

Scaling Irrigation for Small-scale Producers: the Role of Private Sector Solutions

Landscape Report



April 2024

CONTENT OUTLINE

- 0. Scope and objectives (*slides 2-8*)**
1. Executive Summary (slides 9-16)
2. Impact case for scaling irrigation (*17-20*)
3. Current state of small-scale irrigation, expansion opportunity, and enabling environment barriers (*21-37*)
4. Emerging private sector solutions (*38-49*)
5. Barriers to scale and sustainability (*50-57*)
6. Recommended actions to scale irrigation for small-scale producers (*58-82*)
7. Appendix (*83-178*)

Purpose of this report

ISF Advisors and Hystra created this report to understand the current state of the small-scale irrigation market in Africa and its future potential, articulate the investment and activities required to scale private sector irrigation technology for small-scale producers, and to identify potential opportunities for stakeholders (e.g., donors, investors) to catalyze further investment in this sector.

This report presents our findings from an extensive desk review of existing research, interviews with 70+ key stakeholders in the sector, and in-depth case studies of 6 private sector solution providers. The intended audience is the broader agricultural development community, including donors, private sector actors, investors, government stakeholders, researchers, and recipients.

This research was made possible by funding from the Bill & Melinda Gates Foundation. The opinions and findings expressed herein are those of the author(s) and do not necessarily reflect the views, strategy, or funding priorities of the Foundation.

For questions or comments on the research, please contact ISF Advisors and Hystra:

Dan Zook

Executive Director, ISF Advisors
dan.zook@isfadvisors.org

Lucie Klarsfeld McGrath

Partner, Hystra
lklarsfeld@hystra.com

Hayden Aldredge

Manager, ISF Advisors
hayden.aldredge@isfadvisors.org

Robin Bonsey

Senior Project Manager, Hystra
rbonsey@hystra.com

This research explores the current state and future potential of the small-scale irrigation market in Sub-Saharan Africa

Background and context

- Irrigation can play a key role in developing the agricultural sector in Sub-Saharan Africa by addressing barriers, gaps, and risks at the production stage of food systems, especially for small-scale producers (SSP)
- Despite this promise, just ~3-6% of total cropland in the region is irrigated, lagging far behind the global average of ~20%
- Limited existing adoption is due to barriers in knowledge, technology, finance, and policy/legal dimensions
- Fortunately, innovative business models and technologies are emerging that address some of these constraints in an effort to scale irrigation for small scale producers across the region

Key objectives

To understand the current state of the small-scale irrigation market in Africa and its future potential, articulate the investment and activities required to scale private sector irrigation technology for small-scale producers, and to identify potential opportunities for stakeholders (e.g., donors, investors) to catalyze further investment in this sector

Specific goals:

1. Summarize the impacts of access to irrigation for small-scale producers and overall market potential in Sub-Saharan Africa
2. Identify barriers at the customer, company, and country levels that are preventing irrigation potential from being realized
3. Unpack emerging private sector solutions that could scale irrigation usage
4. Explore potential for future collaboration between key actors in the space

The report is informed by an extensive literature review, key stakeholder interviews, field visits, and in-depth case studies

A

80+ sources consulted

*Leveraged **80+ key sources to inform this assessment**, including academic articles, working papers, public policy documents, industry materials, and journalistic articles*

B

70+ stakeholders engaged

***Consulted 70+ stakeholders** across government organizations, private sector, academics, donors, investors, and industry experts*

C

Case studies

Conducted 6 in-depth case studies on leading private sector small-scale irrigation solution providers (Agriworks, Bonergie, Davis & Shirtliff, KickStart, Stable Foods and SunCulture)

C

Field visits

*Visited 5 countries (Ethiopia, Nigeria, Kenya, Senegal, Uganda) **to meet with stakeholders in person and to conduct field visits to observe irrigation solutions in use***

Note: further detail on specific stakeholders consulted and works referenced can be found in the appendix

This report focuses on farmer-driven, small-scale irrigation (SSI)

This report focuses on small scale irrigation (SSI) - large schemes have historically been the primary focus of development initiatives in SSA despite being rarely economically-viable, coming with significantly more land-rights and other social, bureaucratic, and environmental challenges, and tending to benefit a relatively small numbers of farmers compared with the total farming population

Note: further information about terminology used throughout can be found in the appendix

High cost

- Complex
- Costly
- Extended timelines

Illustrative cost

- Farmer labor
- Financial costs
- Transaction costs

Low cost

- Simple
- Cheap
- Shorter timelines

- Irrigation structures such as large-scale intakes
- Large-scale storage systems
- Large distribution systems (e.g., canals, pipelines, aqueducts)
- Related infrastructure (e.g., roads, water monitoring)

New public large-scale irrigation schemes

- Rehab of existing large-scale irrigation schemes
- Intake and canal repair
- Water measurement and monitoring
- Established governance structures (e.g., Water User Associations)
- Low pressure pipelines

Rehabilitation of existing large schemes

- Small-scale community dams
- Waterway diversions
- Water harvesting
- Pumped group systems

Community-led small dams and shared systems

Primary focus – small-scale irrigation, focused on farmer-led private irrigation on small plots, can be more accessible and democratic for farmers across geographic contexts and has become the primary irrigation development outcome for many Sub-Saharan African governments over the past two decades

- Deeper wells (e.g., ~25m)
- Distance from SW up to 500M
- Larger hillside canals
- Boreholes and tube-wells
- Sprinklers / drip

Small-scale irrigation: step-up in tech sophistication

- Shallow wells
- Nearby rivers and wetlands
- Small hillside canals
- Limited or no storage

Small & simple irrigation systems

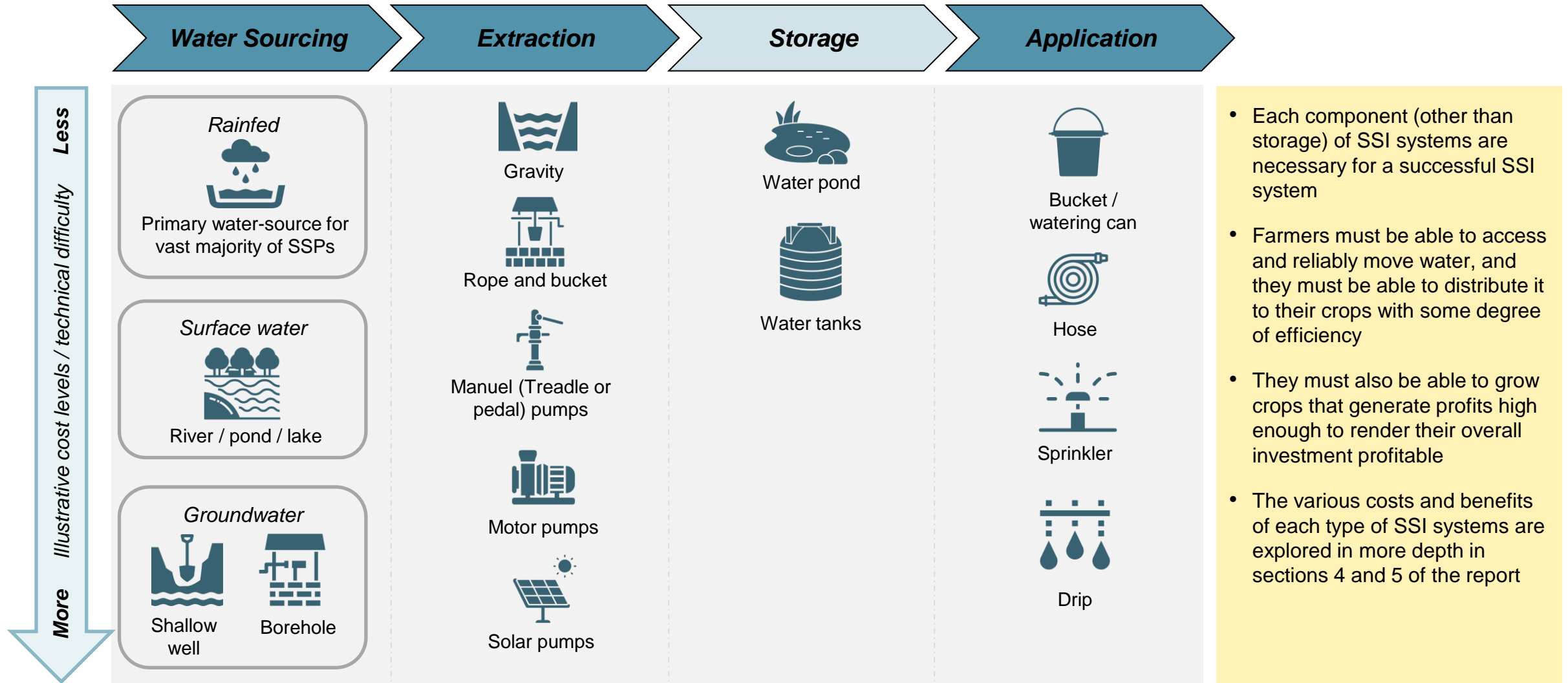
Public investment

Private investment

← **Mostly farmers' groups and shared/collective system**

Mostly individual farmers →

Small-scale irrigation systems typically involve 4 steps: water sourcing, extraction, storage, and distribution or application



- Each component (other than storage) of SSI systems are necessary for a successful SSI system
- Farmers must be able to access and reliably move water, and they must be able to distribute it to their crops with some degree of efficiency
- They must also be able to grow crops that generate profits high enough to render their overall investment profitable
- The various costs and benefits of each type of SSI systems are explored in more depth in sections 4 and 5 of the report

Note: further details on small-scale irrigation systems and solutions can be found in [section 4](#)

Acronyms used throughout this report

BM: Business Model

COGS: Cost Of Good Sales

D&A: Data & Analytics

Fx: Foreign Exchange

GWI: Ground Water Irrigation

LMIC: Low and Middle Income Countries

HH: Household

IaaS: Irrigation as a Service

MFI: Micro-Finance Institution

MoA: Ministry of Agriculture

MoF: Ministry of Finance

MoW: Ministry of Water

PayGo: Pay as you Go

R&D: Research and Development

ROI: Return On Investment

SACCO: Savings and Credit Co-Operatives

SSA: Sub-Saharan Africa

SSI: Small-Scale Irrigation

SSP: Small-Scale Producers

SWP: Solar Water Pumps

WCR: Working Capital Requirements

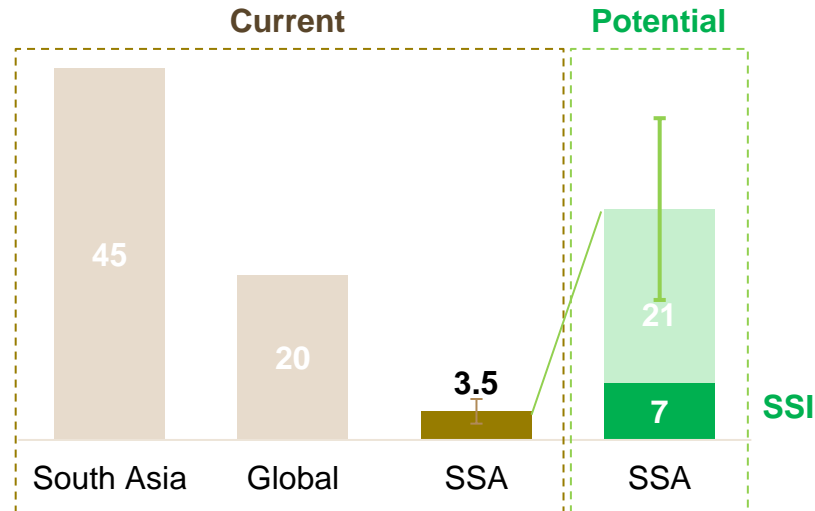
WUA: Water Use Association

CONTENT OUTLINE

0. Scope and objectives
- 1. Executive Summary**
2. Impact case for scaling irrigation
3. Current state of small-scale irrigation, expansion opportunity, and enabling environment barriers
4. Emerging private sector solutions
5. Barriers to scale and sustainability
6. Recommended actions to scale irrigation for small-scale producers

Executive summary (1/7): Despite its significant potential for impact, usage of irrigation in Sub-Saharan Africa (SSA) remains limited

Percent of cultivated area equipped with irrigation



The impact case for scaling-up irrigation in SSA is compelling

- Irrigation can be a key lever for agricultural development and food security in SSA: +50-400% increase in yield relative to rainfed crops, +100-350% increase in farmer income +25% available calories
- Irrigation also increases resilience to extreme climate events, which will become increasingly frequent

Current irrigation usage remains limited

- Current irrigation usage in SSA (~2-5% of total cropland) remains far below global (~20%) and regional averages (45% in South Asia)
- Over 50 years, only an estimated 400K manual pumps and 1.5M motor pumps have been distributed to SSA farmers

20-30M farming households stand to sustainably benefit from small-scale irrigation

- Research indicates that SSA has enough water resources to expand irrigation to 45 to 105M hectares, i.e., 17% to 39% of cropland, without depleting aquifers
- Potential for expansion of SSI is at least 19M (i.e., 7% of cropland), taking into account resource potential as well as key agro-economic and social criteria (e.g., ROI, market access, crop-mix, etc.). This represents 20-30 farming households

Impact potential of SSI in SSA



~19.1 million hectares



~20-30 million farming HHs



~120-200 million rural population



~28% ROI for SSI in SSA



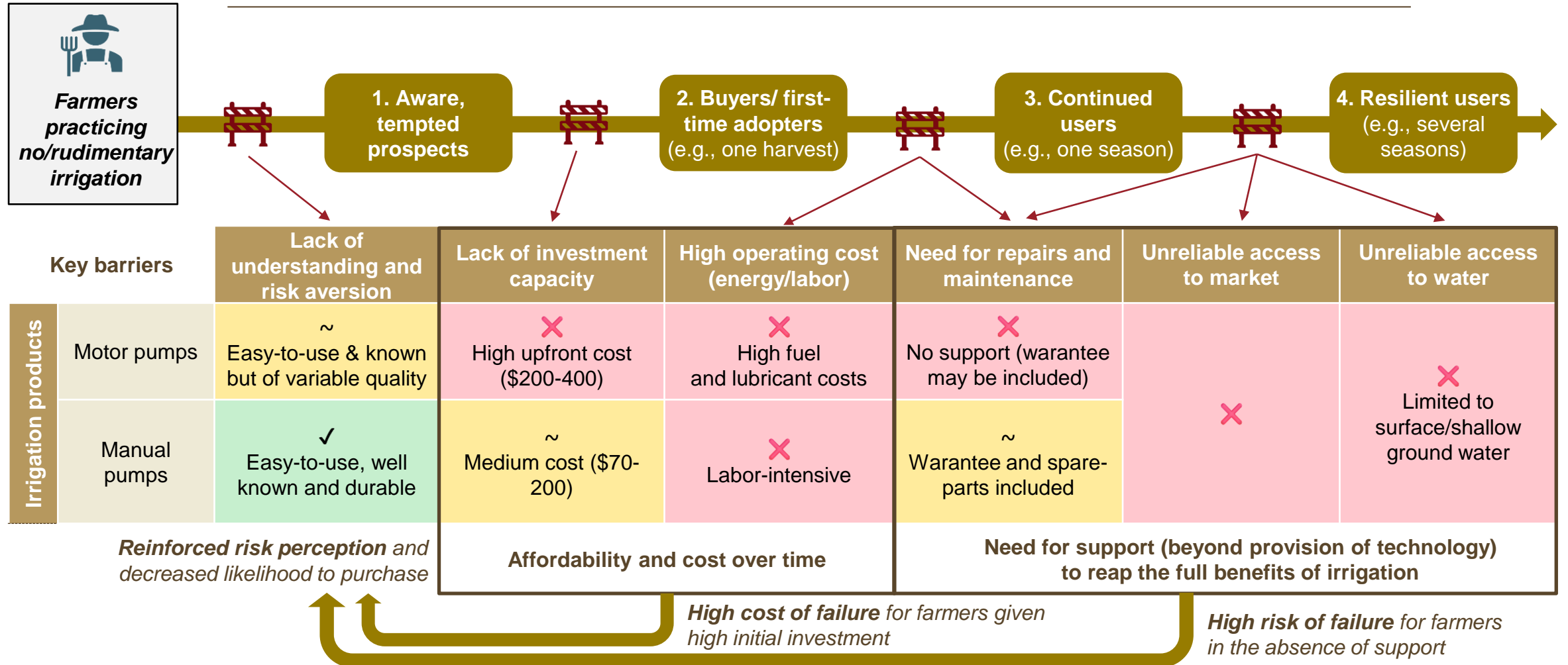
~5% reduction in food insecure population



~60% reduction in food import dependency

Executive summary (2/7): Adoption of SSI has been mostly limited by the high cost of acquiring and operating irrigation pumps

Customer journey to irrigation and corresponding barriers from awareness to resilient usage

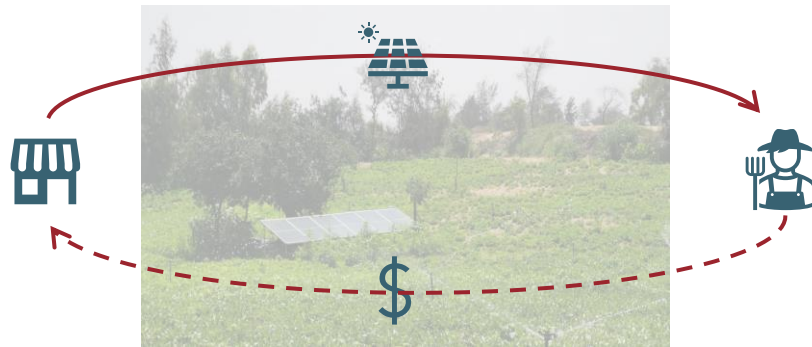


Executive summary (3/7): To tackle this affordability barrier, solar pumps with PayGo have recently emerged as the main innovation but still at limited scale (50k units), followed by Irrigation-as-a-Service at a nascent scale (2k farmers)

Solar pumps with PayGo (>50k units sold)

1. Irrigation providers sell solar irrigation kits to farmers

- Kits including pump, panels, controller, piping and sprinklers are sold starting at **\$380 for 1 acre**
- Sales happen mostly via group events with coops or farmer groups initially, and later through **word-of-mouth**
- Systems are installed by technician after an in-person or remote **site assessment**
- When sold on credit (70-85% of sales), providers also carry out **credit risk assessments**



2. Farmers pay back through Pay-as-you-Go (PayGo)

- A **10-30% downpayment** is required from the farmer
- Monthly repayments** can be fixed or flexible, over 24-36 months, made through **mobile money**
- Maintenance** and a 2-year warranty is typically **included**
- Financing cost** for the farmer is **20-40%** of total price paid
- In case of non-payment providers can remotely lock and eventually repossess the system

Mobile Irrigation-as-a-Service (<2K farmers reached)

1. Mobile irrigation agents bring pumps to the farmers' fields

- Farmers become aware of the service mostly through **word-of-mouth** and call to order 1-6 hours of irrigation
- Branch manager dispatches agents to the farmer's field
- Agent pumps **accessible surface water** onto the farmer's field (max 250m distance)
- Pumps are powered by motorcycle's engine



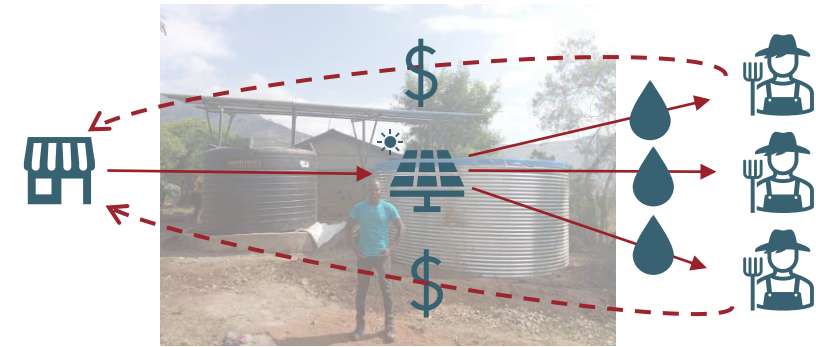
2. Farmers pay per hour of irrigation

- The company charges farmers **\$3 per hour** of irrigation
- Out of the \$3, **the company collects 25%** (\$0.75)
- Riders typically use c. \$1.5 for fuel and maintenance expenses, and end up with **net earnings of \$0.75/hr**
- Farmers can get discounts with volumes

Fixed Irrigation-as-a-Service (<100 farmers reached)

1. Fixed IaaS installs a fixed solar pump and connects neighbouring farmers

- The company finds suitable areas for a new site and **convinces enough farmers to subscribe**
- The company then installs a high-capacity solar pump with borehole and equips farmers with **drip lines**

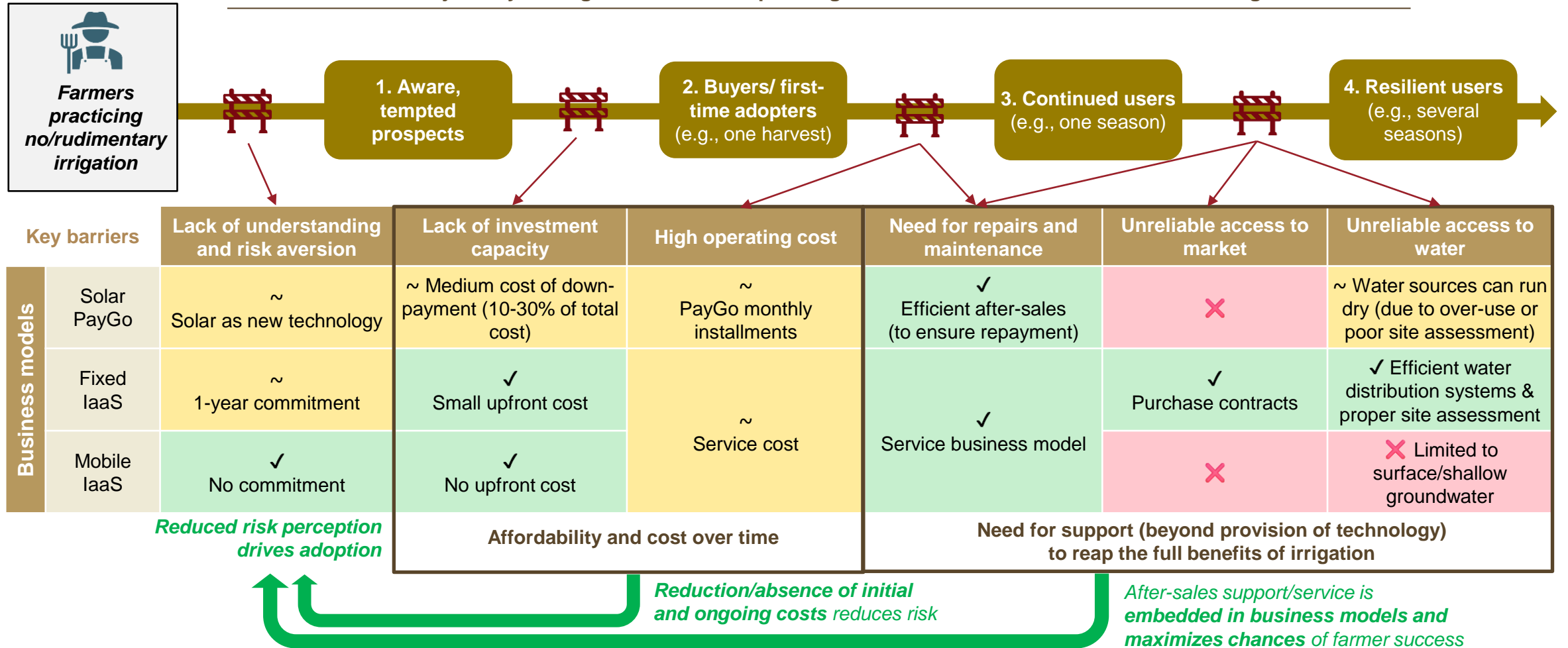


2. Farmers pay the company under one of 3 models:

- Irrigation-as-a-Service:** farmers pay for water (\$42/acre/month) with at least 6 payments per year
- Lease & Operate (L&O):** the company **leases and cultivates the land** for the farmers.
- Jumla model (new):** the company provides irrigation and inputs on credit (20% down-payment) and **guarantees crop purchase** with a floor price

Executive summary (4/7): Solar pumps with PayGo and mobile IaaS can address or avoid the upfront investment barrier, while fixed IaaS can also provide long-term access to market and water resources

Customer journey to irrigation and corresponding barriers from awareness to resilient usage



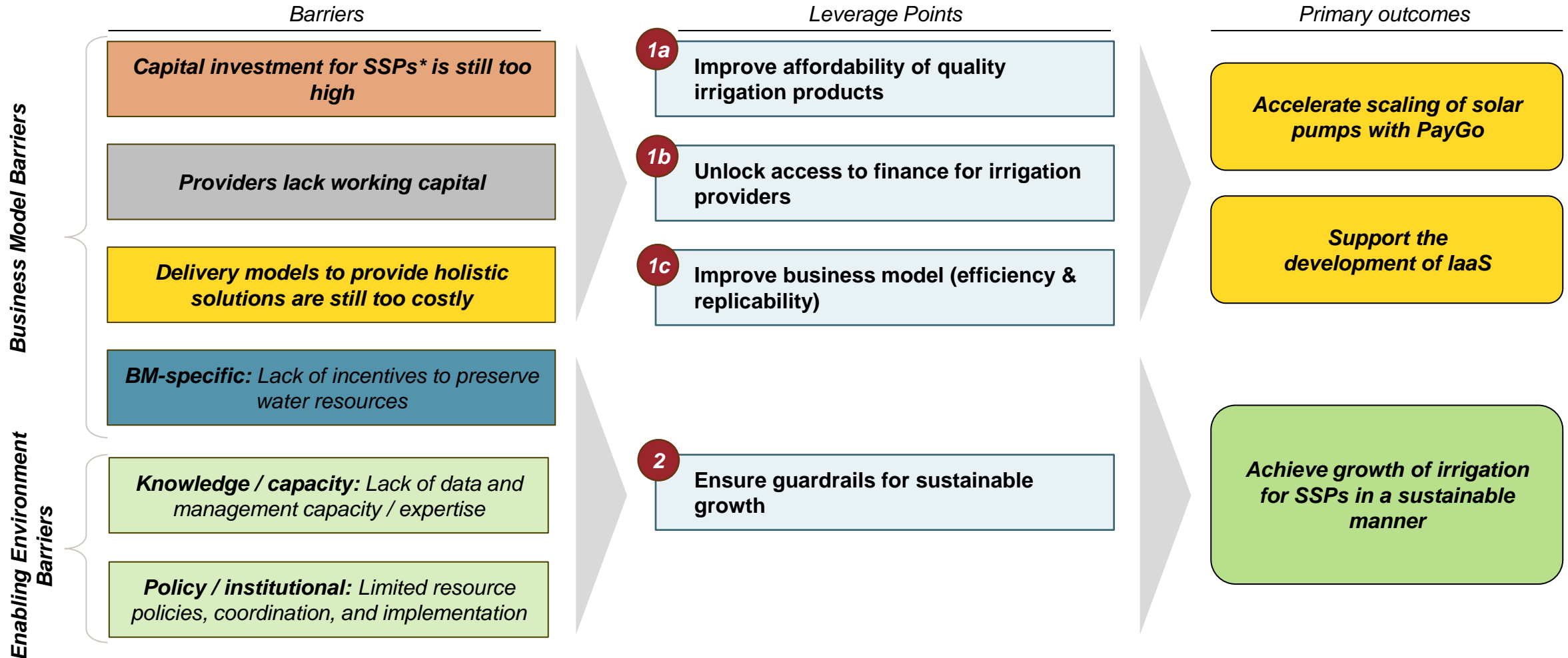
Executive summary (5/7): These emerging models still face barriers to achieving both short/medium-term commercial success and scale, as well as preserving longer-term water resource availability

Providers of SWPs with PayGo are all less than 5 years old (> 50K pumps sold overall) and still finetuning their models, with remaining issues to address:

Farmer barriers	Lack of understanding and risk aversion	Lack of investment capacity	High operating cost	Need for repairs and maintenance	Unreliable access to market	Unreliable access to water
Solution from PayGo models	~ Solar as new technology	~ Medium cost of down-payment (10-30% of total cost)	~ PayGo monthly installments	✓ Efficient after-sales (to ensure repayment)	✗	~ Water sources can run dry (due to over-use or poor site assessment)
Remaining challenges for farmers		/// Even with PayGo, upfront cost remains a barrier for small farmers	/// Most models have fixed recurring payments not meeting seasonality of farmer income		/// Market access remains a key condition for farmer success and is still mostly not provided.	/// Additional cost of drilling a borehole (\$5-10k) can be required to ensure year-round water availability
Challenges for PayGo providers	/// Acquisition costs are high due to need for behaviour change and reassurance; conversion cycles are long	/// High WCR of PayGo is a strong constraint to scale		/// The last mile delivery network required to ensure adequate site assessment and efficient after-sales services is complex to set up and run	For off-season irrigated crops it is not yet a constraint, but it will be a challenge at scale	/// Null marginal cost of extraction provides little incentive to use water efficiently and in some places, it will challenge farmers' long term success
Barriers faced by PayGo (as well as IaaS) providers can be grouped into 4 categories:	/// Investment for farmers is still a challenge (upfront cost, monthly payments vs. seasonality of income)		/// Providers lack working capital			
	/// Delivery models to provide holistic solutions are still too costly		/// Incentives to preserve water resources are limited			
























Additionally, Irrigation-as-a-Service models are still very nascent (c. 2K farmers) and their profitability, scalability and replicability need to be further tested

Executive summary (6/7): Barriers to the sustainable uptake of small-scale irrigation can be unlocked by focusing on 4 points of leverage



*Small-scale Producers

Executive summary (7/7): Donors, public authorities and financial institutions can help unlock each of these leverage points

Barriers	Leverage Points	Recommendations	Key SH involved
Capital investment for SSPs is still too high	1a Improve affordability of quality irrigation products	<ol style="list-style-type: none"> 1 Provide targeted and cost-effective price subsidies via tax exemptions 2 Unlock cost reduction in borehole drilling and pumping systems 3 Develop industry standards and guidelines for irrigation equipment 4 Streamline carbon financing of solar water pumps 	      
Providers lack working capital	1b Unlock access to finance for irrigation providers	<ol style="list-style-type: none"> 1 Unlock aligned development capital 2 Build partnerships between local financial institutions (MFIs/banks) and PayGo providers 3 Unlock Fx constraints 	   
Delivery models to provide holistic solutions are still too costly	1c Improve BM (efficiency & replicability)	<ol style="list-style-type: none"> 1 Finance ongoing innovative pilots to optimize their value proposition and delivery model 2 De-risk and support the expansion of successful providers into new/adjacent geographies via direct funding as well as policy advocacy 3 Develop irrigation knowledge amongst relevant promoters (e.g., extension workers) 	    
Lack of incentives to preserve water resources	2 Ensure guardrails for sustainable growth	1 Develop irrigation management information systems	 
Lack of data and management capacity / expertise		2 Incentivize water efficient systems	
Limited resource policies / coordination / implementation		3 Fund R&D for optimized distribution systems and remote monitoring systems	
		4 Establish and support organizations or associations governing water use rights	
		5 Create regional coordination platforms by convening key stakeholders	 

CONTENT OUTLINE

0. Scope and objectives
1. Executive Summary
- 2. Impact case for scaling irrigation**
3. Current state of small-scale irrigation, expansion opportunity, and enabling environment barriers
4. Emerging private sector solutions
5. Barriers to scale and sustainability
6. Recommended actions to scale irrigation for small-scale producers

Irrigation can be a key lever for agricultural development and food security in SSA

Sub-Saharan Africa urgently needs to accelerate the pace of agricultural growth to improve livelihoods, ensure food security, and keep droughts from turning into famines

Food security and poverty reduction for rapidly growing population

- Despite ongoing efforts, **Sub-Saharan Africa is not on track to meet the food security and nutrition targets** of SDG2 on Zero Hunger for 2030
- SSA faces the **largest projected food gap in the world**, with cereal demand projected to triple by 2050 driven by the highest global population growth
- Agricultural growth has been found to be **2-4X more effective in reducing poverty** from economic growth within the sector than other sectors

Farmer productivity and yield gap is a key issue to address

- **SSA's 76% yield gap** is far above the global average of 50% yield gap for LMICs
- **75% of additional food in the next decade could come from the world's low-yield farmers**, increasing their production to 80% of the amount achieved by high-yield farmers
- Enhancing future food security will require a primary **focus on sustainable intensification** of African SSP farming systems

The ongoing impact of climate change will make agri development more difficult

- Climate change will lead to **increase in variability, temperature** and slightly **reduced average rainfall**
- **Rainfed farming is highly vulnerable** (longer dry seasons, more off-season, and heavier rains leading to floods)
- **Yield reduction of 10-20% of major grain crops** across most of Africa

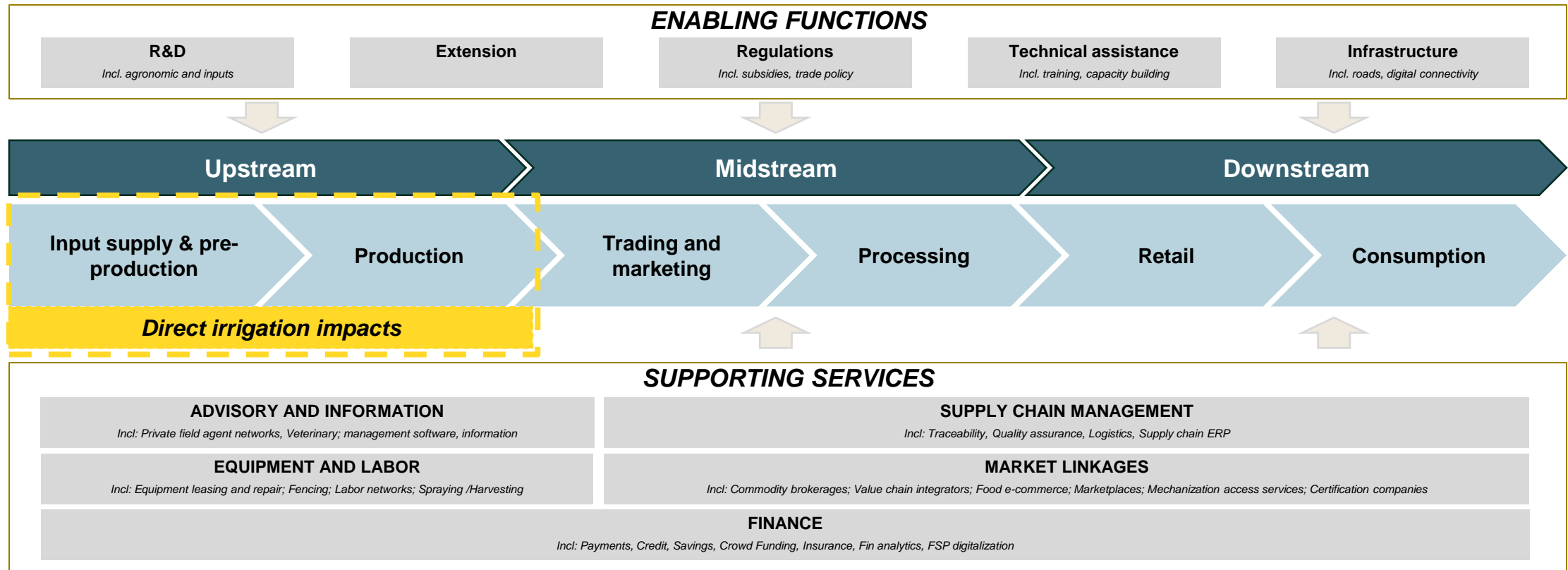
Scaling irrigation can play a crucial role in addressing these needs in Sub-Saharan Africa

- ❖ Irrigation has played a crucial role in the global increase in farm productivity over the past 60 years. Irrigated land provides 40% of the world's food supply on only 20% of agricultural land
- ❖ While rainfall has historically allowed sufficient production of indigenous crops adapted to the climate and soils of the region, climate change has altered this harmonious balance, and patterns of rainfall are changing faster than farmers can adapt
- ❖ Estimates show that, without substantial additional investment in irrigation, the share of people at risk of hunger in Africa could increase by 5% by 2030 and by 12% by 2050 due to climate change
- ❖ The IWMI estimates that 29% more irrigated land will be required by the year 2025 to sustain food production and reduce poverty on the continent
- ❖ Other productivity/resilience enhancing methods such as fertilizers, drought resistant seeds, and weather forecasting all continue to rely on water for production

Note: further detail on the household and macro-level impact case can be found in [appendix 1](#)

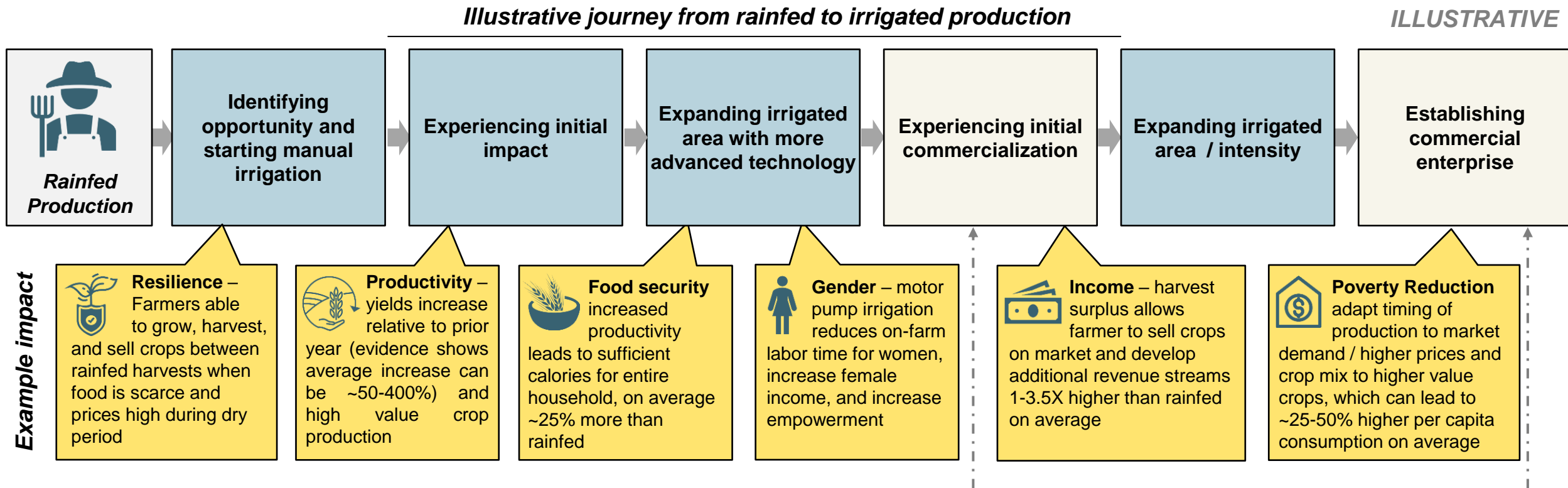
Sources: FAO, 2023; FAO, 2018; FAO, 2021; IWMI, 2000; World Bank, 2018; IFAD, 2022; African Union, 2020; IFPRI, 2018; IFPRI, 2022

Irrigation can address barriers, gaps, and risks at the production stage food systems and fits into a broader set of ecosystem interventions



Food systems transformation requires an ecosystem approach that embraces multi-stakeholder methods across various leverage points to increase productivity, resilience, and empowerment for SSPs. While **scaling irrigation will be key in addressing the existing barriers, gaps, and risks that occur at the production stage of SSA food systems**, it is a solution that fits into a broader set of ecosystem interventions

Access to irrigation can accelerate a farmer's journey towards commercialization and deliver multiple positive outcomes



While scaling irrigation can be a technical solution that leads to specific farmer-level impacts, some impact outcomes are reliant on other development areas within the broader system

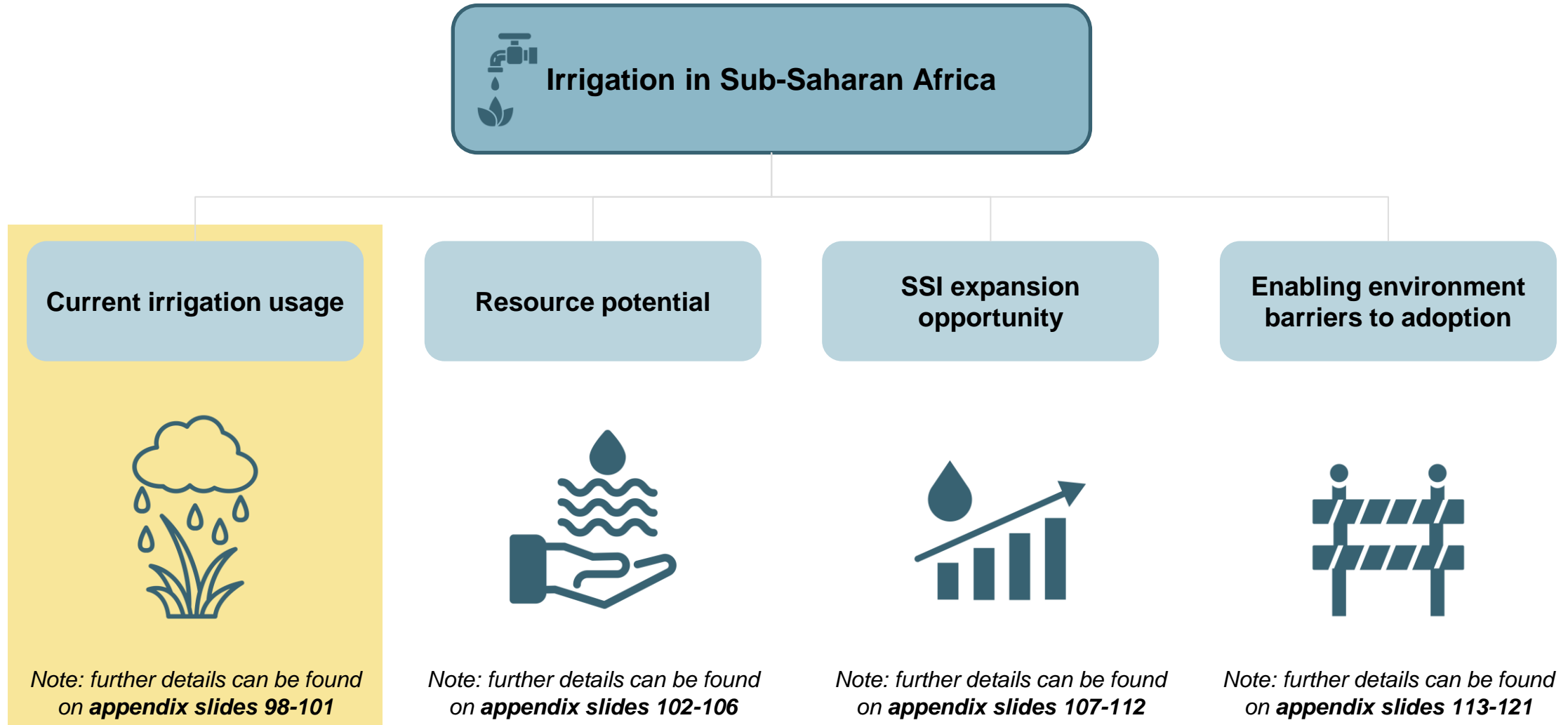
Furthermore, farmers would need to be further segmented as different farmer segments need different levels of support to scale up irrigation (i.e. gender differences, crop variations, seasonality, level of access to finance)

This illustrative journey highlights the role that market access and linkages plays for any farmer seeking to commercialize activities using irrigation. While irrigation cannot address the potential barriers at these steps, it can be an effective way to develop and de-risk the production-component of food systems development

CONTENT OUTLINE

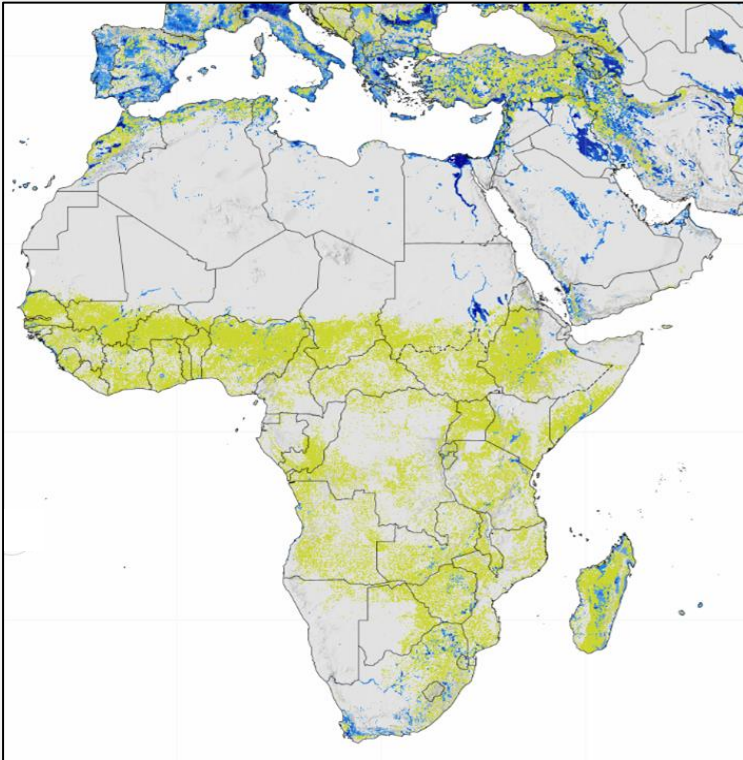
0. Scope and objectives
1. Executive Summary
2. Impact case for scaling irrigation
- 3. Current state of small-scale irrigation, expansion opportunity, and enabling environment barriers**
4. Emerging private sector solutions
5. Barriers to scale and sustainability
6. Recommended actions to scale irrigation for small-scale producers

Current state of SSI, expansion opportunity, and barriers

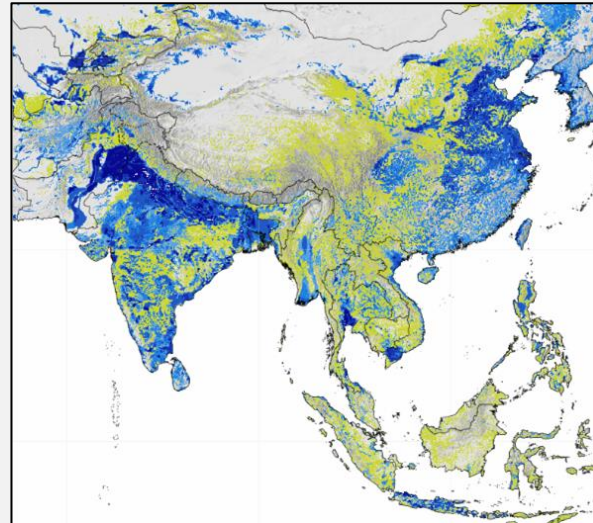


Only ~2-5% of cropland in SSA is irrigated, far below the global average (~20%), South East and East Asia average (~56%), and South Asia average (~45%)

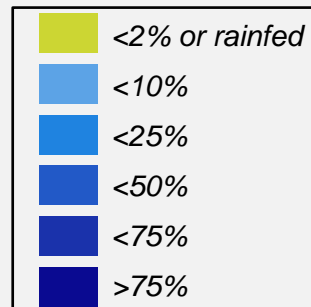
Percent of area equipped for irrigation (FAO AQUASTAT)



Africa, Southern Europe, and the Middle East



Asia



Irrigation in SSA lags far behind global peers

- The cultivated area in Africa is estimated at ~270 Mha, but only ~6-14 Mha of that area is recorded as being irrigated, of which are mostly large scale
- This accounts for ~2-5% of all cultivated land across SSA, far below the global average (~20%), South-East and East Asia average (~56%), and South Asia average (~45%)
- Even the low level of existing irrigation across SSA is relatively concentrated in certain geographic areas, primarily Southern Africa and areas of the Sahel (further discussion on country-level differences can be found later in this section)

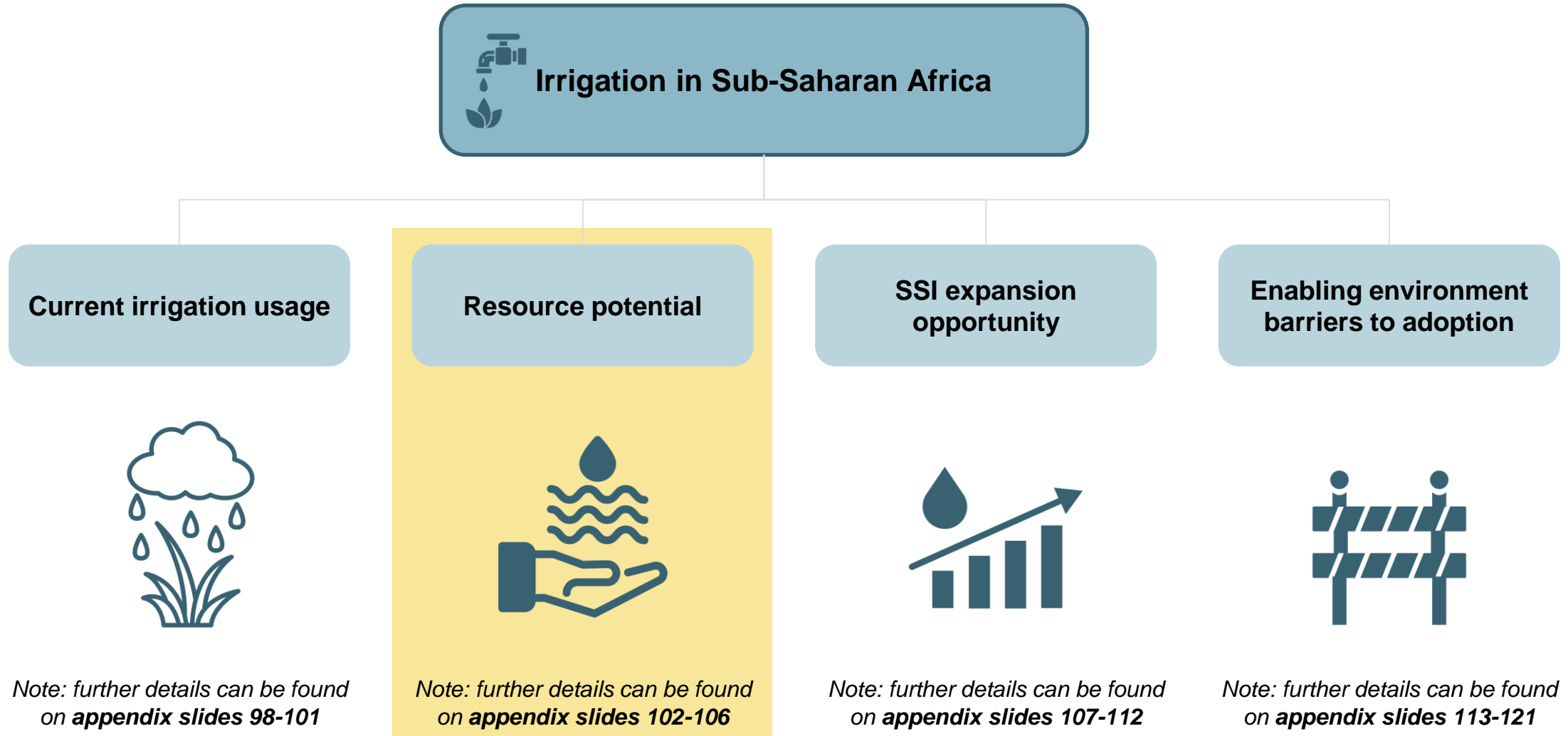
Key parameters define geographic concentration of irrigation

