against the contact pads on the reader and the light will change color to show the soil water status. It could not be simpler.

Figure 1 Chameleon Card starter kit

How does it work?

The sensors measure soil water suction, or how hard it is for a plant to extract water from the soil (like a tensiometer). They do not need to be calibrated for soil type. Whether the soil is sandy or clay, blue means the soil is adequately wet and red indicates the need for water.

The Chameleon Card contains a micro-processor and LED and is powered by a watch battery which will last for at least 1 000 readings. The battery can be replaced. Rigorous testing of each batch of sensors in a modern laboratory ensures accuracy.

Figure 2 The Chameleon Card

Farmer's Testimony

Figure 3 Farmer holding a Chameleon Card

"I am set to earn Tsh 5 124 000 (about USD 2 329) from yellow bell pepper from just a 0.5 acre. I have already started harvesting 10 bags monthly. It is not magic; it is about relying on the Chameleon monitoring tools to determine when to provide water and manage the use of fertilizer."

- Robert Chiliwa, (Farmer from Tanzania)

What is the Wetting Front Detector?

The Wetting Front Detector shows you how deeply water infiltrates into the soil and helps you to save fertilizer.

The Wetting Front Detector helps you to "see" what is happening down in the root zone when you irrigate the soil. Wetting Front Detectors are plastic tubes (shown in Figure 1) which are buried in the soil at the bottom of the root zone and pop up an indicator to show when the infiltrating water goes past. They also capture and store a sample of water from the wetting front.

The Wetting Front Detector can be used to:

- Find out if you are irrigating too little or too much
- Assist in the management of fertilizer and salt
- Show if the soil is water-logged

A water sample can be taken from the Wetting Front Detector, using the syringe that is supplied, and tested for nitrate nitrogen using simple paper strips to measure the soil fertility. This then informs the farmer a) whether they are leaching nitrate out of their root zone and b) whether they have any nitrate in their root zone for the plants. Whether you are using mineral or organic fertilizers, nitrogen (nitrate) is the key nutrient to monitor, as it is easily washed out of the root zone. The color strips show how much nitrate is in the soil by turning white (no nitrogen content) or pink or purple (high nitrogen content).

Figure 4 Wetting Front Detector kit

Soil-water management technology – benefits

Management technology triggers benefits

Smallholder irrigation water and fertilizer management is rarely optimal in African contexts. This negatively impacts crop productivity, labor demand, energy use and water abstractions. Yields and profits suffer. Understanding management by answering "when and how much to irrigate" is key to improving irrigation management, reducing fertilizer wastage, and increasing water-use efficiency. Accurate monitoring of water in the root zone allows farmers to vary the timing and amount of water applied, based on crop-water consumption that varies with crop development stage and daily changes in rainfall and evapotranspiration. Improved irrigation scheduling further reduces fertilizer loss and so improves yields and reduces environmental pollution (Van der Laan et al. 2015; Jacobs et al. 2014; Stevens et al. 2005; Senzanje et al. 2003).

Well-informed, adaptive irrigation scheduling is not practised by most smallholders **because they lack the equipment and knowledge to understand the status of water across the root zone soil profile.** It is almost impossible for farmers to know whether they are retaining fertilizer in their soil or leaching it out. Monitoring equipment ranges from simple mechanical sensors to multi-depth continuous recording electronic sensors with web-based data access. The main reasons for non-adoption of technologies include the difficulty and high cost of using older-generation tensiometers and the perception that scheduling provides little benefit (Myeni, Moeletsi, and Clulow 2019; Olivier and Singels 2004). While sophisticated technologies abound, there are only a few suitable, robust and cost-effective instruments on the market (Figure 1).

Figure 1 Soil water management instruments need to be simple to use and affordable to catalyze FLID processes.

In practice, farmers often irrigate with fixed amounts, or at a constant interval, with little regard for variability in weather conditions and actual crop-water requirements. The generalized observation is the tendency to over-irrigate in the early and late stage of crop growth but under-irrigate in mid stages. The benefits of managing soil water are substantial in water, productivity and financial terms (Chilunda et al. forthcoming; Moyo et al. 2020; Schmitter et al. 2017). These benefits result from:

- Reduced fuel consumption and costs when using petrol/diesel pumps.
- Reduced wastage of fertilizer through deep percolation.
- Reduced groundwater pollution from nitrates and agricultural chemicals through less deep percolation.
- Reduced labor requirements by irrigating less frequently and only when needed.
- Increased crop productivity and yields by ensuring close to optimum water availability in the root zone and avoiding water-stress.
- Increased profitability through reduced costs and increased production.

- Expanded irrigated areas with the same equipment and labor due to overall lower irrigation applications.

Willingness to pay for the instruments was also found to be high despite their cost (approximately USD 100 to 200 per farmer), because farmers witnessed the gains that could be made (Resilience BV 2020). **Importantly, improving crop production was not achieved only by introducing technology, but included farmer-to-farmer knowledge-exchange processes** such as those described in Module 4.

Case Narratives

Case 1 – Crop productivity increased five fold in Zimbabwe

In Zimbabwe smallholder farmers in two smallholder schemes (Mkoba and Silalatshani) were provided with easy-to-use tools to measure their soil water and nitrogen content. Their water productivity went from a low 0.19-0.2 kg/m^3 to 1.00–1.28 kg/m^3 two years later (Figure 2). That is a 5 to 6-fold increase. Interestingly, even farmers not given the tools increased their water productivity to 0.69–0.95 kg/m^3 by learning from those with the instruments (Schmitter et al. 2017).

Zimbabwe

Crop water productivity in maize increased from 0.2 kg to over 1 kg/m3 in 2 years of use.

Case 2 – Water use in Ethiopia drops by a third

In Ethiopia farmers using tools to manage irrigation in their wheat fields achieved spectacular results. According to key farmers, they extended the irrigation cycle from the local storage reservoirs from 8–11 days to

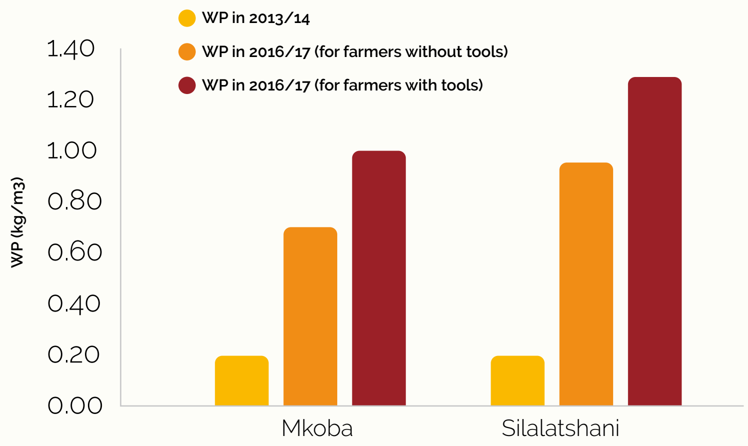


Figure 2 Water productivity (WP) before and after the introduction of the tools, for farmers with and without tools (Moyo et al. 2020)

12–13 days – effectively a water-use reduction of 35%. With reduced water applications the wheat crop yield also went up by 10–20%. The gain in terms of water productivity or "crop per drop" was high at 75%. The farmers noted that improved water management resulted in a faster rotation among water users in the same group – and a decline in water-related conflicts. The saved water was used to extend the area under cultivation (Van Steenbergen and Schmitter 2020).

Ethiopia

Water abstraction for wheat was reduced by 35% while yields increased by 20%.

Case 3 – Half the labor and with less water needed in Mozambique

In a Mozambique smallholder irrigation scheme half the green maize growers were provided with the easy-to-use tools to measure their soil content and soil nitrogen. The changes in irrigation water management were tracked over six seasons. The number of irrigation events declined rapidly both for those with and without the instruments – a 40% decrease for the farmers with, and 14% for the farmers without. In addition, the farmers reduced the duration of irrigation from 4.6 hours at the beginning to 3.2 hours by the end. In the first season the irrigation applied was roughly the same for both groups. This combination of fewer and smaller irrigation events resulted in 38% decrease in the irrigation water applied. The improved irrigation also resulted in massively improved yields (see Figure 3 below) (Chilunda et al. forthcoming).

Mozambique

Labor for irrigation was reduced by 31%, water use by 38%, and gross financial margins increased nearly 4 times. Cash value of savings averaged USD 300/annum.

The benefits of reduced irrigations and increased yields resulted in farmers with tools increasing their gross margins by 370%, and those without tools by 250%. As with other similar interventions, these gains cannot be attributed to the instruments alone, as they were accompanied by farmer-to-farmer learning on better irrigation practice and agronomy, that is also reflected by the progressive increase in yields over time for farmers both with and without instruments. Those without instruments or tools learnt from neighboring farmers using the instruments or tools.

In a separate study in other horticultural crops in the Chimoyo locality involving nine farmers, it was found that equivalent cash savings due to the use of the equipment was USD 880/annum (Resilience BV 2020). Eight of the farmers were willing to pay up to USD 180 capital cost for the Chameleon Technology without any subsidy or support, because they witnessed the direct benefits. That willingness is indicative of the technology value to smallholders.