- Irrigation is concentrated geographically, often in areas that have both physical access to enough water, whether surface or ground, where it can address a water yield gap or allow shoulder/dry season production, and where the economic and enabling conditions support development
- Hence irrigation is common across parts of Asia, the Middle East and North Africa, and Mediterranean countries
- SSA stands out for its relative lack of irrigation given large swathes of land that have physical access to enough water resources and its relative economic reliance on agriculture

The pace of growth of such SSI in Sub-Saharan Africa has remained tepid at about 3% per year

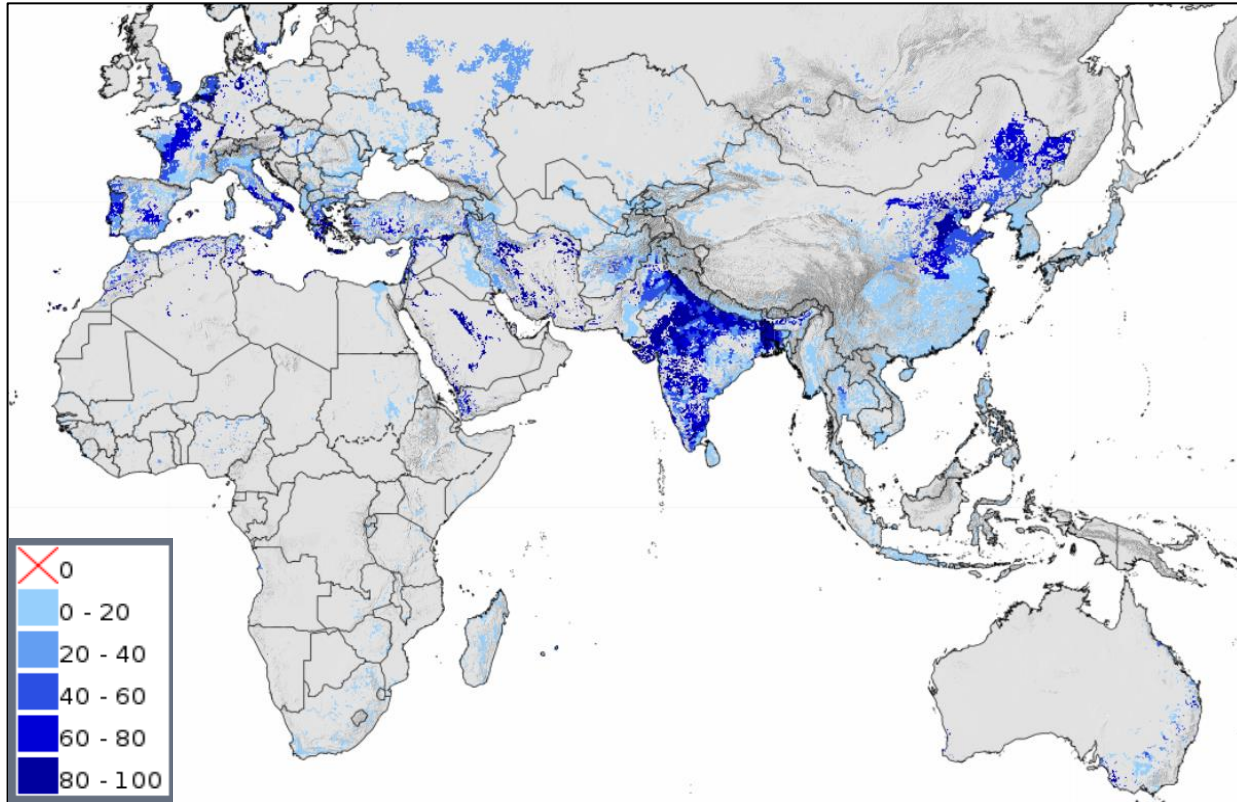
- SSA is estimated to be adding ~60 Kha per year of SSP irrigated land, concentrated in a few countries
- In comparison, South Asia added, on average, 1.5 Mha per year of SSI between 1985 and 2010 in a much smaller geography than SSA

Current state of SSI, expansion opportunity, and barriers



Sub-Saharan African groundwater use, especially for agricultural purposes, remains lower than global levels

Percent of irrigated area serviced by groundwater (FAO AQUASTAT)



Groundwater irrigation as % of total irrigated area:

- SSA: 9%
- Global average: 33%

Agricultural water use as portion of overall renewable water resources in SSA (1.3%) falls below the global average (4.2%). But there are key regional differences, with the arid Sahelian zone more dependent on renewable water sources for agricultural production

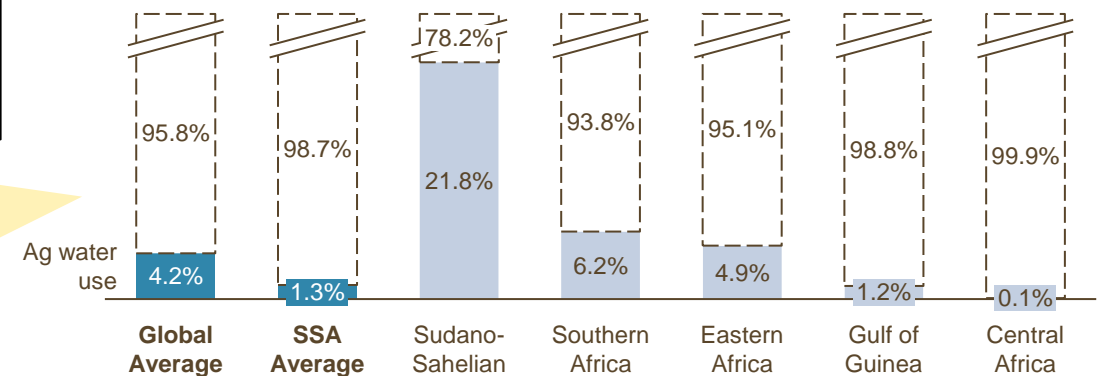
Expanding access to irrigation for small-scale producers inherently creates increased demand for freshwater, both surface water and groundwater

- Given water's fundamental societal importance it is crucial to establish an understanding of the resource potential available to scale irrigation in an environmentally and socially sustainable manner
- Groundwater resources are of a particular concern, given both its slower renewal rate than surface water as well as its position as the primary source for small-scale and farmer led irrigation development through privately-held pumps

The strategic importance of groundwater for global water and food security will likely intensify under climate change adaptation strategies

- Groundwater irrigation can act as a buffer against the impacts of climate variability and hydro-climatic extremes, such as droughts and floods, and it can alleviate poverty in low income settings by reducing crop failures and increasing yields and incomes

Agricultural water withdrawal as share of total renewable water resources



Research indicates that SSA has enough water resources to expand irrigation to 45 to 105M hectares, i.e., 17% to 39% of cropland, without depleting aquifers

44.5-105.3
million hectares of
irrigation potential

- Sub-Saharan Africa **has enough shallow groundwater to irrigate between 44.5 million ha and 105.3 million ha without depleting aquifers** according to a 2015 study that uses hydrological data, allocating only that fraction of groundwater recharge that is in excess after satisfying other present human needs and environmental requirements (Altchenko and Villholth, 2015)

120x increase
on current groundwater
irrigated areas

- Based on a comprehensive study of 13 SSA countries, Pavelic et al. (2013) has suggested that the known **groundwater resource can easily support 120x their current groundwater-irrigated area**. This study shows that all countries have variable but significant potential for GWI expansion, in total an area of 13 million ha, potentially serving 26 million additional SSP households

~90% of countries
with sufficient water
resources

- Zaki et al. 2018 results show that, except for Zimbabwe, **the current available surface water and groundwater resources could be sufficient to farm all of the potential cultivable areas in 15 selected countries** when both rain-fed and irrigated systems are fully operational

**5.5% of renewable
water resources**
currently being
withdrawn

- Data from FAO's AQUSTAT database indicates that in SSA as a whole, current annual **water withdrawals amount to just 5.5% of total annual internal renewable water resources** (a measure of water generated within a given country, equal to runoff + groundwater recharge from precipitation and seepage from rivers into aquifers)

~90% of countries
with high water storage
and recharge levels

- Macdonald et al. 2012 showed that **African water security is greatly enhanced by the distribution of groundwater storage and recharge**; many countries that feature low recharge, possess substantial groundwater storage, whereas countries with low storage typically have high, regular recharge. Only five countries have both water recharge and storage below median level (Eswatini, Zambia, Lesotho, Zimbabwe and Eritrea)

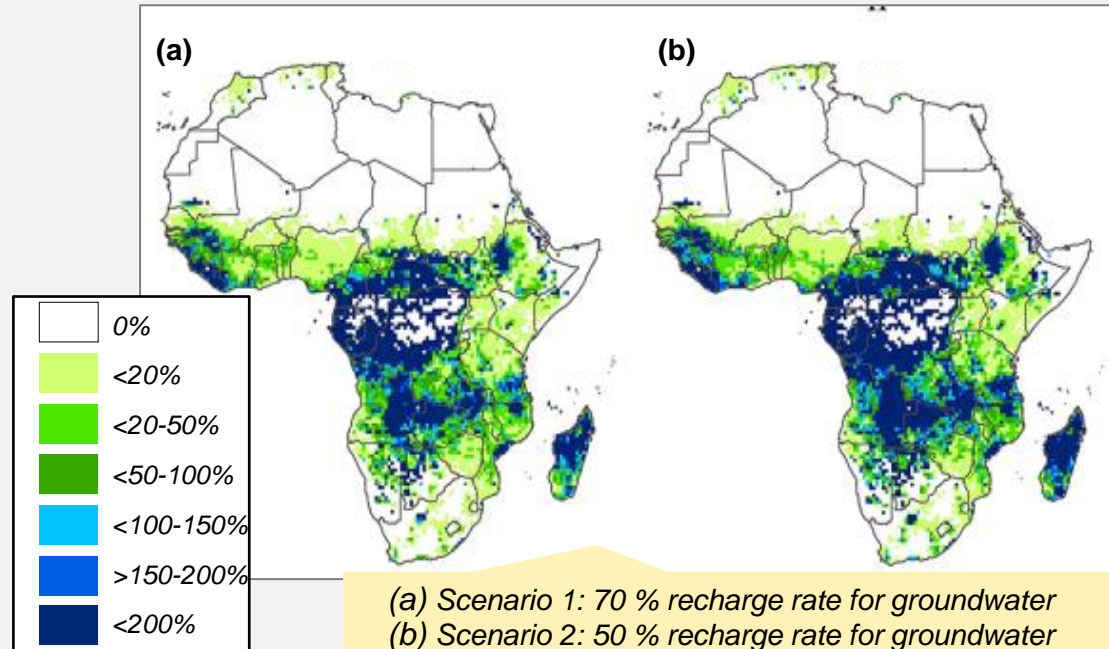
However, this resource availability on a continental level varies greatly across different regions, countries, and localities

There is no recent evidence of significant widespread decline in groundwater storage in regional aquifers but localized depletion, particularly in urban and highly arid areas, has been observed

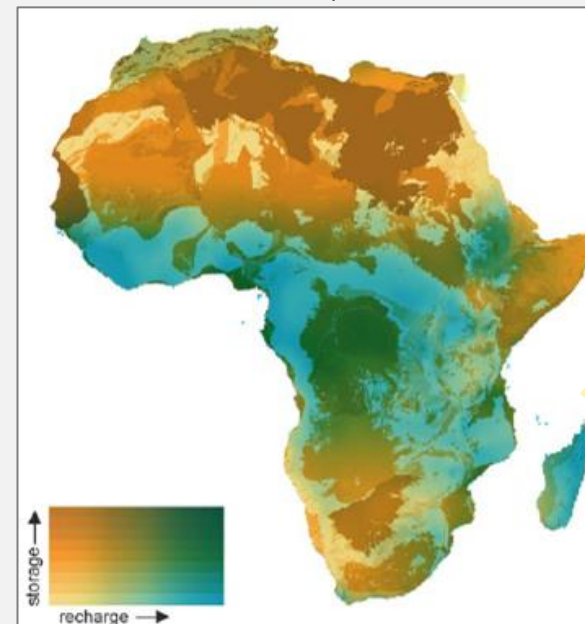
- SSA countries face incredibly diverse water resource situations, ranging from arid regions with high reliance on groundwater and accompanied water stress (e.g., Sahelian countries such as Senegal, Mali, Niger) to East African countries with highly localized water resource variance (e.g., Ethiopia, Kenya, Tanzania), and to central African countries with incredibly extensive renewable water resources (e.g., DRC, Congo)
- IFPRI modelling of irrigation potential (see next section for more detail) shows that the top 10 countries account for ~70% of the irrigation expansion potential

Researchers have mapped this varying potential at a continental scale. However, despite these relative advances in granular data, additional granularity is still needed to truly understand water resources for irrigation at the local implementation level

% of cropland irrigable with groundwater, for various levels of groundwater requirements (Altchenko and K. G. Villholth, 2015)



Average groundwater recharge and storage (MacDonald et al., 2012)



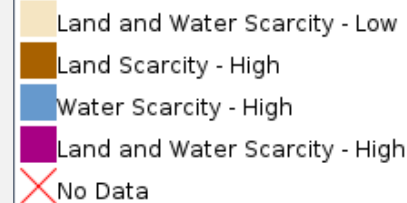
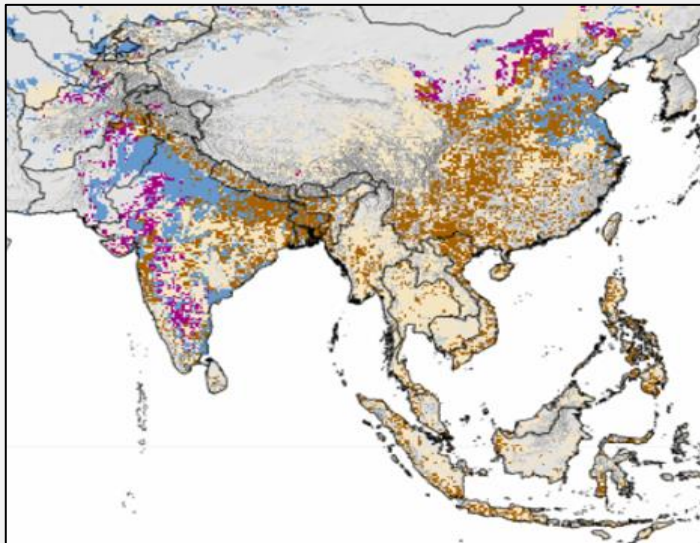
Renewable water resources depend on both recharge (e.g., via rainfall and/or surface water) as well as storage (e.g., natural aquifers). Areas with particularly high levels of renewable water resources appear as dark green in figure

Understanding the long-term availability of resources is crucial to avoid the mistakes seen in other regions

The key potential challenge with scaling small-scale irrigation is managing potential groundwater externalities that arise as a result

- Global examples show a large-scale groundwater depletion has been a source of major socioecological concern across India, Pakistan, China, The Islamic Republic of Iran, Jordan, Mexico, Morocco, and Yemen
- In many arid and semiarid areas, the groundwater being pumped is old and may never recover. Groundwater depletion has caused landslides in many countries and dried up wetlands and stream flows. Sustained groundwater depletion beyond natural recharge rates has resulted in water-quality deterioration

Agricultural systems at risk: human pressure on land and water (FAO AQUASTAT)



This depletion has primarily been driven by pump-driven small-scale irrigation

- ❑ The rapid rise in the numbers of mechanized irrigation pumps—diesel, petrol, kerosene, and grid-electricity powered—is a key indicator of the “silent revolution” in SSI in much of Asia
- ❑ In India, there were about 5K mechanized tubewells in 1951; by 2000 this number stood at 19M (Molle, Shah, and Barker, 2003)
- ❑ In Bangladesh, the total number of shallow tubewells increased from 45K in the early 1985 to more than 800K by 1999 (BADC 2013) and in the 2000s exceeded 1.2M. In 1980, tubewell irrigation accounted for just 15% of irrigated area in Bangladesh, but by 2000, this had increased to 71%
- ❑ In Pakistan, well numbers increased from ~200K in 1980 to 1.1M in 2015 (PBS 2012)
- ❑ In 1980, Vietnam had about 30K pumps, which soared to 150K in 1991 and then to 800K in the next eight years (Barker and Molle 2004)
- ❑ China had hardly any small private pumps until 1970, but there was an explosive growth in small tubewells and pumps to more than 17.5M in 2000 (FAO 2011b)

Focusing on SSI, the expansion potential is 19M hectares i.e. 7% of cropland, considering agroeconomic and social conditions

There is **abundant evidence that the potential for expanding SSI in SSA is immense** (taking into account other variables beyond just resource availability)

However, **these estimates vary significantly at the continental level**. Estimated ranges of potential expansion area include:

- ~3-15 million hectares (You et al., 2011)
- ~25-29 million hectares (Xie et al., 2014)
- ~38 million hectares (Malabo Montpellier Panel, 2018)
- ~10-19 million hectares (Xie et al., 2018)
- ~47 million hectares (FAO Aquastat, 2020)

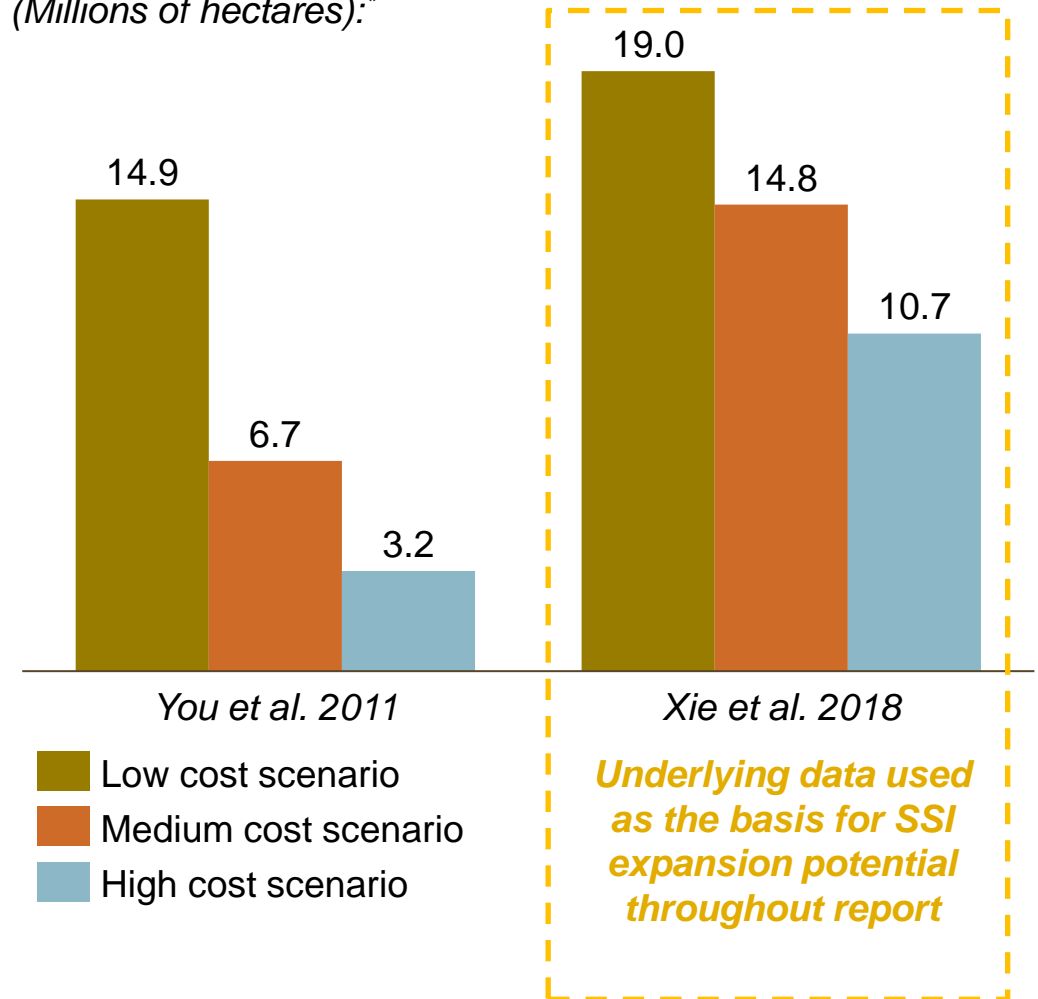
The wide variation in irrigation potential results from different assumptions. While water, in the form of runoff, may easily be quantified and translated into theoretical potential irrigation areas, **assessments do not account equally for a set of practical realities**

An alliance between the World Bank, IFAD, AfDB, and CGIAR carried out a series of studies to **more accurately assess the potential for SSI expansion that takes economic dimensions further into account**

- This model **identified potential areas for irrigation development**, using distance to market, existing arable farmland, and distance to water resources. An optimization model calculated the potential for small- and large-scale irrigation for each country as well as various impact and ROIs

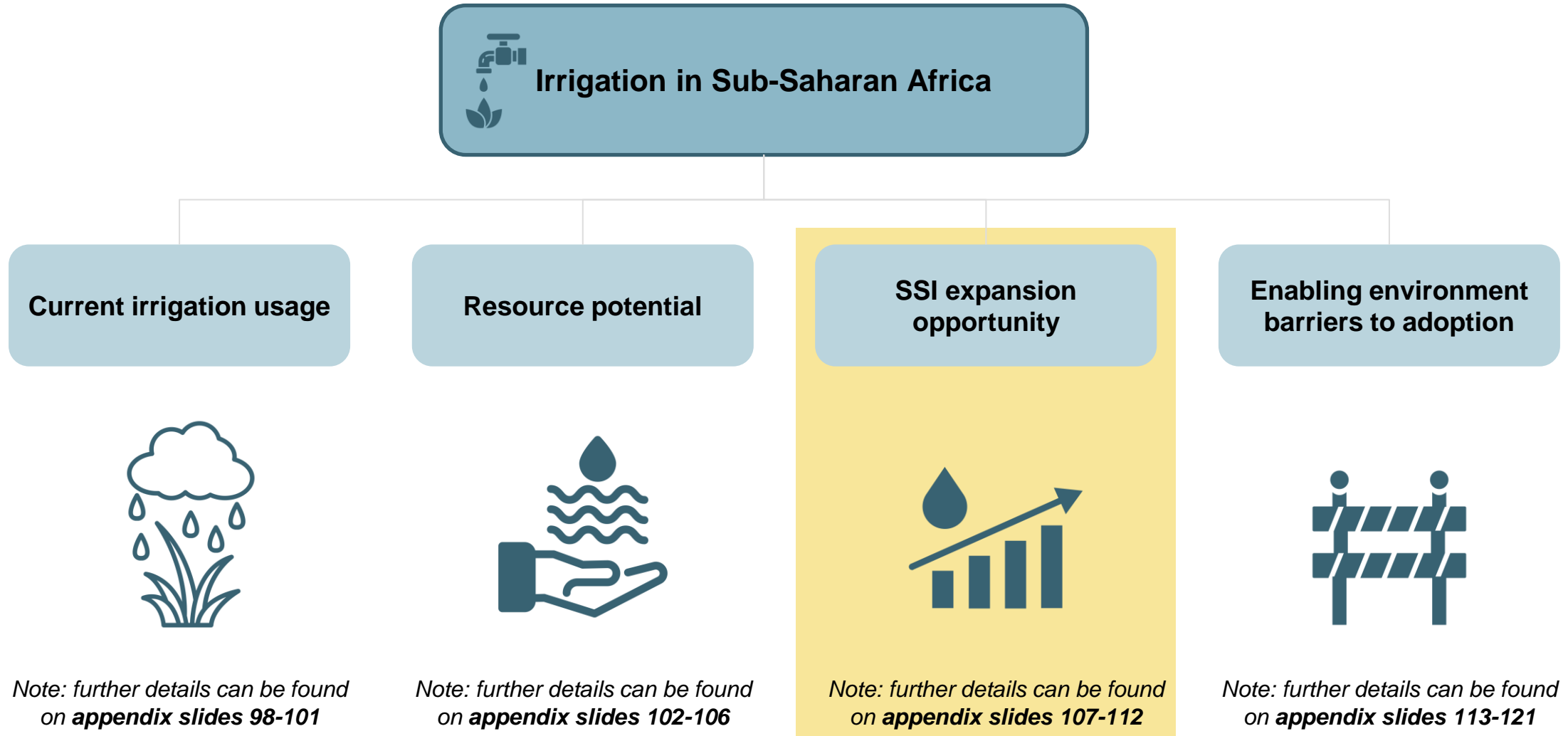
We use the latest figures from this model, provided by the IFPRI team via personal communication, as a basis for understanding the potential expansion opportunity for SSI at both a continental and country level

Potential Irrigation Expansion, from two leading studies (Millions of hectares):*









Source: You et al. 2011; Xie et al. 2018; *Cost scenarios indicate the assumed cost associated with irrigation investment. Thus, the higher cost scenarios results in lower expansion potentials due to decreased theoretical ROI

Current state of SSI, expansion opportunity, and barriers

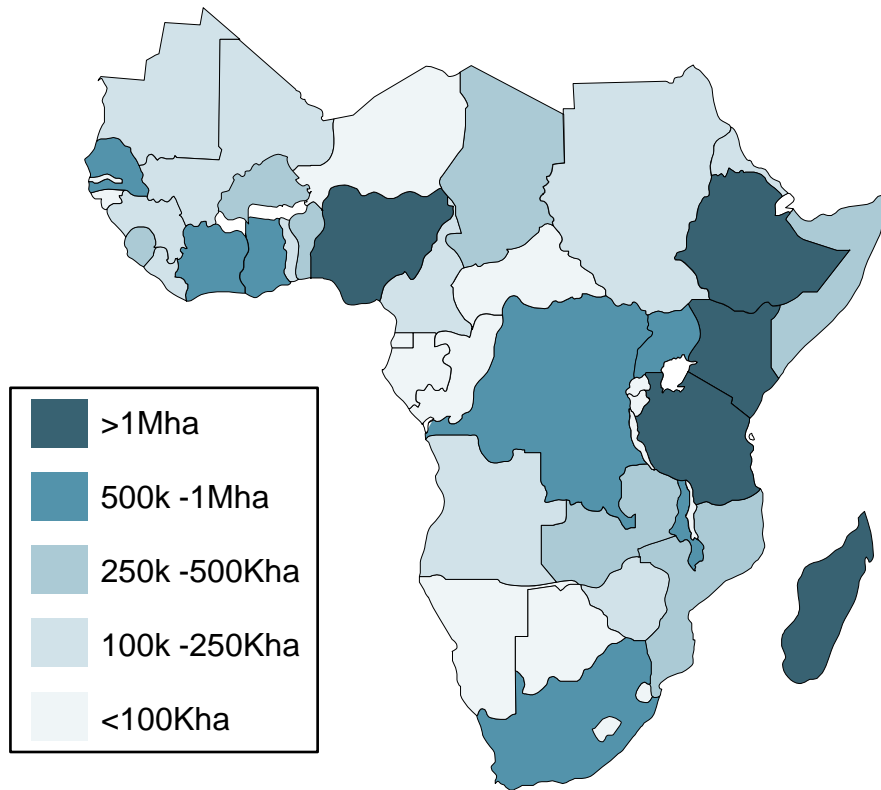


Expansion of SSI in SSA across 19M hectares has the potential to impact 20-30M farming households across the region

~19.1 million hectares¹
 ~20-30 million farming HHs²
 ~120-200 million rural population²
 ~28% ROI for SSI in SSA³
 ~5% reduction in food insecure population⁴
 ~60% reduction in food import dependency⁴

Potential area for SSI expansion in SSA by country

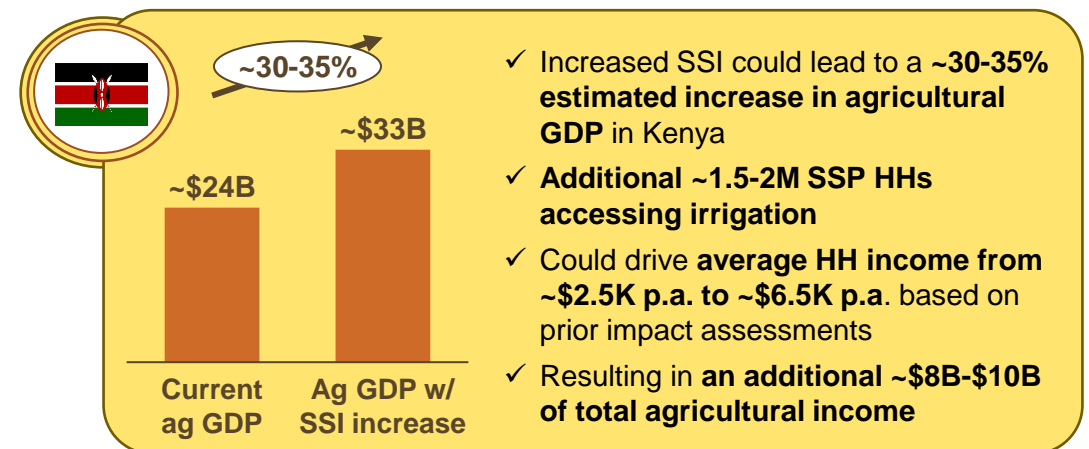
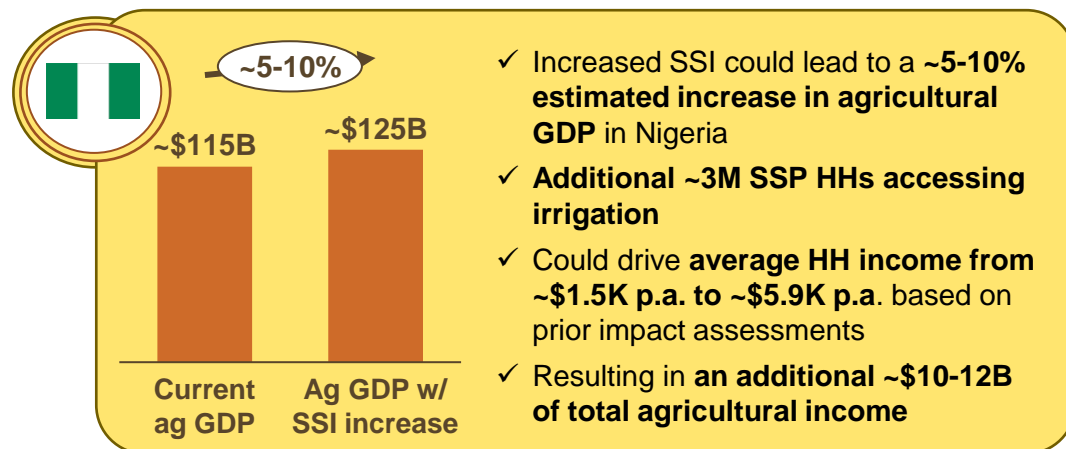
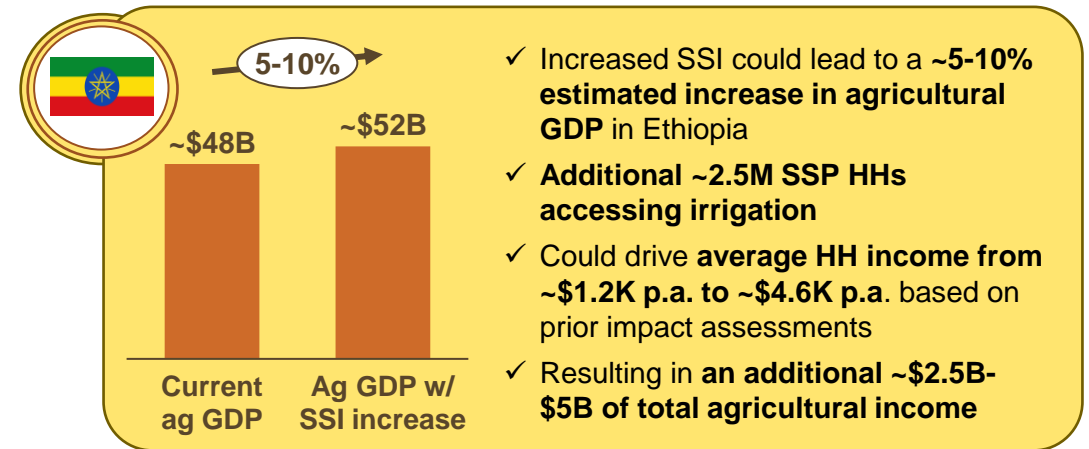
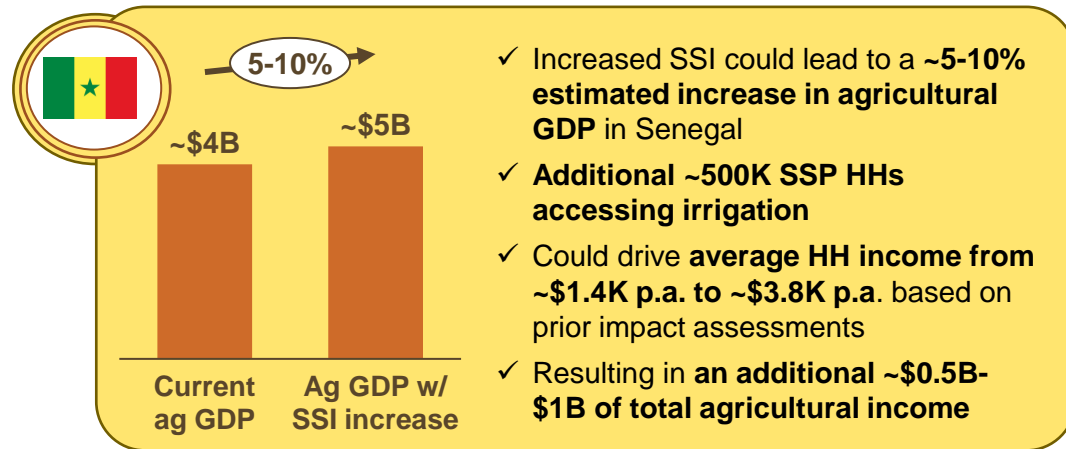


Countries	SSI expansion potential (Kha) ¹	Potential # of farming HHs with irrigation ²	Arable Land (Kha)	Current Irrigated Area (Kha)	% of Cultivated Area Currently Irrigated
Nigeria	2,900	2.73 mil	35,000	218	0.8%
Tanzania	1,768	1.47 mil	13,500	189	2.3%
Kenya	1,349	~2 mil	5,800	97	3.2%
Madagascar	1,344	1.54 mil	3,000	1,080	23.1%
Ethiopia	1,095	2.5-3 mil	16,200	290	4.6%
Côte d'Ivoire	999	409k	3,500	67	0.9%
Uganda	961	991k	6,900	5.9	0.1%
South Africa	949	1.1 mil	12,000	1,500	17.1%
DRC	923	616k	13,500	6.8	0.1%
Malawi	807	1.7 mil	3,600	54	2.4%
Senegal	790	439k	3,200	69	3.7%
Ghana	598	363k	2,500	55	0.6%

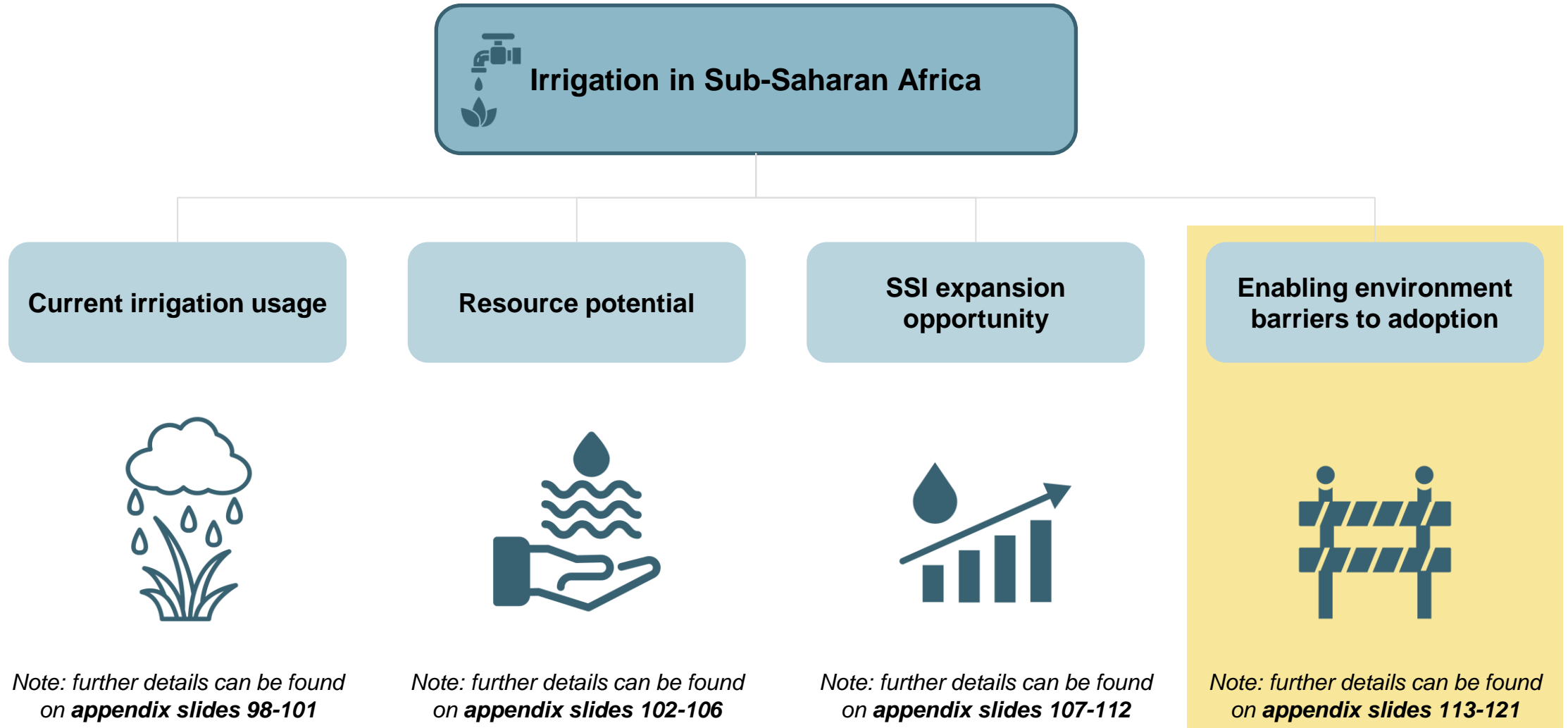
1) IFPRI modelling; Xie et al. 2018 "Can Sub-Saharan Africa feed itself? The role of irrigation development in the region's drylands for food security"; 2) ISF Analysis based on SSI land potential from Xie et al, 2018's research divided by the average SSP farm size in each country; 3) You et al. 2011; 4) Potential reduction if potential irrigated land is addressed

This expansion potential could have major economic and other impacts across the continent as illustrated by impact in four focus geographies

Illustrative economic impact on agricultural GDP with potential SSI expansion



Current state of SSI, expansion opportunity, and barriers



A number of general cross-cutting enabling features can enable SSI and farmer-led irrigation to scale across various contexts

Key enablers for effective scaling of irrigation for farmers

Irrigation can only be impactful for SSPs if it is profitable at the farm level, economically viable, and sustainable. To achieve this, key conditions typically must be met across policies, institutions, support services and other conditions to create a setting where SSPs can easily start, develop, and thrive with irrigation

Policy / legal / institutional

- Supportive policy environment with policies, laws, and regulations that institutionalize water, land, financial and environmental institutions, can enable or constrain SSI scaling
- *Note that the policy and legal context informs other enabling environment pillars as well*

Finance

- Access to affordable finance across stakeholders and across different potential financial sources is crucial in enabling farmers to invest in irrigation
- External finance and accessible financing mechanisms such as microcredit or farmer led cooperatives can unlock the growth process for SSPs by enabling acquisition of technology

Knowledge / Capacity

- Knowledge of irrigation, technologies, practices, benefits, skills, water resources, etc., across sectors and stakeholders involved
- This can include 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

Market linkages

- Small scale irrigation should be linked to agricultural, technology, and financial markets including upstream and downstream market linkages to ensure effective use of adjacent inputs alongside irrigation as well as the ability to benefit from increased productivity via reliable well-functioning markets supported by transport, storage and information infrastructure

Equipment / Technology

- SSI technologies must be profitable for farmers and must fit the context of the farm, the biophysical environment, and the market, without compromising access to water resources in the environment or for marginalized parts of the population, particularly women

This section focuses on the key enablers and constraints across these 4 key pillars of the broader enabling environment for small scale irrigation. Business model and technology barriers/constraints is explored in the next section

Further discussed in next section

These key enabling pillars often face common challenges across contexts that act as barriers to irrigation adoption

Key components

- Includes policies and regulations for scaling irrigation and water management solutions
- These impact behaviors and power relations of value chain actors in irrigation development and performance
- Rule of law and farmers' ability to assert their rights
- Direct interventions include policy changes or subsidies and incentives to promote new irrigation activity

Key barriers to irrigation adoption

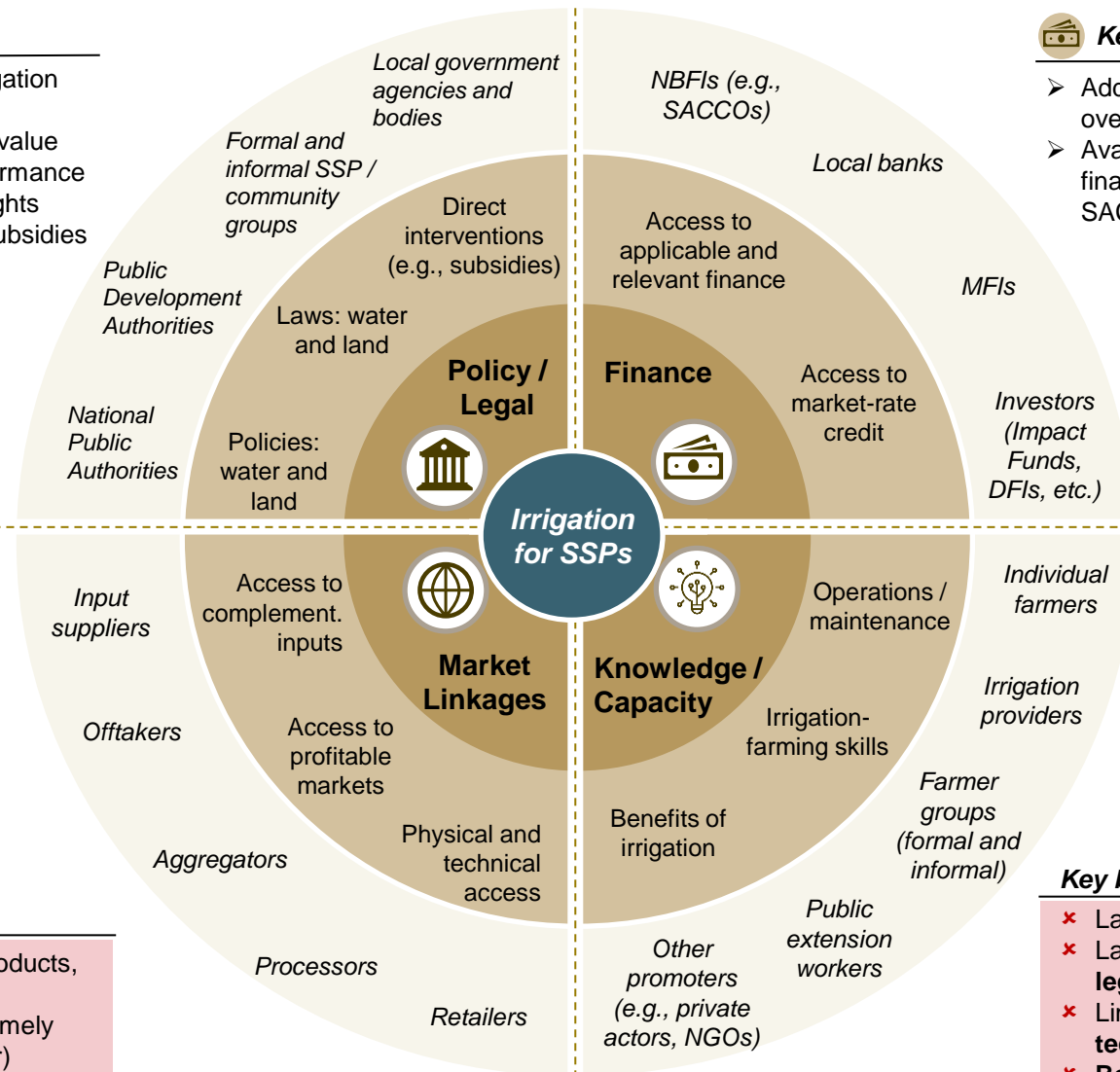
- ✗ **Weak institutional arrangements**
- ✗ Lack of **reliable and legal access to water**
- ✗ Limited publicly **available irrigation data**
- ✗ Weak **land-tenure laws**
- ✗ Poorly suited **permitting/enforcing systems**
- ✗ Limited **expertise, knowledge, and capacity**

Key components

- Irrigation can only create positive income and poverty reduction for SSPs when irrigated produce is able to be sold at profitable rates
- Physical access (e.g., roads) and commercial linkages are crucial enablers to ensure SSPs can benefit economically from irrigation
- Informal markets can play a large role in process
- Harvesting and selling in off seasons between rainfed markets is key to market access

Key barriers to irrigation adoption

- ✗ **Limited market access** for irrigated products, especially high-value products
- ✗ **Lack of input market linkages** (e.g., timely availability of quality seeds and fertilizer)



Key components

- Address scarcity of capital to take up irrigation by overcoming lack of access to finance for SSPs
- Availability and access to applicable and relevant rural financing for SSPs (presence and functioning of MFIs, SACCOs, etc.) that can finance irrigation equipment

Key barriers to irrigation adoption

- ✗ **Lack of investment capacity** to afford high upfront costs
- ✗ **Limited access to credit** and other forms of financing to address above barrier
- ✗ **Expensive informal sources of credit**
- ✗ **Macro financial constraints** stemming from broader policy environment

Key components

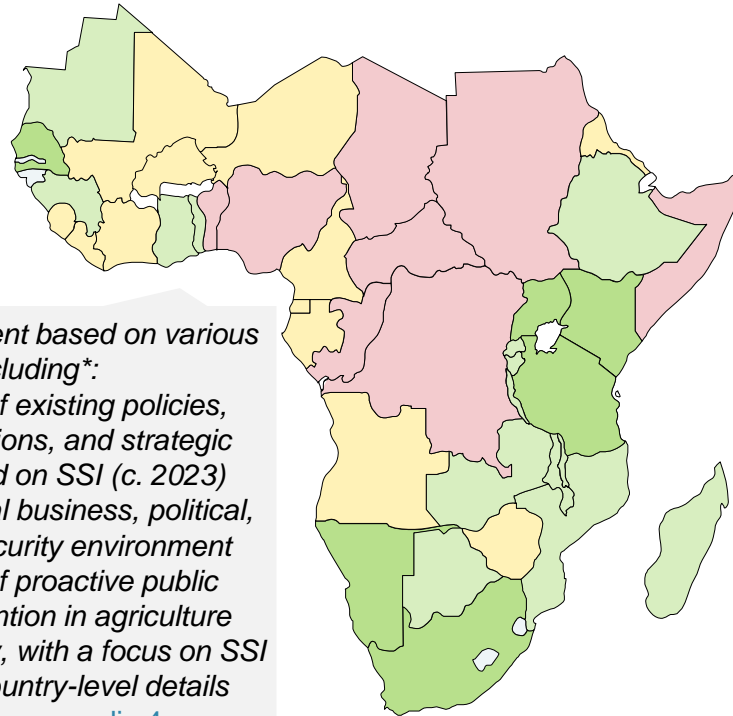
- Awareness of benefits from irrigation
- Knowledge of technical aspects of irrigation operations and maintenance is important to maintain positive ROIs on equipment
- Farmer awareness of irrigation water management, agronomic practices, technical knowledge of irrigation technologies

Key barriers to irrigation adoption

- ✗ Lack of **awareness of benefits** to irrigation
- ✗ Lack of knowledge and capacity for **reliable access to legal and usable water**
- ✗ Limited knowledge at farm-level **on irrigation technologies and farming techniques**
- ✗ **Behavioral changes** to move from rainfed to irrigated

While challenges for creating supportive enabling policy environment are shared across contexts, differences can be assessed by country