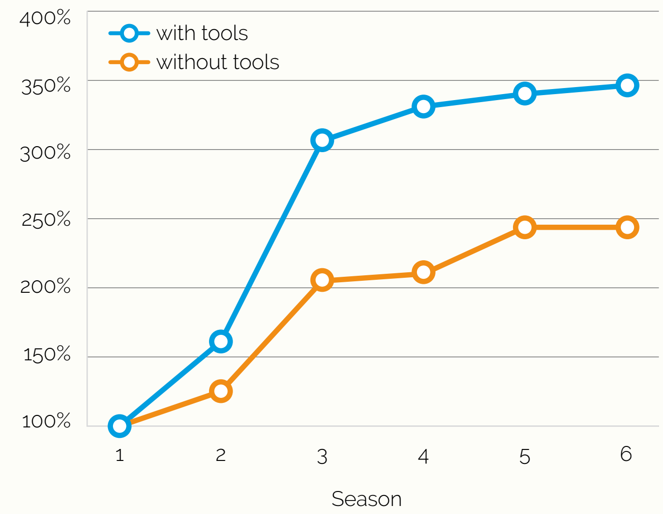


Figure 3 Relative yield of green maize over six seasons with and without management instruments in Mozambique (Chilunda et al. forthcoming)

Comparative capital costs of solar versus petrol for irrigation

Upfront costs of solar are high and widespread uptake depends on affordable financing and/or subsidies. There are significant challenges in relation to financing of solar pumping systems. The capital cost is high, technology quality and access can be limited, and quality and backup services may be weak or absent. In Sahelian countries and in East Africa, for example, **the entry price for (low quality) petrol pumps** is six to seven times less that of **entry-level solar systems** that are of much smaller flow capacity (Abric et al. 2019). The costs for **comparable** systems in terms of their ability to service irrigation demands (i.e. meet the same crop water demand per hectare) is between 10 to 15 times the initial purchase price depending on quality. The reason for the large price differential is that in purchasing the solar panels, the farmer is purchasing all of their energy upfront for the next 10 to 15 years. Indicative costs for different systems are shown in Table 1.

Table 1 Pumping energy options and advantages (indicative costs in USD from authors' field notes)

	Human-powered pump	**Petrol pump < 3 HP**	**Solar pump < 1 HP**
Upfront cost	USD 60 to 200	USD 100 to 200	USD 600 to 4500
Operational cost	Food or labor cost to pump	0.5 to 1.2 USD/hour or 0.05 to 0.12 USD/m^3	Effectively zero
Maintenance cost	Seasonal	Weekly or monthly (oil drainage)	Seasonal or yearly
Pumping depth limit	7 m for treadle pumps and up to 15 m for rope pump (low volumes – not ideal)	Maximum of 7 m but up to 10 m if the pump is lowered (excavation to a lower platform for the pump)	0 to 80 m with a decrease of flow with the depth
Operating flow	1 to 3 m^3/h	5 to 15 m^3/h	1 to 15 m^3/h
Pumping time	Any time	Any time	6 to 7 hours per day
Lifetime (years) – sensitive to sediment load and maintenance frequency	2 to 5	2 to 5 (2 500 to 3 500 running hours)	Surface pump 3 to 5 Submersible 5 to 7 Controller 3 to 5 PV panel 15 to 20
CO2 emission	0 kg	60 to 110 kg/crop season for 0.1 ha	0 kg
Level of adoption in countries	A hundred to a thousand pumps	Tens of thousands	Nascent but accelerating
Suitable for	Drip with elevated tank, spray hose	Furrow/basin combined with Californian system, spray hose, spray tube, sprinkler (low pressure)	Drip without elevated tank, spray tube, water can with water storage, low pressure sprinkler

HP: horsepower

Comparative benefits of solar versus petrol for irrigation

Comparative lifetime benefits of solar irrigation versus fossil fuels are generally positive but highly sensitive to assumptions – rigorous analysis for irrigation is scarce. Comparisons of lifetime cost estimates in domestic water supply are well documented and show between two and ten times the benefit for solar systems versus fossil fuels (Global Solar and Water Initiative [GSWI] 2018; Energy Sector Management Assistance Program [ESMAP] 2017). The wide variation is linked to differences in the lifecycle (10 or 20 years) and the inclusion, or not, of lower greenhouse gas (GHG) emissions and other benefits.

There are few detailed comparative assessments in irrigation and rigorous analysis seems to be a gap in the literature. There are many more variables to consider (climate, crop type, monthly variation in demand, irrigation application type, cost of financing, and subsidy effects, etc.). Unlike domestic water supply that has a consistent water demand, irrigation demand tends to vary greatly across the year and this has the effect of reducing the comparative net benefit of solar versus fossil-fuel pumping. The electrical power generated by the photovoltaic panels is partly redundant in the off-peak months. While the residual electrical power is potentially available for other beneficial uses, distance from panels (located at the pumping site) to the point of use (such as a homestead), and the inconsistent availability of supply over the year for other uses, tends to limit the residual value in practice. Costs of equipment in different countries also vary widely.

The net financial benefits for a horticultural crop enterprise can be two to three times better for solar when compared to petrol where financing costs are modest.

Numerous anecdotal narratives, from suppliers and NGOs among others, do show consistently positive and noteworthy savings when a switch is made from petrol to solar pumping. In Kenya, enterprise benefits of between 235% and 350% were recorded for farmers switching from petrol to solar systems with loan finance at 15% (Winrock 2015, 2016). These kinds of gains were confirmed in a comparative study conducted by the authors in Uganda that showed net financial benefits for horticultural crops that were approximately double for solar compared to petrol pumps over a 10-year lifecycle (zero subsidy or loan). The Uganda analysis is conservative compared with many other African countries, as the cost of equipment was comparatively high there, given that the Uganda solar-technology market is nascent. Solar equipment in Kenya, for example, was assessed to be approximately two-thirds the cost in Uganda, with petrol equivalent in USD terms, aligning the higher Kenyan results (Winrock cases) to the Ugandan findings. Inclusion of GHG and other environmental benefits such as reduced pollution from fossil fuels and oils, would have the effect of increasing the relative benefits even further. High interest rates, absence of subsidies for solar, assumptions of short lifecycles in the assessment, and low crop-water demand (equating to low petrol consumption), all contribute to petrol pumping competitiveness. The point here is that **rigorous country and farmer-specific analysis is needed to quantify the comparative farm-level benefits of solar pumping.**

Solar pump indicative costs and selection considerations

A wide range of solar pumps is on the market for almost any situation, at different prices and various capacities. Each component of the solar irrigation solution must be considered in order to know the implication in the choice of a pump.

Water availability – knowledge of the water flow and depth are essential

The flow of the water resource will tell you how much surface you can irrigate, according to the water requirements of the crops, and which water application can be used depending on the operating flow rate. The flow can be high for surface water (river, stream, pond, dam reservoir) beyond 50 m^3/ha, but variable during the season. Yield of underground water is often limited by hydrogeological conditions and the type and quality of construction of water infrastructures (well, borehole). From Northern Nigeria (Fadama), to the large fossil valleys

Table 1 Type of solar pumps most commonly used for irrigation depending on water availability.[1]

	Mobility	Water availability (m^3/h)	Volume (m^3/day)	Volume x TDH (m^4)	Price (USD)	Irrigated surface per day (m^2/day)
Submersible	Yes	1	6	90	500 to 1 500	750 to 1500
Surface	Yes	2	12	90	1 000 to 1 500	1 500 to 3 000
Submersible	Yes/No	3	18	270	1 500 to 2 500	2 500 to 4 500
Submersible	No	5	30	450	2 500 to 4 500	4 000 to 7500
Submersible	No	10	60	900	4 000 to 6 500	8 000 to 1.5 ha

TDH: Total Dynamic Head

Volume x TDH in m4 facilitates the comparison between different pumping conditions

Irrigated surface per day for a range of water applications from 4 to 8 mm with the use of efficient irrigation methods (basin and spray can, spray hose, drip, spray tube)

1 Table 1 is a compilation of data collected from West and East Africa for the most common situations encountered on project experiences (authors' field notes). The range of results emphasizes the importance of the context.

in Niger (Dallol), and the coastal areas of Benin, Senegal and Togo, the shallow aquifer (< 10 m) in sandy soils is highly productive beyond 10 m^3/h. In consolidated soils and metamorphic geology, encountered everywhere in Africa, the yield of the shallow aquifer is rarely beyond 1 m^3/ha and can reach 5 m^3/ha at great depth (30 to 60 m) in bedrock fractures, through using heavy mechanized drilling machines.

The flow rate of the water resource guides the type of pump: helical or piston when the flow is less than 3 m^3/ha and centrifugal when it is higher. Submersible pumps have no depth limit and can be installed for surface water (horizontally if the water level is low), or in a well or borehole. The depth limit for the use of surface pumps is 7 m but can be lower where the pump is installed below the level of the ground (by means of an excavated platform with an access ramp).