Assessment of enabling environment for SSI development by country (c. 2023)



Assessment based on various factors including*:

- Level of existing policies, regulations, and strategic focused on SSI (c. 2023)
- General business, political, and security environment
- Level of proactive public intervention in agriculture broadly, with a focus on SSI

Further country-level details provided in [appendix 4](#)

Challenges for creating effective policy environments and implementation to sustainably scale SSI include:

- Irrigation is an **unusually extensive and deep change for agriculture and can thus create heavy demands on public authority's** capacity and coordination across actors
- Within any country and locality **irrigation demands, resource potential, and applicability can differ drastically** – complicating any potential standard approaches
- **Policy needs of irrigation development evolve as irrigation is scaled** (e.g., early stage needs more traditional development support to instigate growth, later stages resource regulation is increasingly important)
- Thus, a **static view of enabling environment can miss some key nuance but is still a helpful gauge to assess the broader enablers/constraints. Some key nuances include:**
- Arid countries with less available surface and rainwater sources have **historically relied more on irrigation and thus often have more well-developed policy support in place** (often with a focus on sustainable water use) – examples include **Niger, Mali, Namibia, and Burkina Faso**
- Conversely, **countries with very limited historical irrigation demand** (e.g., due to plentiful rain) often have **very limited (if any) formal policy or regulatory** considerations for SSI – examples include **DRC, Nigeria, CAR**
- Many countries have responded to recent broader push for SSI development by establishing **seemingly supportive frameworks and policies, but still suffer from ineffective implementation and/or key existing constraints** – examples include **Ethiopia** (which faces key challenges associated with private sector enabling conditions) and **Ghana** (lack of effective local implementation of water rights/regulations)

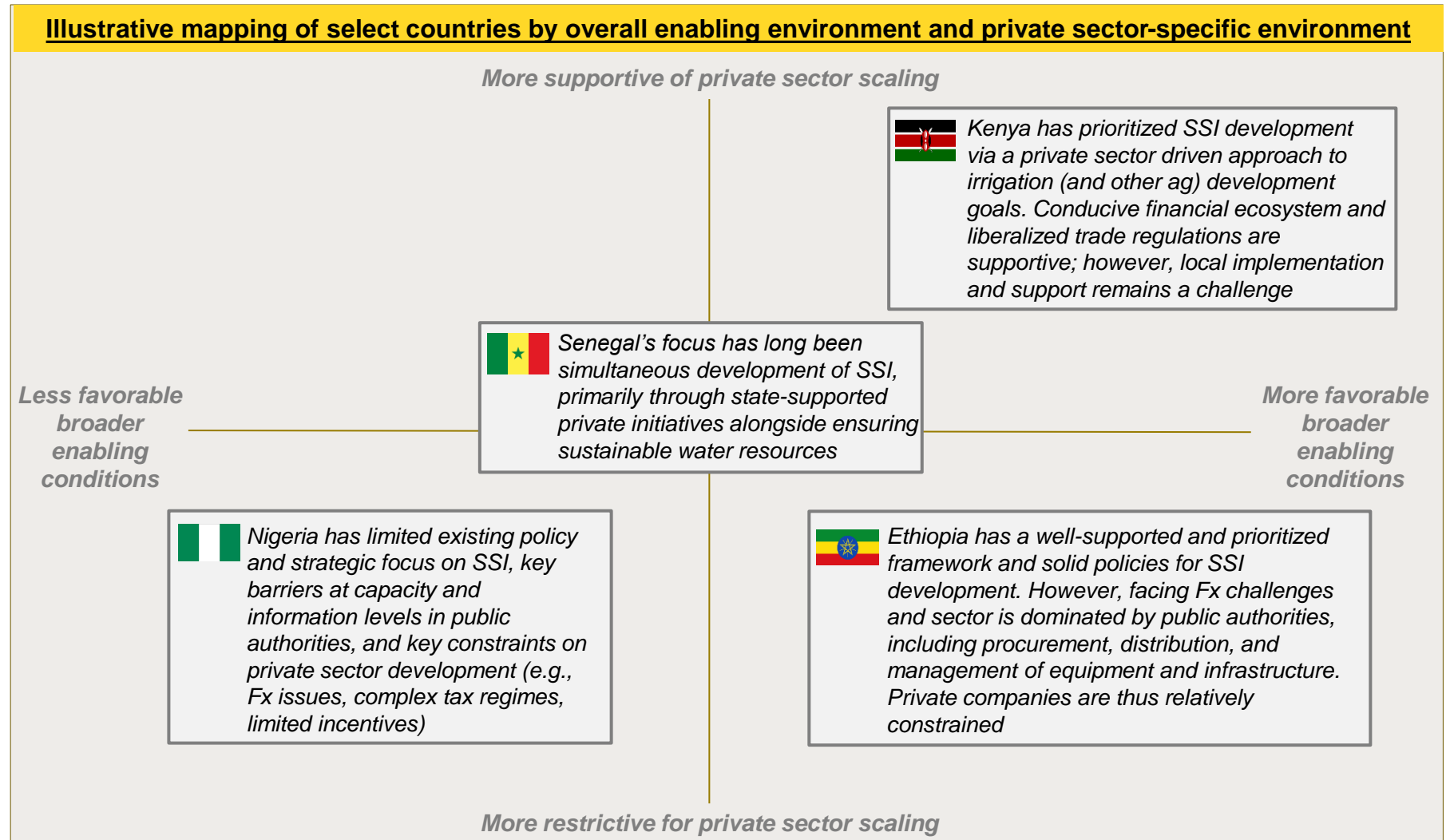
- Favorable** - supportive conditions that enable sustainable and effective scaling of SSI and the elimination of the most burdensome barriers/challenges for stakeholders
- Moderately favorable** – while supportive conditions generally exist, key challenges and constraints persist
- Emerging** – while there is limited conducive conditions at present steps are being taken to develop and implement effective supporting elements
- Unfavorable conditions** – key constraints exist and must be addressed

Note: assessment is taken on a relative basis and even the most favorable enabling conditions still face challenges and barriers

The degree to which countries have a supportive environment for just *private-sector* SSI development differs from *overall* SSI development

Context:

- Given the various ways in which scaling irrigation can occur, as well as the various cross-cutting components (e.g., water resources, economic considerations, technical considerations) any given enabling environment context can achieve different level of support depending on the focus
- While the previous slide focused on the holistic enabling environment conditions for SSI growth by country across SSA, this graphic adds the additional specific focus on *private-sector driven* SSI development
- Key drivers of conducive private sector support include liberalized financial regulations and tax regimes, limited trade restrictions, high ease of doing business ranking, and level of proactive support for specific SSI companies



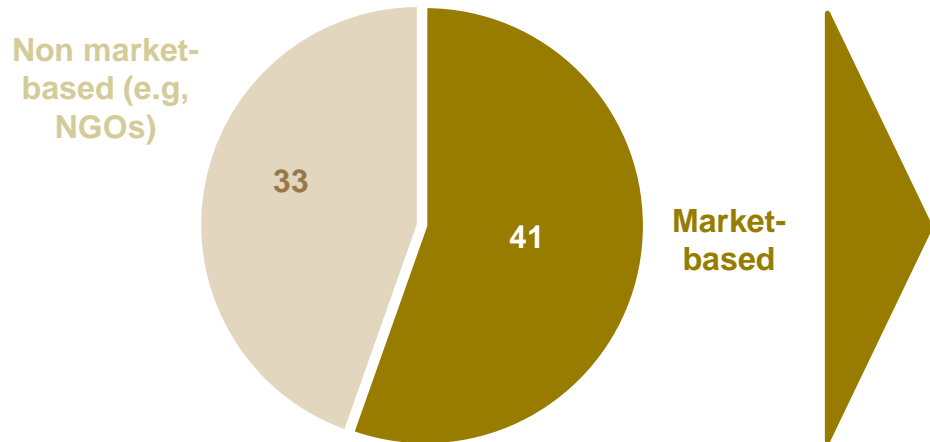
CONTENT OUTLINE

0. Scope and objectives
1. Executive Summary
2. Impact case for scaling irrigation
3. Current state of small-scale irrigation, expansion opportunity, and enabling environment barriers
- 4. Emerging private sector solutions**
5. Barriers to scale and sustainability
6. Recommended actions to scale irrigation for small-scale producers

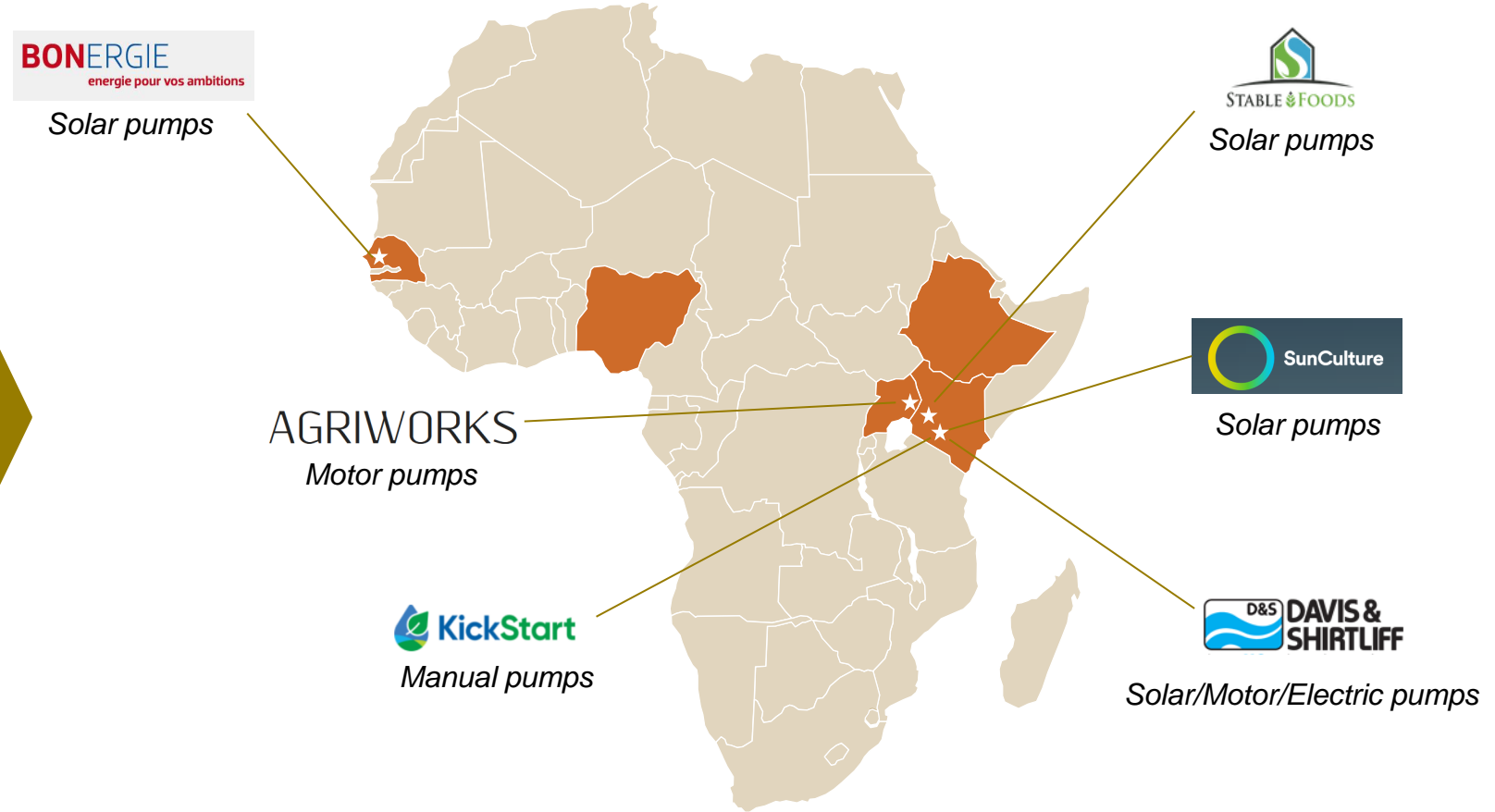
Our analysis focused on 6 private sector providers, representative of the 4 main SSI pumping technologies

Mapping of SSI initiatives in SSA¹

Over the 74 SSI initiatives mapped, 41 are market-based.

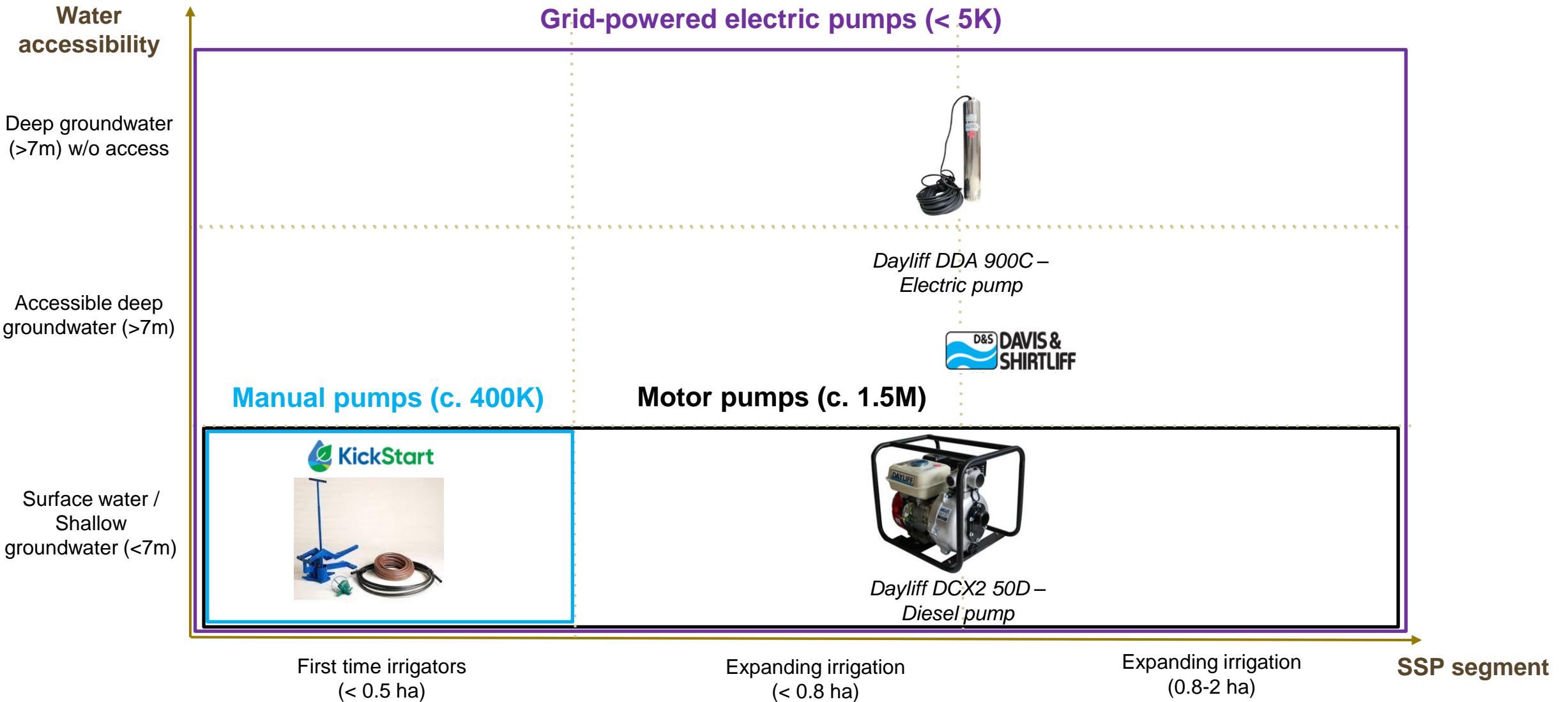


Private sector providers analyzed in-depth and countries visited during the project



¹Hystra's analysis based on scanned initiatives from desk research and expert interviews.

Historical sales of pumps in SSA have been estimated to less than 2M in total

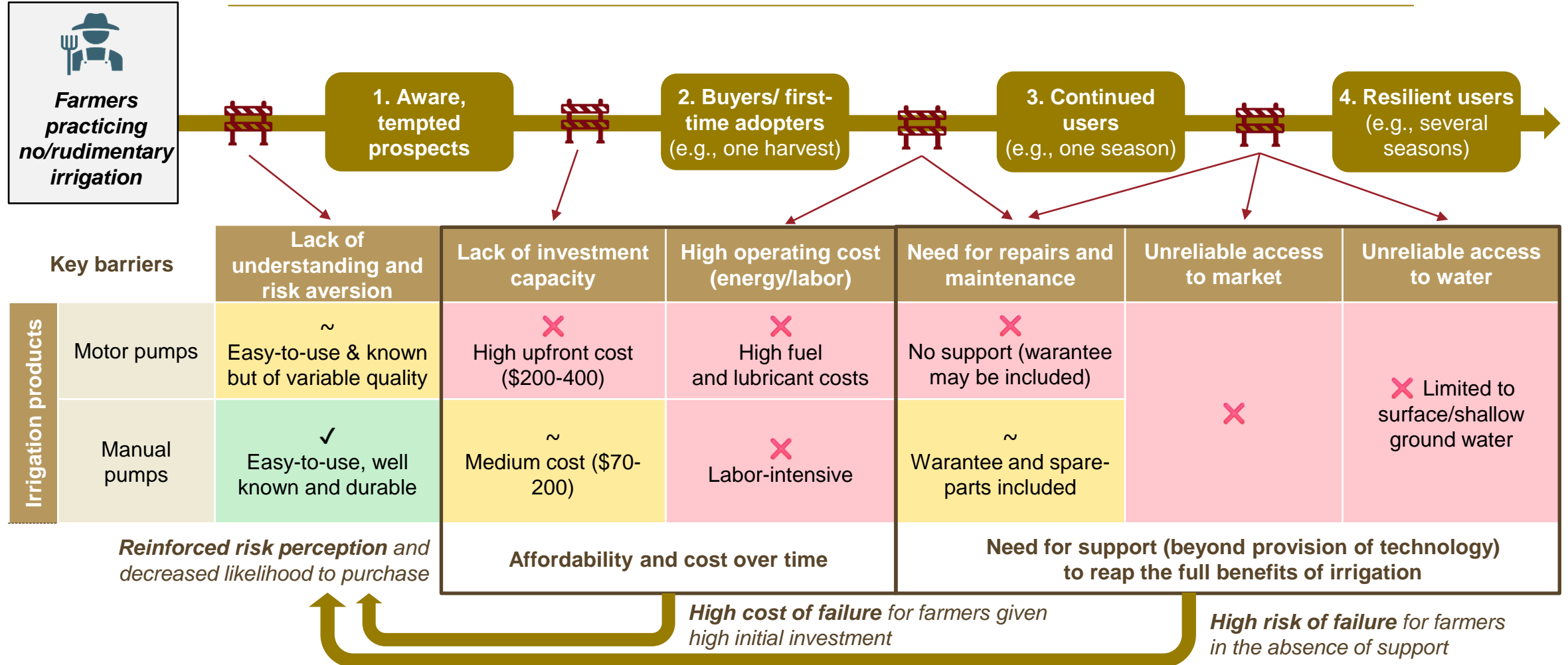


*Estimates from KickStart

Logos represent providers featured in case studies ([Appendix 5](#))




Wide-spread adoption of SSI has been mostly limited by the high cost of acquiring and operating irrigation pumps

Customer journey to irrigation and corresponding barriers from awareness to resilient usage



Solar pumps have emerged as an alternative technically adapted to most use-cases

Comparison of 3 main pumping technologies targeting farmers¹

	Solar 	Motor 	Manual 
Flow rate (m ³ /h)	1 – 5	20 – 60	1 – 3
Pumping depth limit ² (m)	7 – 80 (<i>smaller flow rate for greater depth</i>)	7 (up to 10 if the pump is lowered)	7 (treadle) 15 (rope)
Lifetime of high-quality products (years)	5 – 10 (<i>pump</i>) 10 – 15 (<i>panels</i>)	2 – 5	4 – 7
Limitation for distribution system	-	-	No drip w/o elevated tank

- Flow rate of solar pumps depends on solar irradiance, with an average pumping time of 6 hours per day
- Elevated storage tanks can be used with solar pumps to irrigate when the sun is not shining
- Depending on field slope, solar and manual pumps with low flow rates might not be suitable for flood/furrow irrigation.



Futurepump SF2 - solar surface pump



Lorentz PS2-600 - solar submersible pump



SunCulture ClimateSmart Battery & RainMaker2- solar submersible pump

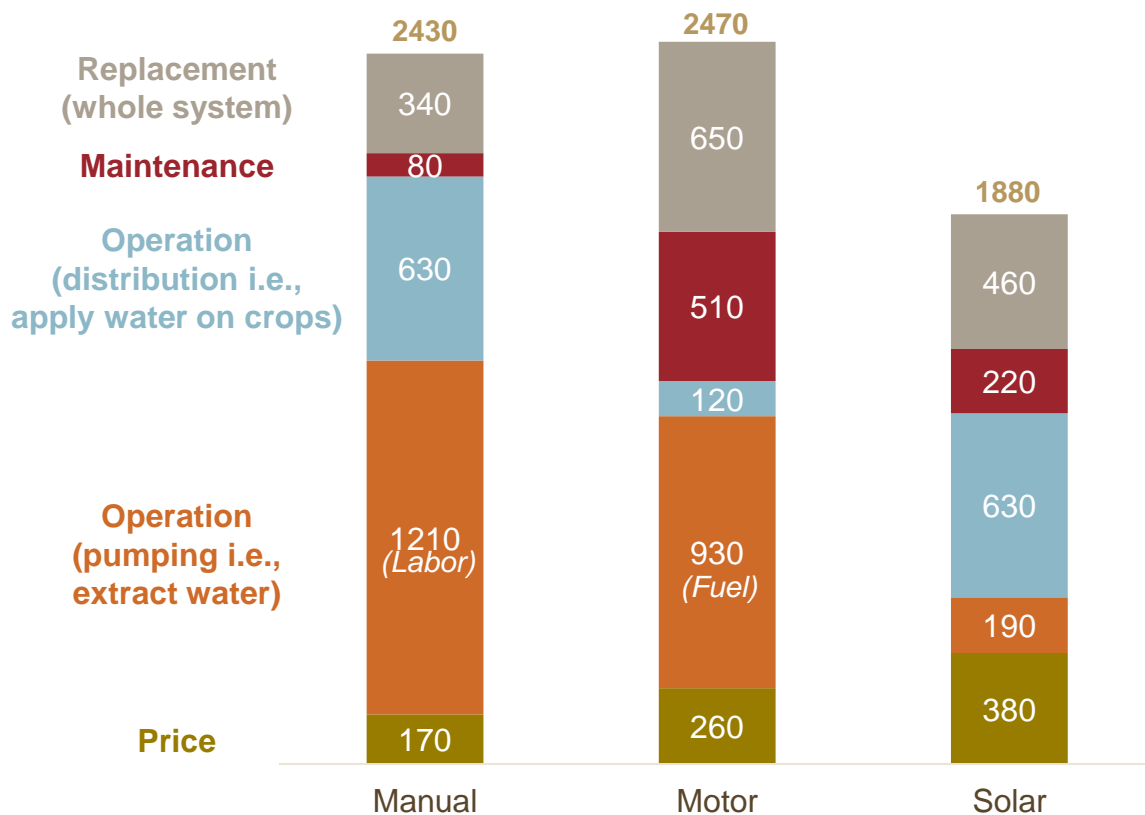


Dayliff Sunflo S300S - solar submersible pump

¹Hystra's analysis from desk research. The ranges give orders of magnitude of available products' specifications. Performances of solar pumps can vary significantly depending on quality and size. ²Maximum suction head (pulling water from below the pump). Pressure head (pushing water above the pump) for manual pumps is about 7-8m, while for motor pumps it can be up to ~60m. More details can be found in [Appendix 3](#).

Solar pumps enable farmers to significantly reduce energy or labour costs, making them cheaper over time, and shielding farmers from hikes in energy prices

Cost analysis of 3 main pumping technology over 10 years for a 1-acre farm, assuming c. 1K m³ of irrigation water per year (\$) ^{1,2,3}



“Thanks to solar, I’m saving \$2 per day of irrigation and don’t have to worry about rising fuel prices anymore”

Bonergie customer

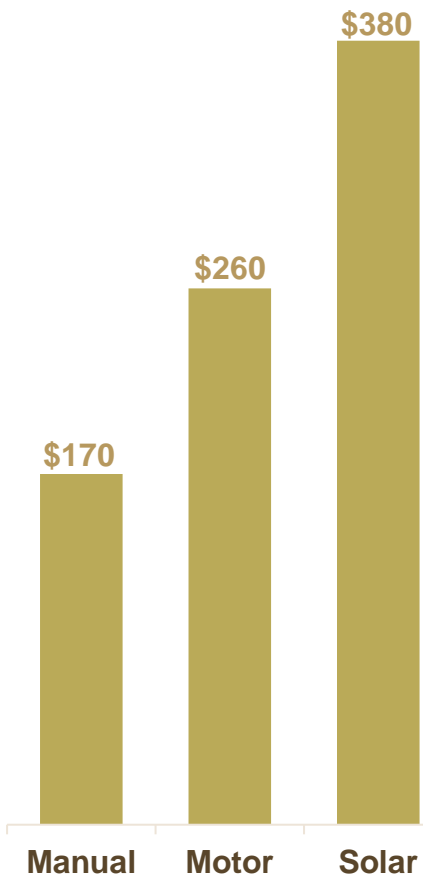
Key hypotheses

- Based on annual water consumption of 1K m³ (enough to irrigate ½ acre of most vegetable crops, for 2 harvests a year⁴), with resp. flow rates of 2.5; 25 and 0.8 m³/h at 14m head
- Pumping: resp. operation time of 100% (extract water manually); 5% and 5%
- Distribution: assuming sprinklers for manual and solar, and hose for motor, with resp. distribution time of 1h per irrigation day (to move the sprinklers) and 100% of pumping time.⁵
- Replacement of the whole system: resp. pump lifetimes of 5; 4 and 7 years, with solar panels lasting 15 years and representing c. 30% of system cost
- Other assumptions: fuel consumption = 1.7 L/h; fuel cost = 1.35 \$/L; lubricant cost = 10% fuel cost; labor cost = 0.3 \$/h

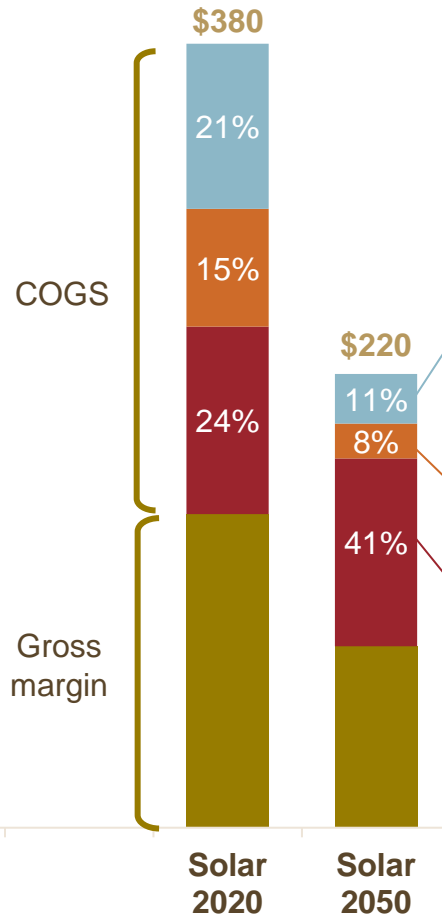
¹Hystra’s analysis from desk research. ²World Bank, *Solar pumping: The Basics*, 2018. ³Pump models used: SunCulture RainMaker2 ClimateSmart Direct, Dayliff DCX1-50P & KickStart MoneyMakerMax, retail prices in Kenya. ⁴ Assuming one harvest is 500K m³ of water applied during 3-4 months. ⁵ Motor pump pressure is too high for sprinklers on a small farm. Additional cost (c. 40\$) and water savings (+10%) of sprinklers compared to hose are not included here.

However, without specific intervention, the high initial cost of solar pumps is expected to remain a barrier for farmers in the short/medium term

Current price of 3 main pumping technologies for a 1-acre farm (\$) ¹



Expected impact of cost reduction in components over consumer price of solar irrigation kit²



Solar PV panel

- The production cost of solar PV has declined dramatically since 1975: in 2021, the average cost was \$0.27/W, i.e., 7 times less than a decade ago³
- It is expected to keep decreasing in the next three decades, by 30% in 2030 and 70% in 2050 (compared to 2021)⁴

Solar PV module price (\$/W)¹

Controllers/inverters & auxiliaries

The cost of inverters is also expected to decrease by 70% in 2050⁵

Pump

The cost of the pump itself is not expected to decrease significantly in the next years, similarly to motor pumps

¹ Assuming c. 1K m3 of irrigation water per year. Pump models: SunCulture RainMaker2 ClimateSmart Direct, Dayliff DCX1-50P & KickStart MoneyMakerMax, retail prices in Kenya.

² COGS breakdown: Hystra's analysis from desk research and Efficiency for Access, SWP outlook, 2019. ³ Our World in Data. ⁴ IRENA, Future of Photovoltaic, 2019. ⁵ Agora, Current and Future Cost of Photovoltaics, 2015. ⁶ A battery could be added for c. 30% of the kit price, with an expected cost decrease of 50-70% by 2050, according to Mauler et al., 2021.

Promising innovations in business models have emerged to solve the affordability barrier, at different scales

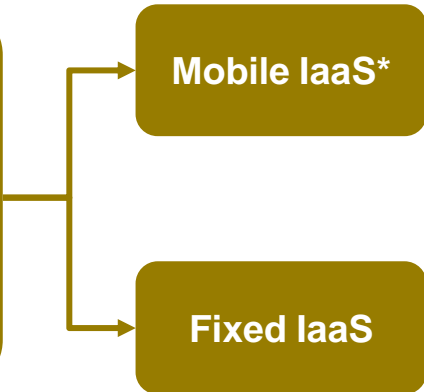
Pay-as-you-Go (PayGo)
offers credit to farmers for solar pumps



Number of units sold or farmers reached



Irrigation-as-a-Service (IaaS) makes irrigation a variable cost



AGRIWORKS



*Mobile Irrigation-as-a-Service models has so far been primarily developed with motor pumps

Logos represent providers featured in case studies (Appendix 5)

Solar pumps with PayGo has become the leading improved irrigation solution (>50K units sold), both for first-time users and farmers expanding irrigated areas



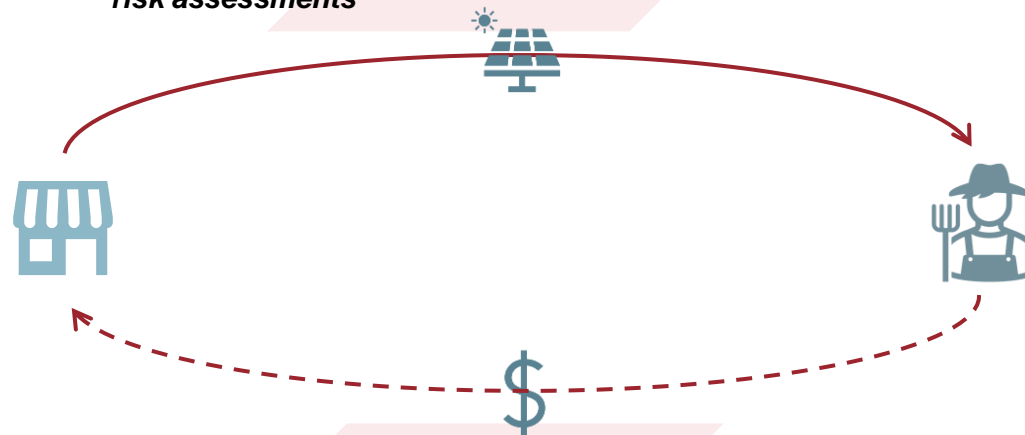
- ✓ In-house financing guarantees a **long-term relationship** with farmers, ensuring high-quality after-sales service...
- ❖ ... but creates a working capital burden for the provider

« Access to finance to cover our working capital requirements is our largest barrier to growth at this stage: the demand is there »
Solar PayGo irrigation provider



1. Irrigation providers sell solar irrigation kits to farmers

- Kits including pump, panels, controller, piping and sprinklers are sold starting at **\$380 for 1 acre** (drip lines optional at \$1k/acre)
- Sales happen mostly via group events with coops or farmer groups initially, and later through **word-of-mouth** and reference from farmers
- Systems are installed by technician after an in-person or remote **site assessment** to check water availability
- When sold on credit (70-85% of sales), providers also carry out **credit risk assessments**



2. Farmers pay back through PayGo

- A **10-30% downpayment** is required from the farmer
- **Monthly repayments** can be fixed or flexible, over 24-36 months, made through **mobile money**
- **Maintenance** and a 2-year warranty is typically **included**
- **Financing cost** for the farmer is **20-40%** of total price paid
- In case of non-payment (often in rainy seasons), after a grace period of 2 to 4 weeks, provider can remotely lock and eventually repossess the system



- ✓ For first-time irrigators: PayGo **reduces risk by limiting initial investment** to 10-30%
- ✓ For farmers switching from motor pumps: solar **provides savings** (up to \$5/day for 2ha)

« Thanks to my solar pump I made \$1K in net profit in just one year by selling tomatoes off season, when the price is at its highest »
SunCulture client in Western Kenya



Mobile IaaS offers complete de-risking for the poorest farmers but has so far only been deployed at small-scale (< 2K farmers)

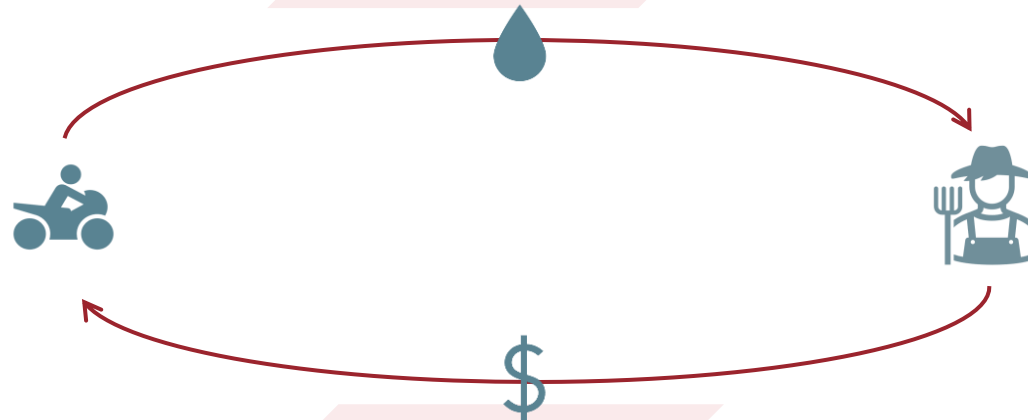


1. Mobile irrigation agents bring pumps to the farmers' fields

- Farmers become aware of the service mostly through **word-of-mouth** and call a branch manager to order 1-6 hours of irrigation
- Branch manager dispatches an agent to the farmer's field
- Agent pumps **accessible surface water** onto the farmer's field (max 250m distance)
- Pumps are powered by motorcycle's engine, but could be powered by solar if and when panels become portable enough, or a battery



- ✓ **SSPs show a clear willingness to pay for irrigation services of which the higher limit has not yet been explored:** in 4 seasons, Agriworks has doubled its price per hour from \$1.5 to \$3 and demand has remained high
- ✓ **Leveraging part-time staff and pumps such as bodaboda riders and their bikes helps tackle the issue of seasonality,** and reduces both CAPEX and OPEX



2. Farmers pay per hour of irrigation

- Agriworks charges farmers **\$3 per hour** of irrigation i.e., c. 10 m³
- Out of the \$3, **Agriworks collects 25%** (\$0.75)
- Riders typically use c. \$1.5 for fuel and maintenance expenses, and end up with **net earnings of about \$0.75/hr.**
- Farmers can get discounts when ordering many hours of irrigation at a time (i.e., >5h)

- ✓ For first-time irrigators, **mobile IaaS considerably reduces risk** by making irrigation a variable cost
- ✓ For farmers who have their own pump, mobile IaaS brings **savings on operating costs** as well as convenience
- ✓ Almost 60% of users would not grow any dry season crop if the service was not available, and **average profit is c. \$250 per dry season**

« My petrol pump was very expensive in fuel and maintenance. Agriworks also makes it a lot easier to irrigate my different plots of land in different areas»

Agriworks client in Eastern Uganda

AGRIWORKS



¹ Taxi drivers who are carrying passengers or goods on their motorcycles
Source: case study on Agriworks (see [appendix 5](#))

Although still at pilot stage (< 100 farmers), **fixed IaaS** offers complete de-risking for farmers, and is expanding into market access to ensure shared success

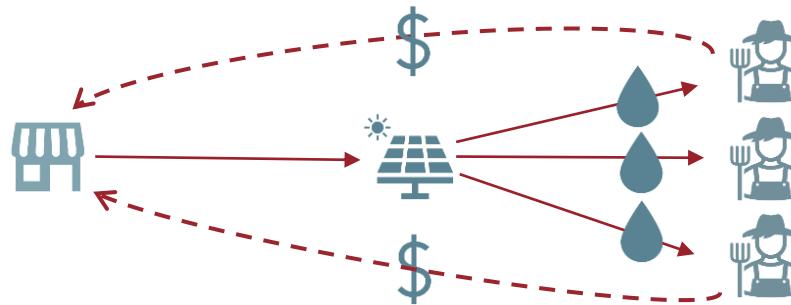


1. Fixed IaaS installs a fixed solar pump and connects neighbouring farmers

- a. Stable Foods finds suitable areas for a new site and **convinces enough SSPs to subscribe to the model** (with a minimum of 10 acres in total).
- b. The company then installs a high-capacity solar pump with borehole and equips the farms of SSPs who signed off with **drip lines**



- ✓ Embedding market access can ensure **long-term success** of both farmer and business
- ✓ Model creates **direct incentive to distribute water efficiently** and connect more farmers to the same site
- ✓ **Ensure reliable water access**, with efficient water distribution systems (e.g., drip)



- ✓ No initial investment required, which **strongly reduces the risk for SSPs**, as they can easily go back to their old ways
- ✓ By providing market access, Stable Foods guarantees a high ROI (2-3 times more revenue) and **embeds its success with the farmer's**



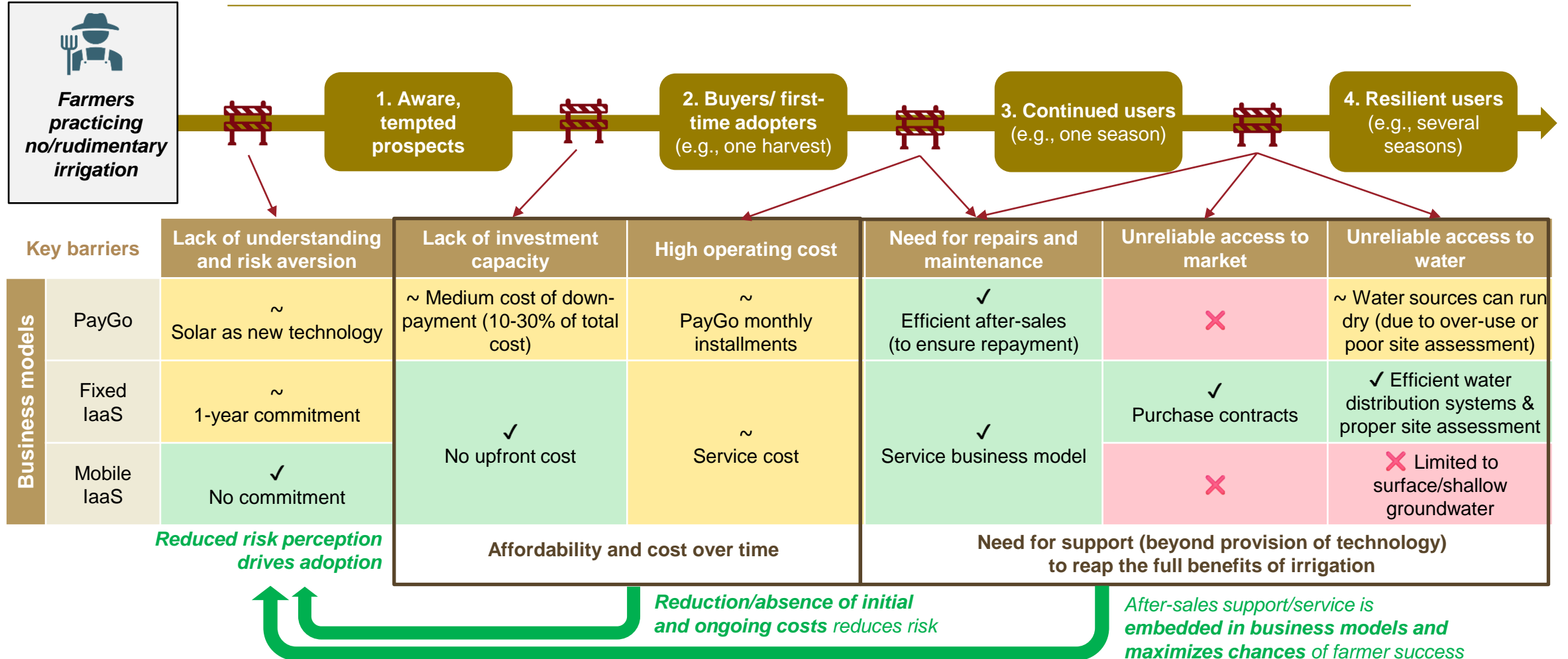
2. Farmers pay Stable Foods under one of 3 models

- **Irrigation-as-a-Service:** SSPs pay for water (\$42/acre/month) with at least 6 payments per year. Inputs and market access can be provided on demand.
- **Lease & Operate (L&O):** Stable Foods **leases and cultivates the land** for the SSPs. The company can also provide agro-training to the SSPs so they can grow crops by themselves after 2 years
- **Jumla model (new):** Stable Foods provides irrigation and inputs on credit (20% down-payment) and **guarantees crop purchase** with a floor price.

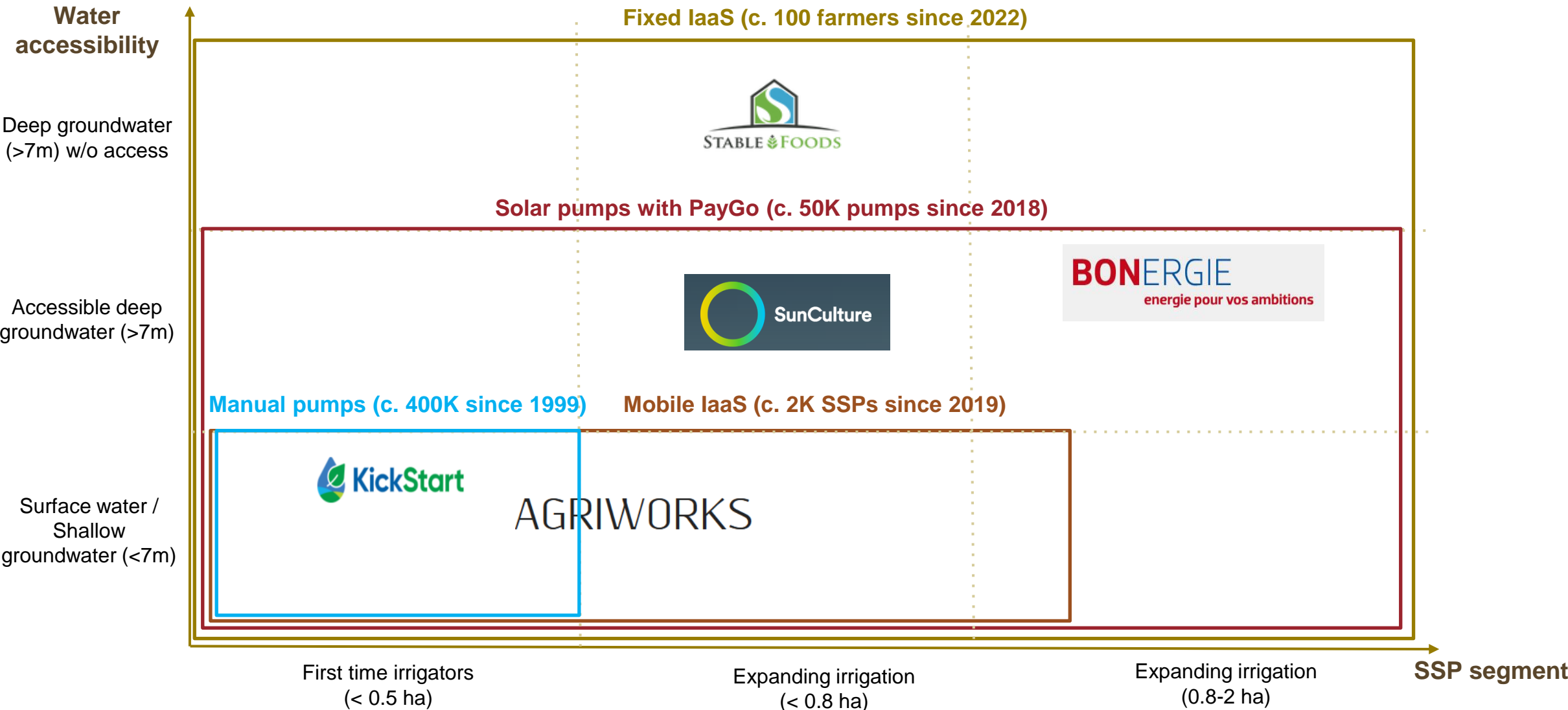


Solar pumps with PayGo and mobile laaS can address or avoid the upfront investment barrier, while fixed laaS can also integrate long-term market and water access

Customer journey to irrigation and corresponding barriers from awareness to resilient usage



These innovative businesses have the potential to cover every farmer segment, with manual pumps remaining a possible stepping-stone for the smallest farmers*



* Manual pumps can help the poorest SSPs to make enough profit to afford to buy a solar pump, while also being a back-up solution when the sun does not shine.