Application methods and pump type

Water application systems are important in the choice of a solar pump. High pressure and flow will increase the cost of the pump and the solar generator. Low operating pressure and efficient irrigation methods are the preferred solutions, but not the norm, as it depends on the context of the irrigated plot. When the water contains fine particles, filtration is mandatory but increases the need for pressure and maintenance to prevent clogging. In this case it is preferable to use a less efficient irrigation technique to facilitate adoption by the users.

Table 2 Type of water application systems and their efficiencies

	Furrow/basin	Spray can	Spray hose	Spray tube	Sprinkler	Drip
Saving water						
Operating pressure			orange/red			
Labor intensity					green/orange	
Ease of adoption						
Affordability					orange/red	
Sensitivity to silt				green/orange		
Solar compatibility						

General guidance on the applications and use of solar irrigation pumps and systems

Small stand-alone solar systems

Solar pumps come in two categories: suction type or submersible. The suction-type pumps cannot lift water from more than 6–8 m below ground but there is no physical limit to the lift above ground. In some cases suction pumps can be lowered into the well (if the diameter of the well allows it) to enable the extraction of water from up to 10–12 m depth. This could be particularly advantageous when the ground water level drops towards the end of the dry season. Manufacturers of portable solar surface pumps are few in number, such as Ennos and FuturePump, with distributors in Asia and Africa. Submersible pumps are, as the name implies, submerged in the water, so there are no suction issues. These pumps are widely available on the market from various manufacturers. The 2019 Global LEAP Awards Buyer's Guide for solar pumps gives a partial overview of manufacturers and models according to flow and head ranges.

Shared group solar systems

Communal systems are generally heavy in infrastructure costs and highly prone to failure due to dependence on a single solar pump. Since one large pumping system is expensive, users cannot replace it once it is broken. The REGIS-ER (Niger and Burkina Faso) project showed that both the infrastructure cost and risk of failure can be reduced by using several shallow tube wells and small solar pumps instead of one large pumping system on a deep borehole. If one pump fails, there is still water from the other solar pumps.

Mobility issues and solutions

Pumps and lightweight panels, if left in the field, can easily be stolen. The portability of the pump and panel is thus an asset, depending on weight and size. Submersible pumps are more fragile and difficult to transport. In general, the size of the solar panels and length of pipes makes transportation more difficult than the pump itself. Beyond 250W panels, the pump becomes very difficult to move in remote areas. Here the efficiency of the pump plays a role. A highly efficient pump can deliver the same amount of water per day with the power from a smaller panel, whereas an inefficient pump will need a bigger panel for the same output.

Solar spares and maintenance

For cheaper solar pumps, spare parts are simply not available, and even if they were, it is often not possible to open the pump to replace parts full of electronic components. If it breaks down, you have to buy a new one. The lifetime of these pumps depends on intensity of use and quality of water. A high sand content in the water can wear out a pump very quickly in a year, as is the case in Senegal in the Niayes region, even with expensive European brand pumps.

If a pump is designed with repairability in mind, a minimum of local know-how and available spare parts will be required to keep it running for many years. Futurepump SF2 model comes with a five-year warranty and a set of spare parts. Despite these precautions, many causes of failures are due to misuse or poor maintenance by farmers, as reported by SISAM program on 100 installed solar irrigation pumps in Benin, Burkina Faso and Togo.

Solar design guidance and conceptual pitfalls

The choice of a solar pump depends on the specifications for each component of the solution. Different configurations are possible depending on the context.

Unlike a petrol-driven pump, a typical solar pump has no surplus capacity. It can only deliver so much water per day and running it for more than 8 hours a day is not possible. In practice, the output of a solar pump is limited to 6–7 hours at full capacity per day. The capacity of the pump should be such that it can deliver enough water to cater for the peak needs of the plants.

Water storage in an elevated tank is not mandatory. A solar pump can be connected directly to irrigation equipment as long as the pressure and flow rate are sufficient to operate it as recommended. This has been documented by field experiences in Senegal, where 70% of the volume of water in a day was applied by spray tube or drip in acceptable conditions. The remaining volume is stored in small ground basins (2 m^3) for irrigation with a spray can, giving a good combination of modern and traditional irrigation methods (Video).

Oversizing the panels usually means that the pump starts operating earlier in the day and continues to operate longer in the afternoon. It is a way to increase the number of hours in the day during which flow and pressure are sufficient to irrigate directly without water storage. Performance will also be less affected by cloudy conditions, but the investment in panels will be higher. In Madagascar, the experiences conducted by the Integrated Growth Pole Project (World Bank) in a commercial farm (13 ha), showed that it is possible to irrigate the entire surface without water storage from three solar pumps supplying water to sprinkler, drip, and travelling big gun.

An advantage of small solar pumps is that the solar panel can easily be moved to be pointed at the sun throughout the day. This will give about 25% extra output per day as compared to fixed panels. An automatic sun tracker is an option but not affordable.

The use of batteries allows irrigation at any time of the day with no variation in pumping conditions. This option is not recommended because of its high cost, short lifespan, heaviness to transport, and lack of recycling capacity. However, technology is evolving rapidly and new generations of more efficient batteries are appearing on the market, though at this stage still too expensive. In the next decade we can expect a significant decrease in the cost of energy storage similar to that recorded for solar panels.

Report on Solar Irrigation Powered System gives an extensive overview of the state of the technology in terms of the water-lifting, energy supply and irrigation system components, its economics, ecological boundaries and management requirements as well as potential and barriers.

Alternative effective water application systems for FLID

Hose and spray can – example of effective irrigation in practice

Labor is widely available in communal gardens and the irrigated surface per person is relatively small. In the REGIS-ER project 44 solar pumps were installed at communal gardens in Burkina Faso and Niger. Several application set-ups were installed, and the most popular was to pump water directly to the field using a flexible hose. The second preferred option was to fill basins that could be used by many farmers at the same time to fill spray cans. Despite being labor intensive, such simple methods seem to be more durable than complex solutions like drip irrigation and easy to manage for collective irrigation for small plots.

Spray tubes

Since 2015, in the coastal area of Benin and Togo, well known for intensive vegetable production, the spray tube (mist irrigation with perforated tubes) is quickly spreading without any external support. Gradually it is replacing or co-existing with other efficient methods (spray hose and sprinkler), because of its simple installation and use, energy saving (less pressure) and low cost. By changing the context in Burkina Faso the retail price becomes 3 times higher. Modelling a new import business model in Senegal, involving a large farmers' association in the supply chain which links an Asian manufacturer to customers in the field, makes the spray tube affordable for farmers, even cheaper than at the cost found in Benin.

California system (low-cost piped to simple outlet box - surface irrigation)

Californian system is the perfect example of non-invasive technique without changing farmer practices. The earth canals to convey water are replaced by buried PVC pipes with several outlets located as close as possible to the irrigated basins or furrows. It can reduce by 30 to 40% the pumping time, including fuel and labor expenses, while increasing the irrigated surface. Saving water in the conveyance system has a major impact on the global irrigation efficiency of the system from pump to plant roots. Its simple design, low cost, and easy application makes the Californian system popular among farmers since its introduction in Mauritania (VISA project) and Niger (PIP2 project). Californian system is the perfect example of non-invasive technique without changing farmer practices. The earth canals to convey water are replaced by buried PVC pipes with several outlets located as close as possible to the irrigated basins or furrows. It can reduce by 30 to 40% the pumping time, including fuel and labor expenses, while

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Challenges with drip irrigation technology

While drip irrigation has advantages in application efficiency if well maintained, and will be relevant to some smallholder farming contexts, caution is needed with regard to widespread promotion regardless of context. Drawing from Venot et al. (2014) and Abric et al. (2019), some challenges include:

1 **High capital cost:** Drip systems are relatively costly, between USD 2 000 to USD 3 000 per ha, and often unaffordable for smallholders. Quality is highly variable and national standards may be weak or absent, with the consequence that cheaper systems can have poor irrigation performance and shorter lifespans. The price of the drip kit is only one part of the system, and the price of the borehole, pump and tank must be added. The whole system cost is what the farmer considers, and the addition of a drip installation reduces affordability.

2 **High maintenance costs and limited access to spares:** Drip systems have high replacement costs every three to five years, and the replacement cycle is often not affordable. The routine maintenance requirements are also significant, and while cost is one factor, simple access to the necessary spare emitters, drip lines, fittings and filtration unit parts, is another.

3 **Standard drip kits are often unsuitable for the circumstances:** Standard equipment in kit form is often unsuitable for crop combinations, planting density, spacing, farming cultural practices, or for the needs of larger producers.

4 **Specialist knowledge in maintenance:** Maintenance of drip-lines, emitters and filtration units, when not conducted properly, leads to failure. Water quality (particularly water that is heavy in iron and/or fine colloidal particles) is a key factor limiting wider use. Where water quality is low, after just a few crop cycles the transmitters clog up, distribution efficiency is compromised, and yields suffer, triggering abandonment.

5 **Sophistication in irrigation practice and agronomy:** Drip systems need specialist knowledge for the proper and effective irrigation application, most obviously because the volume of water cannot be seen, unlike with sprinklers or furrow systems. Inadequate design in relation to soil types, emitter spacings and water quality, compounded by maintenance challenges (unequal flows or blocked emitters), means that more sophisticated management knowledge and instruments is important complementary technology to achieve successful outcomes.