Logos represent providers featured in case studies (Appendix 5)

CONTENT OUTLINE

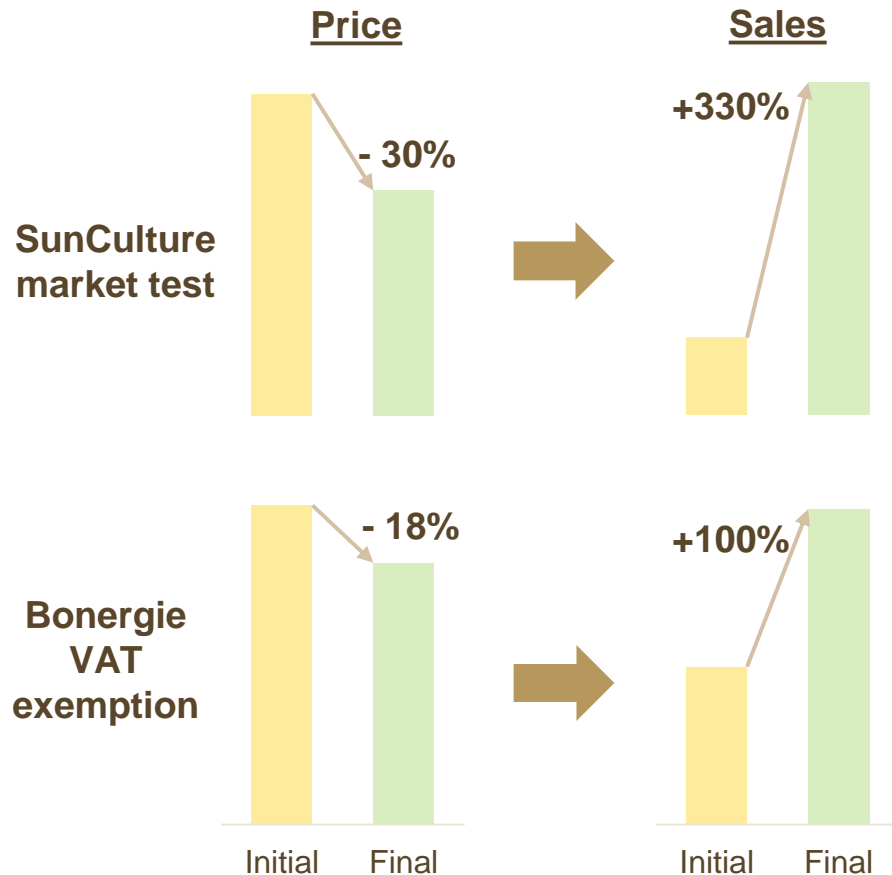
0. Scope and objectives
1. Executive Summary
2. Impact case for scaling irrigation
3. Current state of small-scale irrigation, expansion opportunity, and enabling environment barriers
4. Emerging private sector solutions
- 5. Barriers to scale and sustainability**
6. Recommended actions to scale irrigation for small-scale producers

However, holistically meeting farmer needs creates delivery challenges for **Paygo** irrigation models, which has so far hindered faster growth

Farmer barriers	Lack of understanding and risk aversion	Lack of investment capacity	High operating cost	Need for repairs and maintenance	Unreliable access to market	Unreliable access to water
Solution from PayGo models	~ Solar as new technology	~ Medium cost of down-payment (10-30% of total cost)	~ PayGo monthly installments	✓ Efficient after-sales (to ensure repayment)	✗	~ Water sources can run dry (due to over-use or poor site assessment)
Remaining challenges for farmers		<ul style="list-style-type: none"> Even with PayGo, upfront cost remains a barrier for small SSPs 	<ul style="list-style-type: none"> Most models have fixed recurring payments not meeting seasonality of SSP income 		<ul style="list-style-type: none"> Market access remains a key condition for SSP success and is still mostly not provided. For off-season irrigated crops it is not yet a constraint, but it will be a challenge at scale 	<ul style="list-style-type: none"> Additional cost of drilling a borehole (\$5-10k) can be required to ensure year-round water availability
Challenges for PayGo providers	<ul style="list-style-type: none"> Acquisition costs are high due to need for behaviour change and reassurance; conversion cycles are long 	<ul style="list-style-type: none"> High WCR of PayGo is a strong constraint to scale 		<ul style="list-style-type: none"> The last mile delivery network required to ensure adequate site assessment and efficient after-sales services is complex to set up and run 		<ul style="list-style-type: none"> Null marginal cost of extraction provides little incentive to use water efficiently and in some places, it will challenge farmers' long term success
<p>Barriers faced by PayGo (as well as laaS) providers can be grouped into 4 categories:</p> <ul style="list-style-type: none"> Investment for SSPs is still a challenge (upfront cost, monthly payments vs. seasonality of income) Providers lack working capital Delivery models to provide holistic solutions are still too costly Incentives to preserve water resources are limited 						

Even with financing, the cost of solar pumps remains a barrier for access, as shown by the high elasticity of demand

Impact on solar pump sales of a reduction in price

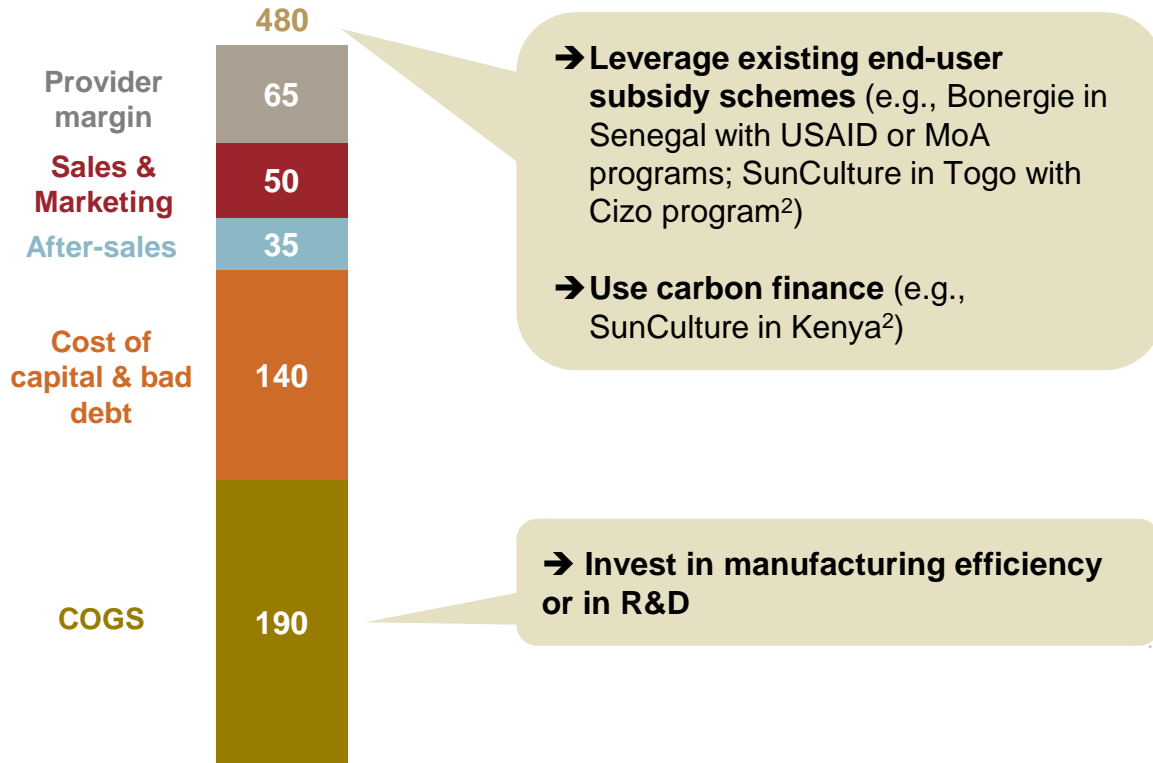


- **Upfront payments** between 10 and 30% of the pump price can represent several months of income for SSPs
- **Monthly recurring payments for PayGo are often larger than the mean non-food expenditures in rural areas** (e.g., \$19/month in Kenya¹ vs. \$24/month for the entry-level SunCulture’s pump²)
- Based on experience from two of the leading providers (Bonergie and SunCulture), we can conservatively assume that **price reduction and demand increase are at least linearly correlated** (e.g., if the price decreases by 20%, demand will increase by 20%)

¹Assuming \$12/month in 2016 (from Economic Survey, 2018), adjusted for inflation. ² Current pricing for SunCulture RainMaker2 ClimateSmart Direct

Irrigation providers are pulling several levers to reduce costs

Cost structure of a solar pump sold on credit¹ and best practices from providers



Other levers include:

- **Improve business model efficiency** to reduce costs of after-sales and sales & marketing
- **Partner with financial institutions** to reduce cost of capital (e.g., blended finance) & bad debt (e.g., first-loss guarantee)



Increasing manufacturing efficiency

The UK-based company Futurepump, founded in 2014, have sold more than 17k pumps in SSA. The company offers two models of **high-quality solar surface pumps**: SE1 for 1-acre or less (retailed from \$520) and SF2 for 2-acres or less (retailed from \$650), both with a 10-year guarantee. Futurepump is only selling through local distributors (in >30 countries), who provide after-sales service and might offer financing (PayGo or lease-to-own). The company manufactures its pumps in India and is currently **looking on decreasing the manufacturing cost by investing in a new plant, with more automation**. With an investment of around \$1M, the company believes it could launch a new entry-level (irrigating ~1 acre) solar pump retailing at sub \$200.



Developing a low-cost solar water pump

KickStart's **in-house R&D team is currently developing a low-cost submersible solar pump** suitable for irrigating ~½ acre, and targeting \$250 retail price. **KickStart says its pump will be easily repairable with fully replaceable plug-and-play spare components**. It will work with dirty water, have an optional extra panel to enable pumping in low-light conditions, and **be modular, allowing two pumps to be easily connected in series to double the pressure head**—which would all be unique features on the market.

¹Approximate values for SunCulture RainMaker2 ClimateSmart Direct. ²See [case study on SunCulture](#) and [Appendix 3](#)

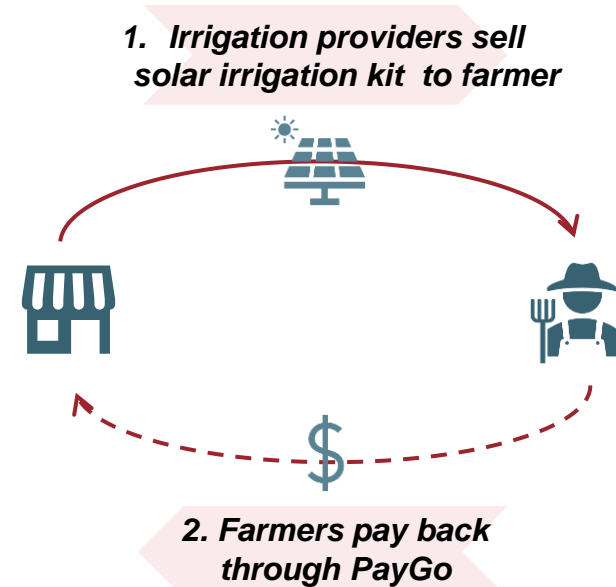
A few best practices emerge in irrigation and other sectors that could help PayGo irrigation providers answer delivery model challenges

Capital investment for SSPs is still too high

- ✗ **Additional investment into drilling a borehole** (\$5-10k) can be required to ensure year-round water availability
 - ➔ **Diversify into borehole drilling** (e.g., Bonergie)

Providers lack working capital

- ✗ **In-house financing creates high WCR which have so far not been met with adequate financing**
 - ➔ **Build partnerships with MFIs** e.g., Bonergie and U-IMCEC to finance 300 pumps in Senegal
 - ➔ **Sell to wealthier SSPs**, including complementary solutions (such as cold storage solutions or borehole drilling) improves caSSPlow and cross-subsidizes credits to poorer SSPs (e.g., Bonergie)
 - ➔ **Access dedicated credit lines at concessional rates from DFIs**, like Grameen Shakti which pioneered credit sales of solar home system in Bangladesh in early 2010s thanks to working capital from development agencies, and reached 2M households

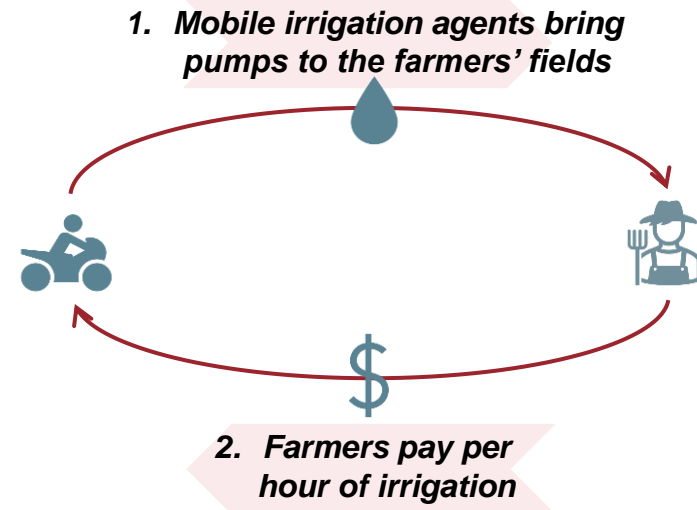


Delivery models to provide holistic solutions are still too costly

- ✗ **Acquisition costs are high** due to behaviour change and outreach
 - ➔ **Maximize penetration in one cluster before moving to the next by encouraging word-of-mouth through referrals** (e.g., SunCulture's app)
 - ➔ **Maximize customer lifetime value** by expanding irrigated area (additional pump or more efficient distribution system, e.g., Bonergie) or offering additional long-term services or cross-selling other solar appliances (e.g., SunCulture TV)
- ✗ **The extended LMD network** required to ensure adequate site assessment and efficient after-sales services is costly
 - ➔ **Leverage existing network of certified technicians** (e.g., D&S network of dealer shops and technicians with app for site assessment and training)
- ✗ Most models are **asset-based financing with fixed recurring payments** not meeting seasonality of SSP income
 - ➔ **Adapt payment schedules to harvests and allow SSPs to prepay flexible amounts** (e.g., Bonergie)
- ✗ **Market access remains key condition for SSP success** and is mostly not guaranteed
 - ➔ **Build partnerships with agro-buyers** (e.g., SunCulture pilots)

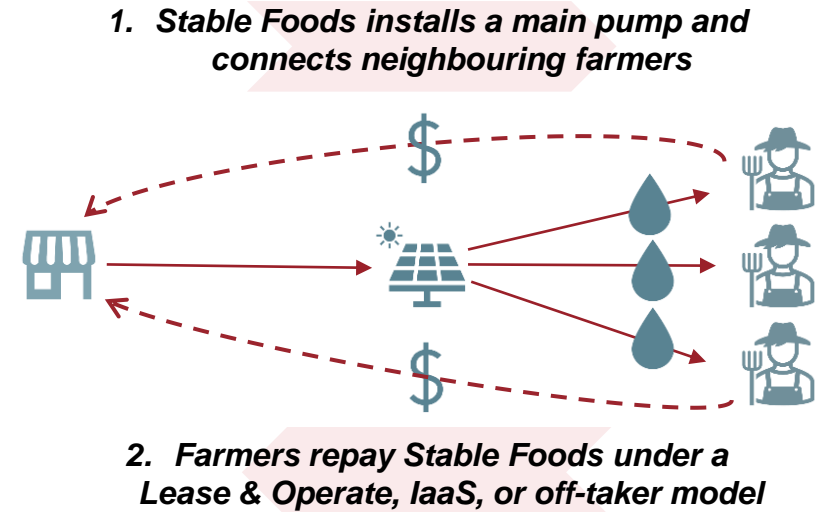
Mobile and fixed IaaS have so far only been implemented at a small scale (< 2K farmers), and have not yet reached profitability

Mobile IaaS



- ✗ **Farmers willingness to pay** is not yet fully understood
→ Pricing can be adapted to encourage first trial, regularity and volume
- ✗ **Optimizing logistics** (e.g., minimizing transportation time) is a major challenge and cost driver
- ✗ **Access to surface or shallow groundwater** is required
- ✗ **Water regulation laws** might prevent replication in some countries
- ✗ **Seasonality of irrigation** endangers overall profitability
- ✗ **Market access remains a key condition for SSP success** and is not guaranteed

Fixed IaaS






- ✗ **High initial investment required** to find and open a new site, and convince farmers to subscribe
- ✗ **Economic viability** depends on capacity to ensure market access

These models (exc. fixed IaaS) rarely use water-efficient distribution systems (like drip irrigation) and have limited incentives to maximize water use efficiency and safeguard long-term resources

Drip irrigation has the potential to save water resources but remains complex to operate and expensive

Only fixed IaaS uses drip irrigation, with a direct incentive to efficiently use water

	Hose	Sprinkler	Drip
			
Water savings¹	Baseline	-10%	-40%
Lifetime (y)	2-3	7-10	3-5
Price for 1-acre farm (\$)	25-75	75-125	500-1000
Operating limitations	High labor costs	Can cope with relatively clean water; limited labor costs	Requires clean water or flushing filter every week and regular checks
Pressure requirement	Low	High	Medium

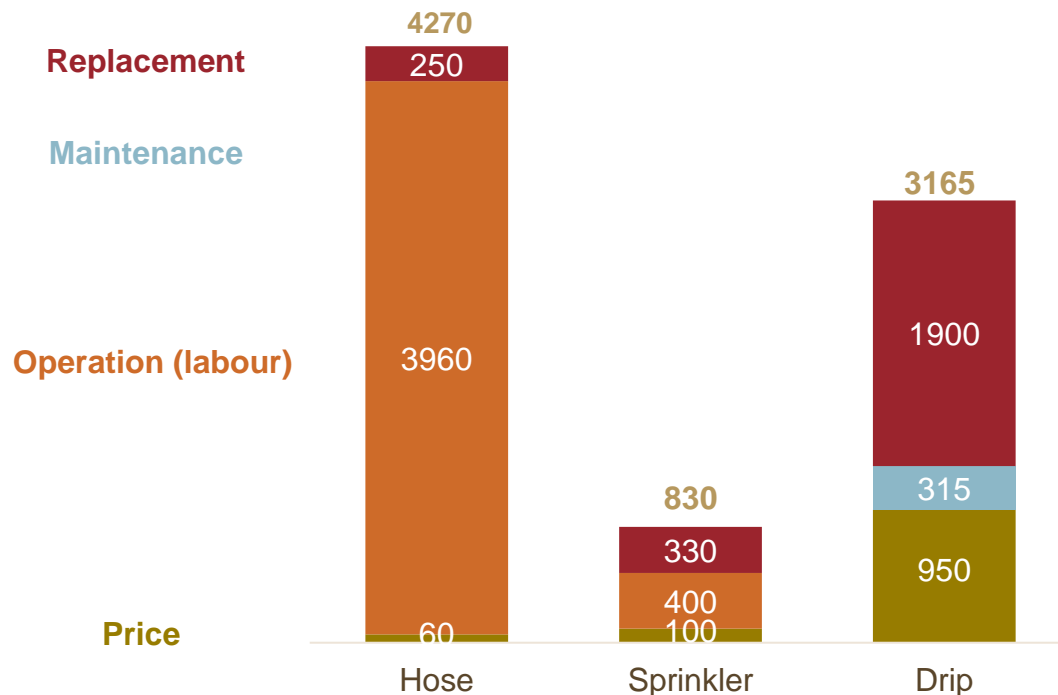
		Solar PayGo	Mobile IaaS	Fixed IaaS
Distribution	Hose	Default usage	Agriworks / KickStart	NA
	Sprinkler	20-40% sales	PayNPump	NA
	Drip	<5% sales	NA	100% of farms with drip
Incentive to save water		<p>✗</p> <p>SSPs accessing solar pumps are not incentivized to be water-efficient</p> <ul style="list-style-type: none"> • SWPs have virtually no marginal cost of water extraction • Without storage (tank or battery), SWPs are best used with max sunlight² 	<p>✗</p> <p>Mobile IaaS sells water as a service per the hour and not per m3</p>	<p>✓</p> <p>Fixed IaaS creates a direct incentive to use water efficiently thanks to drip lines, and connect more farmers to same site</p>

¹Measured compared to hose, negative values implies less water used. ² i.e., when evapotranspiration is at its highest

Data comes from Hystra's analysis and: CDurable.info, l'irrigation goutte à goutte en Afrique subsaharienne, 2010 and Grekkon Limited, The most efficient way to irrigate your crop, 2022

In particular farmers lack short-term incentives to adopt water-efficient drip lines, despite their potential for long-term additional return

Total cost analysis of 3 distribution technologies over 10 years for a 1-acre farm equipped with a solar pump (\$)¹



Over a solar pump's lifetime, sprinklers require the least investment

- Hose irrigation is time-consuming, especially for submersible solar pump with higher head pressure but smaller flow rates
- Drip lines represent a significant additional investment (30% higher than the solar kit itself) and require regular maintenance (e.g., changing the filter) and clean water
- When taking into account additional revenue from more irrigated land with the same water quantity, drip can become a profitable investment²

¹Hystra's analysis from desk research. ²3 years ROI of +30% assuming one tomato harvest on 1 acre can generate \$1770 of profit and assuming drip increases water productivity by 40% compared to hose. Other hypotheses: yield = 5t/acre, sale price = \$0.6/kg, inputs/labor expenses = \$1200/acre.

CONTENT OUTLINE

0. Scope and objectives
1. Executive Summary
2. Impact case for scaling irrigation
3. Current state of small-scale irrigation, expansion opportunity, and enabling environment barriers
4. Emerging private sector solutions
5. Barriers to scale and sustainability
- 6. Recommended actions to scale irrigation for small-scale producers**

Potential actions to scale irrigation for small-scale producers

Potential leverage points and recommendations



Across stakeholders and markets

- 1) Summary of priority leverage points that the broader market can focus on to address key barriers
- 2) Exploration of specific recommendations within each leverage point, including rationale, examples and/or best practices, and primary stakeholders involved



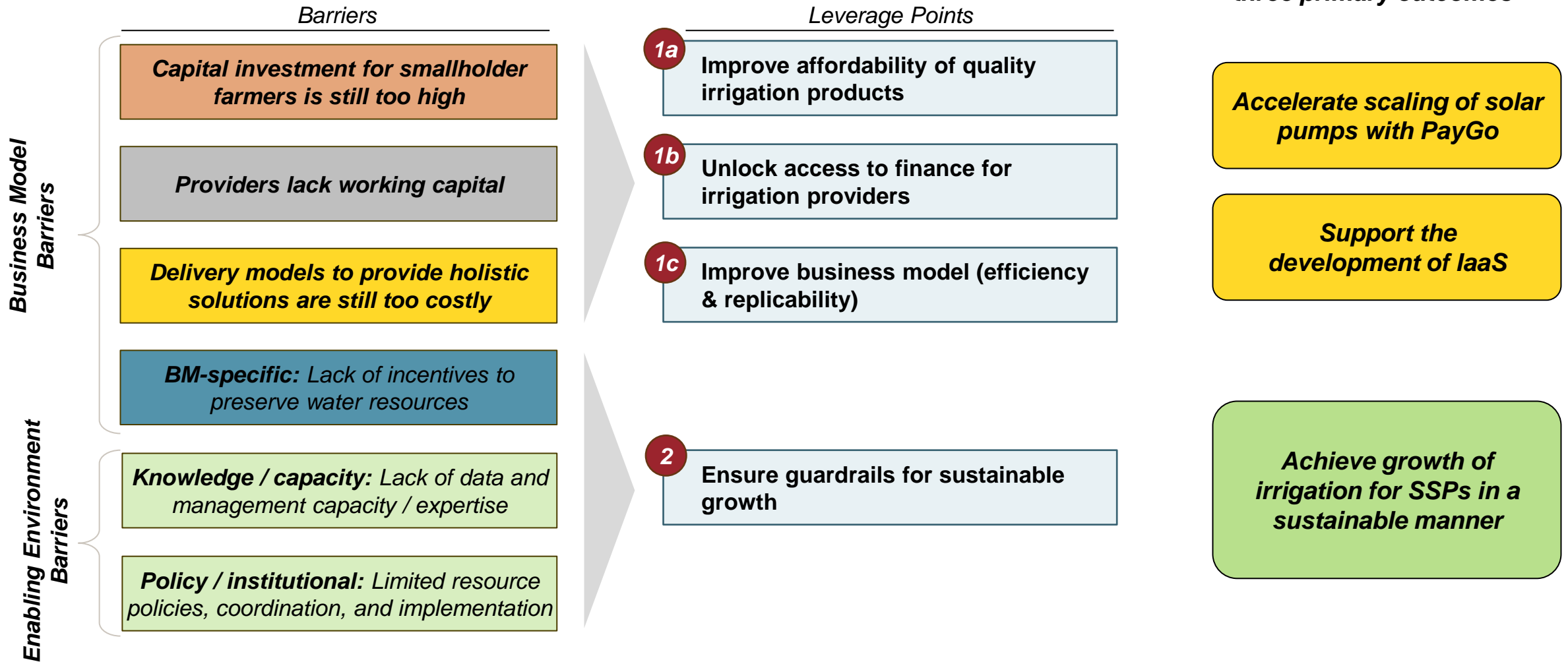
Deep dive on selected interventions for donors

- 1) Detailed view on selected activities in key geographies that donors could potentially pursue, including rationale and approach
























Barriers to the sustainable uptake of small-scale irrigation can be unlocked by focusing on 4 points of leverage

Key barriers and constraints can be addressed by pursuing specific leverage points





... which can ultimately lead to three primary outcomes






Donors, public authorities and financial institutions can help unlock each of these leverage points

Barrier	Leverage Point	Recommendations	Key stakeholders involved
Capital investment for SSPs remains too high	1a Improve affordability of quality irrigation products	<ol style="list-style-type: none"> 1 Provide targeted and cost-effective price subsidies via tax exemptions 2 Unlock cost reduction in borehole drilling and pumping systems 3 Develop industry standards and guidelines for irrigation equipment 4 Streamline carbon financing of solar water pumps 	      
Providers lack working capital	1b Unlock access to finance for irrigation providers	<ol style="list-style-type: none"> 1 Unlock aligned development capital 2 Build partnerships between local financial institutions (MFIs/banks) and PayGo providers 3 Unlock Fx constraints 	   
Delivery models to provide holistic solutions are still too costly	1c Improve BM (efficiency & replicability)	<ol style="list-style-type: none"> 1 Finance ongoing innovative pilots to optimize their value proposition and delivery model 2 De-risk and support the expansion of successful providers into new/adjacent geographies via direct funding as well as policy advocacy 3 Develop irrigation knowledge amongst relevant promoters (e.g., extension workers) 	    
Lack of incentives to preserve water resources	2 Ensure guardrails for sustainable growth	<ol style="list-style-type: none"> 1 Develop irrigation management information systems 	 
Lack of data and management capacity / expertise		<ol style="list-style-type: none"> 2 Incentivize water efficient systems 	
Limited resource policies / coordination / implementation		<ol style="list-style-type: none"> 3 Fund R&D for optimized distribution systems and remote monitoring systems 	
		<ol style="list-style-type: none"> 4 Establish and support organizations or associations governing water use rights 	
		<ol style="list-style-type: none"> 5 Create regional coordination platforms by convening key stakeholders 	 




1a Improving affordability of quality irrigation products (1/2)

Recommendations	Rationale	Example(s) / Best Practices	Primary Stakeholder (Supporting Actors)
<p>1 Provide targeted and cost-effective price subsidies via tax exemptions, specifically removing import tariffs and VAT on impactful and high-quality irrigation equipment</p> <p>a) Public authorities (typically Revenue/Tax authorities, MoA, and MoF) must work together to 1) define and align on standards for quality and water-efficient equipment, with a specific focus on SWPs and efficient distribution systems (e.g., drip lines) that should be exempt and 2) find which taxes are most burdensome and could have the highest impact for reducing consumer prices. A comprehensive approach for systems should be taken rather than exempting certain parts (e.g., just the panels) as uptake is then limited</p> <p>b) Once applicable standards are developed, implementation should be as streamlined as possible (e.g., approval comes from only a single organization).</p>	<p>Impactful and efficient irrigation equipment is largely not exempt from import tariffs and VATs (which is more often the case for other productive-use tech). The result is higher consumer prices and/or lower gross margins for providers. Removing these tax burdens has proven to be an effective and efficient public subsidy that can drive more increased economic production from agricultural development than foregone tax revenue</p>	<ul style="list-style-type: none"> Various successful examples (globally and in SSA) of tax exemptions lead to higher adoption of various productive use appliances, agricultural equipment and solar-powered systems (e.g., solar home kits) Similar approaches have been taken for SWPs specifically in Senegal, Niger, and Uganda. While recent, primary feedback indicates positive correlation with reduced consumer prices (and more stable margins for providers) In Bangladesh, the 1985 removal of import tariffs on irrigation pumps resulted in a boom of SSI growth (30k+ pumps per year) due to lower prices and increased access.¹ The country became a net exporter of rice in the decade following this, driven in part by the boom in affordable pumps Ignite Solar's Public Private Multilateral Partnership model allows the provider to negotiate duty waivers and tax exemption with governments in its countries of operation (e.g., in Rwanda). 	 <p>Public Authorities</p>  <p>Donors</p>
<p>2 Unlock cost reduction in borehole drilling and pumping systems, especially in geographies that have more groundwater than surface water resources</p> <p>a) Key cost drivers of borehole drilling include:</p> <ul style="list-style-type: none"> small economies of scale with restricted competition within the sparse market high set up costs due to the vast area covered, often with poor transport infrastructure low standards of service provision amongst drilling and pumping contractors high duties and taxes on imported drilling equipment (e.g., rigs), with limited manufacturing of spare parts Low success rate of drilling due to unreliable info on aquifer characteristics and borehole yield. <p>b) Manufacturing costs for pumping systems (e.g., SWPs) could be reduced through automation and scale</p>	<p>The high costs of drilling boreholes and wells tends to limit the adoption of SWPs and prohibit the expansion of groundwater resources. Unit costs for boreholes in SSA typically range \$6-23K within individual countries and are considerably more expensive compared to Latin America or South Asia³. Lowering this cost by addressing key drivers can play a substantial role in increasing broader affordability and adoption of SWP and SSI as a whole</p> <p>A 25% reduction in COGS for a solar pumping system would allow a 10% reduction in price</p>	<ul style="list-style-type: none"> Recent research in Ethiopia revealed that reducing borehole costs and ambiguities/uncertainties involved with the process can be a cost-effective approach to induce adoption of groundwater irrigation by SSPs.² SSPs sometimes have to dig several boreholes before installing the pump, due to lack of aquifer knowledge In the 1960s in India, the government implemented a free boring scheme in which the government absorbed the cost of making a borewell, with banks offering low-interest loans for diesel pumps.¹ The scheme became an instant hit and was replicated across the country, driving a massive surge in irrigation However, the reduced costs and easy accessibility of borehole drilling across South Asia, where an estimated 20M wells are found, is partly responsible for the groundwater challenges in those regions. Thus, R&D should also focus on simultaneous outcomes of more effective monitoring and supervision technology within the equipment and processes involved. Futurepump is currently looking on decreasing the manufacturing cost by investing in a new plant, with more automation. With an investment of around \$1M, the company believes it could launch a new entry-level (irrigating ~1 acre) solar pump retailing at sub \$200. 	 <p>Donors</p>  <p>Public Authorities</p>



1a Improving affordability of quality irrigation products (2/2)

Recommendations	Rationale	Example(s) / Best Practices	Primary Stakeholder (Supporting Actors)
<p>3 Support the development and implementation of industry standards and guidelines for solar water pumps and efficient distribution systems (e.g., drip lines) alongside manufacturers and other key stakeholders to ensure high quality and durability of equipment for consumers and future leverage for tax exemptions</p> <p>a) There is a wide breadth of existing and ongoing work around this topic (see best practices section). Rather than replicate this work, this recommendation aims to further implement the quality standards and existing evaluation by advocating for their uptake and use, convening stakeholders to ensure applicability in specific contexts/geographies (e.g., private companies, local authorities, implementers), and ensuring farmers are aware of their existence</p>	<p>At present, even highly educated farmers cannot easily compare and contrast the different pumps available to make an informed decision. Quality pumps can last up to 10-20 years and so produce much better long-term economic return. Experience with solar home systems shows that poor quality products can distort the consumer perception across the whole industry. Finally, lack of guidelines and consensus standards results in premium pricing for those that can guarantee quality</p>	<ul style="list-style-type: none"> The SWP market is relatively nascent and experiencing rapid innovation, making established (and static) quality standards difficult to establish However, key metrics are being established, largely drawing upon a deep history of work in adjacent equipment (solar home systems, other PULSE items) In particular, LightingGlobal is establishing VeraSol as a full quality assurance program for SWPs It focuses on certification (evaluate and confirm product meet quality standards), quality standards (determine and set baseline level of product quality), testing & data (generate product performance and quality data to inform actions), and test lab methods (define how product quality and performance is measured) VeraSol and other adjacent standardization and quality assurances efforts by Lighting Global are supported by organizations including: World Bank, IKEA Foundation, UKAID, CLASP, and Schatz Energy Research Center 	 <p>Donors / NGOs</p>  <p>(Public Authorities as key supporting partner)</p>
<p>4 Streamline carbon financing of solar water pumps to reduce certification costs and avoid market distortions, starting by increasing R&D into carbon credits and voluntary credit markets and assessing the opportunity for a regional/international vehicle to collect and channel carbon finance (and other forms of subsidies/monetized externalities) to approved solution providers to reduce prices for BoP</p>	<p>Monetizing carbon externalities can help improve GM for providers and stabilize or reduce consumer prices leading to uptake.¹</p> <p>Creating a mechanism that reduces the cost and complexity of certification so that all quality providers can access carbon finance would prevent potential market distortion caused by any individual provider able to invest in certification (\$200k per market)</p>	<p>D-REC:</p> <ul style="list-style-type: none"> Multistakeholder and industry led initiative to facilitate the creation of an Energy Attribute Certificate for Distributed Renewable Energy projects Circumvents cost and complexity of certifying carbon offsets in tCO2e by certifying kWh of renewable energy production based on data collected from providers At \$20 target price/kWh, revenue per pump per year could range from \$8 to \$60 (assuming 6h/day, 220 day/year) 	 <p>Donors</p>






1b Unlock access to finance for irrigation providers (1/2)

Recommendations	Rationale	Example(s) / Best Practices	Primary Stakeholder (Supporting Actors)
<p>1 Unlock aligned development capital</p> <p>1. Advocate and provide catalytic support for irrigation as a promising and relatively investable climate adaptation asset class to invest development capital</p> <p>2. Leverage PayGo systems for results-based financing</p> <p>3. Provide tailored financial solutions and capacity building for local financial institutions (MFIs; SACCOs, large coops, commercial banks) including wholesale lending, derisking support (guarantee schemes or first loss), or revolving funds dedicated to SSI</p>	<ul style="list-style-type: none"> Climate adaptation investment opportunities is an increasingly important focus for ag-investors, but investable (i.e., appropriate risk/return profiles) and impactful solutions in the space remain relatively limited. Irrigation is a crucial adaptation intervention for farmers and the market has investable opportunities (i.e., companies with existing products and business models rather than opportunities that require widespread behavioral change, such as regenerative farming). By advocating for this as an attractive asset class and providing catalytic support via funding or other avenues, actors can unlock additional capital. Results-based finance (e.g. subsidy to provider triggered by monthly payment from user) improves effectiveness of spend and reduces risk for Donors & DFIs 	<ul style="list-style-type: none"> In the adjacent agricultural sub-sector of nutrition, GAIN's work in advocating and providing catalytic support (e.g., their Nutritious Foods Financing Facility – N3F) for nutrition as an asset class provides a clear example that could be followed. Their efforts helped unlock key capital via blended finance approach that focuses on improving nutrition by supporting SMEs in SSA to scale up the production and sale of locally produced nutritious, safe foods destined for domestic markets Financed by AfDB and EIB, the CIZO program brought together EDF, SunCulture, Bboxx and the Togo Ministry of Agriculture, to sell 4k solar pumps in 2 years with PayGo financing. The program provided a 50% subsidy on both the deposit and monthly fees: each 50% payment from a customer registered on the CIZO platform to the distributor (Bboxx) released an equivalent payment from the government to the distributor through mobile money Receivables financing platforms connecting distributors and investors e.g. BridgIn by PaygOps 	 <p>Donors & DFIs / Impact Investors</p>  <p>Financial Institutions</p>
<p>2 Build capacity and partnerships between local financial institutions (MFIs/banks) and PayGo providers to enable:</p> <ul style="list-style-type: none"> Irrigation loans carried by financial institutions, leveraging PayGo for repayments, and sharing default risk with providers Access to client base and promotion of irrigation solutions Alignment of credit product offering to upstream (e.g., inputs) and downstream farmer needs (e.g., cold storage) 	<p>Commercial banks and MFIs are typically both:</p> <ul style="list-style-type: none"> Deterred from lending to resource-poor SSPs by the level of risk involved Unaware of the de-risking potential of irrigation through rapid and durable improvement in productivity and income 	<ul style="list-style-type: none"> Bonergie building partnerships with MFIs (e.g., with U-IMCEC for 300 solar pumps) which embed: <ul style="list-style-type: none"> Loans carried by MFIs but repaid through Bonergie's PayGo system Default risk shared between MFIs and Bonergie through delayed repayments Contractual ability for Bonergie to repossess the system in case of default Water.org, via their Water Credit Initiative offers a comprehensive package of product support (including financial product design, marketing support, to technical equipment training) and de-risking to MFIs in order to promote drinking water 	 <p>MFIs / Commercial Banks</p>




1b Unlock access to finance for irrigation providers (2/2)

Recommendations	Rationale	Example(s) / Best Practices	Primary Stakeholder (Supporting Actors)
<p>3 <u>Unlock Fx constraints in geographies where this is a key barrier for irrigation providers and distributors (e.g., Nigeria, Ethiopia)</u></p> <ol style="list-style-type: none"> Public authorities should conduct a cost benefit analysis on allocating Fx reserves for importing of irrigation equipment (specifically SWPs) relative to other agriculture-related imported equipment Create and manage a revolving Fx fund that has the specific aim of financing imported irrigation equipment, ideally based on previously established standards 	<p>Fx constraints were cited as a top concern for providers interviewed in both Ethiopia and Nigeria. Increased access to Fx for distributors would decrease the COGS of imported equipment, resulting in immediate impact on gross margins as well as expected reduction/stability in consumer prices</p>	<p>While still in the early stages, the Ethiopian government is setting up a pilot revolving Fx fund projected to be \$5-10M to begin with, with the potential to expand to \$100M+. The fund aims to support the private sector in Ethiopia procure and obtain imported irrigation technologies, with a specific focus on SWPs, that are currently made highly inaccessible due to Fx shortages</p>	<div style="text-align: center;">  <p>Public Authorities</p>  <p>(Donors)</p> </div>





1c Improving business models (efficiency & replicability)

Recommendations	Rationale	Example(s) / Best Practices	Primary Stakeholder (Supporting Actors)
<p>1 Support innovative providers in optimizing their value proposition and business model through:</p> <ul style="list-style-type: none"> • Grants to de-risk and finance innovative pilots • Technical assistance to help structure their growth, access complementary expertise and learn from best practices in adjacent industries • Visibility among partners and investors 	<p>Management teams among start-ups/scale-ups are generally stretched and focused on operational efficiency, growth and fundraising, to the detriment of innovations in their value proposition that can bring more holistic solution to farmers</p> <p>Tailored incubation or acceleration programmes can bring unlocks to growing businesses in specific impact industries (e.g. sanitation, last-mile distribution, menstrual hygiene, digital innovation)</p>	<ul style="list-style-type: none"> • Agriworks needs to assess farmers' willingness to pay for Irrigation as a Service • SunCulture needs to leverage its mobile app as a marketplace to match farmers with buyers • Stable Foods needs investment to deploy its utility model in Western Kenya and build proof of concept for integration of irrigation, input supply and market access services to SSPs 	 <p>Donors</p>
<p>2 De-risk and support the expansion of SWP providers into new/adjacent geographies</p> <ol style="list-style-type: none"> 1. De-risk the expansion of established SWP providers into new geographies through grant financing for pilots in countries that are earlier in the process of scaling SSI (e.g., Nigeria) incl. funding demonstrations to SSP groups (through coops, SACCOs, buyers) to catalyze early sales 2. Support key policy measures in new geographies that can enable the replication of innovative (but relatively untested) business models in that context. For example, reforming water regulation laws to allow replication of IaaS providers in new geographies 	<p>Given the complexity and challenges associated with a conducive enabling environment for scaling SSI and the high barriers to commercial success, replicating existing business models or technology solutions in new geographies is very difficult and involves a high risk of failure. Technologies can face key adoption barriers (knowledge/awareness of SWP at farm-level) while business models can face major legal/policy barriers (local regulations making IaaS illegal). Helping address these enabling constraints could be a high-leverage way to enable scale</p>	<p>Irrico International is a Kenyan irrigation company dealing in irrigation design, installation, maintenance and consultancy for irrigation and greenhouse projects. The company was able to expand into new geographies (Uganda, Tanzania, Ethiopia, and Zambia) in part by setting up field days and demo sites with assistance from public authorities and donors/NGOs primarily. This allowed them to drive adoption in new markets, especially for their more advanced systems (e.g., drip kits)</p>	 <p>Donors</p>  <p>(Public Authorities)</p>
<p>3 Develop irrigation knowledge among extension workers, existing client segments, other relevant promoters</p> <ol style="list-style-type: none"> 1. Support public authorities to train extension workers on irrigation incl. preservation of water resources, in coordination with solution providers 2. Promote irrigation knowledge through existing client segments 3. Partner with solution providers and local training institutes to develop vocational and dual-training on irrigation (e.g. Bonergie and GIZ in SNG) 	<p>Public agricultural development agents (e.g., extension workers) are often the most crucial conduit of knowledge and training for new techniques for SSPs. Research and direct feedback indicates that the level of knowledge/awareness about SSI at the extension worker level is very low. Addressing this could enable innovative business models and technologies to address adoption barriers with potential consumers</p> <p>Promotion by existing clients and by client segment is also key to equitably promoting any irrigation equipment or service as women's information sources and communication differ from men.</p>	<p>Solar Village, a SWP distributor in Ethiopia, has utilized the country's well-developed and widespread agricultural development apparatus to drive increased awareness/knowledge at farm-level and ultimately grow adoption. The company partnered with NGOs (e.g., ILSSI) and public authorities (e.g., MoIL) to directly train local extension officers on irrigation techniques. They then rely on officers as de-facto sales reps in the field to drive adoption and ongoing use</p>	 <p>Public Authorities</p>  <p>(Donors)</p>

2 Ensure guardrails for sustainable growth (1/2)

Recommendations	Rationale	Example(s) / Best Practices	Primary Stakeholder (Supporting Actors)
<p>1 Develop irrigation management information systems in collaboration with private sector actors to collect up-to-date data and information on irrigation activities by actors (i.e., # of SSPs using solar pumps), water potential, and water resource levels, to be made publicly available (e.g., for borehole drillers, private sector, government authorities). Data and management systems should be linked with existing global endeavors, such as the Global Groundwater Monitoring Network (GGMN), given the shared nature of water resources</p> <ol style="list-style-type: none"> 1. Fund pilots with tech-enabled irrigation providers to collect real-time data on pumping hours, flow-rate, dry-run 2. Fund the development of national/regional protocols to centralize data from pump providers and report to relevant authorities 3. Link drilling companies, water utilities, mining companies and nonprofit organizations to regional or national groundwater data collection initiatives 4. Standardize and digitize existing groundwater data held in national databases could lead to more effective and sustainable resource mobilization. 	<p>Despite a large amount of ongoing and existing research on the topic, SSA suffers from an acute lack of granular and usable groundwater data and information. In some African countries, groundwater level or quality monitoring are practically non-existent while in more developed areas regional or national maps and datasets often adequately describe average conditions but lack detail at finer scales. The public sector in Africa struggles to fund and staff long-term hydrogeological data collection, and there are few incentives for private sector engagement.</p> <p>Increased knowledge and visibility leads to increased overall support - SSI is currently low on the policy agenda because of resource knowledge deficiencies and associated sustainability concerns and lack of clarity on how to balance multiple demands on groundwater resources.</p>	<ul style="list-style-type: none"> The government of Uganda created the National Groundwater Database and a series of local hydrogeological maps in the 1980s. Continued investment and attention has made these knowledge resources invaluable in planning for Uganda's future demand in the context of population growth and climate change The South African Development Community established the SADC Groundwater Management Institute in 2016. This coordinates several regional groundwater initiatives, including the collation of groundwater data and an assessment of institutional groundwater capacity in SADC member states 	 <p>Public Authorities</p>  <p>(Donors)</p>
<p>2 Incentivize the distribution of water efficient systems, starting with a study of most cost-efficient incentives (e.g., subsidies targeted at high quality drip lines for individual pumps; scaling fixed laaS model)</p>	<p>Drip lines offer a 40% improvement in water savings vs. hose irrigation and can significantly contribute to safeguarding long-term water availability; yet the additional cost and behaviour change they require prevent most farmers from adopting them</p>	<p>Fixed laaS model embeds drip lines as a key driver of profitability, since improved water efficiency allows to maximize number of farmers connected to one pump</p>	 <p>Donors</p>

2 Ensure guardrails for sustainable growth (2/2)

Recommendations	Rationale	Example(s) / Best Practices	Primary Stakeholder (Supporting Actors)
<p>3 Identify opportunities for lowering the production and distribution costs of drip lines, remote monitoring systems for solar pumps</p>	<p>In some regions, water availability might not be ensured in the short to medium term. Some SSPs are already experiencing water scarcity at the peak of dry season. Reducing the cost of optimized distribution systems (e.g., drip lines which can improve savings by 40%) will increase the uptake. Remote monitoring systems integrated into or added onto solar pumps would also enable to monitor water withdrawal cost efficiently</p>	<p>Providers such as Solarislab specialize in the development of low-cost Paygo hardware and software</p>	 Donors
<p>4 Establish and support formal and informal organizations, groups, or associations governing water use rights and issues at the local level to ensure the equitable and environmentally sustainable use of resources</p>	<p>Ensuring local-level buy-in, management, and support for sustainable water use by irrigating SSPs is crucial. Policy, strategic frameworks, and information systems are only as good as the implementation on the ground. Local organizations and groups provide a direct path to ensuring this sustainable growth occurs. This recommendation is also crucial to ensure a balance between outside support and local institutions with internal autonomy, to avoid the emergence of a culture of dependence in the face of “top-down” and “engineering-led” approaches</p>	<p>Site-level studies in Tanzania (Mutabazi et al., 2017), Senegal (Woodhouse, 2003), and various other locations across SSA (Shah, 2013) indicate one of the key arrangements that arises from both formal (e.g., government established community Water Associations) and informal (e.g., community-led water abreaction groups) water organizations is more established rules and enforcement of water abstraction, pollution, and use</p>	 Public authorities
<p>5 Create regional coordination platforms by convening key stakeholders (e.g., farmer organizations, private solution providers, public authorities, other donors, implementers) to tackle issues of jurisdictional conflict over water resources, such as groundwater aquifer depletion and surface water access (for transnational and transregional sources)</p>	<p>The transboundary and trans-industry nature of water (both ground and surface) as a resource means any scaling of use for irrigation must be accompanied by effective frameworks, agreements, and communications from the local level up to the regional level. While many countries are striving for national/local policies, regional considerations must be encouraged to sustainably scale. These include regional cooperation in sharing data, harmonizing rules and regulations, and cooperating on regional-scale challenges (such as transboundary groundwater resources). Addressing these barriers through convening and advocacy work is a key recommendation that should be pursued.</p>	<p>The Southern Africa Development Community regional strategy aims to provide a framework for governing groundwater resources in arid areas that are under threat from over-exploitation. Currently, there is very limited groundwater management in the countries of the region with inadequate resources dedicated to the task and a general lack of effective institutions and technical capacity. To date, this regional approach is proving effective in supporting national stakeholders and implementers at the community level</p>	 Donors  (Public Authorities)

Potential actions to scale irrigation for small-scale producers

Potential leverage points and unlocks



Across stakeholders and markets

- 1) Summary of priority leverage points that the broader market can focus on to address key barriers
- 2) Exploration of specific recommendations within each leverage point, including rationale, examples and/or best practices, and primary stakeholders involved



Deep dive on selected interventions for donors

- 1) Detailed view on selected activities in key geographies that donors could potentially pursue, including rationale and approach

Donors could pursue a selection of key recommendations in specific geographies and settings to support the scaling of SSI

Barriers and Leverage Points

Business Model Barriers	1a Improve affordability of quality irrigation products
	1b Unlock access to finance for irrigation providers
	1c Improve BM (efficiency & replicability)
Enabling Environment Barriers	2 Ensure guardrails for sustainable growth

Selected Interventions

- 1** Advocate for **targeted price subsidies via tax exemptions on SWPs** in **Nigeria, Kenya, Tanzania**
 - 2** Streamline **carbon financing of solar water pumps**, working with existing providers (e.g., SunCulture, Davis & Shirliff) and other donors
 - 3** Unlock **cost reduction in borehole drilling and pumping systems**
-
- 1** **Unlock aligned development capital** by via tailored financial solutions, leveraging PayGo systems for RBF, and advocacy
 - 2** **Unlock Fx constraints in large markets but constrained markets such as Ethiopia, Nigeria**
-
- 1** Build or support an **acceleration programme for innovative providers** to refine their value proposition and delivery model
 - 2** De-risk and **support the expansion of SWP (and manual) pump providers into Nigeria** via direct funding as well as policy advocacy
-
- 1** Develop **irrigation management information systems** in relevant countries
 - 2** Fund R&D for **optimized distribution and remote monitoring systems** as well as the most cost-efficient ways to incentivize use. Work with existing SWP providers (e.g., Bonergie, SunCulture) and donors already active in space

Taken together, these interventions can help the market reach the following key outcomes:

Accelerate scaling of solar pumps with PayGo

Support the development of laaS

Achieve growth of irrigation for SSPs in a sustainable manner

These recommended interventions include specific recommendations within 6 countries as well as systemic ones that apply across contexts



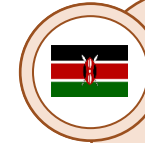
Nigeria

- Advocate for **targeted tax exemptions on SWPs**
- Fund research into cost-benefit of **allocating Fx reserves towards irrigation equipment**
- De-risk and **support the expansion of SWP and manual pump providers into Nigeria**
- Develop **irrigation management information systems and comprehensive database(s)** of water potential, water resource levels, and existing irrigation usage



Ethiopia

- Support the design and grant financing of a **pilot revolving Fx fund** alongside other development organizations and donors
- Fund and provide D&A support for the **expansion of the existing Irrigation Management Information System**
- **Support the borehole drilling industry** to increase affordability while ensuring better monitoring and supervision



Kenya

- Advocate for including SWPs as part of existing solar-based tax exemptions
- **Unlock aligned development capital**
- Provide grant financing and D&A support to set up a national, open access irrigation data and info platform
- Help providers (e.g., SunCulture and Stable Foods) **de-risk and finance innovative pilots** likely to optimize their value proposition and delivery model



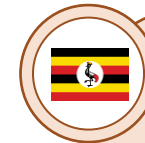
Senegal

- Provide **tailored financial solutions and capacity building** to local financial institutions
- **Support the borehole drilling industry**
- Develop **irrigation management information systems** and comprehensive database(s)
- Fund pilots with leading SWP providers (e.g., Bonergie) to **collect real-time data** on pumping hours, flow-rate, dry-run



Tanzania

- Advocate for SWPs to be registered as farm implements and/or as “Exempt Solar Supplies”, which would **grant such pumps exemption VAT**
- Provide **tailored financial solutions and capacity building** to local financial institutions
- Develop **irrigation management information systems** and database(s)



Uganda

- Finance ongoing innovative pilots with IaaS companies (e.g., Agriworks) to **optimize value proposition and delivery model** (e.g., assess farmers’ willingness to pay for Irrigation as a Service)
- Provide **tailored financial solutions and capacity building** to local financial institutions



Systemic Interventions - *Certain interventions are applicable and often most-impactful when done at a systemic scale*

- Streamline **carbon financing of solar water pumps**, working with existing providers (e.g., SunCulture, Davis & Shirliff) and other donors
- **Unlock cost reduction in borehole drilling and pumping systems**
- Provide **de-risking support and capacity building to focus banks and MFIs on SSI**
- **Unlock aligned development capital:** 1) advocacy for SSI as a promising climate adaptation asset; tailored financial solutions; leveraging PayGo systems for RBF

Note: further detail on barriers and potential recommendations / leverage points across each country can be found on [appendix 4](#)

These countries each have high potential for SSI expansion and key attributes that make donor-intervention potentially impactful

Countries	SSI Expansion Potential	SSI Private Sector Maturity	Enabling Environment	Water Constraints	Commentary and rationale for prioritization
Nigeria	2,900	<i>Under-developed</i>	<i>Limited</i>	<i>Localized</i>	<ul style="list-style-type: none"> Nigeria has massive potential of scaling irrigation for SSPs (in terms of overall area, number of farmers impacted, and resources available to scale) and has a moderate to high level of vulnerability to drought and climate change impacts Existing private sector solutions for SSI are scarce and the policy and enabling environment is nascent
Kenya	1,349	<i>Well-developed</i>	<i>Supportive</i>	<i>Localized / Moderate</i>	<ul style="list-style-type: none"> As a business model innovation hotspot with a large potential for irrigation (albeit localized in specific regions), Kenya is an attractive market to scale SSI
Ethiopia	1,095	<i>Under to Moderately-developed</i>	<i>Supportive</i>	<i>Localized / Moderate</i>	<ul style="list-style-type: none"> SSI development in Ethiopia is public sector driven receiving high levels of public policy support and focus, presence of diverse programs focused on SSI, presenting a large potential for growth However, private sector's role needs to be developed as existing private solution providers are limited and face key policy and enabling environment barriers
Tanzania	1,768	<i>Well-developed</i>	<i>Supportive</i>	<i>Localized / Moderate</i>	<ul style="list-style-type: none"> Tanzania's large potential for irrigation expansion and rural population that could be impacted, its low/moderate water stress, and attractive existing private sector and enabling environment makes it a high leverage geography to provide targeted support
Senegal	790	<i>Well-developed</i>	<i>Supportive</i>	<i>High</i>	<ul style="list-style-type: none"> With a medium-sized potential for irrigation and a high-level of water stress (esp. in the Northern region), Senegal will need to preserve water availability in its efforts to scale SSI It is home to innovative providers that are benefitting from a relatively supportive enabling environment, and must be further nurtured to scale sustainably
Uganda	961	<i>Moderately-developed</i>	<i>Supportive</i>	<i>Low</i>	<ul style="list-style-type: none"> While demand for irrigation is currently very low, Uganda has ample water resources for expansion, a supportive enabling environment, and burgeoning innovative private sector players

Note: further detail on longer list of countries can be found on [appendix 4](#)

1a.1. Advocate for targeted price subsidies via tax exemptions in Nigeria, Kenya, and Tanzania

Advocate for removing import tariffs, VAT, and other taxes from impactful and high-quality irrigation equipment

- Support defining quality and water-efficiency standards for withdrawal and distribution components (specifically SWPs and drip) with key public authorities and equipment manufacturers
- Advocate for removing import tariffs and VAT from irrigation equipment that meets standards. Follow similar approach seen in Senegal, Niger, Bangladesh, and India
- Work alongside impacted companies (e.g., SWP distributors) to encourage passing along cost savings from initiative to consumers via reduced prices rather than simply increasing margins; however, increased gross margins for SWP distributors can result in positive impacts for the broader markets as it encourages more private sector engagement in the sector



- Rationale**
- ✓ Can be a highly cost-effective method of public subsidy to stabilize / reduce prices for consumers and/or GM for distributors
 - ✓ Similar initiatives saw more economic growth generation than foregone tax revenue. This should be done in high potential growth countries with relevant tax and import duties
 - ✓ Identified as key need by private sector

Potential approach – apply in countries with relevant tax constraints:

Nigeria – Work with the SoN, MoF, and MoA to streamline existing duty exemptions by simplifying process for equipment that is exempted from import taxes (5-14%), with a specific focus on manual pumps and SWPs. Existing duty-free exemptions for ag-equipment, including SSI equipment, is burdensome and requires lengthy approval timeline. Thus, most distributors end up paying duty

Kenya – Advocate for including SWPs as part of existing solar-based tax exemptions. Currently, various productive use solar equipment is exempted from import tariffs (5%) and VAT (16%), but this only covers the panels; full pump systems continue to face the tax burdens. Thus, in practice the exemptions are not fully utilized. Donors should support existing private sector and NGO initiatives working to address this

Tanzania – advocate for SWPs to be registered as farm implements and/or as “Exempt Solar Supplies”, which would grant such pumps exemption VAT (18%). Current applications of exemption regime can be haphazard and not inclusive of SWPs, with “Exempt Solar Supplies” only covering panels, solar charger controllers, solar inverter, lights, and solar batteries from VAT

Potential relevant actors¹

- ❑ **Public authorities:** Standards of Organization (SON), Ministry of Finance, Ministry of Agriculture, MoW River Basins, MoW Irrigation, WUAs
- ❑ **Private sector and NGOs:** KickStart and distributors (OmniAgric, Augenta AgriCare) Heifer International, IFDC, SNV, World Bank, USAID

- ❑ **Public authorities:** Ministry of Finance, Ministry of Agriculture
- ❑ **Private sector and NGOs:** Kenya Renewable Energy Assoc., GOGLA, the Clean Cooking Association of Kenya, Africa Minigrad Developers Association, Power Africa Off-Grid Project; SNV; Green Mini-Grid Facility Kenya; Africa Clean Energy Technical Assistance Facility, Sistema.bio, SunCulture, D&S

- ❑ **Public authorities:** Ministry of Finance, National Irrigation Commission; Tanzania Revenue Authority
- ❑ **Private sector and NGOs:** ILSSI, Tanzania Renewable Energy Association Climate Response Facility (CERF); Simusolar

1 – This list of actors is illustrative and non-exhaustive: the mentioned actors have not been consulted on supporting this recommendation.

1a.2. Streamline carbon financing of solar water pumps to reduce certification costs and avoid market distortions

Streamline carbon financing of solar water pumps to reduce certification costs and avoid market distortions
 ➤ Offer support to an existing mechanism or, if not promising, develop a multi-stakeholder working group to help collect and channel carbon finance to irrigation providers



Rationale

- ✓ Monetizing carbon externalities can help improve GM for providers and stabilize or reduce consumer prices leading to uptake
- ✓ Creating a mechanism that reduces the cost and complexity of certification so that all quality providers can access carbon finance would prevent potential market distortion caused by any individual provider able to invest in certification (\$200k per market)

Potential approach – systemic intervention across multiple steps:

Donors can pursue this intervention across multiple steps:

- Analyze and benchmark existing mechanisms** trying to accomplish similar goals of within carbon finance solutions. Particular focus should be on the D-REC initiative
- If any existing mechanism appears promising, **offer support via convening and influence capacity** (and potential funding opportunities if applicable)
- If not, **leverage interest and existing investment in carbon finance from irrigation providers** (SunCulture, Davis & Shirliff) and **donors active across SSA to build a multi-stakeholder working group** tasked with assessing the opportunity for a national/regional (e.g., East Africa) vehicle to collect and channel carbon finance (and other forms of subsidies/ monetized externalities) to irrigation providers meeting quality and water-efficiency standards

Potential relevant actors¹

Existing mechanisms / solutions: D-REC Initiative
Active donors: Corporates seeking to offset emissions
Private sector actors: SunCulture, Davis & Shirliff, Bonergie

¹ – This list of actors is illustrative and non-exhaustive: the mentioned actors have not been consulted on supporting this recommendation.

1a.3. Unlock cost reduction in borehole drilling and pumping systems

Unlock cost reduction in borehole drilling and pumping systems, especially in geographies that have more groundwater than surface water resources

➤ Priority should be to address key cost drivers (see below)



- Rationale**
- ✓ The high costs of drilling boreholes and wells tends to limit the adoption of SWPs and prohibit the expansion of groundwater resources. Unit costs for boreholes in SSA typically range \$6-23k within individual countries and are considerably more expensive compared to Latin America or South Asia
 - ✓ Lowering this cost by addressing key drivers can play a substantial role in increasing broader affordability and adoption of SWP and SSI as a whole
 - ✓ A 25% reduction in COGS for a solar pumping system would allow a 10% reduction in price

Potential approach – systemic impact by working with specific companies:

Donors could support R&D and D&A efforts by existing organizations and private sector actors to address key cost drivers, including:

- For borehole drilling:
 - Small economies of scale with restricted competition within the sparse market
 - High site set up costs due to the vast area covered, often with poor transport infrastructure
 - Low standards of service provision amongst drilling and pumping contractors
 - High duties and taxes on imported drilling equipment, with limited manufacturing of spare parts
 - The lack of reliable info on aquifer characteristics and borehole yield leads to high uncertainty in aquifer potential and risk for over extraction
- For pumping systems (e.g., SWPs): Manufacturing costs, which could be reduced through automation and scale

Potential relevant actors¹

Researchers: IWMI, World Bank GWSP, ILSSI, Water Partnership Program, International Groundwater Resources Assessment Center

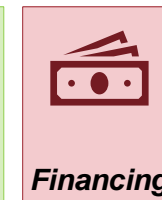
Private sector actors: SunCulture, Davis & Shirliff, Bonergie (Ethiopia), Solar Village (Ethiopia)

¹ – This list of actors is illustrative and non-exhaustive: the mentioned actors have not been consulted on supporting this recommendation.

1b.1. Unlock aligned development capital

Unlock aligned development capital

- Advocate and provide catalytic support for irrigation as a promising and relatively investable climate adaptation asset class to invest development capital
- Leverage PayGo systems for results-based financing
- Provide tailored financial solutions and capacity building to local financial institutions (MFIs, SACCOs, large coops, commercial banks) including wholesale lending, de-risking support (guarantee schemes or first loss), or revolving funds dedicated to SSI



Rationale

- ✓ Opportunity to direct existing development capital towards SSI as an investable adaptation investment asset class and subsequently unlock additional capital
- ✓ Results-based finance (e.g. subsidy to provider triggered by monthly payment from user) improves effectiveness of spend and reduces risk for Donors and DFIs
- ✓ Commercial banks and MFIs are typically both deterred from lending to resource-poor SSPs by the level of risk involved and unaware of the de-risking potential of irrigation through rapid and durable improvement in productivity and income

🌐 Potential approach – systemic with key outcomes in more mature private sector irrigation markets:

Systemic – Advocate and influence for irrigation as a promising and relatively investable climate adaptation asset class for existing ag-investors, specifically impact funds and DFIs, to invest into. Donors should use influence to call attention to the benefits, relative investability, and specific opportunities SSI providers represent as climate adaptation targets. Additionally, catalytic financing could drive this forward.

Link existing PayGo systems to relevant results-based finance frameworks and donors/DFIs interested in the space. Donors should use combined advocacy and financing capacity to encourage other investors to establish these innovative financing mechanism.

Potential relevant actors¹

Investment funds: Mercy Corps Social Venture Fund, MCE Social Capital, Novastar Ventures, Ceniarth, Acumen Resilient Agriculture Fund
DFIs: US DFC, FMO, KFW, BIO-Invest, NorFund

More mature private sector irrigation markets (Kenya, Tanzania, Senegal, Uganda) – Provide tailored financial solutions and capacity building to local financial institutions (MFIs, SACCOs, large coops, commercial banks) including wholesale lending, de-risking support (guarantee schemes or first loss), or revolving funds dedicated to SSI

- ☐ *Kenya:* Equity Bank, KCB, Stanbic, ABSA, Juhudi Kilimo, KUSCCO SACCO
- ☐ *Tanzania:* NMB, CRDB
- ☐ *Senegal:* PAMECAS
- ☐ *Uganda:* Opportunity Bank, Centenary Bank, DFCU

1 – This list of actors is illustrative and non-exhaustive: the mentioned actors have not been consulted on supporting this recommendation.

1b.2. Unlock Fx constraints in Ethiopia and Nigeria

Address and unlock Fx constraints in Ethiopia and Nigeria with the goal of positively impacting gross margins for SSI equipment distributors and reducing/stabilizing consumer prices on key equipment, specifically SWPs in Ethiopia and both manual pumps and SWPs in Nigeria

- Fund and support a cost-benefit analysis on allocating Fx reserves for importing of irrigation equipment (e.g., compared to other agriculture-related imported equipment)
- Advocate for, and subsequently finance, a revolving Fx fund with the specific aim of financing imported irrigation equipment in each respective country



Rationale

- ✓ Fx constraints were cited as the top concern for providers interviewed in both Ethiopia and Nigeria. Increased access to Fx for distributors would decrease the COGS of imported equipment, resulting in immediate impact on gross margins as well as expected reduction/stability in consumer prices. Direct feedback indicated limited existing donor/NGO focus on this specific area despite key barrier expressed by private sector

Potential approach – apply in countries with relevant Fx constraints:

Ethiopia – Support the Ministry of Irrigation and Lowlands (MoIL) with design and grant financing of its pilot revolving Fx fund alongside other development organizations and donors (e.g., World Bank, Heifer International). The MoIL is actively searching for funding for its initial pilot fund, which they project to be fund size to be \$5-10M to begin with. The fund aims to support the private sector in procuring and obtaining imported irrigation technologies, with a specific focus on SWPs

Nigeria – Fund research into cost-benefit of allocating Fx reserves towards irrigation equipment (both manual pumps and SWPs), working directly with the Ministry of Finance and (to a lesser degree) the Ministry of Agriculture. Once completed, further financing and coordination support could be advocated to existing Fx program for ag-equipment working directly with the MoF to ensure relevant SSI equipment and distributors are effectively included

Potential relevant actors¹

- ❑ *Public authorities:* Ministry of Irrigation and Lowlands (MoIL), ATA, MoA
- ❑ *Private sector:* Solar Village, Rensys
- ❑ *Donors and NGOs:* World Bank, USAID, Heifer International, ILSSI

- ❑ *Public authorities:* MoW River Basins, MoW Irrigation, MoA, MoF, WUAs
- ❑ *Private sector:* KickStart, Omniagric, Bonergie, SunCulture
- ❑ *Donors and NGOs:* World Bank, USAID, Heifer International

1 – This list of actors is illustrative and non-exhaustive: the mentioned actors have not been consulted on supporting this recommendation.

1c.1. Build or support an acceleration program for innovative providers to refine their value proposition and delivery model

Support innovative providers in optimizing their value proposition and business model through:

- Grants to de-risk and finance innovative pilots
- Technical assistance to help structure their growth, access complementary expertise and learn from best practices in adjacent industries
- Visibility among partners and investors



Rationale

- ✓ Management teams among start-ups/scale-ups are generally stretched and focused on operational efficiency, growth and fundraising, to the detriment of innovations in their value proposition that can bring more holistic solution to farmers
- ✓ Tailored incubation or acceleration programmes bring grants, technical assistance and visibility to innovative businesses can create unlocks leading to direct impact and learning agenda in specific industries (e.g. [sanitation](#), [last-mile distribution](#), [menstrual hygiene](#), [digital innovation](#))

Potential approach – Work with specific companies to create replicable impacts

Partner with an existing accelerator, or (if none are adapted) build specific acceleration programme. Potential candidates for first cohort:

- **Agriworks** – provide grant funding and data & analytics support to help Agriworks assess farmers’ willingness to pay for Irrigation as a Service in new geographies
- **Stable Foods** – Provide grant to deploy its model in Western Kenya and build proof of concept integration of irrigation, input supply and market access services
- **SunCulture** – Help the company leverage its mobile app as a marketplace to match farmers with downstream buyers

Potential relevant actors¹

Co-funders: Mastercard Foundation, BII, Unilever... / Research/content partners: ILSSI, IMWI...

1 – This list of actors is illustrative and non-exhaustive: the mentioned actors have not been consulted on supporting this recommendation.

1c.2. De-risk and support the expansion of legacy manual pump as well as SWP providers in Nigeria

De-risk and support the expansion of existing manual and SWP providers in Nigeria via direct funding as well as policy advocacy

- Support KickStart in expanding into new regions of Nigeria (currently highly focused in Northern regions) via direct funding and advocacy work
- Finance and provide advocacy support for an existing SWP distributor currently not operating in Nigeria to potentially enter the market. While a specific RFP should be pursued to establish the optimal partner, potential options include Bonergie and SunCulture



Rationale ✓ Given the low usage of irrigation across Nigeria but especially in the Southern and Central regions, as well as the overall large market opportunity for growth, Donors should play a role in encouraging the broader scaling of the private sector by working with both legacy actors (e.g., KickStart) and more innovative SWP distributors to facilitate knowledge, awareness, and demand for irrigation across end-user types

Potential approach – Apply in Nigeria given low level of private solutions in such a large market

<p>Potential relevant actors¹</p>	<p>Providers with existing presence in Nigeria – work with KickStart to leverage existing network, relationships, and in-country experience to penetrate new regions within Nigeria. Specifically, work in the South/Central regions to increase awareness and knowledge by funding demos for farmer groups, working with local public extension officers, and convening local public authorities along with WUAs to help KickStart expand into new areas</p>	<p>Providers with no presence in Nigeria – conduct a structured RFP to find an optimal partner for a SWP distributor/provider to enter the Nigerian market. Provide grant funding and data/analytics support for market assessments, strategic entry plans, and business model refinement. Convene key public authority stakeholders alongside the private company to create a clear dialogue, including on key measures the government can implement to help support expansion (e.g., targeted tax expansion).</p>
	<ul style="list-style-type: none"> ❑ KickStart ❑ Ministry of Finance, Ministry of Agriculture, MoW River Basins, MoW Irrigation, WUAs 	<ul style="list-style-type: none"> ❑ Potential private partners including: Bonergie, SunCulture, Davis & Shirtliff ❑ Ministry of Finance, Ministry of Agriculture, MoW River Basins, MoW Irrigation, WUAs

1 – This list of actors is illustrative and non-exhaustive: the mentioned actors have not been consulted on supporting this recommendation.

2.1 Support developing irrigation management information systems and approaches

Develop irrigation management information systems and comprehensive database(s) of water potential, water resource levels, and existing irrigation usage

- Support public authorities and private stakeholders in collecting up-to-date data and information on irrigation activities by actors, water potential, and water resource levels
- Fund pilots with tech-enabled irrigation providers to collect real-time data on pumping hours, flow-rate, and dry-run as well as
- Fund the development of national/regional protocols to centralize data from pump providers, drilling companies, water utilities, and NGOs and report to relevant authorities
- Support the development of info systems that are accessible usable, and to be made publicly available (e.g., for borehole drillers, private sector, government authorities)



Rationale

✓ Every country and locality in SSA struggles with a lack of granular and usable data on irrigation usage, water resource potential, and other hydrological parameters for SSI development. Increasing the level of knowledge is crucial not just for sustainable scaling but also to drive further policy and commercial support

Potential approach – Can be applied systemically across levels (local to global):

	<p>Systemic – given the cross-cutting nature of resource management/information systems, Donors should work with existing projects (both regional and national/local) to ensure that outcomes can be applicable for private sector use and that replication of existing systems is leveraged where possible</p>	<p>Ethiopia – fund and provide D&A support for the expansion of the existing Irrigation Management Information System currently in development by the MoIL alongside FAO</p>	<p>Kenya – provide grant financing and D&A support to set up a national, open access irrigation data and info platform, owned and operated by the NIA but with input and support from local authorities, NGOs and other stakeholders and private providers</p>	<p>Nigeria – provide grant financing and advocacy support for the MoW to develop a database and information system of potential resource levels and existing irrigation usage. Current data used by MoW is outdated, relies on secondary research estimations, and entirely lacks granularity</p>
<p>Potential relevant actors¹</p>	<p>❑ Ongoing global/regional initiatives: IFPRI, World Bank, SADC Groundwater Management Institute, CILLS, IGRAC, JICA, Dutch Ministry of Foreign Affairs, AGRA</p>	<p>❑ Ministry of Irrigation and Lowlands, Ministry of Agriculture, Agriculture Transformation Agency, FAO, CIAT, IWMI, Ethiopian Construction Works Design and Supervision Enterprise (ECWDSE)</p>	<p>❑ National Irrigation Authority (NIA), County Irrigation Development Units, SNV, KfW, World Bank, SunCulture, Davis & Shirliff</p>	<p>❑ Ministry of Water (MoW), district Water User Associations, Heifer International, KickStart, World Bank</p>

1 – This list of actors is illustrative and non-exhaustive: the mentioned actors have not been consulted on supporting this recommendation.

2.2 Identify opportunities for lowering the production and distribution costs of drip lines remote monitoring systems for solar pumps

Identify opportunities for lowering the production and distribution costs of drip lines remote monitoring systems for solar pumps



Rationale
✓ In some regions, water availability might not be ensured in the short to medium term. Some SSPs are already experiencing water scarcity at the peak of dry season. Reducing the cost of optimized distribution systems (e.g., drip lines which can improve efficiency by 50%) will increase the uptake. Remote monitoring systems integrated into or added onto solar pumps would also enable to monitor water withdrawal cost efficiently

Potential approach – Systemic :

- Fund research with companies specialized in water-efficient distribution systems (e.g., Netafim for drip) to develop systems adapted to working conditions in SSA (e.g., ease filter change with ferrous water)
- Fund pilots with tech-enabled irrigation providers to collect real-time data on pumping hours, flow-rate, dry-run (e.g., Bonergie in Senegal, SunCulture in Kenya)
- Fund analytical studies to determine the most cost-effective subsidies to incentivize use of water-efficient distribution systems and partner with public authorities to pilot tests

Potential relevant actors¹

Research organizations: AGRA, CLASP, IFPRI, IKEA Foundation, UKAID, CLASP
Private sector actors: Bonergie in Senegal, SunCulture in Kenya, Netafim

1 – This list of actors is illustrative and non-exhaustive: the mentioned actors have not been consulted on supporting this recommendation.

Thank you for reading

For questions or comments on our research, please contact ISF Advisors and Hystra:

Dan Zook

Executive Director, ISF Advisors
dan.zook@isfadvisors.org

Hayden Aldredge

Manager, ISF Advisors
hayden.aldredge@isfadvisors.org

Vivian Wu

Associate, ISF Advisors
vivian.wu@isfadvisors.org

Lucie Klarsfeld McGrath

Partner, Hystra
lklarsfeld@hystra.com

Robin Bonsey

Senior Project Manager, Hystra
rbonsey@hystra.com

Thomas Charoy

Consultant, Hystra
tcharoy@hystra.com

CONTENT OUTLINE

0. Scope and objectives
1. Executive Summary
2. Impact case for scaling irrigation
3. Current state of small-scale irrigation, expansion opportunity, and barriers
4. Emerging private sector solutions
5. Barriers to scale and sustainability
6. Recommended actions to scale irrigation for small-scale producers
- 7. Appendix**

Appendix

1. Appendix – supporting materials

1. Impact case for scaling irrigation
2. Current state of small-scale irrigation, expansion opportunity, and barriers
3. Emerging private sector solutions
4. Recommended actions to scale irrigation for small-scale producers
5. Case studies

Aligning on key terminology used in this report

Key terminology:

- **Irrigation** – the artificial application of water to land for the purpose of agricultural production, where water is either unavailable or insufficiently available most water used for irrigation comes directly from a natural water body, including rivers, creeks, lakes, or groundwater, or other water stores, such as dams and rainwater harvesting tools. The water is then transferred to agricultural land, either using gravity diversion methods (for example, through canals or floodwater spreading) or human-powered technologies such as rope-and-bucket or watering cans, or more complex and sophisticated technologies including boreholes, pipes, sprinklers, liquid-fuel engine-driven systems, and solar-powered pumps
- **Small scale producers (SSPs)** – as defined by BMGF are crop or livestock farmers that farms on 4 hectares or less and commercializes less than half of his or her output
- **Small-scale irrigation (SSI)** – irrigation initiatives led by SSPs who own and manage an individual plot of land or are part of a community-managed irrigation scheme. Small-scale irrigation includes a variety of irrigation activities, including manual pumps, manual pumps, and surface water diversion
- **Farmer-led irrigation (FLID)** – is a process in which small-scale farmers drive the establishment, improvement or expansion of irrigated agriculture, often in interaction with external actors, including the government, private sector, or non-governmental organizations. Farmer-led initiatives cut across existing irrigation types in terms of scale, technologies, crops and governance arrangements
- **Large-scale irrigation** – any system where there is a formal, usually government sponsored irrigation organization responsible for the development and management of the upper tiers of the distribution system and for the delivery of water to farmers

There is a broad set of evidence that irrigation can lead to significant positive impact outcomes for SSPs across key strategic categories

Summary of key impact outcomes from irrigation for SSPs*



Productivity

Irrigation can lead to significant productivity increases for SSPs, with estimated increase in yields for most crops of 50-400%. The opportunity for productivity increases in SSA is large – 76% yield gap is far above the global average of 50% yield gap for LMICs



Income

Irrigation can lead to an average household income increase of 1.5-3X relative to rainfed. It also provides a stabilizing effect on seasonal farmer income and can contribute to extended effective employment, household consumption, gross margin, and asset ownership



Poverty Reduction

There is a positive association between irrigation and poverty reduction for SSPs. Studies show irrigation results in increased incomes, greater on/off farm employment, upward wage pressure, and lower food prices



Nutrition / Food Security

At a household level, irrigation can increase the daily calorie intake for SSPs relative to rainfed households and can have a positive impact on food security (e.g., consistent calorie intake and consumption levels)



Resilience

Provides greater resilience to seasonal weather variability and climatic shocks such as rising temperatures, changing rainfall patterns, and more extreme weather events sparking more frequent and intense floods and droughts



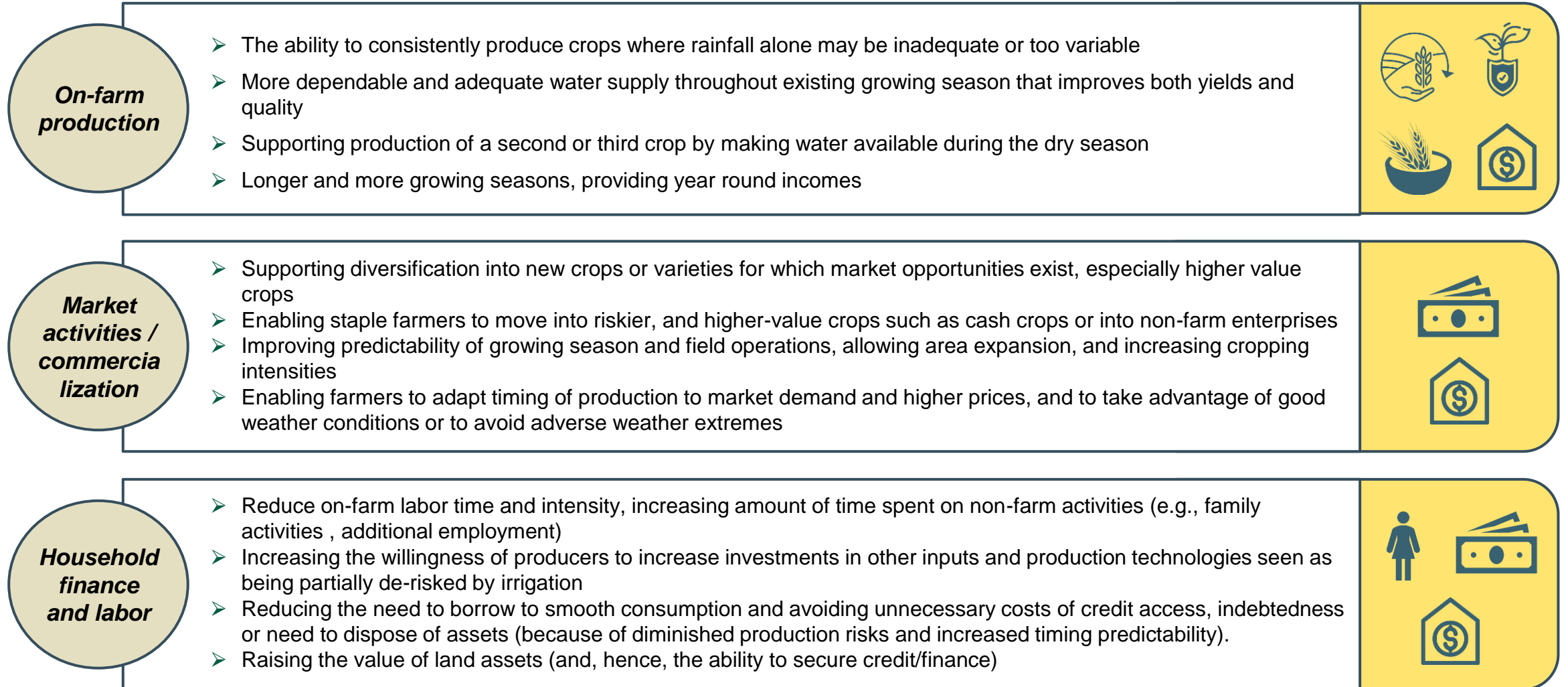
Gender

Access to irrigation can empower women who own or drive decisions on technologies and irrigated land. Specific tech can also reduce the need for women's labor, reaping physical benefits and allowing women to allocate more time to other activities

Impact is driven by various key pathways common to most use cases of irrigation for small scale producers

Key pathways and drivers for through which irrigation can drive

Impact Outcomes



Evidence is strong linking irrigation access to productivity improvements



Key Drivers of Productivity Impacts

- Irrigation enhances crop productivity by **increasing yield increments, intensifying cropping and land use, and improving the use of agricultural inputs** (seeds, fertilizers and pesticides), consequently improving overall productivity
- **Opportunity for productivity increases in SSA is large** – 76% yield gap is far above the global average of 50% yield gap for LMICs



Global Evidence

- ❑ Globally, FAO estimates that **irrigation can increase yields for most crops by 100-400% (FAO, 2019)**
- ❑ Ex-post studies suggest that **irrigation contributed around 92% of the near doubling of world grain production** between 1966 and 1990 (IWMI, 2000)
- ❑ It is estimated that expanding irrigation and increasing irrigated cropland productivity in LMICs could cost between USD 26 billion and USD 50 billion per year over the next 20 years, enabling between 70 million and 150 million hectares to be added, or a 32 percent increase in irrigated areas in developing countries. (IFAD)
- ❑ A study on irrigation's impact on ag performance and poverty reduction in China showed that irrigation can significantly increase crop yields: wheat yields of irrigated plots were **70.9% higher than those of non-irrigated ones**, irrigated **cotton yields were 177% higher** and irrigated **maize 16.4% higher** (Huang et al., 2014)
- ❑ A survey of more than 17,000 farmers in India showed that farm households with wells or surface water access (compared with farm households without such access), **contained 35% higher land-use intensity and 35% more livestock** (World Bank, 2018)
- ❑ After the shallow tubewell boom erupted in Bangladesh its **rice yields began growing twice as fast as historical rates (2.6% p.a.) between 1985 and 2000**, turning a perennial rice importer into an exporter (Huang, Rozelle, and Hu 2007).
- ❑ Research indicates that contributions from expanded irrigated area were at least as large as those from improved genetics and plant nutrition in Asia's Green Revolution, as irrigation drives increased yields in areas where rainfall cannot fully meet crop water requirements and amplifies the benefits of fertilizer (Cassman and Grassini, 2013)



SSA-specific evidence

- ❑ A review of 5 recent studies in SSA shows **evidence of 2-4x crop yields**, increased performance and efficiency relative to rainfed
- ❑ The irrigation sector in Sub-Saharan Africa offers the greatest potential for change and may learn from Asia's experience by intensifying agriculture in areas of cultivated land which are currently unproductive by bringing them under irrigation. This is critical to address the supply-demand gap in food production
- ❑ A comparative review of various studies conducted in Ethiopia showed that irrigated farms generally had higher technical efficiencies and productivity than rainfed farms. **Average crop yields per hectare from irrigated land were 2.3x higher than those from rainfed agriculture**, enabling farmers to transition from subsistence to market-oriented production (Fikirie and Muluaem, 2017)
- ❑ In Tanzania, a studies found that the **technical efficiency of irrigated rice production was 96% compared to an average of 39% for rainfed lowland systems**. The study highlighted the efficiency of irrigators and the potential gains that could be achieved by improving technology (Mkanthama et al., 2018)
- ❑ Irrigation is usually combined with more intensified production. For example, at 18 sites of FLI in Mozambique and Tanzania, purchased fertilizer was applied to 42% and 49% of irrigated plots, respectively, while improved seeds were planted on 52% and 38% of irrigated plots, respectively. Irrigated plots were **much more likely to receive manufactured fertilizer and improved seeds than plots that were not irrigated at the 18 sites** (de Bont et al., 2019)

Irrigation has been shown to improve household income relative to rainfed production across a series of study-level results



Key Drivers of Income Impact

- **Longer and more growing seasons**, providing year round incomes
- **Diversification of cropping patterns** towards higher value crops
- Ability to access **higher market prices during times of lower market supply** (e.g., dry seasons)
- Improving **predictability of growing season and field operations**, allowing area expansion, and increasing cropping intensities
- Supporting **production of a second or third crop by making water available during the dry season**
- Facilitation of **multiple farm enterprises around livestock, crops and agro-processing** providing opportunities
- **Raising the value of land assets** (and, hence, the ability to secure credit/finance)

1.5X-3X income relative to rainfed farming

- ❑ Household incomes are recorded across various studies in developing countries to be **increased between approximately 1.5 to 3 times** (African Union, 2020)
- ❑ Annual and lifetime assessments comparing irrigation and rainfed scenarios in Uganda showed that net **irrigation farm incomes were 2-3x higher than rainfed farms**. Irrigated farms saw \$5,000 to \$7,100/ha/annum for mixed horticultural crops with double cropping enabled by irrigation while rainfed generated a net average farm income of \$2,300/ha/annum
- ❑ In Ethiopia, irrigation generated an average **income of US\$323/ha compared to US\$147/ha for rainfed farming**
- ❑ Huang et al. 2014 found that irrigation significantly increased incomes for farmers, with **revenues from irrigated plots being 93% higher than non-irrigated ones**
- ❑ In Lume District of central Ethiopia during the early 2010s, some farmers had dug shallow wells then used motor pumps to irrigate small plots of between 0.1 and 0.5 ha with vegetables. These were sold in Addis Ababa two hours' drive away along a tarmac road or in the closer, regional centre of Nazaret. While previously dryland crops could generate gross margins of up to \$1,400 per ha, irrigated onions could result in a margin of \$3,500 per ha (Figure 4.3) (Wiggins et al., 2014)

Higher wages and longer employment

- ❑ Communities in Ghana with **irrigation facilities had higher average farm incomes (US\$713.29) and longer duration of effective employment (20 weeks) compared to those without irrigation**. Irrigation was found to significantly improved farm household consumption and food security (Akudugu et al., 2019).
- ❑ Analysis of the Revitalization of Smallholder Irrigation Schemes program in South Africa showed it **positively impacted household income, asset ownership, and access to food** (Maepa et al. 2014).
- ❑ Smallholder irrigation at the Panganai irrigation scheme in Zimbabwe **created employment, generated income, and facilitated asset acquisition** for farmers (Mhembwe et al., 2019)
- ❑ Regression analysis **across 17 Indian states revealed a positive and significant association between irrigation access and the real wage rate of agricultural laborers**. States with higher levels of irrigation **experienced a narrower gender wage gap and faster narrowing of interstate wage rate variation**, likely due to increased labor demand from multiple cropping, intensive practices, and irrigation system maintenance (Bhattarai and Narayanamoorthy, 2003)

Research across various contexts has revealed a lower incidence of poverty for farmers that irrigate relative to rainfed farmers



Key Drivers of Poverty Reduction Impact

- Raising incomes and consumption through greater farm/non-farm employment, upward wage pressure, and lower food prices
- Supporting production of a second or third crop by making water available during the dry season
- Enabling farmers to adapt timing of production to market demand and higher prices, to take advantage of good weather conditions or to avoid adverse weather extremes, and to transition to high-value market-oriented production

Lower incidence of poverty

- ❑ Hussain and Hanjra (2004) found strong direct and indirect linkages between irrigation and poverty reduction. Irrigation technology increased crop production, yields, employment opportunities, and facilitated the transition to high-value market-oriented production. Investments in irrigation were shown to have a positive long-term impact on growth and reducing rural poverty
- ❑ Huang et al. (2005) found that the cost-benefit analysis demonstrated positive returns on irrigation and concluded that irrigation played a crucial role in poverty reduction in China
- ❑ Tesfaye et al. (2008) found statistically significant differences between irrigators and non-irrigators in a scheme in Ethiopia in terms of total expenditure and off-farm income. The incidence, depth, and severity of poverty were significantly lower among irrigators, with 34.6% of irrigators below the poverty line compared to 63% of non-irrigators
- ❑ Bacha et al. (2011) found that poverty incidence and severity were higher in rural areas of Ethiopia compared to urban areas. The incidence of poverty decreased from 65.8% for households in the first quartile of irrigated area to 40.3% for those in the fourth quartile.
- ❑ Desulie and Abebe reviewed 12 studies and emphasized that investments in SSI are a key poverty reduction strategy in Ethiopia
- ❑ Hussain & Wijerathna (2004) found that the poverty reduction potential of irrigation varied across systems in Bangladesh, China, India, Indonesia, Pakistan, and Vietnam. Poverty impacts were influenced by factors such as landholdings, water resources, production technology, cropping patterns, and market infrastructure. The study emphasized that water, along with other complementary inputs, can make significant contributions to poverty alleviation when used in the correct combination

Macro cash impacts on economy

- ❑ A study in Ethiopia showed that SSI contributed 4.46% (US\$262.3 million) to national agricultural GDP and 1.97% to total GDP in the 2005/06 cropping season (Gebreyohannes et al, 2013)
- ❑ In Tanzania, the mean value of sales from irrigating households at 10 sites surveyed in 2015/16 was \$884 a year: among similar households not irrigating, the value was just \$162 a year (de Bont et al., 2019). The additional value of sales from irrigated land was estimated at \$22.8M–\$44.4M a year. Given that farmers are likely to spend additional earnings locally this represents a crucial multiplier effect on the local economy

Employment generation

- ❑ Irrigation can affect the wider economy substantially by generating more jobs per unit of land due to increased productivity at field-level and more diverse crop mix (e.g., horticulture requiring additional labor requirements). One study in Ghana calculated that more than 350k days of labor per year were created on irrigated plots during the dry season, when almost no alternative employment is on offer, a considerable boost to the local economy Namara et al. (2011)

Increased consumption

- ❑ Haji et al. (2013) found that irrigators in Ethiopia had 25% higher per capita consumption expenditure and a significantly lower incidence of poverty (27%) compared to non-irrigators (55%). SSI was concluded to have a positive impact on poverty reduction

Irrigation can be a strong driver of food security at the household and macro level; evidence of nutrition impacts are limited but positive



Key Drivers of Nutrition / Food Security

- Irrigation can lead to higher crop yields, increased overall food production, and lower food prices
- The year-round food availability that irrigation offers is also crucial for food security and nutrition
- It also improves crop diversification and market access, which together have positive effects on dietary diversity
- Income from crop sales enabling irrigators to buy food, health care
- Key nutrition impact pathways include: (i) food production, (ii) income (agricultural and non-agricultural) and (iii) female employment

Increase in household food security

- ❑ Comprehensive assessment of SSI schemes globally found strong evidence that investments in irrigation enhance food security Hanjra and Williams (2020)
- ❑ There is strong evidence from Asia that irrigation improves food security (Hussain and Hanjra 2003, 2004; Shinkai et al. 2007; Fan et al. 2008; Pingali 2012; Ward et al. 2013; Unver et al. 2016; Giordano et al. 2017) and emerging evidence from SSA (Hanjra et al. 2009a, b; Burney and Naylor 2012; Wichelns 2014; Williams 2015)
- ❑ A study in **northern Mali** (Dillon 2011) showed that between 1998 and 2006, households with access to irrigation greatly increased their daily calorie intake (1836 cal) compared to those without irrigation (925 cal), suggesting that irrigation helped to improve calorie intake over time.
- ❑ Furthermore, participation in SSI was found to increase the daily calorie intake of irrigators by 643.76 kcal over non-irrigating households. Irrigation was found to have a positive impact on crop production, consumption and revenue generation.
- ❑ The results from a study conducted by Wondimagegnhu and Bogale (2020) revealed that out of all sampled households, 74% were food secure and 26% were not
- ❑ The gap in food calorie availability ranged from 753 to 6659 kcal/adult equivalent/day in the study area. About 85% of the irrigators were food secure, while, only 65% of the non-irrigators were food secure

Nutrition outcomes are anecdotally supported

- ❑ Evidence also points to SSI improving nutrition outcomes driven by (i) food production, (ii) income (agricultural and non-agricultural) and (iii) female employment (i) food production, (ii) income (agricultural and non-agricultural) and (iii) female employment
- ❑ Data from **Burkina Faso** on household and child nutrition and dietary diversity measures showed an increase in household micronutrient-rich foods, such as dark green leafy vegetables and yellow or orange fruits, and maternal and child intake of leafy vegetables or eggs as a result of irrigation (Olney et al. 2015)
- ❑ A study in Zimbabwe that examined the linkages between irrigation and dietary diversity ranked independent irrigators (highest), and scheme irrigators, home gardens and non-irrigators (lowest), based on diversity of food produced and weekly food consumption (Moyo and Machethe 2016)

Macro food security implications

- ❑ Can **reduce the growing net food import dependency in SSA from 54% under a business-as-usual scenario to a potential 17–40% (Xie 2018)**
- ❑ The IFPRI team modeled the impacts of expanded irrigation development on the number of people at risk of hunger by 2050: 272 million people will be at risk of hunger in Sub-Saharan Africa. More than one-third of this population is based in Central Africa (92 million people), followed by Eastern Africa (67 million), West Africa (57 million) and Southern Africa (approximately 56 million). Accelerated irrigation development reduces these numbers by up to **14–15 million people under the low-cost scenarios (12% and 5% IRR respectively) and by 6–11 million people under the medium-cost scenarios**

SSPs can experience significant resilience outcomes driven by irrigation adoption



Key Drivers of Resilience / Adaptation

- Irrigation systems can help ensure that crops receive proper amounts of water and nutrients during periods where crop water requirements exceed available rainfall, such as prolonged dry seasons and droughts
- Irrigation is a crucial defense and mitigation for key climate change-driven events, such as extended droughts, unpredictable and reduced rainfall, and extreme temperatures

Climate change is a existential threat for farmers

- ❑ Today, 25% of all economic damage caused by climate-related disasters is linked to agriculture, and drought causes 84% of that damage.
- ❑ Studies also indicate that maize, a staple crop in much of sub-Saharan Africa, will have lower yields with increasing temperatures, especially in regions where rainfall is expected to diminish
- ❑ With droughts, irregular rainfall patterns, and temperature spikes predicted to become more frequent and severe in many places as a result of climate change, it is critical for SSPs—the most vulnerable communities in agriculture—to have tools to mitigate these risks. Irrigation can form part of the solution, and solar water pumps are important means of making this irrigation accessible to SSPs
- ❑ Projections show that, under current management practices, climate change will have a negative impact on agricultural production. On average, yield is expected to decline from 5 percent to 20 percent, depending on the crop and the agroecological zone. Higher declines are likely among long cycle cultivars of rainfed crops in the Soudanian zone (FAO, 2018)

Irrigation offers an essential solution to these issues

- ❑ Access to irrigation improves farmers' resilience to climate change. It enables farmers to offset some of the risks of low or unpredictable rainfall with an additional water source. The technology also allows farmers to plant more diverse crops and can increase the number of planting seasons, thereby diversifying revenue streams. More stable income streams are also shown to lead to more stable security environments, since drought and low agricultural yields are correlated to the growth of extremist armed groups
- ❑ Estimates show that, without substantial additional investment in irrigation, the share of people at risk of hunger in Africa could increase by 5 percent by 2030 and by 12 percent by 2050 due to climate change (Ringler, 2017)
- ❑ The FAO found that the use of adaptation practices and technologies to improve soil quality and water delivery to crops tends to have a positive impact on the financial and economic investment returns to family farmers under various climate scenarios across West Africa. Producing under irrigated agriculture – using current irrigation practices – appears to be economically profitable for SSPs in almost all cases, especially the use of Californian systems, tidal irrigation (rice), rainfed (maize - the Gambia), Semi-Californian (tomato), seuils d'épandage (tomato - the Niger), and line canals (maize)
- ❑ In South Asia, the increasing frequency and severity of droughts has been a key drivers of increased farmer-led irrigation from groundwater storage, which is often more reliable during dry spells and has greater value as a strategic buffer
- ❑ Several studies have found substantial profitable potential for irrigation expansion in Africa south of the Sahara under both a both a drier and wetter climate future (using the most extreme climate scenarios available at the time), as well as under alternative crop price and irrigation cost trajectories

Scaling access to irrigation for SSPs can lead to potential negative environmental impacts; true impact at scale must be further evaluated

<i>Potential Negative Environmental Impacts</i>	<i>Risk potential</i>	<i>Key Systemic Mitigating Actions</i>
<p>Water Depletion</p> <ul style="list-style-type: none"> ❖ Overexploitation of groundwater for irrigation can cause depletion of groundwater aquifers, river depletion, and drainage of wetlands¹ ❖ However, the extent of groundwater depletion from overexploitation is highly context-dependent and currently broadly uncertain ❖ Studies indicate large hydrological potential remaining in SSA; one study estimated that the area of cropland irrigable with groundwater across Sub-Saharan Africa can be expanded by between 27-64 million has² 	<p>Short/medium term: Low potential</p> <p>Long term: High potential</p>	<ul style="list-style-type: none"> ➤ Sustainable groundwater management can include supply and demand-side measures ➤ Invest in monitoring and data collection ➤ Strengthen capacity of existing (traditional) systems of governance and support community involvement ➤ Integrate risk management framework in SWP planning ➤ Support cross-sector / scale coordination of actors
<p>Water Pollution</p> <ul style="list-style-type: none"> ❖ Projections show SSA experiencing the world's fastest increase in agricultural water pollution, with intensification spurred by irrigation as a key contributor³ ❖ Irrigated farming uses larger quantities of fertilizers, and many application techniques are prone to wash out excessive fertilizer and pesticide applications⁴ ❖ Many countries lack national guidelines on allowable levels of agrochemicals in water sources and mechanisms to regulate, monitor, and enforce standards 	<p>Short/medium term: High potential</p> <p>Long term: High potential</p>	<ul style="list-style-type: none"> ➤ Policy support and capacity development are needed to create health, safety and quality standards as well as transparent governance mechanisms/regulations ➤ Pursue an integrated input approach ➤ Develop more sophisticated measuring and monitoring techniques to track pollution impacts
<p>Land Degradation</p> <ul style="list-style-type: none"> ❖ Increased irrigation could lead to land degradation, alterations to local/regional climate systems due to land use change, and increased farming land use ❖ Poor irrigation management can also lead to soil erosion and river sedimentation, waterlogging, and salinization ❖ Potential for loss of biodiversity, from changed ecosystems and from the loss of agricultural biodiversity on farms that can result from intensified production 	<p>Short/medium term: Low potential</p> <p>Long term: Medium potential</p>	<ul style="list-style-type: none"> ➤ Education and extension services for farmers ➤ Deficit, or supplementary irrigation, and conjunctive use of surface water and groundwater can reduce negative effects on soil erosion, water-logging and salinization

1) Xie & Ringler, 2017; 2) IWMI, 2021; 3) Ringler, 2021; Maeo-Sagasta et al. 2018; 4) Thebo et al. (2017); 5) Ringler 2021, Sheahan and Barret 2017

Negative social and economic impacts are also possible, however there is more certainty around the risk and mitigation of these impacts

Potential Negative Social / Economic Impacts	Risk potential	Key Systemic Mitigating Actions
<p>Conflict</p> <ul style="list-style-type: none"> ❖ Conflicts among water users may arise when upstream users abstract too much water, leaving little or none available for downstream users for agriculture or household consumption ❖ Inefficient water use and the use of potable water for irrigation can intensify competition for water, particularly for drinking water, as treated wastewater is not commonly used in African agriculture 	<p>Short/medium term: Medium potential</p> <p>Long term: High potential</p>	<ul style="list-style-type: none"> ➤ Risk assessment should be a crucial part of any initial decisions regarding whether to implement new systems or to expand and upgrade existing irrigation systems ➤ Education at the SSP-level is crucial to mitigate potential conflicts
<p>Equity Concerns</p> <ul style="list-style-type: none"> ❖ Households that irrigate tend to have better-than-average incomes, land, labor, and education, particularly those who irrigate with motor pumps and larger areas ❖ Irrigation may disproportionately benefit those who are already better-off, while others may receive little or no benefit or even suffer harm ❖ Women may face negative impacts from irrigation, such as spending more time on household fields and labor intensive irrigation practices 	<p>Short/medium term: Medium potential</p> <p>Long term: Medium potential</p>	<ul style="list-style-type: none"> ➤ Support rural institutions to manage natural resources collectively, including groundwater and surface water, to enable more equitable access ➤ Consider post-adoption household decision-making dynamics when targeting women via investments ➤ Women and men within households both need access to information on technologies
<p>Human Health</p> <ul style="list-style-type: none"> ❖ Waterborne disease, including malaria and schistosomiasis, resulting from irrigation water providing a habitat for vectors of disease ❖ Toxic chemicals used on plots either ingested through touch or inhalation, or else polluting sources of domestic water ❖ Runoff pollution from irrigation practices can potentially enter potable water sources and have adverse impacts on human health 	<p>Short/medium term: Low potential</p> <p>Long term: Medium potential</p>	<ul style="list-style-type: none"> ➤ Regular maintenance of irrigation infrastructure is an effective and feasible option for minimizing this potential risk to human health ➤ Coordinating stakeholders across sectors (e.g., agriculture and healthcare) to ensure health outcomes are monitored during scaling of SSI

While the majority of empirical evidence indicates positive impacts associated with irrigation for SSPs, caveats must be acknowledged

Key caveats and areas for further research across impact evidence

Reliance on study-level and single-system evidence and success bias

- Most evidence is based on studies focused at the single system level rather than impact across broader irrigation systems
- These studies focus on irrigation projects that, at least to a degree, are functioning as there is little benefit to evaluating the impact at the household level of a system which is clearly dysfunctional. This biases the available evidence toward single irrigation investments that have been viewed as effective