6 **Long-term financial rationale:** Drip irrigation, given the high upfront cost, requires a different financial rationale for farmers who tend to focus on obtaining short-term results with the least amount of risk.

7 **Appreciation of technology-need linked to water scarcity:** Unlike in water-scarce contexts, where water is abundant, it is more difficult to convince farmers they should adopt expensive technology, which is understandable given the low financial costs (essentially labor) of alternatives such as furrow irrigation.

Outline TOR for the technology diagnostic

The consultant will analyze the technical aspects of irrigation as they impact on individual and group irrigation schemes. The approach to, and challenges of, assessing the scale of the FLID sector is addressed in Module 1. A resource assessment described in the outline Terms of Reference (TOR) in Module 1 will aim to quantify:

1. the current hectarage that has been developed through FLID
2. the different physical contexts
3. the types of farmers involved in irrigation and develop a classification or typology.

The diagnostic in this assignment will cover first, the policy and legal aspects of the technical environment that is informed by Module 3, i-boxes 3.4 and 3.5, with more detailed information on review and diagnostic approaches in Minh et al. 2021. This information can be attached to the consultant's TOR.

Based on the above analysis a detailed assessment of the technologies that are currently in use, the demand and need for new technologies that can support FLID growth in the varied physical contexts, and the likely range of types of farmers, will be assessed. The assessment must consider both existing and new irrigation farmers, as well as individuals and small groups.

Information on tech preferences, challenges, and opportunities can be obtained through interviews with farmers, farmer-representatives and organizations, selected suppliers, and ad-hoc visits to supplier shop floors. More systematically, data can be collected through surveys, market-sounding processes (Module 6), and consultative workshops with suppliers, government, farmer-organizations, and NGOs in the sector.

It is important to understand **what kinds of on-farm irrigation systems are widely used** (open furrows, hose-pipes, spray-tubes, rain-guns, drip irrigation, petrol pumps, solar pumps, etc.), for which crops, and what the related areas of difficulty may be. It is then possible to better predict the mix of customized technical solutions that might fit different segments of farmer interest, given their crop type and affordability profile.

A **country-specific database of prices for typical irrigation system components**, and related budget prices, would be useful to facilitate concept design options. This would include: information on petrol, diesel and solar pumps suitable for 0.2 ha to 10 ha (indicative data is included in i-box 7.4 and 7.6); plastic pipelines (LDPE, HDPE, uPVC from 32 to 110 mm range) including a percentage markup for control valves and fittings; on-farm irrigation application systems (flexible hose, sprinkler, rain-gun, spray tube, drip).

The prices would contribute to a **comparative lifetime cost-benefit assessment** for some typical systems addressed in Module 2; the tech costs are needed to "build the case for FLID". The options would include fossil fuel and solar pumps and two or three main crops of interest (generally high value horticultural plus others like banana, coffee, etc.). A sensitivity analysis is useful to understand the effect of drought cycles, yields, market-price variations, and loan-financing interest rates.

Guidance on scoring the technology factor

After the diagnostic is concluded the score of the surrounding technical environment, ranging between very-weak and very-strong, will indicate how important it is for an intervention to address the technology supply chain. The scoring is informed by some guiding questions outlined below.

A constrained environment in regard to technology would be one where:

Transformative technology is not readily available on irrigation equipment supplier shop floors across the country:

- There are few suppliers (and where they exist, they are only in major centers) where farmers can find innovative enterprise-transforming technologies, and obtain information about their suitability, costs and operational advantages and disadvantages.
- Items like small portable solar pumps (< 0.5 ha mobile or semi-portable systems), low-pressure spray-lines, sprinklers and drip-lines, are not well known or routinely supplied by irrigation equipment outlets.
- Robust management instruments are seldom supplied or used by farmers.
- Larger solar pump installations (> 0.5 ha) for *irrigation* are few in practice, and the related design and operational experience among suppliers is lacking.

Transformative technology is relatively costly for farmers:

- Supplier prices are so high that sales turnover is limited.
- Returns on investment for technologies are marginal, whereas truly transformative tech should result in at least a doubling of gross margins (though even greater levels are found in practice and are possible, as referenced in the i-boxes) in a comparative lifetime-costing over 10 years.

National quality standards for equipment are absent or are weakly formulated to ensure necessary quality control for all irrigation equipment:

- National quality standard documents have gaps in technical system specifications with regard to all of their component elements and installation requirements.
- The testing facilities and knowledge around quality testing are inadequate to ensure quality control nationally.
- The compliance and regulation of equipment quality is weak in practice.