Broader site selection bias

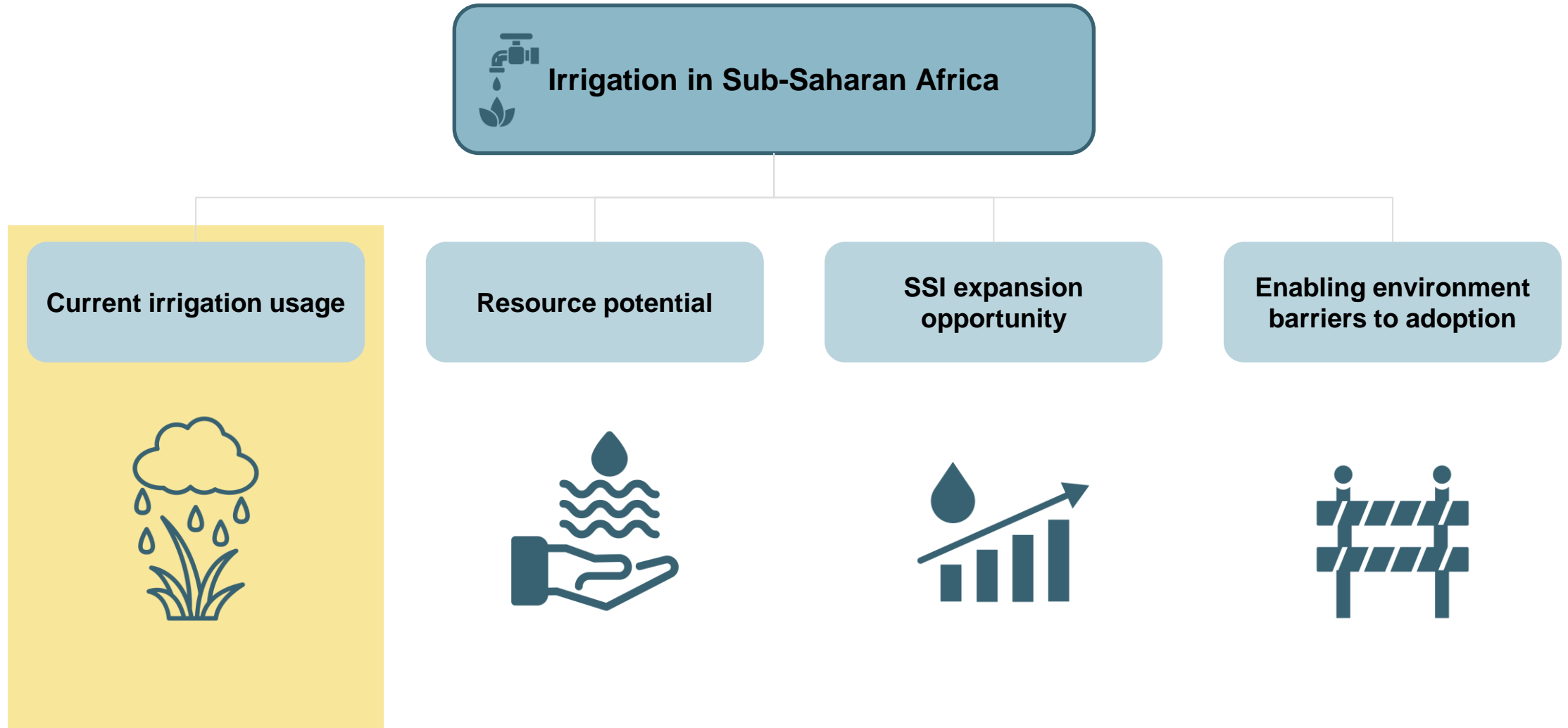
- Irrigation investments are likely to be undertaken where there is agricultural potential making the areas, and households that farm there, fundamentally different from neighboring areas
- Differences between those with irrigation access and those without may be due to fundamental differences between the two types of households rather than the impact of the irrigation investment – thus, it is hard to separate why differences emerge
- While experimental and non-experimental approaches are used in some cases to identify an unbiased estimate of the impact of irrigation investment, this is not always possible and has rarely been done
- Many studies have significant limitations and can only show correlation between irrigation access and outcomes and not causation
- The end result is that there are few studies with reliable estimates of household level impact
- *Note: the selected evidence in this report focus on those studies, which attempt to address selection issues*

Appendix

1. Appendix – supporting materials

1. Impact case for scaling irrigation
2. **Current state of small-scale irrigation, expansion opportunity, and barriers**
3. Emerging private sector solutions
4. Recommended actions to scale irrigation for small-scale producers
5. Case studies

Current state of SSI, expansion opportunity, and barriers



The low usage of irrigation in SSA can be explained in part by the history (and failures) of irrigation development

Pre-colonial

*Sub-Saharan Africa had ancient traditions of rain-adapted farming in different parts – for example, the traditional *décrue* irrigation methods of accessing shallow groundwater sources in the floodplain environments of northern Mali*

Colonial period

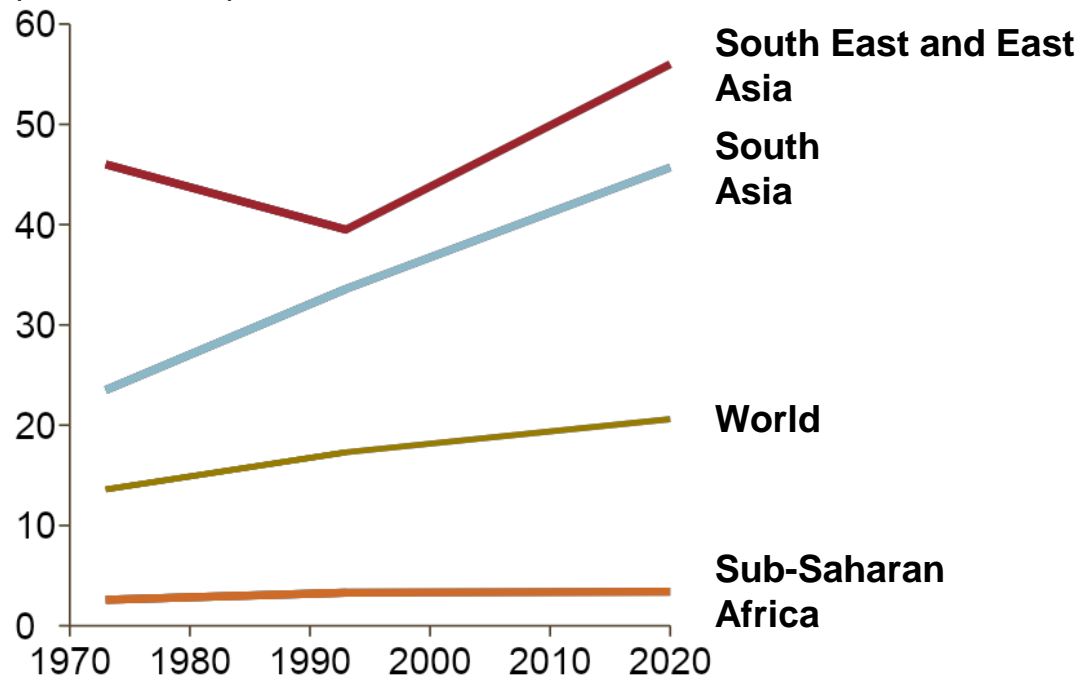
- *During the first half of the 20th century, colonial administrations in SSA invested in large-scale, gravity-fed public irrigation schemes covering thousands of hectares*
- *These were designed and managed as globally integrated agribusinesses, imposing monocrop regimes, providing all inputs, and marketing all outputs, with the African farmer having little entrepreneurial role*
- *Central public agencies built and operated dams, water diversion structures and conveyancing canals*
- *The irrigated area was then typically divided into family-sized plots worked by households who were tenants of the scheme. Prominent examples include Gezira in the Sudan and the Office du Niger in Mali, schemes that covered more than 800k ha and 75k ha respectively*

Post-colonial

- *In the postcolonial era, efforts were made to turn over the management of preexisting and new systems to local communities but with variable outcomes*
- *Decline in operation and maintenance, lack of institutional reform, bureaucratic inefficiency, poor service delivery, and lack of demand for irrigation all led to severe deterioration in the performance of public and community-managed irrigation systems in SSA, as elsewhere in the developing world*
- *With its low population density and dispersed farming areas, irrigation projects needed to either provide longer canals per irrigation acre or populate the command area by (often forcibly) relocating farmers near canals. The latter was easier under colonial powers who could treat irrigation landscapes as tabula rasa, which modern governments find hard to do. As a result, at about US\$10,000 per hectare, centrally planned large-scale irrigation projects turned out costlier to construct in Sub-Saharan Africa than elsewhere in the developing world*
- *Thus, between 1980 and 2000, international financial institutions became increasingly reluctant to invest in large canal irrigation projects in Sub-Saharan Africa*
- *Since the 1980s, however, small pockets of informal SSI have emerged throughout Sub-Saharan Africa, supported sometimes by NGOs and donors, using manual or motorized pumps to lift small amounts of water from ground or surface sources*
- *Behind this groundswell in small-scale, informal SSI is mostly private initiative by individuals or small groups of SSPs*
- *These schemes mobilize water from temporary shallow wells, ponds, streams, rivers, and other sources; they often involve lifting by manual or motor pump and conveyance of water through open channels or pipes or both*
- *Common to these are several distinct features: a new entrepreneurial model of irrigation organization in which the SSP was the decision maker rather than a laborer; the technology used was familiar and affordable; and institutional arrangements promoted farmer management, either in groups or individually*

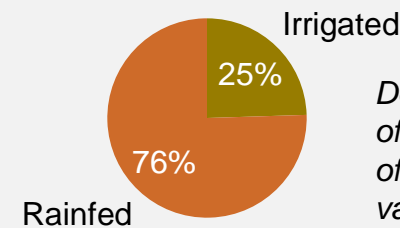
This gap between SSA and global irrigation penetration has only increased over the past decade

Total irrigated land area as a % of cultivated land (1970-2020)



- The pace of growth of such SSI in Sub-Saharan Africa has remained tepid at **about 3% per year**
- **SSA is adding about 60,000 hectares per year to its stock of SSI**, and this too remains concentrated in a few countries
- In comparison, **South Asia added, on average, 1.5 million hectares per year of SSI between 1985 and 2010** in a much smaller geography than Sub-Saharan Africa

Value of crops by water input method in SSA (all crops)



Despite accounting for such a small portion of cropland, irrigated crops make up ~25% of all production in SSA when assessed by value

Evaluating existing irrigation use, especially for SSPs, is difficult

Evaluating existing irrigation use, especially for SSPs, is difficult

Existing statistics lack accuracy

- ❖ Official statistics on irrigation, and particularly SSI, in SSA are imperfect and often not representative of the realities on the ground
- ❖ This is partly due to methodological problems associated with assessments and partly because of rapid changes, quickly outpacing the data

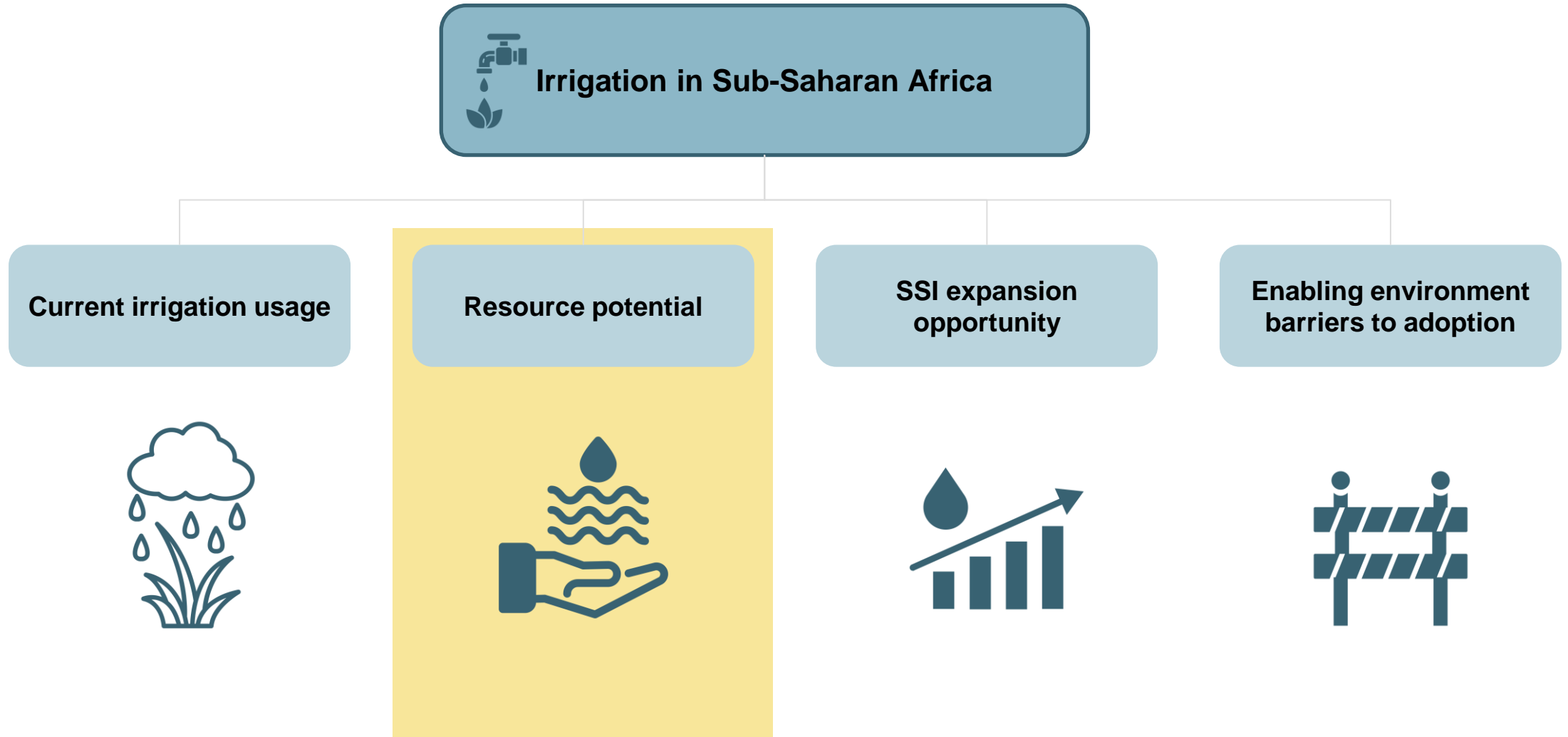
Uncertainty driven by lack of coordination and technical difficulties

- ❖ Aligning on *what* irrigation specifically is as well as *how* it can be measured is a key challenge for effectively tracking the existing usage
- ❖ SSI is often informal, sporadic use of traditional methods which makes it difficult to fully assess and evaluate what is irrigation
- ❖ Additionally, to be defined as the area for which physical infrastructure allows for 'total water control'. The Aquastat database of the FAO, for instance, differentiates between areas with 'total' or 'partial' water control, the first one being 'equipped' for irrigation, but overlooks the diversity of irrigation practices in SSA
- ❖ In the dominant narratives and statistical data, small adjustments made by farmers, for instance when supplying water to crops during dry spells in the rainy season, do not qualify as irrigation

Recent studies have also demonstrated that farmer-led irrigation is far more common in SSA than has been recognized - evidence from satellite imagery shows that the irrigated area could be two to three times the official figures

However, even if that is the case the existing irrigation penetration lags far behind peer regions globally

Current state of SSI, expansion opportunity, and barriers

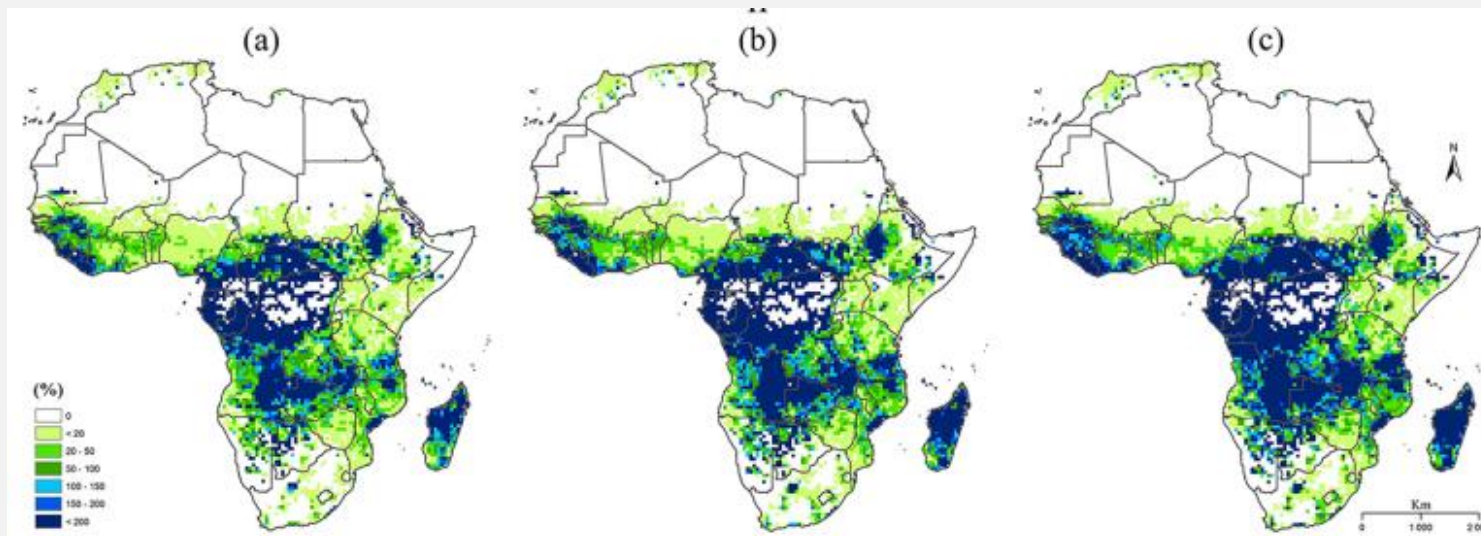


Research shows 45-105 million hectares of cropland is irrigatable with renewable groundwater; however this varies greatly by geography

Mapping irrigation potential from renewable groundwater in Africa – a quantitative hydrological approach, Y. Altchenko and K. G. Villholth – 2015

- **Key findings:** The total area of cropland irrigable with renewable groundwater ranges from 45 -105 million has, equal to 21 - 49% of Africa's cropland
- This paper derives a continentwide, distributed (0.5° spatial resolution) map of groundwater irrigation potential, indicated in terms of fractions of cropland potentially irrigable with renewable groundwater.
- The method builds on an annual groundwater balance approach using 41 years of hydrological data, allocating only that fraction of groundwater recharge that is in excess after satisfying other present human needs and environmental requirements, while disregarding socio-economic and physical constraints in access to the resource
- Three scenarios, leaving 30, 50 and 70 % of recharge for the environment, were implemented
- Results show an unevenly distributed groundwater irrigation potential across the continent, even within individual countries, mainly reflecting recharge patterns and presence or absence of cultivated cropland

Proportion of cropland irrigable with groundwater, for various levels of environmental groundwater requirements as a fraction of recharge

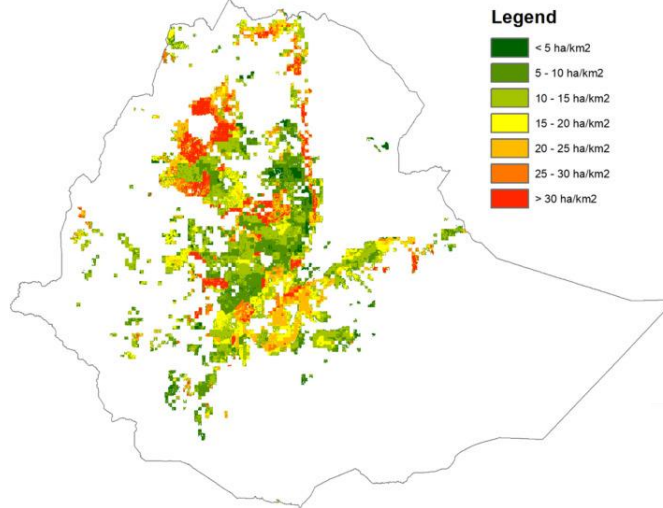


- (a) Scenario 1: 70 % recharge rate for groundwater
- (b) Scenario 2: 50 % recharge rate for groundwater
- (c) Scenario 3: 30 % recharge rate for groundwater

← Increasing water /
environmental requirements

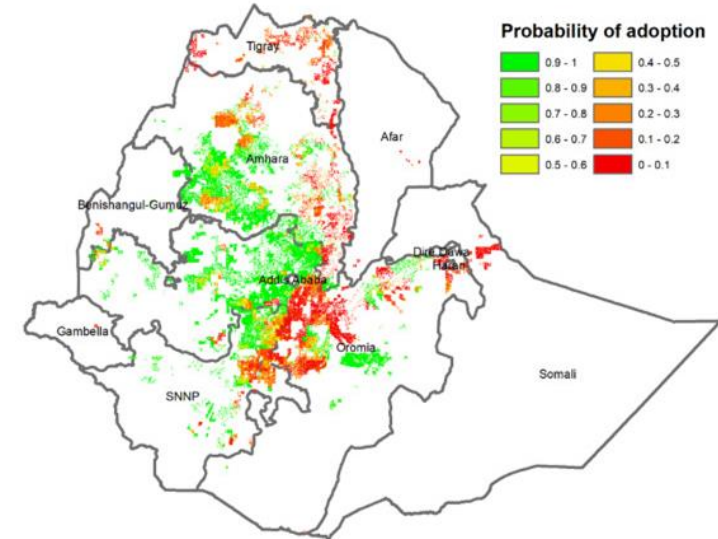
Even within countries there is a wide range of resource potential and opportunity; Ethiopia provides an example

Spatial distribution of rainfed cultivation area (farm size) of non-perennial crops in Ethiopia



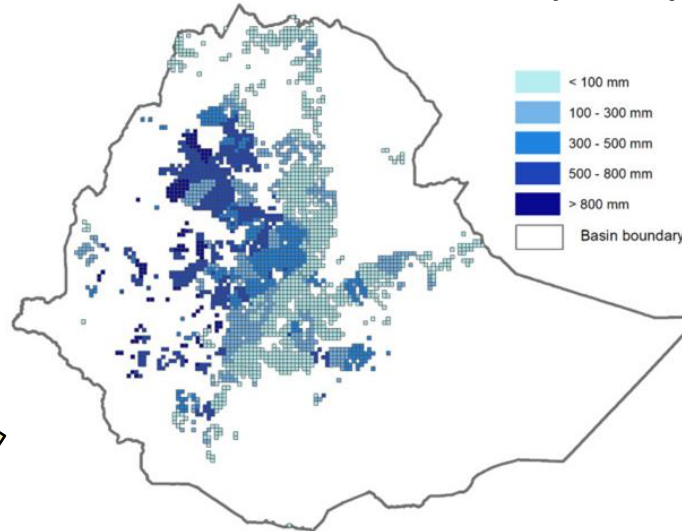
A large portion of the country produces vegetables and other non-perennials on primarily rainfed land

Estimated development potential of dry-season small-scale irrigation



High adoption probability for SSI at Lake Tana and Ethiopian Great Rift Valley areas

Annual water yield results from the Soil and Water Assessment Tool (SWAT)



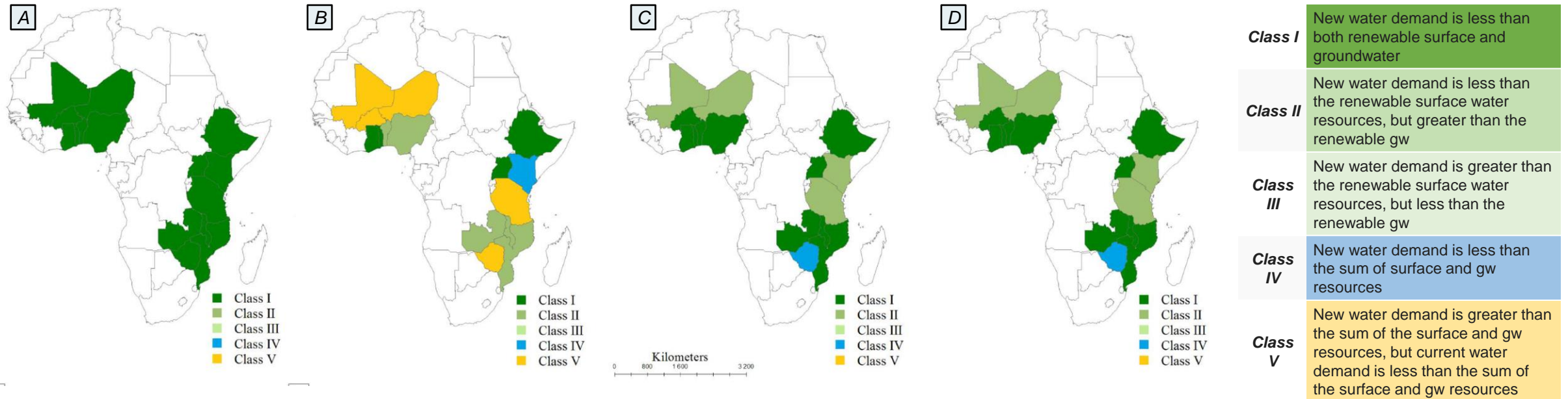
There is a significant amount of surface runoff and groundwater recharge available across the country to expand SSI. However, the extent of this varies by location

Zaki et al. (2018) assessed the potential for scaling irrigation based on water resource potential of 14 specific countries (1/2)

Zaki et al., An Index-Based Approach to Assess the Water Availability for Irrigated Agriculture in Sub-Saharan Africa. Water, (2018)

- Developed an index considering renewable water availability of both surface water and groundwater to assess the potential increase in arable land area in 15 selected SSA countries
- The selected countries were classified using the index, based on the availability of renewable water resources nationwide and also assessed the future water demand by employing three scenarios and combining different rain-fed and irrigated options.
- The results show that, except for Zimbabwe, the current available surface water or groundwater resources could be sufficient to farm all of the potential cultivable areas in the selected countries when both rain-fed and irrigated systems are fully operational.
- Ethiopia, Ghana, Togo, and Uganda were the only countries that did not have limitations on either of their water resources in any of the three scenarios analyzed. Niger, Mali, Burkina Faso, Tanzania, and Zimbabwe lacked the water resources, of both surface water and groundwater, for fully farming their potential cultivable area using irrigation systems.
- All countries, except Zimbabwe, had enough renewable resources to increase their potential cultivable area using the current situation

Allocation of the 15 selected countries to classes based on different scenarios. (A) Current situation; (B) Scenario 1; (C) Scenario 2; and (D) Scenario 3

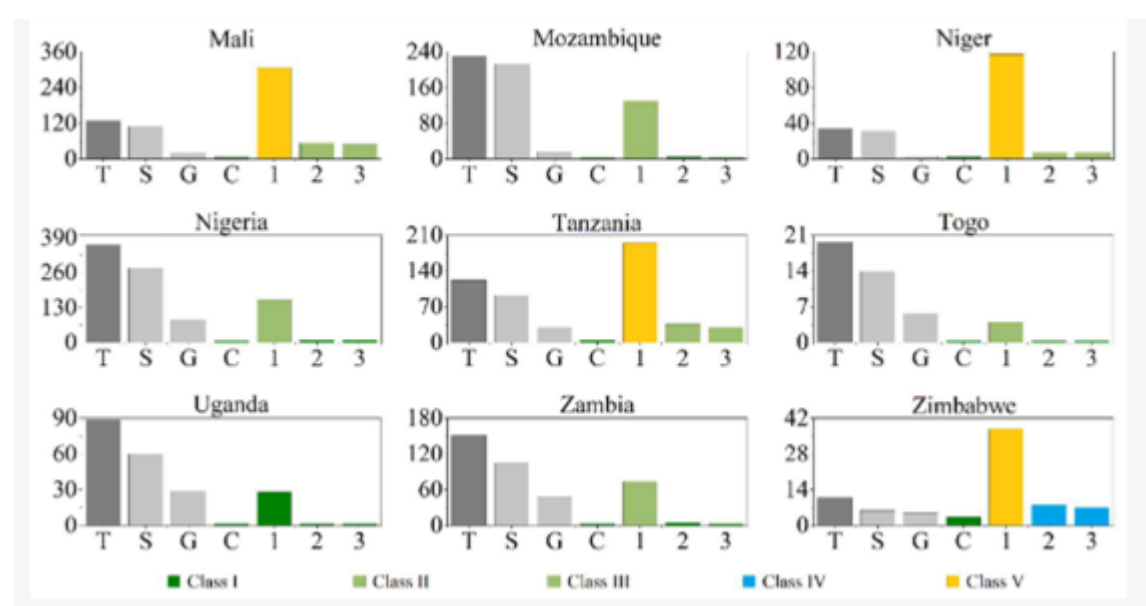
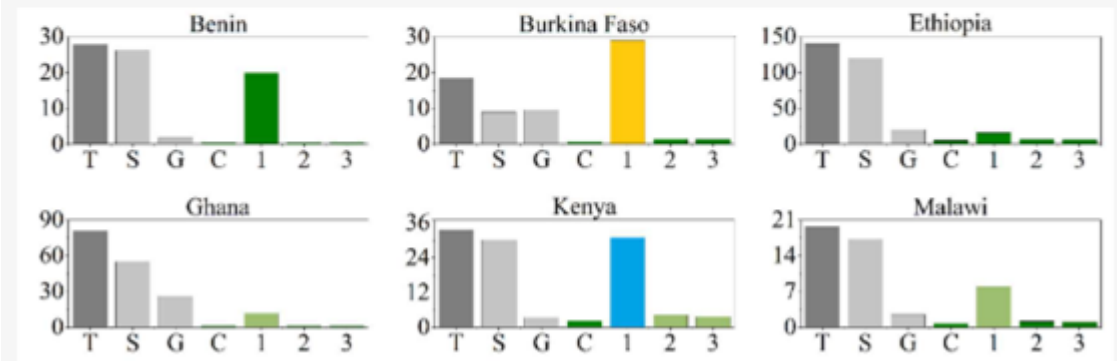


Source: Zaki et al., An Index-Based Approach to Assess the Water Availability for Irrigated Agriculture in Sub-Saharan Africa. Water, (2018)

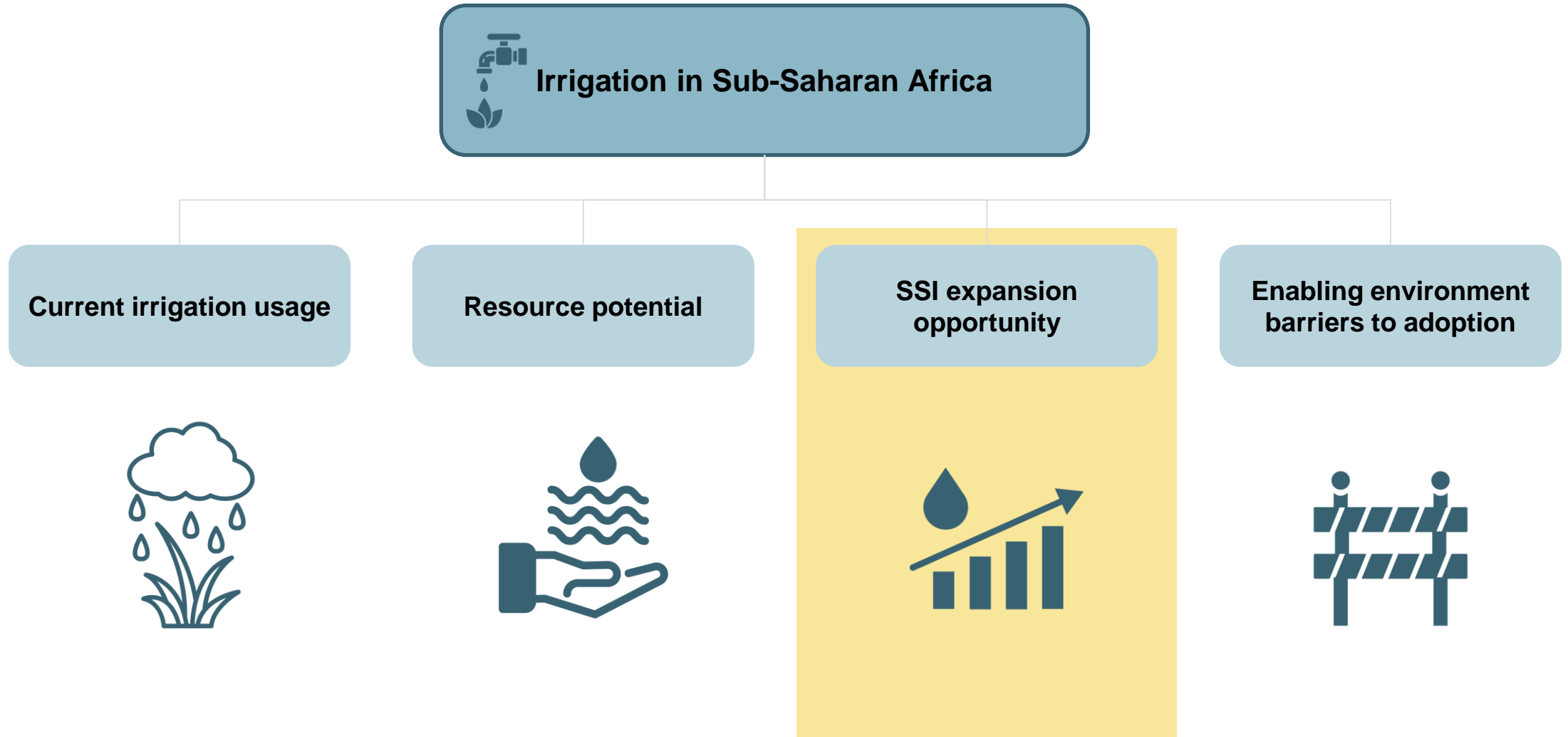
Zaki et al. (2018) assessed the potential for scaling irrigation based on water resource potential of 14 specific countries (2/2)

Source	Results	Methodology
<p>Abou Zaki N, Torabi Haghighi A, Rossi PM, Xenarios S, Kløve B. An Index-Based Approach to Assess the Water Availability for Irrigated Agriculture in Sub-Saharan Africa. <i>Water</i>. 2018; 10(7):896. https://doi.org/10.3390/w10070896</p>	<ul style="list-style-type: none"> The results show that, except for Zimbabwe, the current available surface water or groundwater resources could be sufficient to farm all of the potential cultivable areas in the selected countries when both rain-fed and irrigated systems are fully operational. Ethiopia, Ghana, Togo, and Uganda were the only countries that did not have limitations on either of their water resources in any of the three scenarios analyzed. Niger, Mali, Burkina Faso, Tanzania, and Zimbabwe lacked the water resources, of both surface water and groundwater, for fully farming their potential cultivable area using irrigation systems. All countries, except Zimbabwe, had enough renewable resources to increase their potential cultivable area using the current situation 	<ul style="list-style-type: none"> An index was developed to assess the potential for agriculture, considering renewable water availability of both surface water and groundwater. The index-based approach was then used to assess the potential increase in arable land area in 15 selected SSA countries. The selected countries were classified using the index, based on the availability of renewable water resources nationwide. We also assessed the future water demand by employing three scenarios and combining different rain-fed and irrigated options. The findings also indicate that targeted infrastructure projects (e.g., reservoirs, channels), crop management, and water saving techniques could improve surface and groundwater availability in the SSA region.

Figure 3. Water resources versus water consumption in the 15 different countries. T—total available annual renewable water resources; S—annual renewable surface water; G—annual renewable groundwater; C—current annual water consumption (includes domestic, industrial, and irrigation), 1—annual water consumption in scenario 1; 2—annual water consumption in scenario 2; 3—annual water consumption in 3. The Y-axis represents the water volume in 10^9 m^3 .



Current state of SSI, expansion opportunity, and barriers



When accounting for water depletion risks along with agroeconomic and social conditions, SSI could be expanded by 19m

There is **abundant evidence that the potential for expanding SSI in SSA is immense** (taking into account other variables beyond just resource availability)

However, **these estimates vary significantly at the continental level**. Estimated ranges of potential expansion area include:

- ~3-15 million hectares (You et al., 2011)
- ~25-29 million hectares (Xie et al., 2014)
- ~38 million hectares (Malabo Montpellier Panel, 2018)
- ~10-19 million hectares (Xie et al., 2018)
- ~47 million hectares (FAO Aquastat, 2020)

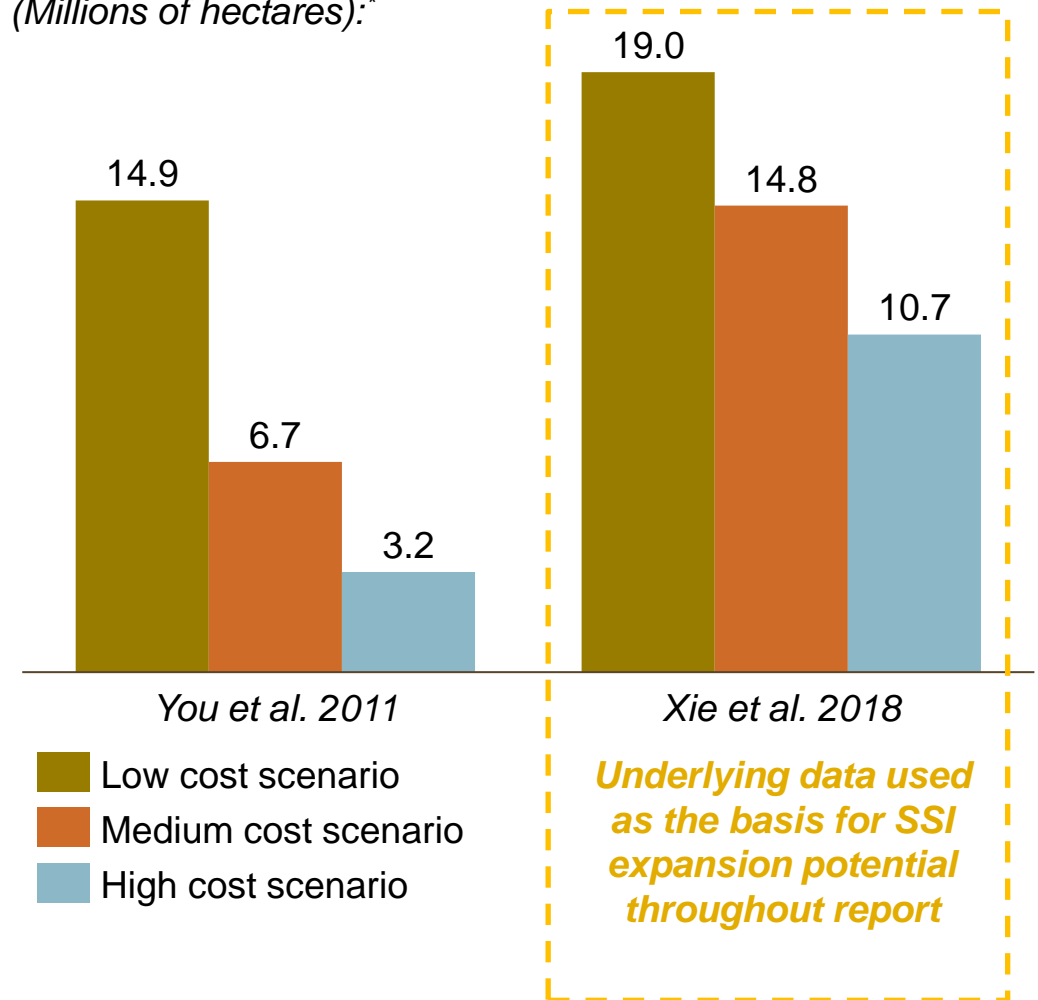
The wide variation in irrigation potential results from different assumptions. While water, in the form of runoff, may easily be quantified and translated into theoretical potential irrigation areas, **assessments do not account equally for a set of practical realities**

An alliance between the World Bank, IFAD, AfDB, and CGIAR carried out a series of studies to **more accurately assess the potential for SSI expansion that takes economic dimensions further into account**

- This model **identified potential areas for irrigation development**, using distance to market, existing arable farmland, and distance to water resources. An optimization model calculated the potential for small- and large-scale irrigation for each country as well as various impact and ROIs

We use the latest figures from this model, provided by the IFPRI team via personal communication, as a basis for understanding the potential expansion opportunity for SSI at both a continental and country level

Potential Irrigation Expansion, from two leading studies (Millions of hectares):*



Expansion potential and key country datapoints (1/3)

Countries	SSI potential (Mha)	Rural Population Size (M)	Arable Land (Mha)	Current Irrigated Area (Ha)	% of Cultivated Area Irrigated	% irrigated using GW	% irrigated using SW	Renew. water resources per capita (m ³ /year)	Ag. water withdrawal as % of renew. water resources	Water Stress Index
Nigeria	2,900,516	100,840,661	35,000,000	218,840	0.8%	29%	71%	1,388	1.9%	9.7%
Tanzania	1,768,942	40,725,784	13,502,500	189,047	2.3%	9%	91%	1,612	4.8%	13.0%
Kenya	1,349,920	37,902,724	5,800,000	97,011	3.2%	1%	99%	571	10.5%	33.2%
Madagascar	1,344,563	17,578,693	3,000,000	1,080,691	23.1%	0%	100%	12,170	3.9%	11.3%
Ethiopia	1,095,576	93,611,468	16,195,100	290,729	4.6%	1%	99%	1,061	7.9%	32.3%
Côte d'Ivoire	999,489	13,140,099	3,500,000	66,930	0.9%	0%	100%	3,190	0.7%	5.1%
Uganda	961,288	34,136,762	6,900,000	5,900	0.1%	1%	99%	1,314	0.4%	5.8%
South Africa	949,566	19,096,392	12,000,000	1,498,000	17.1%	9%	92%	866	23.3%	65.0%
DRC	923,813	51,557,473	13,477,000	6,800	0.1%	0%	100%	14,325	0.0%	0.2%
Malawi	807,126	16,370,252	3,600,000	54,134	2.4%	0%	100%	903	6.7%	17.5%
Senegal	790,813	8,674,634	3,200,000	69,000	3.7%	10%	90%	2,327	7.1%	16.3%
Ghana	598,203	13,794,798	2,513,400	55,910	0.6%	21%	76%	1,809	1.9%	6.3%
Zambia	458,390	10,672,830	3,800,000	155,912	4.1%	4%	96%	5,701	1.1%	2.8%
Mozambique	379,167	20,007,111	5,650,000	40,063	2.0%	1%	99%	6,946	0.5%	1.8%
Burkina Faso	340,124	15,196,430	6,000,000	25,000	0.9%	12%	88%	646	3.1%	7.8%

Source: Xie et al. 2018; FAO AUQASTAT

Expansion potential and key country datapoints (2/3)

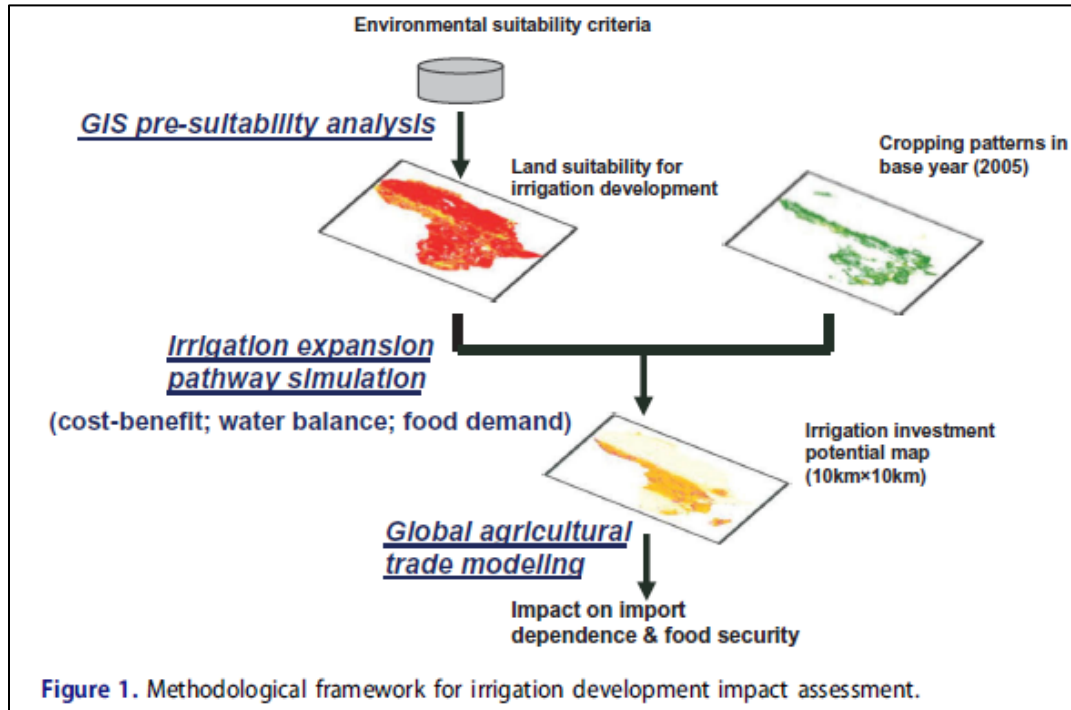
Countries	SSI potential low cost (ha)	Rural Population Size	Arable Land	Current Irrigated Area	% of Cultivated Area Irrigated	% irrigated using GW	% irrigated using SW	Renew. water resources per capita (m ³ /year)	Ag. water withdrawal as % of renew. water resources	Water Stress Index
Somalia	317,490	9,090,664	1,100,000	65,000	17.8%	15%	85%	925	22.3%	24.5%
Sierra Leone	299,148	4,768,441	1,584,000	10,000	1.7%	1%	99%	20,058	0.0%	0.5%
Chad	288,200	13,094,226	5,200,000	26,200	0.6%	20%	80%	2,782	1.5%	4.3%
Benin	251,986	6,632,056	2,800,000	7,131	0.7%	18%	82%	2,177	0.2%	1.0%
Togo	203,814	4,896,604	2,650,000	6,278	0.3%	1%	99%	1,776	0.5%	3.4%
Zimbabwe	187,165	10,827,136	4,000,000	123,866	4.4%	12%	88%	1,346	15.2%	35.4%
Cameroon	171,485	11,383,170	6,200,000	25,654	0.3%	4%	96%	10,666	0.3%	1.6%
Mauritania	159,328	2,024,451	400,000	22,840	11.0%	11%	89%	2,452	10.7%	13.2%
Mali	144,975	12,118,494	6,411,000	176,843	5.7%	0%	100%	5,926	4.2%	8.0%
Liberia	138,512	2,463,081	500,000	2,100	0.3%	1%	100%	45,871	0.0%	0.3%
Angola	137,032	11,227,528	#N/A	35,000	#N/A	20%	80%	#N/A	#N/A	#N/A
Sudan	126,151	29,406,434	20,994,840	800,000	8.7%	4%	96%	862	68.5%	118.7%
Eritrea	117,886	2,100,324	690,000	42,637	3.1%	24%	76%	2,063	7.5%	11.2%

Expansion potential and key country datapoints (3/3)

Countries	SSI potential low cost (ha)	Rural Population Size	Arable Land	Current Irrigated Area	% of Cultivated Area Irrigated	% irrigated using GW	% irrigated using SW	Renew. water resources per capita (m ³ /year)	Ag. water withdrawal as % of renew. water resources	Water Stress Index
Guinea	117,245	8,489,377	3,100,000	94,914	2.5%	0%	100%	17,209	0.3%	1.4%
Congo	84,010	1,850,943	550,000	220	0.3%	0%	100%	150,777	0.0%	0.0%
Guinea-Bissau	79,074	1,141,289	300,000	#N/A	4.1%	#N/A	#N/A	15,955	0.5%	1.5%
Burundi	76,646	10,786,763	1,200,000	21,430	1.4%	0%	100%	1,054	1.8%	10.2%
Niger	67,395	21,022,639	17,700,000	65,615	0.6%	2%	98%	1,407	6.9%	11.0%
Rwanda	57,766	11,096,904	1,151,700	8,500	0.6%	1%	99%	1,027	2.7%	20.2%
Gabon	57,157	224,215	325,000	4,450	0.9%	0%	100%	74,582	0.0%	0.5%
Namibia	55,234	1,189,044	800,000	7,573	0.9%	22%	78%	15,707	0.5%	0.9%
Central African Republic	51,340	3,129,787	1,800,000	69	0.0%	0%	100%	29,194	0.0%	0.3%
Botswana	50,556	736,148	260,000	621	1.5%	46%	54%	5,205	0.7%	2.3%
Lesotho	47,298	1,608,881	596,000	67	0.4%	75%	25%	1,411	0.1%	2.6%
Gambia	45,058	970,908	440,000	1,400	0.5%	1%	99%	3,310	0.5%	2.2%
Equatorial Guinea	6,904	432,136	138,600	0	#N/A	#DIV/0!	#DIV/0!	18,532	0.0%	0.2%

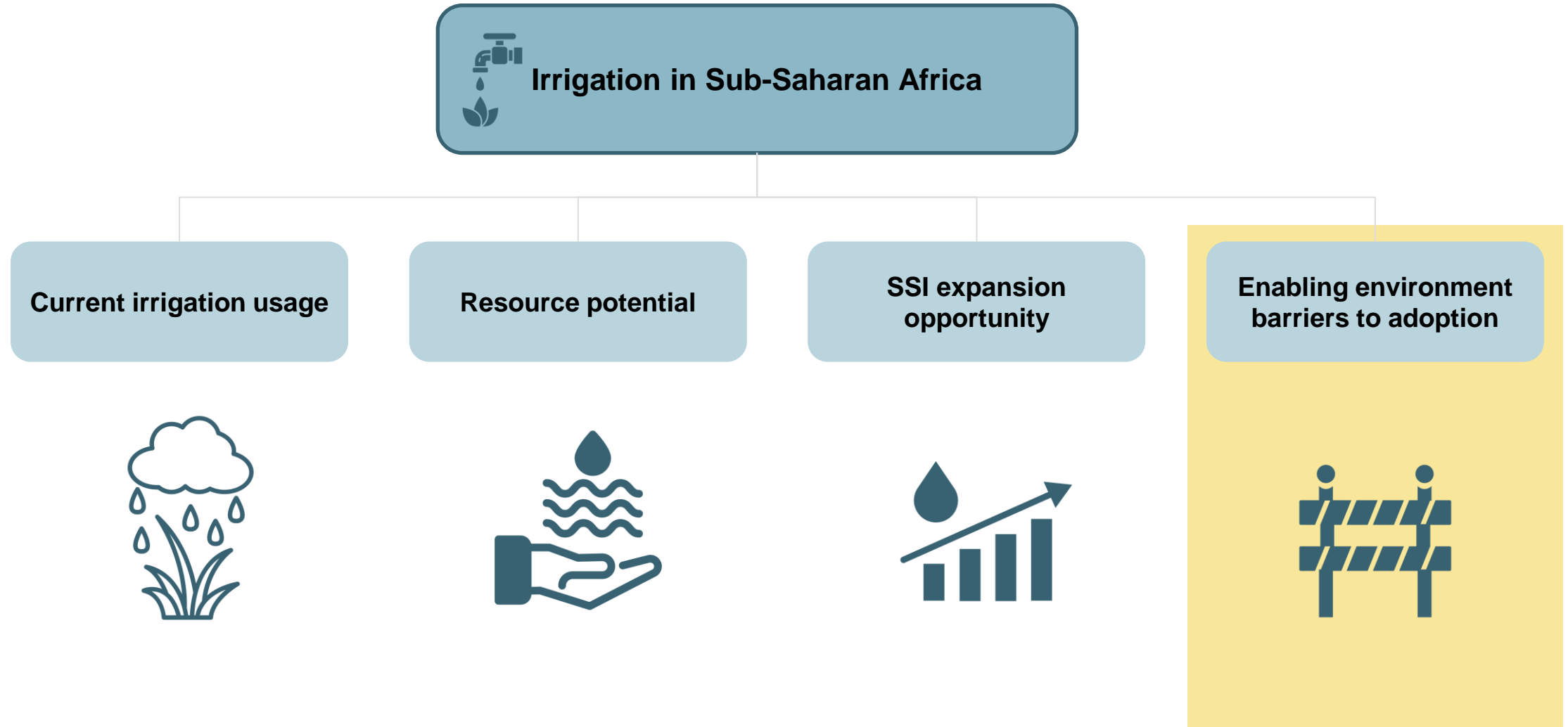
Methodology for IFPRI's modelling of irrigation expansion potential

Takes into account factors including geospatial data analysis, predictive hydrologic modeling, economic modeling, crop optimization, cost benefit analysis, and market demand modeling



- The adoption of irrigation occurs in a sequence according to the suitability ranking of the pixels in a country. Irrigation first expands to the pixel with the highest suitability score, followed by the pixel with the second highest score etc.
- Given the adverse impacts on forest cover and biodiversity of expanding agricultural land in Sub-Saharan Africa, pixels with existing rainfed croplands were first converted to irrigation, and only when irrigation remains sufficiently profitable were areas not yet cultivated converted.
- Internal rates of return (IRR) were used as a criterion for irrigation investment decisions, that is, irrigation investments will only be made if the IRR of irrigated crop production in the pixel is greater than a predefined level
- The adoption of irrigation can be accompanied by a change in crop mix. We considered this important issue as follows. Irrigation development leads to double cropping with key second-season crops being maize, rice, wheat and vegetables. We allow for a larger set of candidate irrigated crops for the rainy season, including groundnuts, maize, millet, potatoes, sorghum, sugarcane, sweet potatoes, rice, vegetables and wheat. Second, farmers tend to plant high-value crops under irrigation given the higher input costs of irrigated agriculture. We reflect this by assuming that in each season the cultivated area of each crop is proportional to its net profitability
- The potential for irrigation expansion is also constrained by the availability of renewable water resources and projected demand for irrigated crops. Water availability was evaluated at the river basin level for SSI analysis. Irrigation expansion within the potential command area of a reservoir or in a basin stops when the irrigation water supply capacity of the reservoir is reached or renewable water resources of the basin allocated to irrigation are fully used.
- The food demand constraint was applied to each individual irrigated crop at the national level. A crop is removed from the list of candidate irrigated crops or remaining simulations when the projected domestic demand for that crop by 2050 is fully met through increased irrigated production.
- The irrigation development potential reported serves as an update to the estimate reported by You et al. (2011), which was established in a similar conceptual methodology framework. More recently available input data and a new implementation approach were used in this study

Current state of SSI, expansion opportunity, and barriers



Low irrigation use is driven both by historical development failures alongside existing farmer-level and systemic barriers

Historical – large schemes failed

Colonial rule prioritized large-scale centralized schemes

- Colonial governments across SSA favored large-scale public schemes for irrigation, with tenant farmers supervised by a central authority
- Designed with priority to engineering considerations, these large show-case schemes all too often failed to meet their objectives and did so at high cost

Independence brought the promise of publicly driven large-scale irrigation

- In the 1960s and 1970s, under the newly independent governments, further such public schemes were favored. Large-scale irrigation schemes (LSIS) were seen as highly promising initiatives that could lead positive impacts

But the majority of large-scale schemes continued to result in failure

- By the mid-1980s it was clear that many of the LSIS were failing, often quite badly
- Decline in operation and maintenance, lack of institutional reform, bureaucratic inefficiency, poor service delivery, and lack of demand for irrigation all led to severe deterioration in the performance of public and community-managed irrigation systems in SSA
- With its low population density and dispersed farming areas, irrigation projects needed to either provide longer canals per irrigation acre or populate the command area by (often forcibly) relocating farmers near canals. As a result, at about US\$10,000 per hectare, centrally planned large-scale irrigation projects turned out costlier to construct in SSA than elsewhere in the developing world (ICID 2010; Lankford 2009)
- Failures included schemes at Bura on the Tana River in Kenya, schemes to irrigate along the Gambia River, and several dams in northern Nigeria

Thus, between 1980 and 2000, international financial institutions became increasingly reluctant to invest in large canal irrigation projects in Sub-Saharan Africa

- Many preexisting colonial (or in South Africa, the apartheid era) irrigation systems constructed to benefit SSPs continued to be managed in a centralized manner as “estates.” But the performance of these small systems—in terms of productivity, equity, and sustainability—was no better than large ones (Barnett 1984; Carter 1989; Perret 2002; Shah et al. 2002).

Small-scale irrigation – faces a number of barriers

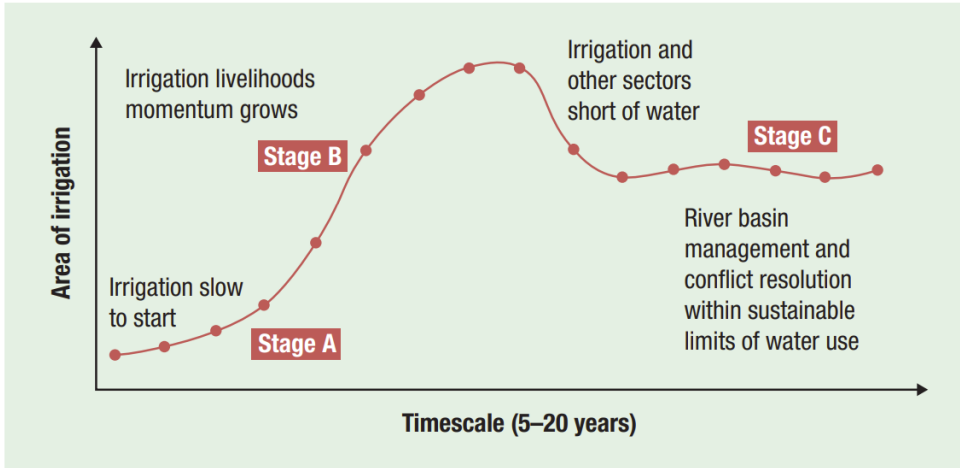
Subsequently, much of the expansion in irrigation has been from farmer-led initiatives

- Since the 1980s small pockets of informal SSI have emerged throughout SSA, supported sometimes by NGOs and donors, using manual or motorized pumps to lift relatively small amounts of water from ground or surface sources to irrigate
- This approach, often termed as farmer-led irrigation development (FLID) or simply small-scale irrigation development, has gained increasing importance in Africa in the last 20 years and is identified as the dominant process driving agricultural water expansion in Africa
- This sector comprises individuals and small groups who make their investments to advance irrigation and AWM practices
- They are mostly SSPs, market-oriented producers; typically farming horticultural crops for urban markets
- FLID has expanded rapidly in West, East and Southern African regions and studies have identified that the areas under AWM are likely much larger than what is officially recorded.

Small-scale and farmer-led irrigation faces a number of key barriers to adoption – these are explored in more depth on the following pages

As irrigation is scaled in a geography the policy and supporting environment implications evolve

Stages of policy environment for irrigation development:



Source: Lankford, “Irrigation-based livelihood trends in river basins: theory and policy implications for irrigation development”, 2003

Description

- **Stage A** – Little irrigation may initially take place because conditions are lacking. Missing conditions may include: prices and incentives to grow more; skills and knowledge of irrigation possibilities; scarcity of capital to take up irrigation opportunities; and the inability of farmers to combine where collective action is needed to put water to use
- **Stage B** – conditions for irrigation become more attractive. Many more farmers, individually or in groups – depending on water resource, technology knowledge and social cohesion – take up the opportunity. This can often happen rapidly and suddenly. Once thresholds of returns to irrigated crops, of technical skills and understanding, of acceptance of risk, and indeed of the confidence to act, are passed, individuals and groups may quickly and simultaneously act, with cumulative effect, as innovators provide examples for others.
- **Stage C** – irrigation becomes significant in the water basin, as substantial fractions of the irrigation potential are taken up – surpassing water capacity in some cases. Systems amalgamate: both the physical irrigation schemes and the human interactions. What may have worked well at smaller scale can become problematic when aggregated

Policy Implications

- **Stage A** – policies and public investments to support SSI are largely relatively straightforward, such as building public infrastructure while ensuring that significant obstacles to investment in agriculture – heavy taxes, cross border tariffs, etc. – are remedied as far as possible. Activities include those seen in traditional development projects
- **Stage B** – additional measures to facilitate farmer-led development become appropriate. These include helping farmers raise the performance of their irrigation including training, soil moisture monitoring and water scheduling, and starting to regulate use of water, especially during the dry season and droughts, to ensure water consumption does not exceed supply
- **Stage C** – more demanding policy challenges are indicated, above all in finding effective ways to regulate water use, assign rights and to mediate any conflicts over water use. Public agencies need to help create institutions and allocate rights (a) to resolve collective problems of water consumption that harm economic sustainability in catchments with substantial irrigation; and (b) to mediate and resolve conflicts between farmers located within and across systems

The African Union established four pathways for ag-water management that countries can pursue to achieve 2014 Malabo Declaration targets



In 2020, the African Union published the “*Framework for Irrigation Development and Agricultural Water Management in Africa*” with the goal of supporting regional and national strategies and project implementation to achieve continental targets, by promoting country-level initiatives in agricultural water management (AWM). The framework fits into the broader African Development Agenda (“Agenda 2063”) and other related policies that call for increased interventions to boost irrigation development and sustainable AWM

The framework focuses on four key pathways that consider the full spectrum of agricultural water management:

1. ***Improved water control and watershed management in a rainfed environment:*** This pathway focuses on rainfed food grain areas where methods such as water harvesting and sustainable land-management practices, combined with a range of climate-smart agricultural practices, are implemented within watersheds to ensure optimal and sustainable use of water resources
2. ***Farmer-led irrigation development:*** These include individual (private) irrigation systems for high-value crops as well as small groups of farmers jointly managing small irrigated areas. Irrigated areas tend to be small, often draw on groundwater resources, and focus on the production of horticultural crops
3. ***Irrigation scheme development and modernization:*** These are often larger irrigation systems, funded publicly or through public-private partnerships, that require upgrading to increase market integration and need to increase cost recovery for the continued operation and maintenance of systems
4. ***Wastewater recovery and reuse:*** Wastewater reuse is a common practice in peri-urban Africa. Rapid urbanization presents an opportunity to adopt wastewater reuse as an important alternative resource, but reuse is also associated with potential environmental and health impacts and thus requires strong management practices for standards and protection

Cross-cutting themes:

1. Inclusiveness in irrigation development and agricultural water management
2. Private sector involvement
3. Climate change adaptation and resilience
4. Microcredit and farm financing mechanisms
5. Policies, institutions, and governance arrangements
6. Improving water and soil quality and other environmental problems
7. Research, monitoring, evaluation, and knowledge transfer

Key barriers at the policy and institutional environment include strategic alignment, weak rule of law, and limited proactive interventions

Policy / legal / institutional – key barriers and implications

Lack of policy and strategic alignment

- ✗ **Lack of national and regional policy and strategic alignment** of small-scale irrigation can result in limited effective resource policy, coordination, and implementation of irrigation development. In particular, governments often lack an explicit priority focus on SSI as a goal
- ✗ The lack of strategic vision and alignment across governing levels can be a **barrier to adoption** (e.g., ineffective local implementation guidelines limits ability to transfer knowledge to farmers) and a **driver of unsustainable SSI scaling** (e.g., leads to limited or unenforceable water management policies and approaches)

Weak institutional arrangements

- ✗ **Weak institutional arrangements** between public policy makers and authorities to support farmers in irrigation development can lead to **poorly suited systems for permitting and enforcing land/water use**. Can also lead to limited ability to mediate any conflicts over water extraction
- ✗ Can lead to **lack of extension services, formal and informal education systems** in relation to irrigation

Weak or ineffective rule of law

- ✗ **Weak or informal land-tenure laws** and customs often **discourage SSPs from investing in irrigation** technologies
- ✗ **Unreliable and difficult to understand water access rights and policies** often deter farmers from accessing available water resources

Lack of granular information and data

- ✗ Lack of publicly **available and granular irrigation data** can limit systemic prioritization of SSI (i.e., a lack of knowledge leads to a lack of action), can make customer acquisition for private sector providers more difficult, and can lead to unsustainable water resource management while scaling irrigation

Limited proactive government intervention

- ✗ National and local government across SSA have historically **underinvested in direct and proactive intervention and promotion of irrigation development** (e.g., effective subsidies, incentive programs, tax exemptions)
- ✗ This has **curtailed the growth of formal SSI across the continent** and can potentially **contribute to unsustainable irrigation practices** that fall outside of more proactively managed projects and initiatives
- ✗ **Limited proactive public financial engagement has also led to key financial barriers across the industry**, such as foreign exchange constrains and a lack of institutional credit lines available for irrigation in broader agricultural development policies

A number of best practices and potential solutions exist to address these policy and institutional barriers

Policy / legal / institutional – key solutions and best practices

Lack of policy and strategic alignment

- Prioritizing small scale irrigation at the national level such as aligning SSI plans with nation strategies (e.g., as seen in Kenya and Senegal), developing dedicated agencies to focus on SSI (e.g., Ethiopia's Ministry of Irrigation and Lowlands), and explicitly linking national level policies with local level implementation

Weak institutional arrangements

- Establish and empower organizations, groups, or associations (e.g., Water User Associations) governing water and land use, rights, and issues at the local level to ensure the equitable and environmentally sustainable use of land and water resources
- In Ethiopia, WUAs exist to manage, operate, maintain, irrigation and drainage systems and watershed management and protection
- Promote good governance in the functioning of organizational structures for irrigation water supply and the provision of ag services

Weak or ineffective rule of law

- Seek increased and formalized land tenure security, guided by the principles of inclusion and participation, fit-for-purpose, realistic planning, sustainability and sound land disputes resolution
- Institute hybrid water resource regulatory arrangements that enable multiple small abstractors to increase security of access to promote water use regulations that encourage high compliance and reduce transactions costs for SSPs

Lack of granular information and data

- Development of publicly available irrigation management information system by national government for private sector market visibility, monitoring and ensuring water resource availability and efficiency, and effective government decision making for irrigation
- For instance, Ethiopia's Ministry of Agriculture is building its own irrigation management information system

Limited proactive government intervention

- Pursue effective subsidies and tax exemptions to encourage sustainable scaling of irrigation
- Regulate water use, especially during dry seasons and droughts to ensure water demand does not exceed supply
- Effective ways to regulate water use, assign rights and mediate any conflicts over water use such as through organizations irrigation cooperatives that can also plan, construct, and implement irrigation development

Key barriers at the policy and institutional environment include strategic alignment, weak rule of law, and limited proactive interventions

Finance – key barriers and implications

Lack of access to suitable and relevant financing

- ✘ **Limited availability of financial products that are suitable and meet the needs of farmers trying to access irrigation equipment**, such as sufficient length of tenor, payback periods reflective of seasonal income, and limited collateral requirements
- ✘ Farmers often **struggle to access credit due to both real and perceived risks**, driven in part by limited credit histories and financial records, limited formal land ownership to use as collateral, limited formal business practices, and inflexible financing structures
- ✘ This is also partly driven by a **lack of capacity for financial institutions** to properly evaluate and diligence farmers as potential clients and irrigation equipment (and ag-equipment more broadly) as a specific asset class
- ✘ A **lack of capacity and knowledge (e.g., financial literacy) at the farmer-level** also contributes to limited financial access

Expensive informal sources of credit

- ✘ Informal financing, such as group saving schemes, rotating credit schemes, community moneylenders, and friends/family, is **often the predominant source of financing for irrigation for farmers** due to lack of access and limited suitability of formal channels
- ✘ However, **informal credit often comes with more onerous costs and terms** and can drive farmers and other borrowers into a unproductive spiral of debt

Macro financial constraints stemming from broader policy environment

- ✘ Actors across the irrigation landscape, from private solution providers to farmers, are often **impacted by systemic financial constraints such as limited foreign exchange reserves** and onerous tax regimes. These are particularly constraining given the importance of (often expensive) equipment within the irrigation space

Potential solutions to create a more enabling financial environment include building linkages and capacity as well as direct interventions

Finance – key solutions and best practices

Lack of access to suitable and relevant financing

Facilitating linkages between actors

- Integrated financing approach that links financing for irrigation equipment purchases with support and advisory services, should encourage a wide range of approaches to provide financial services and access to irrigation equipment with monitoring and evaluation to learn lessons from experience. Capacity building for financial institutions providing financing to farmers for irrigation equipment

Financing and credit solutions

- Financial products can be tailored to the needs of farmers for irrigation and can include equipment financing provided by the irrigation equipment suppliers designed and tailored to farmers, payments using mobile money, e-wallet farmer groups enabling farmers to save towards a down payment, apps linking irrigation customers to buyers to increase output market access, remote sensing and monitoring of pumps to alert of default risk, etc.

Subsidies

- Even with appropriate financing and a conducive credit system, SSPs may still not be able to afford irrigation development as costs are still prohibitive given their limited resources. Subsidies can therefore be a key instrument for accelerating irrigation equipment uptake. To ensure farmers remain the lead of irrigation development, subsidies should be partial and aim at solely bridging the affordability gap for SSPs

Credit guarantee and risk sharing arrangements

- Offer low-cost credit guarantees to local FIs with viable business plans for supporting SSPs to acquire irrigation and other productive equipment and finance training, social marketing, and technological innovation

PAYGO and asset financing

- PAYGO is a financial product targeted for farmers consisting of a down payment followed by installments across 12-36 months, often facilitated by mobile money. SACCOs and FIs are often able to provide farmers with short term credit to cover pump rental or irrigation services

Expensive informal sources of credit

Macro financial constraints stemming from broader policy environment

Knowledge and capacity barriers must be addressed across various levels of the broader irrigation system



Knowledge/capacity – key barriers and implications

Lack of awareness of benefits to irrigation

- ✘ At both farm-level and systemic level (e.g., public authorities and policy makers) **irrigation adoption has long been constrained by a lack of awareness around the potential impact of irrigation** and a traditional societal reliance on rainfed production

Lack of knowledge / capacity for access to legal and usable water

- ✘ Confusing and often unenforceable laws, limited local infrastructure, limited knowledge transfer, and a lack of granular data all contribute to a **lack of knowledge across stakeholders on how and where to access usable water legally and sustainably**

Limited knowledge at farm-level on irrigation tech and approach

- ✘ Farmers are often unawares or lack the knowledge and capacity to properly use irrigation equipment once they have it and/or to properly adopt farming techniques that can best optimize irrigation usage. This leads to **lower ROIs and often unsustainable water use**

Lack of data and management capacity across public authorities

- ✘ National, regional, and local public authorities **lack the expertise and capacity to effectively implement the complex resource controls and mitigation** that must accompany any large-scale growth in irrigation

Solutions / best practices

Outreach to farmers and other SSI actors through mass media, ICT, and communication using word of mouth, print, internet-based media to **contribute to the attitude change towards farmers developing their own irrigation and to raise awareness of service providers that can be approached for support locally**

Help farmers raise performance of their irrigation through **technical, financial, and organizational training, soil moisture management, and water scheduling to help irrigators overcome obstacles in adopting irrigation, spreading benefits to poorest within irrigating communities**. Farmer awareness of irrigation water management, agronomic practices, technical knowledge of irrigation technologies

Invest in **technology such as information management systems and databases and further resource key aspects of the public support apparatus**, namely local development agents and national level research and analytics teams

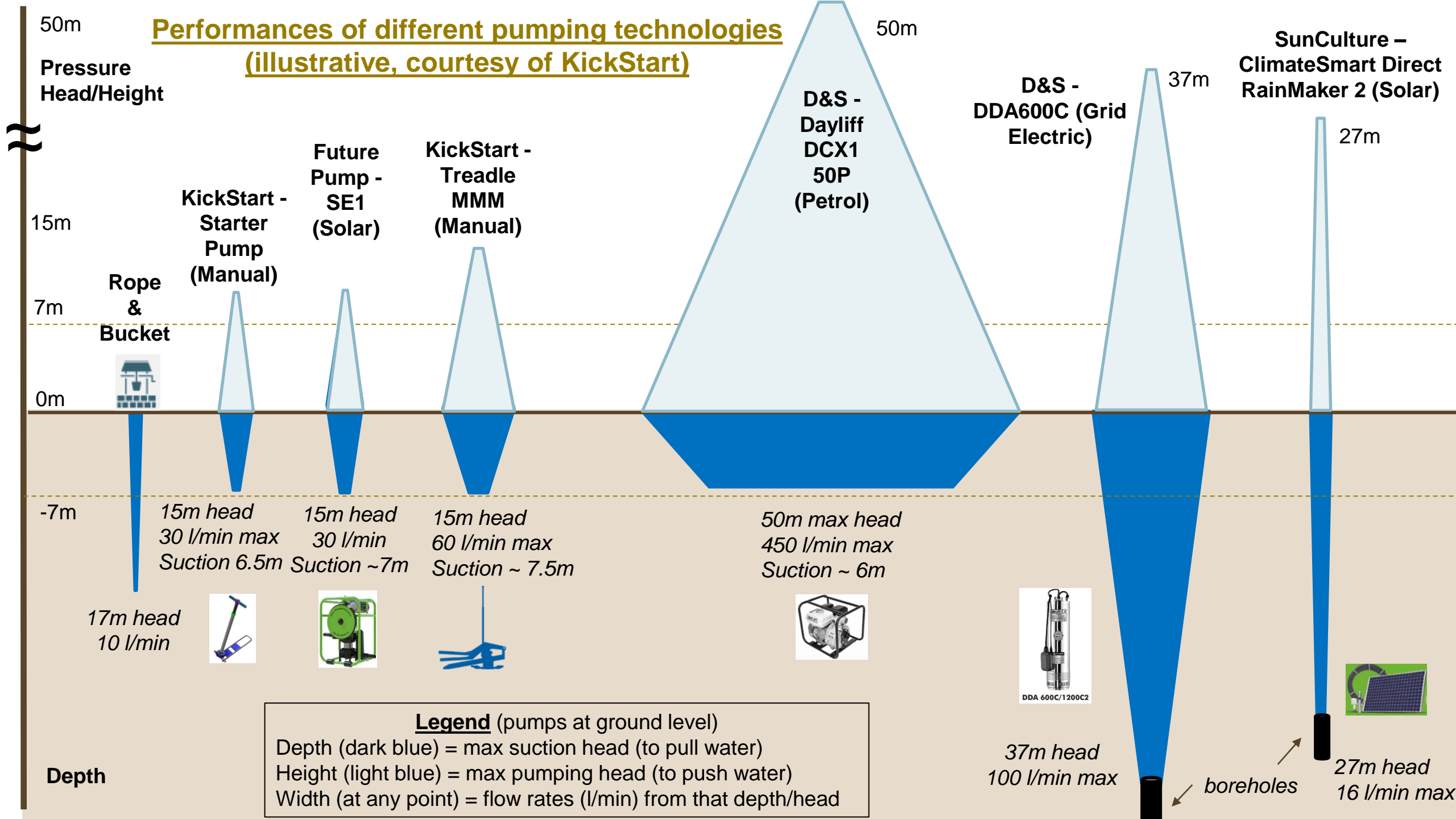
Appendix

1. Appendix – supporting materials

1. Impact case for scaling irrigation
2. Current state of small-scale irrigation, expansion opportunity, and barriers
3. **Emerging private sector solutions**
4. Recommended actions to scale irrigation for small-scale producers
5. Case studies

Performances of different pumping technologies

(illustrative, courtesy of KickStart)



Legend (pumps at ground level)

Depth (dark blue) = max suction head (to pull water)
 Height (light blue) = max pumping head (to push water)
 Width (at any point) = flow rates (l/min) from that depth/head

Depth

50m

Pressure Head/Height

15m

7m

0m

-7m

50m

37m

27m

Rope & Bucket

KickStart - Starter Pump (Manual)

Future Pump - SE1 (Solar)

KickStart - Treadle MMM (Manual)

D&S - Dayliff DCX1 50P (Petrol)

D&S - DDA600C (Grid Electric)

SunCulture - ClimateSmart Direct RainMaker 2 (Solar)

15m head
30 l/min max
Suction 6.5m

15m head
30 l/min
Suction ~7m

15m head
60 l/min max
Suction ~ 7.5m

50m max head
450 l/min max
Suction ~ 6m

37m head
100 l/min max

27m head
16 l/min max

boreholes



DDA 600C/1200C2

Replacing a diesel pump by a solar pump to irrigate a 1-ha farm can avoid 1-3 tCO₂e per year

Annual emissions to irrigate a 1 ha-farm with a diesel pump

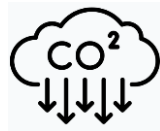
Expected total annual emissions if diesel pumps were used for 100% of potential irrigable surface in SSA



Crop water requirement¹
~ 5,000 m³/ha



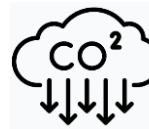
Hours of pumping
needed² ~ 330 – 660



~ 1-2 tCO₂e



Irrigation potential in SSA ~ 19M ha



~ 17-34 MtCO₂e (i.e. 2-4% of current SSA total emissions)



SunCulture's Verified Carbon Standard project

- SunCulture worked with Verra to certify the generation of carbon credits from avoided emissions for solar pumps sold in Kenya
- Main assumptions used⁴:
 - 100% of farmers not using a pump before would have bought a petrol/diesel pump
 - Hours of operation for petrol/diesel pump and SunCulture's pump (remotely measured) are equal (c. 800 hours/year)

➔ **Expected carbon savings per solar pump sold: ~ 3 tCO₂e per year** (i.e. 21 tCO₂e over 7 years)

¹Average over different crops in SSA, based on Abou Zaki et al., 2018. ²Flow rate ~ 15-30 m³/h & Fuel consumption ~ 2 L/h. ³Emission factor diesel = 2.67 kgCO₂/L, source GHG protocol. ⁴Verra registry, [project 2989](https://registry.verra.org/projects/2989).

Appendix

1. Appendix – supporting materials

1. Impact case for scaling irrigation
2. Current state of small-scale irrigation, expansion opportunity, and barriers
3. Emerging private sector solutions
4. **Recommended actions to scale irrigation for small-scale producers**
5. Case studies

Tier 1a - 6 focus countries each have high potential for SSI expansion and key attributes that make donor-intervention potentially impactful

Countries	SSI Expansion Potential	SSI Private Sector Maturity	Enabling Environment	Water Constraints	Commentary and rationale for prioritization
Nigeria	2,900	<i>Under-developed</i>	<i>Limited</i>	<i>Localized</i>	<ul style="list-style-type: none"> Nigeria has massive potential of scaling irrigation for SSPs (in terms of overall area, number of farmers impacted, and resources available to scale) and has a moderate to high level of vulnerability to drought and climate change impacts Existing private sector solutions for SSI are scarce and the policy and enabling environment is nascent
Kenya	1,349	<i>Well-developed</i>	<i>Supportive</i>	<i>Localized / Moderate</i>	<ul style="list-style-type: none"> As a business model innovation hotspot with a large potential for irrigation (albeit localized in specific regions), Kenya is an attractive market to scale SSI
Ethiopia	1,095	<i>Under to Moderately-developed</i>	<i>Supportive</i>	<i>Localized / Moderate</i>	<ul style="list-style-type: none"> SSI development in Ethiopia is public sector driven receiving high levels of public policy support and focus, presence of diverse programs focused on SSI, presenting a large potential for growth However, private sector's role needs to be developed as existing private solution providers are limited and face key policy and enabling environment barriers
Tanzania	1,768	<i>Well-developed</i>	<i>Supportive</i>	<i>Localized / Moderate</i>	<ul style="list-style-type: none"> Tanzania's large potential for irrigation expansion and rural population that could be impacted, its low/moderate water stress, and attractive existing private sector and enabling environment makes it a high leverage geography to provide targeted support
Senegal	790	<i>Well-developed</i>	<i>Supportive</i>	<i>High</i>	<ul style="list-style-type: none"> With a medium-sized potential for irrigation and a high-level of water stress (esp. in the Northern region), Senegal will need to preserve water availability in its efforts to scale SSI It is home to innovative providers that are benefitting from a relatively supportive enabling environment, and must be further nurtured to scale sustainably
Uganda	961	<i>Moderately-developed</i>	<i>Supportive</i>	<i>Low</i>	<ul style="list-style-type: none"> While demand for irrigation is currently very low, Uganda has ample water resources for expansion, a supportive enabling environment, and burgeoning innovative private sector players

Tier 1b countries – should be deprioritized in the short/medium term initially but could represent attractive potential future growth opportunities

Countries	SSI Expansion Potential	Private Sector Maturity	Enabling Environment	Water Constraints
DRC	923	<i>Under-developed</i>	<i>Limited</i>	<i>Low</i>
Zambia	458	<i>Well-developed</i>	<i>Moderately favorable</i>	<i>Localized</i>
Mozambique	379	<i>Well-developed</i>	<i>Moderately favorable</i>	<i>Localized</i>
Burkina Faso	340	<i>Well-developed</i>	<i>Emerging</i>	<i>High</i>
Togo	203	<i>Under to Moderately-developed</i>	<i>Moderately favorable</i>	<i>Localized / Moderate</i>
Mali	144	<i>Under to Moderately-developed</i>	<i>Emerging</i>	<i>High</i>
Angola	137	<i>Under to Moderately-developed</i>	<i>Emerging</i>	<i>Localized</i>
Niger	67	<i>Well-developed</i>	<i>Emerging</i>	<i>High</i>
Rwanda	57	<i>Under to Moderately-developed</i>	<i>Moderately favorable</i>	<i>Localized / Moderate</i>

Tier 2 and 3 countries – deprioritized due to low potential, limited actual demand/impact, and/or resource or security constraints













Countries	SSI potential low cost (ha)	Rural Population Size	Arable Land	Current Irrigated Area	% of Cultivated Area Irrigated	% irrigated using GW	% irrigated using SW	Renew. water resources per capita (m ³ /year)	Ag. water withdrawal as % of renew. water resources	Water Stress Index	Tier
Sierra Leone	299,148	4,768,441	1,584,000	10,000	1.7%	1%	99%	20,058	0.0%	0.5%	2
Chad	288,200	13,094,226	5,200,000	26,200	0.6%	20%	80%	2,782	1.5%	4.3%	2
Benin	251,986	6,632,056	2,800,000	7,131	0.7%	18%	82%	2,177	0.2%	1.0%	2
Cameroon	171,485	11,383,170	6,200,000	25,654	0.3%	4%	96%	10,666	0.3%	1.6%	2
Liberia	138,512	2,463,081	500,000	2,100	0.3%	1%	100%	45,871	0.0%	0.3%	2
Eritrea	117,886	2,100,324	690,000	42,637	3.1%	24%	76%	2,063	7.5%	11.2%	2
Guinea	117,245	8,489,377	3,100,000	94,914	2.5%	0%	100%	17,209	0.3%	1.4%	2
Congo	84,010	1,850,943	550,000	220	0.3%	0%	100%	150,777	0.0%	0.0%	2
Guinea-Bissau	79,074	1,141,289	300,000	N/A	4.1%	#N/A	#N/A	15,955	0.5%	1.5%	2
Burundi	76,646	10,786,763	1,200,000	21,430	1.4%	0%	100%	1,054	1.8%	10.2%	2
Gabon	57,157	224,215	325,000	4,450	0.9%	0%	100%	74,582	0.0%	0.5%	2
Namibia	55,234	1,189,044	800,000	7,573	0.9%	22%	78%	15,707	0.5%	0.9%	2
Central African Republic	51,340	3,129,787	1,800,000	69	0.0%	0%	100%	29,194	0.0%	0.3%	2
Botswana	50,556	736,148	260,000	621	1.5%	46%	54%	5,205	0.7%	2.3%	2
Lesotho	47,298	1,608,881	596,000	67	0.4%	75%	25%	1,411	0.1%	2.6%	2
Gambia	45,058	970,908	440,000	1,400	0.5%	1%	99%	3,310	0.5%	2.2%	2
Equatorial Guinea	6,904	432,136	138,600	NA	NA	NA	NA	18,532	0.0%	0.2%	2
Madagascar	1,344	17,578,693	3,000,000	1,080,691	23.1%	0%	100%	12,170	3.9%	11.3%	3
South Africa	949	19,096,392	12,000,000	1,498,000	17.1%	9%	92%	866	23.3%	65.0%	3
Somalia	317	9,090,664	1,100,000	65,000	17.8%	15%	85%	925	22.3%	24.5%	3
Zimbabwe	187	10,827,136	4,000,000	123,866	4.4%	12%	88%	1,346	15.2%	35.4%	3
Mauritania	159	2,024,451	400,000	22,840	11.0%	11%	89%	2,452	10.7%	13.2%	3
Sudan	126	29,406,434	20,994,840	800,000	8.7%	4%	96%	862	68.5%	118.7%	3

Sources: ISF/Hystra research and analysis; FAOSTAT; Aquastat


Tier 3 – deprioritize due to resource or security constraints

Countries	SSI potential low cost (K ha)	Rural Population Size (M)	Arable Land (K ha)	Current Irrigated Area (Ha)	% of Cultivated Area Irrigated	% irrigated using GW	% irrigated using SW	Renew. water resources per capita (m ³ /year)	Ag. water withdrawal as % of renew. water resources	Water Stress Index
Madagascar	1,344	17,578,693	3,000,000	1,080,691	23.1%	0%	100%	12,170	3.9%	11.3%
South Africa	949	19,096,392	12,000,000	1,498,000	17.1%	9%	92%	866	23.3%	65.0%
Somalia	317	9,090,664	1,100,000	65,000	17.8%	15%	85%	925	22.3%	24.5%
Zimbabwe	187	10,827,136	4,000,000	123,866	4.4%	12%	88%	1,346	15.2%	35.4%
Mauritania	159	2,024,451	400,000	22,840	11.0%	11%	89%	2,452	10.7%	13.2%
Sudan	126	29,406,434	20,994,840	800,000	8.7%	4%	96%	862	68.5%	118.7%

Country assessments were done using various subjective analyses

<p>SSI Expansion Potential</p>	<ul style="list-style-type: none"> <input type="checkbox"/> Area of potential irrigation expansion <input type="checkbox"/> Population size <input type="checkbox"/> Potential for impact 	<ul style="list-style-type: none">  High (500k+ ha potential / 15M+ rural population)  Medium (200-500k ha potential / 5-15M+ rural population)  Low (<200k ha potential / <5M+ rural population)
<p>Private Sector Maturity</p>	<ul style="list-style-type: none"> <input type="checkbox"/> Are there viable business models and/or technical solutions in the market? <input type="checkbox"/> What is the existing distribution network in place? 	<ul style="list-style-type: none">  High  Medium  Low <p><i>Hystra/ISF assessment (based on various analyses and feedback including # of providers, feedback from interviews, country visits, etc.)</i></p>
<p>Enabling Environment</p>	<ul style="list-style-type: none"> <input type="checkbox"/> How conducive is the policy, regulatory, and financial enabling environment to support development of small scale irrigation? 	<ul style="list-style-type: none">  Favorable  Moderately favorable  High level of constraints <p><i>Hystra/ISF assessment</i></p>
<p>Water Constraints</p>	<p>Level of water stress</p>	<ul style="list-style-type: none">  Low stress  Localized stress  High stress <p><i>Water stress index, % of renewable water resources already used for agriculture, Renew. water resources per capita</i></p>

We use detailed illustrative roadmaps of 4 countries to understand the most relevant interventions for various stakeholders across contexts




SSI Expansion Potential ● High demand for SSI but relatively limited resource potential

Private SSI Providers ● Small but mature private sector

Enabling Environment ● Conducive policies, prioritizes SSI growth with sustainable water use

Water Constraints ● Constrained primarily to groundwater-based expansion

Select recommendations could be leveraged in countries with similar profiles or specific characteristics: Burkina Faso, Malawi, Mali, Togo, Zimbabwe




SSI Expansion Potential ● Large demand and adequate but localized resource potential for irrigation expansion

Private SSI Providers ● Developing private sector, with majority of development driven by public forces

Enabling Environment ● Highly supportive and active enabling environment

Water Constraints ● Localized constraints, especially in Eastern and Northern regions. Large GW potential

Select recommendations could be leveraged in countries with similar profiles or specific characteristics: Nigeria, Mali, Burkina Faso, Cote d'Ivoire, DRC




SSI Expansion Potential ● Large market with current low demand for and use of SSI but significant potential for growth

Private SSI Providers ● Underdeveloped private sector providers

Enabling Environment ● Limited historical policy focus on SSI led to current lack of political will or prioritization

Water Constraints ● Plentiful resources in Central/South regions, but localized constraints in arid North

Select recommendations could be leveraged in countries with similar profiles or specific characteristics: Ethiopia, Mali, Burkina Faso, Cote d'Ivoire, DRC



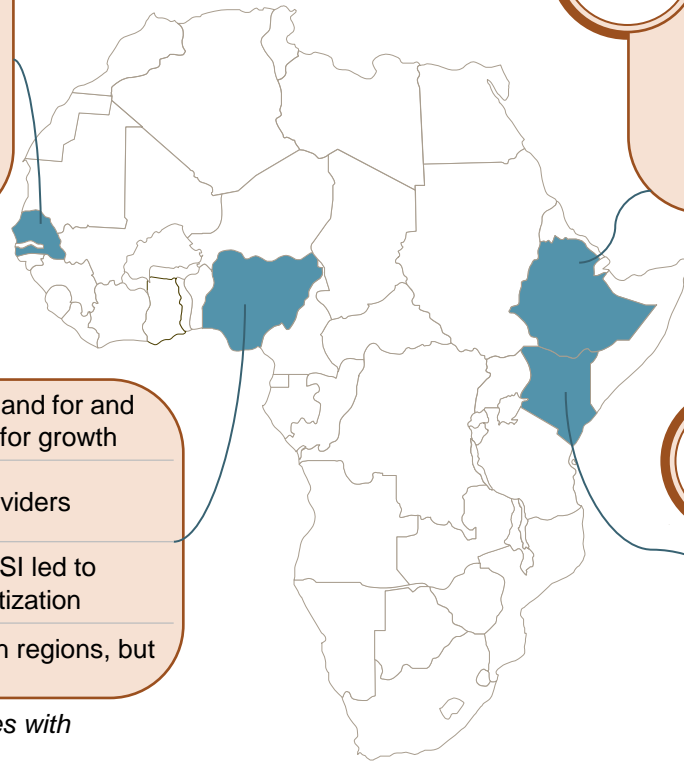
SSI Expansion Potential ● Large demand and adequate (but localized) resource potential for irrigation

Private SSI Providers ● Well-developed private sector and a business model innovation hotspot

Enabling Environment ● Relatively conducive policy and finance, but faces challenges with implementation

Water Constraints ● Localized constraints, especially in Eastern. Large SW and GW in South and West

Select recommendations could be leveraged in countries with similar profiles or specific characteristics: Tanzania, Uganda, Senegal, Ghana, Cote d'Ivoire, Rwanda



➤ Certain interventions are applicable and often most-impactful when done at a systemic scale. While nuances exist across geographies, these recommendations should be pursued more broadly

Nigeria – a high-potential market with limited existing private solutions



- Nigeria has massive potential of scaling irrigation for SSPs, in terms of overall area, number of farmers impacted, and resources available to scale
- Existing private sector solutions for SSI are scarce and the policy and enabling environment is nascent
- Key interventions for scaling in Nigeria should focus on accelerating private solutions found in other geographies as well as adapting policy to drive the SSI agenda


SSI expansion potential


Private providers

Enabling environment

Water stress

Potential Overall Impacts of Scaling SSI*:

 **5 million SSP HHs**

 **34 million rural population**

Public / Private Donors

Priorities

- **De-risk the expansion of successful providers (e.g., Bonergie) into new geographies** by funding pilot studies and supporting demonstrations to catalyze early sales
- **Catalyze financing towards solution providers** by addressing key Fx constraints
- **Facilitate cross-stakeholder collaboration** with a specific focus on sustainable approaches to water use
- **Incentivize water efficient systems** through funding and supporting research

Potential Impact

Catalyze expansion of private solution providers; support portions of market that cannot be market clearing

Financial Institutions

DFIs / Impact Investors:

- **Provide customized solutions** (e.g., guarantee schemes and/or working capital-specific revolving fund) **to address key financing needs of key private sector actors** (e.g., working capital for existing equipment distributors)

MFIs / Commercial Banks:

- **Align finance across the value chain** by creating SSI-specific strategies and financial product offerings

Enable ongoing operations for existing distribution channels and improve access to finance for SSPs

Public Authorities

- **Include SSI as a top development goal and rationalize policy and supportive regulation, directives, and guidelines**
- **Provide targeted and cost-effective subsidies** by simplifying existing tax incentives for irrigation equipment providers
- **Unlock Fx constraints** by conducting cost benefit analysis of stronger allocation to SSI equipment
- Develop **irrigation management information systems**
- **Support organizations or groups governing water use rights** by refining the role of existing groups (e.g., WUAs)

Significant impacts to address policy/legal barriers that are currently a major constraint on scaling SSI

Nigeria – key priorities for public and private donors

Recommendations	Specific Activities and Partners	Impact potential
De-risk the expansion of successful providers into new geographies	<ul style="list-style-type: none"> - Fund pilot studies of existing private solution providers in other geographies (e.g., Bonergie) through grant financing, with a specific focus on areas with existing levels of rudimentary SSI (e.g., Northern regions such as Kano State) - Support existing solution providers operating in Nigeria (i.e., KickStart) to conduct demonstrations for SSP groups in low SSI-penetrated areas, primarily in the South. Work specifically alongside KickStart to catalyze early sales and SSI uptake in these low-penetration geographies 	<ul style="list-style-type: none"> - Increased access to cost-effective, efficient, and reliable SSI equipment for SSPs - Increased knowledge of SSI benefits/techniques - Catalyze early sales
Catalyze financing towards solution providers	<ul style="list-style-type: none"> - Fund research into cost-benefit of allocating Fx reserves towards irrigation equipment, working directly with the MoF and (to a lesser degree) MoA - Provide finance and coordination support to existing Fx program for ag-equipment working directly with the MoF and (to a lesser degree) MoA 	<ul style="list-style-type: none"> - Improved GM for providers and stabilized/reduced consumer prices
Facilitate cross-stakeholder collaboration	<ul style="list-style-type: none"> - Convene key NGOs and implementers (e.g., Heifer International, IFDC, SNV), donors (e.g., BMGF, World Bank, USAID), and public authorities (MoW River Basins, MoW Irrigation, MoA, MoF, WUAs) to align on the right policy and legal approach to scaling SSI, with a specific focus on resource sustainability 	<ul style="list-style-type: none"> - Increased coordination and efficiency leading to more sustainable scaling
Incentivize water efficient systems	<ul style="list-style-type: none"> - Support research through both finance and technical expertise (e.g., data analytics training, leveraging ML/AI capabilities) evaluating most cost-efficient incentives (e.g., subsidies targeted at high quality drip lines) for SSPs to adopt water-efficient technology and approaches in currently water-rich areas (e.g., Southern Nigeria) 	<ul style="list-style-type: none"> - Increase adoptability and usage of water-efficient systems by SSPs

Nigeria – key priorities for public authorities

Recommendations	Specific Activities and Partners	Impact potential
Prioritize SSI as development goal and rationalize policy and supportive regulation, directives, and guidelines	<ul style="list-style-type: none"> - Elevate private sector-led SSI as the key development goal within the GoN’s “Roadmap For National Irrigation Development Program 2016-2030” rather than the existing generic approach to ‘irrigation’. Particularly important with incoming new MoA leadership - Rationalize national-level mandate for SSI development (which is currently split between MoW and MoA). Work with both to select a clear apex organization with full mandate over SSI development 	<ul style="list-style-type: none"> - Conducive policy environment focused on private sector SSI development - Coherent implementation and regulatory guidelines
Provide targeted and cost-effective subsidies (via tax removals)	<ul style="list-style-type: none"> - The MoF and MoA should establish simplified guidelines for irrigation equipment that is automatically exempted from import taxes (Existing duty-free exemptions for importing ag-equipment is burdensome and requires lengthy approval timeline) 	<ul style="list-style-type: none"> - Improved GM for providers and stabilized/reduced consumer prices leading to uptake
Unlock Fx constraints	<ul style="list-style-type: none"> - Conduct a cost benefit analysis on increasing allocation of Fx reserves for irrigation equipment. (While a channel to access Fx for products currently exists it is difficult to access and very rarely used) - Create and manage revolving Fx funds with specific focus on irrigation technology 	<ul style="list-style-type: none"> - Improved Gm for providers and stabilized/reduced consumer prices
Develop irrigation management information systems	<ul style="list-style-type: none"> - MoW should develop a comprehensive database and information system of water potential, water resource levels, and existing irrigation usage working directly with the 12 WUAs 	<ul style="list-style-type: none"> - Knowledge increase to enable overall scaling of SSI as well as sustainable guardrails
Support organizations or groups governing water use rights	<ul style="list-style-type: none"> - Shift the responsibilities of existing Water User Associations from operation and maintenance of SSI schemes to focus on encouraging and monitoring sustainable expansion of private SSI and water use 	<ul style="list-style-type: none"> - Long-term sustainability

Nigeria – key priorities for financial institutions

Recommendations	Specific Activities and Partners	Impact potential
<p><i>DFIs / Impact Investors:</i> Provide customized solutions to unlock aligned capital</p>	<ul style="list-style-type: none"> - Work with local FIs, specifically MFIs and local banks, to provide tailored financial solutions that can then allow for key finance needs of SSI solution providers and distributors to be met. Specifically, DFIs and impact investors should create a guarantee scheme and/or working capital-specific revolving fund that enables local FIs to finance the working capital needs of existing (but rudimentary and small) local providers and distributors (e.g., OmniAgric, Augenta AgriCare) 	<ul style="list-style-type: none"> - Enable scaling of existing distribution channels that can be built upon when/if more established solution providers enter market - Ensure ongoing business operations, including after-sales support, for equipment suppliers
<p><i>MFIs / Commercial Banks:</i> Align finance across the value chain</p>	<p>Create SSI-specific strategies and financial product offerings that are aligned with and (as possible) build from existing agricultural product offerings that currently address both upstream (e.g. inputs) and downstream (e.g., cold storage) farmer needs</p>	<ul style="list-style-type: none"> - Improved access to finance for SSPs, increasing uptake of SSI


Kenya – a leading private sector with relatively high expansion potential




- As a business model innovation hotspot with a large potential for irrigation (albeit localized in specific regions), Kenya is an attractive market to scale SSI
- In the short- and medium-term focus should be on accelerating scaling of successful providers as well as ensuring guardrails for sustainable growth
- Longer term interventions should focus on supporting innovations that can change the game

- SSI expansion potential
- Private providers
- Enabling environment
- Water stress

Potential Overall Impacts of Scaling SSI*:



**2.3 million
SSP HHs**



**11.2 million
rural population**

Public / Private Donors

Priorities

- **Catalyze financing** towards irrigation providers
- **Improve monitoring and supervision** of water withdrawals

Not Kenya-specific:

- **Fund research and development** to ensure sustainable growth
- **Streamline carbon financing** of solar water pumps to reduce certification costs and avoid market distortions

Potential Impact

Ensuring sustainable development of industry

Financial Institutions

MFIs/Comm. banks:

- **Partner with irrigation providers** to reach new customers and align finance across the value chain

DFIs / Impact Investors:

- Provide customized solutions to **unlock aligned capital**
- **Attract green/blended finance into SPVs** to co-finance monitoring equipment and water-efficient distribution systems
- Finance **ongoing innovative pilots (e.g. with Stable Foods)** to optimize their value proposition and delivery model

Enable scale of irrigation providers offering financing

Public Authorities

- **Provide targeted and cost-effective subsidies** through removal of duties/VAT on quality irrigation equipment
- **Ease compliance with existing water regulation** to improve monitoring and supervision
- **Promote cross-stakeholder collaboration and coordination** around market building, market access and technical knowledge

Major recommendations required for sustainable sector growth

Kenya has a leading private sector with relatively high expansion potential, albeit with localized water constraints



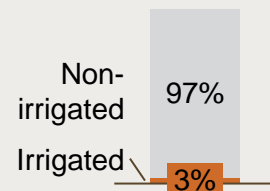
Kenya country context

Rural population size	38 million
Population Growth Rate	2%
GDP per Capita	2,081 USD
Agriculture as a % of GDP	33% (direct) 27% (indirect)
Share of ag. in employment	54%
Ease of doing business rank	56
Land / climate profile	Arid, semi-arid 80%
Primary crops	Maize, coffee, sugarcane, tea,
Current irrigated area	97k ha
Arable land	5,800k ha
% of cultivated area irrigated	3%

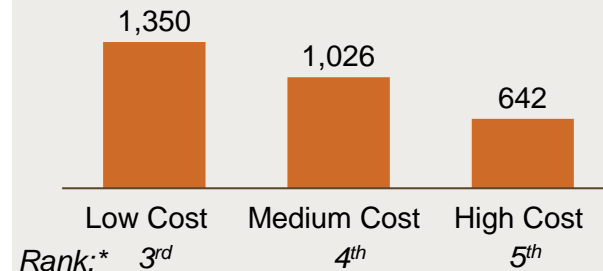
- The agriculture sector is mostly rainfed, and vulnerable to droughts and climate change. Kenya has low and highly variable rainfall patterns, both annually and across seasons, which results in the country being 80-90% arid or semi-arid land
- According to official statistics, out of the 6.1 Mha of cultivated land, only 200k ha (500 000 acres) corresponding to 3%, are irrigated, contributing 18% of the agricultural production
- 54% of irrigated lands are done so via SSI according to the Ministry of Water, Sanitation, and Irrigation (Bancy Mati. 2023)
- Kenya's SSPs face a potentially untenable future, with more frequent and severe food crises provoked by poverty and climate change and little means to face this challenge
- ~6-10 million (30-50% of total) SSPs face climate hazards in the form of drought, dry conditions, or climate variability
- Additionally, water use and users have increased rapidly associated with demand for fresh produce due to increasing urbanization, leading to expansion of irrigated areas.