Remote monitoring systems and digital agriculture

Remote monitoring systems enable new applications

Remote monitoring systems (RMS) are increasingly embedded in new agricultural devices and irrigation equipment such as solar pumps, crop advisory support instruments, and monitoring equipment, among others. Machine to machine communication makes it easy to monitor the water level in a well, the vital signs of a pump, or to geo-locate and/or take control of a device. Where data loggers are connected to the device it automatically sends the data by global system for mobile communications (GSM) to a web platform. Bluetooth functions can transfer data to a smartphone when it is located a few meters away from the data logger – a preferred solution in case of poor mobile network coverage, a situation that is common in rural areas. These functionalities are already well-established and included in numerous manufacturers' solar pump products that are on the market in Africa.

In a water-stressed environment, effective monitoring en masse can be enabled through this kind of innovation. Digitally enabled devices would have to be complemented with alternate monitoring arrangements for other, less sophisticated systems to ensure comprehensive coverage. This kind of monitoring can help farmers to be aware of what others are abstracting and support local water management arrangements. It can also link to higher levels of basin management to keep track of what is being abstracted.

The technology allows a web dashboard to give a complete overview of the entire system – either for abstraction monitoring, or other purposes (user information, distributor support, knowledge bases, payback tracking, repairs etc.). Access is always restricted to authorized persons. In setting up these kinds of systems, pump suppliers can help governments with data to monitor program implementation progress, groundwater levels, energy utilized, or with assessing impacts over time.

A status update of the sector

The Digitalisation of African Agriculture (D4Ag) report (Tsan et al. 2019) reviewed how far the sector has advanced, its prospects, and what it will take to further unlock the potential of the sector. Key findings included:

- A large number of players comprise this relatively young sector
- The economics are improving, and a handful of players are beginning to develop viable businesses with attractive financial models
- Registrations are concentrated. While there are D4Ag solutions present in at least 43 out of 49 sub-Saharan African countries, over half of the solutions are headquartered in East Africa and nearly two-thirds of registered farmers are based in East Africa, with Kenya leading the way
- Investments remain small, and primarily fueled by donors, while private investment is lagging
- Some promising impact metrics are emerging. Though early, limited, and in some cases, mixed, the overall results suggest that D4Ag solutions could achieve transformative results

- While D4Ag's reach is impressive given the relative newness, use in practice remains low

RMS and pay-as-you-go (PAYG) arrangements

One of the solutions with significant potential to overcome the affordability hurdle, is the PAYG payment model also described in Module 5. This is used by suppliers to finance the purchase of solar pumps for their customers through small regular installments. In cases of default of payment, the supplier can remotely switch off and on the pump (by GSM mobile networks if these are good enough to communicate between the pump and a web payment platform [e.g. Angaza, Mobisol]); or a payment code arrangement with an entry keypad that is connected to the device (which is a more reliable method). In the second arrangement, the customer pays with a mobile money facility (e.g. MTN, Orange, MoneyMoov etc.) and receives a digit code by SMS to enter into the keypad which then activates the pump. The presence of mobile money and digitally enabled interactive technologies provides a significant opportunity in intervention design, with the absence thereof presenting something of a constraint. The digitalization of irrigation is part of the wider trend in agriculture and the presence and benefits are skewed across Africa.

Who pays for what? More and more solar pump suppliers (Lorentz, Grundfos, FuturePump, Sunculture, among others) have integrated RMS. When buying a pump, farmers pay for the hardware (data logger), software (web platform) and cost of GSM transfer with no extra costs involved. RMS is a strong commercial sales argument to support climate-smart agriculture with data generated (volume of water used, fuel saving, energy produced, estimation of irrigated surface), but not for the farmers who pay without receiving benefits. Suppliers also give the possibility of buying a pump without RMS to decrease the price of the pump and to adapt the offer to each segment of customer.

Challenges: Several of today's barriers – notably, limited access to technology and connectivity – will start to be overcome as cellphone coverage is expanded. While these support networks are on a positive trajectory, the sophistication of D4Ag solutions has begun to outpace the readiness of entrepreneurs, users, and government actors to embrace and leverage them. The pace of digital solution development is fast, and knowledge application risks being left behind. Many companies are still working to develop viable business models. Weaknesses in data may be limiting in that D4Ag infrastructure, such as farmer registries, digital agronomy data, soil mapping, pest and disease surveillance, and weather data infrastructure, are relatively weak, reducing the effectiveness of D4Ag solutions. While some countries like Kenya and Nigeria are well advanced, there is a wide range of country and regional variation in D4Ag growth across the continent.

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