Potential for Small Scale Irrigation Expansion

Current irrigation penetration
(% of arable land)²



Potential for SSI expansion
(thousands of ha)¹



Range of irrigation potential from other sources (thousands of ha):

- ~760 – 1,200 ha
(National Water Master Plan, 2013)
- 54-240 ha
(You et al. 2014)
- 140-420 ha
(WRG 2016)

Farmers across Kenya have a tradition of taking initiative in irrigation, suggesting that the actual area under irrigation might be higher than official statistics. While estimates have high uncertainty, it is not unreasonable to suggest that informal irrigation might increase the official irrigated area by more than 50%.

Existing irrigation levels and drivers of irrigation in Kenya



Existing levels of SSI

- Despite the recorded low levels of irrigation in Kenya, there is ample evidence to show that small-scale irrigation (SSI) has been increasing, despite the lack of clarity on the exact areas irrigated, or the number of farmers benefitting
- A study by Hornum and Bolwig (2020) documented that SSI was steadily growing, overtaking both large public schemes and commercial schemes, to cover about 110,000 ha.
- The overall irrigated area, crops produced, number of farmers engaged and activities outside of formal irrigation schemes are generally unknown and are expected to be higher than what is quoted in government reports
- Key obstacles to the uptake of SSI include the financing environment and the knowledge, together with output market if the farmer is able to establish only informal relationships
- Policy, legal & institutions, and technology, while not perfect, do not usually represent an insurmountable constraint to farmers' action

Drivers of SSI adoption

- Urbanization associated with higher incomes and changing lifestyles leading to shifts in food preferences, such as increased demand for high value products such as meat, dairy, fruit and vegetables → increased markets for crops from irrigated agriculture → water for production.
 - Irrigation uptake = opportunity for introduction of new irrigation technologies such as energy efficient solar pumps or improved water application systems associated with peri-urban farming.
 - This demand met by SSPs, market-oriented farmers, typically farming horticulture crops through irrigation.
- Main drivers of Farmer led irrigation development uptake:
 - Availability of appropriate irrigation technologies (water supplies, control, and efficient application methods)
 - Land tenure and water security
 - Access to finance, credit, and investment opportunities through appropriate business models for farmers operating at different scales
 - Affordable irrigation equipment to generate economic returns
 - Input market value chains making it easier to access input markets for technology buyers, spares, fertilizers, seeds and irrigation equipment
 - Access to output markets and favorable farm-gate pricing of irrigated produce
 - Information and knowledge flows through opportunities such as internet, radio, TV, mobile phones, print media, and farmer to farmer visits
 - Highly developed mobile money transfer (i.e. M-Pesa) enabling remote farming, financial transactions and knowledge flows more versatile and practical
 - Well educated farming clientele willing to invest funds from other sources (i.e. employment, retirement benefits, other businesses) in irrigated agriculture

Kenya's water resources vary highly throughout the country



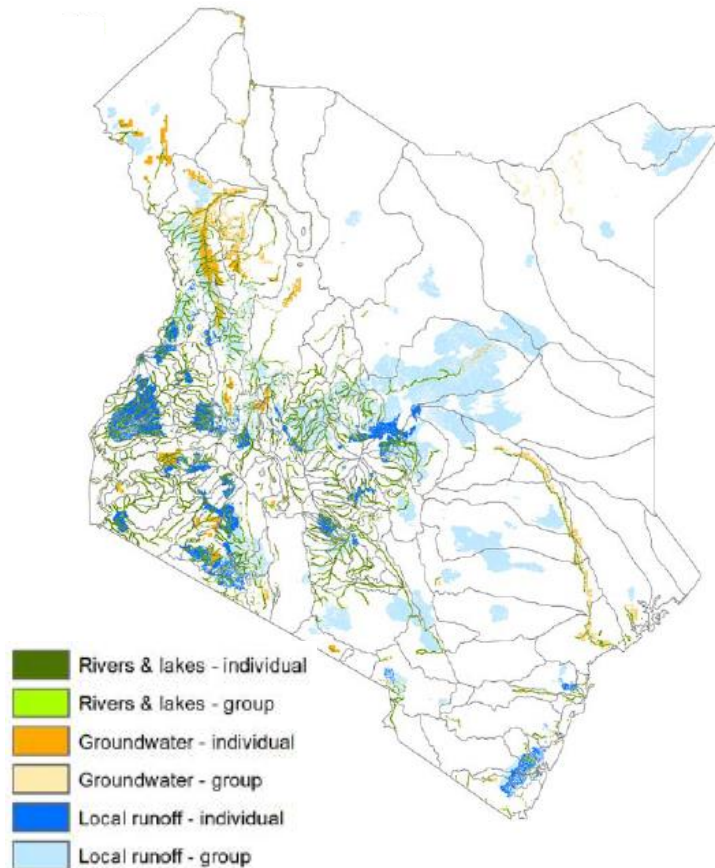
Water Resource Potential

Kenya's water resources vary highly throughout the country. While some areas (e.g., the Southwest regions) have large resources, **80-90% of the country is arid or semiarid. Rainfall patterns are highly variable, both annually and across seasons**, a challenge that is further exacerbated by climate change

Key Metrics

% irrigated using GW	13%
% irrigated using SW	87%
Renewable water resources per capita	571 m ³ /inhab/year
Ag. Water use as % of total water resources	10.5%
Water stress	33.2%
Share of land w/ sufficient aquifer yield	96%

Suitability sites for small-scale irrigation development (IFPRI, 2021)



- A 2021 IFPRI diagnostic estimated a potential of 2.7 million ha (6.6 million acres) of irrigated land, of which 1.7 million ha (4.2 million acres) of individual irrigation (however, this number is theoretical, as it does not account for competing water uses, or for irrigation already developed)
- This analysis reveals the primary geographic differences across the country, with counties in the Southwest making up the majority of the resource potential (driven primarily by surface water) while a much smaller area in ASAL regions are driven by groundwater sources
- Aktchenko (2014) estimated that between 173k – 447k ha could be irrigated, sustainably, using ground water (up from 20,000ha)
- Zaki et al. 2018 found that in all scenarios Kenya has sufficient ground and surface water resources to irrigate all irrigatable arable land across various growth pathways (although in the most intensive pathway a mix of both resources would have to be used)
- However, local water stress is already a factor not only in the arid areas but also in more water-rich regions where water-intensive economic activity has grown rapidly (e.g., Naivasha, Nairobi, and northern Mt Kenya)

Kenya has a well-designed irrigation framework, but implementation is often ad hoc and suffers from lack of coordination



Policy and Legal

Nationally, the country has a well-designed water management and irrigation framework, but implementation is often ad hoc and suffers from lack of coordination

- Public policy and development support for agriculture – and, with it, small-scale irrigation – is devolved to the counties in Kenya
- Government institutions formulate and expand policy framework, manage large national irrigation schemes, build capacity through extension services and research institutions, and act as facilitators, advisors and sometimes implementors in community-based irrigation schemes
- Structural challenges exist in Kenya regarding the application of an effective Integrated Water Resource Management to manage the different uses of the increasingly scarce resource. The Water Resource Authority faces political pressure to allow water use for development, while being responsible for protecting the base flow in rivers.
- Given the growing water scarcity, there is need for interventions that support the uptake of water-efficient irrigation technologies and resource monitoring

Key Policies:

Overarching policy plans:

- ❑ Vision 2030 places irrigated agriculture at the top of the development agenda, to achieve food security, socio-economic development, and resilience for communities against climate change
- ❑ Big 4 Agenda (2017) - Big 4 Agenda goal to increase income of farmers by 34% with the expansion of irrigation leading to higher yield and incentive to grow higher value crops.

Water-sector regulations

- ❑ National Water Master Plan (2013) – comprehensive assessment of irrigation potential and overarching strategy for irrigation (across scales) until 2050

Irrigation laws and plans

- ❑ Irrigation Act (2019) – comprehensive irrigation law, which created the NIA and makes provisions for the development of irrigation, including schemes at multiple levels

Policy shortfalls

- ❖ Current policies and statutes do not classify irrigation according to water use (large or small users) or types of use (full control, supplemental, and other scales)
- ❖ Kenya faces absolute water scarcity with respect to availability of renewable freshwater as population growth has decreased internal freshwater
- ❖ Need for interventions supporting uptake of water efficient technologies as well as developing unconventional water sources (i.e. rainfall-runoff harvesting and storage)

Key Institutions:

- ❑ National Irrigation Authority (NIA) is the public irrigation service provider under the MWSI and provides technical and support services, including capacity building and provision of infrastructure to private and SSP schemes through the National Expanded Irrigation Program.
 - ❑ Authorized to borrow and lend money
- ❑ Ministry of Water, Sanitation, and Irrigation (MWSI) responsible for irrigation development through formulating policies, guidelines, and regulations for an enabling environment for irrigation development.
- ❑ Ministry of Agriculture
- ❑ County Irrigation Development Units (CIDUs) supervise county public and country-initiated irrigation schemes, NIA supervises others.
 - ❑ But more in theory than practice, many instances where irrigation developed through individual or community initiatives with little or no NIA involvement or county government

Kenya – key priorities for public and private donors

Recommendations	Specific Activities and Partners	Impact potential
<p>Catalyze financing towards irrigation providers</p>	<ul style="list-style-type: none"> - Provide de-risking support to financial investors that focus on SSI (e.g. grant support for Climate Smart Agriculture loans in Kenya, first-loss guarantee schemes for commercial banks) - Provide capacity building to local financial institutions (e.g., training on irrigation and its benefits, designing and piloting financial products for irrigation) 	<p>Facilitate growth and resilience of irrigation providers by reducing working capital requirements</p>
<p>Improve monitoring and supervision of water withdrawals</p>	<ul style="list-style-type: none"> - Fund pilots with tech-enabled irrigation providers to collect real-time data on pumping hours, flow-rate, dry-run - Fund the development of national/regional irrigation platforms to centralize data from irrigation and borehole drilling providers and report to relevant authorities 	<p>Establish nation-wide visibility over withdrawals and enable detection of potential areas of excessive pressure on water resources</p>

Kenya – key priorities for public authorities

Recommendations	Specific Activities and Partners	Impact potential
<p>Provide targeted and cost-effective subsidies</p>	<ul style="list-style-type: none"> - Define quality and water-efficiency standards for withdrawal and (specifically SWPs and drip), primarily led by the Ministry of Water, Sanitation, and Irrigation alongside the National Irrigation Authority - Remove import tariffs and VAT from irrigation equipment that meets these standards, facilitated by collaboration between the MWSI and Ministry of Finance 	<p>Improved GM for providers and stabilized/reduced consumer prices leading to uptake (e.g., SunCulture market test: -30% price -> *4 sales)</p>
<p>Ease compliance with existing water regulation to improve monitoring and supervision</p>	<ul style="list-style-type: none"> - Simplify registration procedures for SSPs and incentivize compliance (driven by MWSI and NIA) • Create status for mobile Irrigation-as-a-Service providers - Set up a national, open access irrigation data and information platform, owned and operated by the NIA but with input and support from local authorities (e.g., County Irrigation Development Units), NGOs and other stakeholders (e.g., SNV, KfW, World Bank), and private providers - Work with irrigation and borehole drilling providers to build protocols and reporting systems (e.g., Grekkon or Borehole Masters) 	<p>Establish nation-wide visibility over withdrawals and enable detection of potential areas of excessive pressure on water resources</p>
<p>Promote cross-stakeholder collaboration and coordination around market building, market access and technical knowledge</p>	<ul style="list-style-type: none"> - Set multi-stakeholder (i.e., between donors/DFIs and private actors) principles on market building for irrigation equipment (avoiding give-aways, market-distorting subsidies) - Align value chain development and market access programs/initiatives with development of irrigation through coordination on SSI across ministries and agencies (MoA, MWSI & NIA) - Streamline technical knowledge of irrigation that can then be passed along to SSPs (e.g., connecting public extension workers with irrigation providers) 	<ul style="list-style-type: none"> - Facilitate growth and resilience of irrigation industry - Ensure farmers can translate productivity gains into additional income

Kenya – key priorities for financial institutions

Recommendations	Specific Activities and Partners	Impact potential
<p><i>MFIs/Comm. banks:</i> Partner with irrigation providers to reach new customers and align finance across the value chain</p>	<p>1. Offer receivables financing to irrigation providers to unlock growth 2. Partner with PayGo-enabled providers (i.e., SunCulture, D&S in near future) to enable:</p> <ul style="list-style-type: none"> - Leveraging PayGo system for repayments - Sharing default risk with providers <p>3. Grant PayGo-enabled irrigation providers access to client base and promote irrigation solutions</p>	<ul style="list-style-type: none"> - <i>Enable scale of providers</i> - <i>Help ensure market access for SSPs</i> - <i>Address access to finance challenge for SSPs and irrigation providers</i>
<p><i>DFIs / Impact Investors:</i> Provide customized solutions to unlock aligned capital</p>	<p>1. Provide tailored financial solutions to local FIs, specifically SACCOs (e.g., KUSCCO) including wholesale lending, guarantee schemes, or revolving funds dedicated to SSI 2. Build SPVs to channel green finance into growth of providers (à la SunKing Sustainable Financing Instrument)</p>	
<p>Finance ongoing innovative pilots to optimize their value proposition and delivery model</p>	<p>Invest in Stable Foods to deploy its utility model in Western Kenya and build proof of concept for integration of irrigation, input supply and market access services to SSPs</p>	<p><i>Enable scale and replication of an innovative irrigation business model</i></p>

Senegal – must balance high SSI demand with relative water stress



- With a medium-sized potential for irrigation and a high-level of water stress (esp. in the Northern region), Senegal will need to preserve water availability in its efforts to scale SSI
- It is home to innovative providers that are benefitting from a relatively supportive enabling environment, and must be further nurtured to scale sustainably


SSI potential ●

Private providers ●


Enabling environment ●

Water stress ●

Potential Overall Impacts of Scaling SSI:



**~450k
SSP HHs**



**4.4 million rural
population**

Public / Private Donors

Priorities

- **Catalyze financing** towards irrigation providers
- **Improve monitoring and supervision** of water withdrawals
- **Build demand through irrigation knowledge among extension workers** and other relevant promoters

Potential Impact

Ensuring sustainable development of industry

Financial Institutions

MFIs/Comm. banks:

- **Partner with irrigation providers** to reach new customers and align finance across the value chain

DFIs / Impact Investors:

- Provide customized solutions to **unlock aligned capital**
- **Attract green/blended finance into SPVs** to co-finance monitoring equipment and water-efficient distribution systems

Enable scale of irrigation providers offering financing

Public Authorities

- **Ease compliance with existing water regulation** to improve monitoring and supervision
- **Promote cross-stakeholder collaboration and coordination** around market building, market access and technical knowledge
- **Establish and support organizations or groups governing water use rights**

Guardrails to ensure sustainable sector growth

Senegal – key priorities for public and private donors

Recommendations	Specific Activities and Partners	Impact potential
<p>Catalyze financing towards irrigation providers</p>	<ul style="list-style-type: none"> - Provide de-risking support to financial investors that focus on SSI (e.g. concessional loans for MFIs such as PAMECAS or U-IMCEC, first-loss guarantee schemes for commercial banks) - Provide capacity building to local financial institutions (e.g., training on irrigation and its benefits, designing and piloting financial products for irrigation) - Support providers in developing programmatic, collective expansion plans able to attract funding from DFIs (e.g. Bonergie’s “10k pump” project), and broadening their reach to smaller farmers esp. in Southern regions 	<p>Facilitate growth and resilience of irrigation providers by reducing working capital requirements</p>
<p>Improve monitoring and supervision of water withdrawals</p>	<ul style="list-style-type: none"> - Fund pilots with tech-enabled irrigation providers to collect real-time data on pumping hours, flow-rate, dry-run (e.g., Bonergie with Lorentz solar pumps) - Fund the development of a national irrigation platform to centralize data from irrigation and borehole drilling providers and report to relevant authorities - Create regional coordination platforms by convening key stakeholders (e.g., farmer organizations, private irrigation providers, public authorities, other donors, implementers) to tackle issues of jurisdictional conflict over water resources, such as groundwater aquifer depletion and surface water access (for transnational and transregional sources) 	<p>Establish nation-wide visibility over withdrawals and enable detection of potential areas of excessive pressure on water resources</p>
<p>Build demand through improving irrigation knowledge among extension workers and other relevant promoters</p>	<ul style="list-style-type: none"> - Support public authorities to train extension workers on irrigation incl. preservation of water resources, in coordination with irrigation providers - Partner with irrigation providers and local training institutes to develop vocational and dual-training on irrigation (e.g. partnership between Bonergie and GIZ) 	<p>Facilitate growth and resilience of irrigation providers by providing skilled staff for after-sales service</p>

Senegal – key priorities for public authorities

Recommendations	Specific Activities and Partners	Impact potential
Ease compliance with existing water regulation to improve monitoring and supervision	<ul style="list-style-type: none"> - Simplify registration procedures for SSPs and incentivize compliance - Create status for mobile Irrigation-as-a-Service providers - Set up a national, open access irrigation platform - Work with irrigation and borehole drilling providers to build protocols and reporting systems 	Establish nation-wide visibility over withdrawals and enable detection of potential areas of excessive pressure on water resources
Promote cross-stakeholder collaboration and coordination around market building, market access and technical knowledge	<ul style="list-style-type: none"> - Set multi-stakeholder principles on market building for irrigation equipment (avoiding giveaways, market-distorting subsidies) - Align value chain development and market access programs/initiatives with development of irrigation - Streamline technical knowledge of irrigation that can then be passed along to SSPs (e.g., connecting public extension workers with irrigation providers) 	<ul style="list-style-type: none"> - Facilitate growth and resilience of irrigation industry - Ensure farmers can translate productivity gains into additional income
Establish and support organizations or groups governing water use rights	Create Water User Associations governing water use rights and issues at the local level to ensure the equitable and environmentally sustainable expansion of private SSI and water use	Long-term sustainability

Senegal – key priorities for financial institutions

Recommendations	Specific Activities and Partners	Impact potential
<p><i>MFI/Comm. banks:</i> Partner with irrigation providers to reach new customers and align finance across the value chain</p>	<ol style="list-style-type: none"> 1. Offer receivables financing to irrigation providers to unlock growth 2. Partner with PayGo-enabled providers (e.g., Bonergie): <ul style="list-style-type: none"> - Leveraging PayGo system for repayments - Sharing default risk with providers 3. Grant PayGo-enabled irrigation providers access to client base and promote irrigation solutions 4. Work with other business units to align product offering to upstream (e.g. inputs) and downstream farmer needs (e.g., cold storage) 	<ul style="list-style-type: none"> - <i>Enable scale of providers</i> - <i>Help ensure market access for SSPs</i>
<p><i>DFIs / Impact Investors:</i> Provide customized solutions to unlock aligned capital</p>	<ol style="list-style-type: none"> 1. Provide tailored financial solutions to local FIs (MFIs such as PAMECAS or U-IMEC; large coops) including wholesale lending, guarantee schemes, or revolving funds dedicated to SSI 2. Build SPVs to channel green finance into growth of providers (à la SunKing Sustainable Financing Instrument) 3. Work with internal agriculture sector teams to align upstream and downstream investments 	

Ethiopia – has high potential to build on existing public-led development



- SSI development in Ethiopia is public sector driven receiving high levels of public policy support and focus, presence of diverse programs focused on SSI, presenting a large potential for growth
- However, private sector's role needs to be developed as existing private solution providers are limited and face key policy and enabling environment barriers
- Interventions should prioritize recommendations for accelerating successful irrigation providers in the country, adapting policy to address key constraints, and build on the existing strength and reach of public authorities


SSI potential ●

Private providers ●


Enabling environment ●

Water stress ●

Potential Overall Impacts of Scaling SSI:



1.2 million SSP HHs



6 million rural population

Public / Private Donors

Priorities

- **Provide grant financing for revolving Fx fund**
- **Fund research and development** on hydrogeology and SSP irrigation financing programs to ensure sustainable growth
- **Expand the role of the private sector** irrigation solutions market to scale SSI
- **Support market development** to establish market linkage for farmers using irrigation

Potential Impact

Ensuring sustainable development of industry

Financial Institutions

MFIs/Comm. banks:

- **Provide financing, business, and technical support** to private sector actors across the irrigation value chain

DFIs / Impact Investors:

- Provide customized solutions to **unlock aligned capital** such as tailored financial solutions and support for local FIs

Unlock finance barriers for irrigation providers and SSPs

Public Authorities

- **Address Fx limitations** for obtaining imported irrigation equipment through Fx revolving fund and prioritized Fx
- **Improve water management** for water stressed basins through enhanced policies and regulations, and building on existing data management systems
- **Enable the private sector** to expand the role of irrigation solutions providers to scale SSI
- **Irrigation capacity building across national and local government bodies** to transition farmers from rainfed to irrigated agriculture

Major recommendations required for sustainable sector growth

Ethiopia – key priorities for public and private donors

Recommendations	Specific Activities and Partners	Impact potential
Provide grant financing for revolving Fx fund	<ul style="list-style-type: none"> - Fund the pilot revolving Fx fund via grants to support the private sector in procuring and obtaining imported irrigation technologies (solar water pumps, cold storage, raw materials, etc.) 	<ul style="list-style-type: none"> - <i>Improved gross margins for irrigation providers and stabilized / reduced consumer prices</i> - <i>Increase in accessibility of key technologies needed to scale SSI</i>
Fund research and development on hydrogeology and SSP irrigation financing programs to ensure sustainable growth	<ul style="list-style-type: none"> - Fund public research on hydrogeology to understand the availability of groundwater for farmers and borehole drillers and reduce uncertainties in borehole drilling (alongside ILSSI) - Fund research on completed SSP irrigation financing programs to assess the impacts and lessons from financing programs aimed at enabling farmers to purchase irrigation equipment (in partnership with IWMI) 	<ul style="list-style-type: none"> - <i>Increase adoptability and reduce cost of water efficient SSI</i> - <i>Increase affordability and thus access to irrigation equipment through access to finance</i>
Expand the role of the private sector irrigation solutions market to scale SSI	<ul style="list-style-type: none"> - Partner with existing international partners such as ILSSI in engaging with private sector actors via grants to work through challenges and opportunities in the irrigation supply chain and develop attractive business models (providing sales and marketing, technical support, aftersales services, creating market linkages through mobile apps, etc.) (Rensys & Green Way Farms) - Fund risk mitigation of PAYGO financing pilots via grants to allow solar pump providers to develop PAYGO financing for SSPs (Rensys testing PAYGO with SSPs and suppliers) 	<ul style="list-style-type: none"> - <i>Increase uptake of SSI by SSPs by solutions implemented by private sector irrigation providers</i>
Support market development to establish market linkage for farmers using irrigation	<ul style="list-style-type: none"> - Capacity building programs for farmers via grants to improve their marketing, value addition, and connecting with offtakers to build out access to markets - Fund pilots with water resource use associations via grants to experiment with their potential involvement in irrigation operation, maintenance, marketing, extension services, and integration with the private sector 	<ul style="list-style-type: none"> - <i>Sustainable scale up of SSI from empowering local water user associations</i> - <i>Increase irrigated production particularly during dry season</i>

Ethiopia – key priorities for financial institutions

Recommendations	Specific Activities and Partners	Impact potential
<p><i>MFIs/Comm. banks:</i> Provide financing, business, and technical support to actors across the irrigation value chain</p>	<ul style="list-style-type: none"> - Increase credit access for existing or nascent irrigation providers (manufacturers, distributors, wholesalers, and retailers) willing to scale their business (i.e. Solar Village & Rensys Engineering) - Provide business, technical, and financial support to wholesalers and retailers willing to invest in retailing irrigation equipment in rural areas 	<ul style="list-style-type: none"> - <i>Enable scale of providers</i> - <i>Help ensure market access for SSPs</i>
<p><i>DFIs / Impact Investors:</i> Provide customized solutions to unlock aligned capital</p>	<ul style="list-style-type: none"> - Introduce tailored financial solutions (wholesale lending, guarantee schemes, or revolving funds) for local FIs such as MFIs, Rural SACCOs, cooperatives, and other farmer common interest groups to finance irrigation equipment for SSPs - Support local FIs with developing and marketing irrigation specific financial products to SSPs to invest in irrigation production (Rural SACCOs, coops, MFIs, etc.) 	<ul style="list-style-type: none"> - <i>Improved access to finance for SSPs, increasing uptake of SSI</i>

Ethiopia – key priorities for public authorities

Recommendations	Specific Activities and Partners	Impact potential
<p>Address Fx limitations for obtaining imported irrigation equipment</p>	<ul style="list-style-type: none"> - Pilot and test revolving Fx fund to enable private sector irrigation solutions providers to access Fx needed to import irrigation equipment - Prioritize Fx allocations for irrigation equipment, parts, and raw material imports 	<ul style="list-style-type: none"> - Ability to obtain imported irrigation technologies and manufacture irrigation equipment domestically
<p>Improve water management for water stressed basins through enhanced policies and regulations, and building on existing data management systems</p>	<ul style="list-style-type: none"> - Develop policy and supporting regulations, directives, and guidelines for sustainable exploitation and rechargeable management of groundwater (MIL) - Improve existing Irrigation Management Information System to consolidate and regularly update water and other relevant data and analysis, scheme inventories and usage (MoA, MIL, FAO) - Enhance monitoring and information exchange for groundwater between actors (MIL, WAUs, SSPs) including information related to abstraction control and pollution prevention 	<ul style="list-style-type: none"> - Establish nation-wide visibility and guardrails over withdrawals and enable detection of potential areas of excessive pressure on water resources
<p>Enable the private sector to expand the role of private irrigation solutions providers in scaling SSI</p>	<ul style="list-style-type: none"> - Improve enabling environment for PAYGO financing by improving financial regulations to allow irrigation providers (i.e. solar pump providers like Solar Village) to provider SSPs with PAYGO financing 	<ul style="list-style-type: none"> - Development of the private sector for irrigation solutions to implement scale up of SSI
<p>Irrigation capacity building across national and local government bodies to transition farmers from rainfed to irrigated agriculture</p>	<ul style="list-style-type: none"> - Build capacity of agricultural extension support by training existing agricultural extension workers on irrigation to transition farmers from rainfed to irrigation (MoA) - Increase training and in-kind support to model farmers to use and promote irrigation and drainage good practices 	<ul style="list-style-type: none"> - Disseminate knowledge and best practices on SSI to SSPs to ensure effective and sustainable adoption

Appendix

1. Appendix – supporting materials

1. Impact case for scaling irrigation
2. Current state of small-scale irrigation, expansion opportunity, and barriers
3. Emerging private sector solutions
4. Recommended actions to scale irrigation for small-scale producers
5. **Case studies**



Short description

Agriworks is the **first company providing mobile Irrigation as a Service in SSA**. Starting out as an academic research project in Eastern Uganda, the team experimented with leasing of irrigation equipment, which remained unaffordable to most SSPs. Asset-financing did not address the challenge in collective use of shared equipment between SSPs (competing use quickly arose as an issue) and the risk of shocks in a SSP's life preventing them from repaying the asset.

In 2019, Agriworks started to offer mobile irrigation as a service: mobilizing a **network of c. 50 motorcycle taxi riders (called "Bodabodas")**, they now have a **client base of more than 1,500 SSPs with only 3 permanent staff**. Since 2019, the company has been formalizing and improving its operations with every dry season, but has been limited in its growth by a limited investment capacity to purchase more irrigation equipment.



Bodaboda rider irrigating with an Agriworks pump



Key insights

Irrigation as a Service (IaaS) considerably reduces risk for the SSPs by making irrigation a variable cost. Agriworks' services unlock the affordability barriers for the poorest SSPs who never irrigated before, and even sometimes convert SSPs from owning a pump to irrigating as a service.

Leveraging part-time staff with other income opportunities for the rainy season, such as bodaboda riders, helps tackle the issue of seasonality. Agriworks reduced its operational expenses during the rainy season, while improving the livelihoods of a vulnerable group during the dry season.

SSPs show a clear willingness to pay for irrigation services of which the higher limit has not yet been explored: in 4 seasons, Agriworks has doubled its price per hour from \$1.5 to \$3 and demand has remained high

Local regulation laws could be a deterrent to the development of mobile IaaS in some countries where individual permits associated to a specific source location are required to extract water



Key data

- Date of creation: 2019
- Countries of operation: Uganda
- Model: Mobile Irrigation-as-a-Service
- SSPs reached: c. 1.5k
- Average farm size: ½ acre

Agriworks provides irrigation to SSPs who cannot afford a pump or are finding its ownership too costly



Value proposition

Product offering

Agriworks offers **irrigation services to SSPs through Bodabodas riders that drive to the SSPs' farm and extract water from a nearby surface source** thanks to a **specially-designed pump that attaches to the motorcycle's engine**. The rider runs the engine while the SSP distributes water through in its field through a hose pipe. This system **can only service farms within 250m from an abundant water source**, which is the majority of farms in their current areas of operations.

Agriworks charges SSPs \$3 per hour of irrigation, corresponding to c. 10 m³ of water. **Out of the \$3, Agriworks collects 25% (\$0.75)** and the rest goes to the rider who typically uses c. \$1.5 for his fuel and maintenance expenses, and ends up with net earnings of about \$0.75/hour. The company can give a discount to SSPs ordering many hours of irrigation at a time (i.e., >5h).

So far, Agriworks has not included any other service, but it **is looking at utilizing idle time from riders while the pump is running and the SSP is busy irrigating**, as well as offering services counter-cyclical to the irrigation season, such as digging furrows which allow more water-efficient irrigation and preserves fragile crops.

Target segment

The company typically **targets very small SSPs** (half-acre farms, with an average daily income per HH member of less than \$2) who cannot afford their own pump and have for the most part only ever irrigated with buckets. Interestingly, a few of their customers used to have their own petrol pump but now prefer to use Agriworks's services which they found more convenient to operate (especially when their land is fragmented) and cheaper to maintain.

While the team has not yet run an extensive impact survey, there have had **customers who increased their productivity and income in a single season sufficiently to purchase additional land** which they then also started irrigating with Agriworks' services.



SSP using Agriworks' services in Mbale (Uganda)

Agriworks employs branch managers to best coordinate its two main assets: bodaboda riders and irrigation kits

Delivery model

Prospection & Recruitment

- **With virtually no branding or advertising, Agriworks manages to create hundreds of prospects purely through word of mouth.** In every season of operation so far, customer acquisition was not limiting their growth which shows there is a large natural demand and potential for scale for irrigation as a service once SSPs are aware that it can be made available to them.
- **By mobilizing independent Bodaboda riders, the company has partially solved the issue of seasonality:** during the dry season (6-8 months per year), the riders are eager to work as irrigation providers because they make more money (c. + 30% net income), spend less on maintenance, and enjoy a safer and less physically demanding occupation. **During the rainy season where demand from SSPs is low, they go back to their original job as taxi drivers.**
- Agriworks has no difficulty in recruiting new riders who are trained (in a few days) to be able to **install the irrigation system in around 10 minutes after arriving on a new field. Two branch managers supervise riders and organize their routing** (c. 35 riders for the North branch, c. 10 for the South branch), carrying out background checks within the community before recruitment. On one occasion, a rider did not return the pump and started operating by himself, but this competition was quickly limited by the need for specialized parts.

Supply-chain

- **Agriworks designed the equipment through a grant from Global Good** (now Global Health Labs, a nonprofit corporation funded by Gates Ventures) and **imports parts from China.**
- The component parts designed in-house and attached to the off-the-shelf pump (costing only c. \$50) are very robust. **The pipes are the most expensive part to replace** (c. \$1.4 per meter) and due to their variable quality, they last only 2 seasons on average.
- Whereas Agriworks is responsible for maintaining the irrigation equipment, the riders take care of their own motorcycle (50% of which are rented or leased, with a daily fee paid to the owner).



Sales & service

- **A SSP wishing to irrigate calls the branch manager** who then allocates an available driver. The rider carries the equipment to the SSP's field, and pumps water onto the crop according to the amount of time determined by the SSP. **After the service, the payment is collected by the rider, in cash** (to avoid mobile money fees), who then hands it over to the branch manager in full at the end of day when returning the equipment (pump and hoses). The branch manager then pays the rider his or her commission. Agriworks is considering switching to mobile money payments to avoid riders doing extra service hours without declaring them to the branch manager.
- Riders sometimes provide credit to regular customers, out of their own pocket. Over time **the best-performing riders are able to build a relationship with SSPs** who request their specific services.

Agriworks' branch office in Mbale (Uganda)



Impact

- **Agriworks serves some of the poorest SSPs** who cannot afford to purchase their own irrigation equipment, providing them a clear opportunity to improve their income. Agriworks's internal surveys show that almost 60% of their users would not grow any dry season crop if the service was not available, and **their average profit is c. \$250 per dry season**. For a branch serving 600 SSPs, this represents c. \$144k in additional SSP income, for a cost of less than \$20k per branch.
- Further, **Agriworks is also improving the livelihoods of Bodaboda riders** (typically the next most economically vulnerable group after SSPs in the areas where Agriworks operates), helping them transition to more formal employment, and creating a sense of belonging (with some riders declaring they are going "to the office" on their way to pick up the equipment).



Scale

- Agriworks has been experimenting with the IaaS model for 4 years, with 200 paying customers the first year, and more than 600 the second year. In the third and fourth seasons, Agriworks extended its customer base to more than 1,500 SSPs but **was unable to cater to more than 600 customers each season because it did not have enough equipment to serve them**.
- **Agriworks is looking for funding to purchase more equipment** (c. \$600 for one pumping kit, including pump, pipes, connect plates and bearings) to unlock this barrier to growth. Larger orders would also reduce kit cost through bulk purchase.
- Once it has stabilized its operations and maximized its penetration in current areas of operation, the company will be targeting areas with good supply of surface water, high density of high-value crop growers, and at least one dry season in the year. **The locations with more extended dry periods are the most ideal for this model**, as it reduces down time due to no demand when rain occurs. **The potential for replicating Agriworks' model to other countries where surface water is equally available can be limited by regulation:** in Kenya for instance, a permit is technically required for each extraction site. In such cases, international replication would require finding an arrangement with or exemption from public authorities.



Economic sustainability

While Agriworks has proven that there is strong demand and willingness to pay from SSP for mobile irrigation as a service, it is still in an early phase, and **its long-term economic sustainability will depend on the optimization of key drivers, in order of priority:**

- **Increasing daily service hours per kit** (2-3 hours per day on average for now) and per farm (to minimize transportation costs), which could be done by adding the number of pipes per set of equipment, as well as increasing seasonal staffing to maximize staff working hours per day
- **Optimizing logistics and routing for the riders** (for now done manually by the branch manager)
- **Increasing price to match the high value created**, tapping higher into SSPs' willingness to pay: in 4 seasons, Agriworks has doubled its price per hour without any noticeable contraction in demand



Furrows irrigated by Agriworks in Mbale (Uganda), Credit: Agriworks

Key actionable levers have been identified to make mobile IaaS profitable

Annual branch unit economics under different scenarios (in \$)

Inputs in red are the one modified compared to the baseline

		Baseline	Lever 1	Lever 2	Intermediate scenario	Best case scenario
Key inputs	Available irrigation kits	25	35	25	30	35
	Daily service hours per kit	2,5	6,0	2,5	4,5	6,0
	IaaS price per hour	3,3	3,3	4,9	4,1	4,9
	Branch commercial margin	25%	25%	40%	33%	40%
Relevant variables	Total annual IaaS hours	5625	18900	5625	5625	18900
	Branch hourly fee	0,8	0,8	2,0	0,8	2,0
Totals	Revenue	18493	62137	27740	18493	93205
	Variable OPEX (riders' fee, kit maintenance)	15925	18699	49479	35842	58800
	Fixed OPEX (salaries, utilities, amortisation)	10088	10088	12088	11088	12088
	Profit	-7519	570	-1047	2886	22318
	Profit over revenue	-41%	1%	-4%	6%	24%

Other inputs: Irrigation kit cost = \$600; Irrigation days = 90; Replacement (parts) cost per kit = \$82; Kit lifetime = 3 years; Salaries (one manager) = \$3300 and other OPEX (rent, utilities, etc.) = \$1800.

While Agriworks is currently not profitable at branch level, two major levers have been identified that show potential for profitability:

- **Optimizing equipment utilization efficiency through routing software, better logistics and mobile money payments**, to increase the daily hours per kit and the number of kits which can be handled by the same staff
- **Increasing service price** as well as branch margin.

Two scenarios were projected:

- **Intermediate scenario:** equipment utilization efficiency is improved, **service price is increased by 20%** with a 33% branch margin allowing 6% profit
- **Best case scenario:** equipment utilization efficiency is strongly improved, **service price is increased by 50%**, with a 40% branch margin allowing 24% branch profit which could then cover overheads and generate net profit

This shows that:

- **Improving equipment utilization efficiency is a key lever** to reach profitability and would also allow Agriworks to reach 3x more farmers
- **Increasing prices and branch margin will also be necessary to reach profitability.** A price segmentation could be introduced to keep reaching the poorest farmers
- **Complementary levers** could also be activated, including reducing irrigation kit costs through bulk purchases, increasing irrigation days by targeting dryer regions, and further increasing the number of kits



Short description

Bonergie SARL was founded in 2010 in Dakar, initially as a distributor of solar home systems. They started to diversify in irrigation in 2016, becoming the official distributor of solar pumps in Senegal for Lorentz, a high-quality German manufacturer. Bonergie now has 5 branches across Senegal, employs 52 people and is fully focused on irrigation.

To date, Bonergie has sold over 1,500 solar pumps to small and medium SSPs. The company is well-known in country for the quality of its products and the fact that they are the only ones selling solar pumps with a PayGo solution.



Key data

- Date of creation: 2010
- Countries of operation: Senegal
- Model: Solar pumps with financing
- SSPs reached: > 1,500
- Average farm size: 1-5 ha



Solar pump with water tank, credit: Bonergie



Key insights

Small to medium commercial SSPs are willing to pay a higher price to invest in high-quality, durable equipment which in turn allows irrigation providers to reduce after-sales costs. Despite their being 30% more expensive than the competition, Bonergie's clients value its high-quality products and usually don't feel the need to sign up for a maintenance contract after the guarantee expires

Internalizing financing helps address smaller SSPs while creating a virtuous alignment of interest between aftersales service and payment collection, but implies heavy working capital requirements. Bonergie's sales drastically increased when the company started offering PAYG financing, which also helps ensure customer satisfaction, but limits growth to availability of capital.

Site assessments are critical to ensuring customer satisfaction and should not be overlooked. Bonergie's experienced poor customer satisfaction mainly under indirect customer acquisition (e.g. through partnerships with institutional programmes) where no site assessment was performed

SSPs equipped with solar water pumps have little incentive to preserve water resources due to the low/null marginal cost of extraction. Furthermore, efficient distribution systems (e.g. drip lines) have a much lower ROI for SSPs and are purchased by a minority of Bonergie's customers.

To enable farmers to access its expensive but durable products, Bonergie has launched its own PayGo system



Value proposition

Product offering

- Bonergie sells a wide range of Lorentz solar pumps (from \$2.5k for 1-2 ha, to \$7k for 5 ha). Bonergie essentially **targets small to medium commercial farms** (80% of its revenue, 1 to 5 ha, vs. an average farm size in Senegal at 1.5 ha), with some larger contracts for projects supported by big stakeholders (e.g. FAO, Veolia, etc.) who want to invest in agriculture (20% of its revenue). The company does not target smaller farms to date, but has plans to list a smaller pump adapted to farms between 0.5 and 1 ha (3 m³/h, c. \$1100) developed by Lorentz.
- **Due to their high-quality, Bonergie's products are 30% more expensive than some of the competition.** 70% of clients are switching from diesel pumps to benefits from cost savings on fuel which can represent up to 25% of a SSP's income (the pump ROI ranges from 100 to 200%). As they are used to irrigate with a large flow with hoses or sprinklers early in the morning or late in the evening, **SSPs need to adapt their behaviour to solar pumps** that irrigate at a lower flow through sprinklers when sunlight is available. For 40% of its clients, Bonergie installs **water reservoirs** of an average 5 m³ capacity costing \$3k to allow some irrigation without sunlight.

Financing

Bonergie sells 30% of pumps cash (with a 3-5% discount) and **70% through an in-house PayGo system** developed in exclusivity with Lorentz, dubbed Asset Protection Mode, which so far equips the 3 most popular models (PS600, PS1800 and PS4000). With PayGo, SSPs pay **20-30% upfront and the rest over 18-24 months in instalments of 4 months** that allow SSPs to plant, grow and harvest between payments. SSPs are also able to prepay for any given number of days. Upon receiving payment through mobile money, Bonergie's call center shares a code that SSPs input into the pump controller. SSPs are allowed two 30-day grace periods over the loan duration. **Timely repayments (less than 30 days late) sit at over 95%** and Bonergie has so far never needed to repossess any pumps.



Floating solar pump, credit: Bonergie

Customer satisfaction

- Bonergie aims to position itself as a **development partner for SSPs** and not just a supplier of equipment, emphasizing the quality of its products. It has been described by partners as the "Toyota" of irrigation: expensive but durable.
- A 2021 survey of 88 Bonergie clients by 60_Decibels shows that while the 39% of promoters value the reliability and lack of issues, **the 27% of detractors feel the cost is too high.**
- With support from GIZ and Salesforce, Bonergie is investing in the development and deployment of a **CRM system which aims to improve client satisfaction** through consumer surveys, and facilitate behaviour change through education (mobile workshop and training centers).

High-quality equipments limit cost of after-sales and encourage positive word-of-mouth

Delivery model

Prospection

- Bonergie targets individual SSPs with local market promotion and agricultural fairs, with a current **conversion rate of 1:10** which has been improving over the years. They also **encourage word-of-mouth** by incentivizing SSPs who bring a new customer with a 3-5% commission.
- To optimize client prospection, **Bonergie is leveraging SSP groups and cooperatives**, sometimes as part of broader institutional programmes. It has had challenges in programmes where the dimensioning of a SSP's equipment is dependent on the fund allocation from the programme itself rather than its actual needs, which can lead to insufficient water flow and poor customer satisfaction.
- Bonergie performs **site assessment and pump dimensioning via a Lorentz software**, both in-person and remotely for certain well-known types of SSPs.

Sales & Installation

- Bonergie is **selling in average 50-60 pumps monthly** (with less demand in rainy season, between July and September) with 3 local salesmen and one sales manager, with annual objectives set for each region. While cash sales are a matter of hours, credit sales can take up to two days (Bonergie is forming a credit committee to improve the process).
- Today, **Bonergie installs the pumping system with its own staff** and is working with GIZ to partner with local training institutes for internships (most of Bonergie's technicians were former interns) to ease the scale-up. A new technician with no experience can be trained to install the standard pumps in 2 to 3 months.



Floating solar pump on Senegal river, credit: Bonergie

After-sales service

- Bonergie offers a **2-year guarantee** on all products, and **the 5 local offices provide after-sales service** by addressing requests from SSPs and dispatching technicians when required. As most issues appear in the first few weeks or months after the installation, few SSPs subscribe to a maintenance contract after the 2-year guarantee as they prefer to pay for maintenance and repair costs as needed (with 1,500 pumps installed, Bonergie only performs 5-10 maintenance interventions per month, often for product misuse). The high quality of the pumps and their **10-year lifetime** mean **breakdowns are rare** with some of Bonergie's oldest customers having run their pumps for 7 years so far.
- **Most issues are linked to boreholes running dry**, which is due to the low-quality of some boreholes and the low awareness of SSPs on the water tables depth. After unsuccessful partnerships with local drilling companies (themselves now diversifying into irrigation equipment), **Bonergie is looking to invest into its own drilling capabilities** as a way to both broaden its market base and improve client satisfaction.

Bonergie's growth and expansion is strongly limited by access to working capital



Impact

- According to the 2021 60_decibels research, **70% of Bonergie SSPs reported an increase in income**, corresponding to a 48% increase in number and quality of meals and a 48% increase in amount spend on school-going children in SSP households.
- In terms of environmental impact, **solar water pumps avoid burning up to 10L of diesel per day** (i.e. 6 tCO₂e/year). However, since solar pumps function best when the evapotranspiration is also at its highest, it is **unclear whether they represent a net benefit on water use efficiency vs. motor pumps**. Storage and efficient distribution systems like drip could greatly improve this efficiency but both are about as costly as the pump itself. Drip lines are also sensitive to water quality, require additional maintenance and cannot irrigate on all soil qualities. **Bonergie has partnered with Netafim to provide high-quality drip lines** but only a minority (10%) of SSPs make the additional investment.



Scale

- Bonergie was self-financed until it received a **€1.6m loan from infrastructure fund INFRACO** in 2021 with the **objective of selling 2,000 solar pumps and 500 drip irrigation systems over 2 years**. This loan allowed the team to double in size to 52 staff, and boosted sales from 400 pumps sold in the 3 years prior to 2021 to over 1000 in 2021 and 2022.
- Because Bonergie sells most of its pumps through in-house financing, its **main barrier to scale is access to working capital**. Having reached less than 2% of the estimated national market, Bonergie is developing a **new project** along with other providers to obtain capital from financial institutions **to sell 10k solar pumps by 2030** (with Bonergie supplying half of them).
- In parallel, Bonergie is **planning to expand to other West African countries**, with a priority on Ivory Coast which is a large and well-established agricultural market, similar to Senegal.



Economic sustainability

- With a **gross margin of 20-30%**, Bonergie has **nearly reached breakeven** but is struggling to repay the interests of the loan provided by Infraco (at 12% compound rate). Even with a VAT exemption for high-quality solar pumps in Senegal, competition from other providers with cheaper products are pushing prices down. In such conditions where Bonergie already has premium prices, **reducing logistical costs is key to improving profitability**.
- As complementary revenue streams, **Bonergie is diversifying in solar cold storage** (\$50k units targeting large farms) and **borehole drilling** which would also help grow its core business.



Solar pump installation, credit: Bonergie

Davis & Shirliff (D&S), the largest pump retailer in East Africa



Short description

Davis and Shirliff was founded in Nairobi in 1946 and started to expand regionally in the 1990s. The business is still owned and run by the Davis family.

The business now owns **50 branches in Kenya and 40 more across East Africa**. It employs c. 1000 FTE, including 400 engineers, and has historically supplied equipment for both collective infrastructure in water treatment as well as for individual swimming pools or lawns. **D&S is one of the largest pump distributor in EA with >200k units sold per year, incl. c. 4k for irrigation of SSP farms**. The company offers a **comprehensive range of pumps (electric, petrol driven, solar) adapted to all farm sizes**, including small locally-designed submersible pumping kits including piping, controllers and solar panels starting from \$500. It expanded into solar panels in 2005, becoming the largest importer of solar products in Kenya, and selling over 30MW of solar pumping a year, mostly to **medium and large commercial farms**. Irrigation represents 5% of its total revenue.



Key insights

D&S has proven that it is possible for diversified hardware providers to offer irrigation equipment to SSPs with efficient site assessment and quality after-sales services through a dense network of branches and certified resellers

Thanks to its diversified portfolio of water treatment products, D&S has built an extensive network of branches coupled with a large number of trained and certified resellers allowing them to offer sales, installation and maintenance to medium and small farms throughout Kenya and in parts of EA

To improve its accessibility and reach SSPs, D&S is looking to integrate financing including through an in-house PAYG system

- To overcome the barrier of upfront costs for smaller SSPs, D&S is setting up a JV to offer PAYG financing through its distribution network
- Carbon finance is also considered to reduce pump prices



Key data

- Date of creation: 1946
- Countries of operation: **Kenya**, Uganda, Tanzania, Zambia, Rwanda, South Sudan, DRC, Zimbabwe, Somalia
- Model: Retailer (all pumps and distribution systems)
- SSPs reached: 10-15k
- Average farm size: > 4 ha



D&S demonstration on drip lines, credit: D&S

D&S offers a wide range of irrigation products for all farm sizes, and is building its own PayGo system



Value proposition

Product offering

Regarding its irrigation segment, D&S imports and distributes its solar and pump products under different brands including its own, Dayliff. Out of the **200k pumps D&S sells every year**:

- The **majority are AC electric pumps for use on grid**: even with high price of power (c. 0.2\$/ kWh), they are more attractive to on-grid customers compared to solar pumps due to their lower initial cost
- **Very few (c. 500) are petrol engine pumps**, which start at a relatively low price but are increasingly replaced by electric and solar due to the recent increases in fuel costs
- **c. 7k solar pumps** (half to SSPs) including:
 - Mostly submersible pumps, mostly under **Dayliff's Sunflo** range of pump and solar panel kits
 - A few surface pumps (<500 per year), including Future Pump products, with a limited application due to their low total head (7m)

D&S is slowly phasing out manual pumps, which the company considers ineffective and unreliable.

Financing

To tackle the issue of accessibility for SSPs, **D&S is developing the Daylipa PAYG solution in partnership with 4RDigital**, an advisory firm specialized in digital innovation for social inclusion. Through this service, D&S customers will be able to pay through a dedicated app in instalments. The team has already spent 18 months on R&D and is currently working to reduce the price of the PAYG module developed inhouse and manufactured by Solartech.

Target segments

D&S sells most irrigation pumps to **medium or large farms (10 acres or more)** which, despite their access to surface water (for half of them), tend to drill a borehole to diversify the water sources. **Smaller farmers (from 1/8 to 10 acres) tend to first buy petrol driven pumps** (or electric if they are connected to the grid), followed by surface and submersible pumps, although these products remain inaccessible to most of them. In D&S' experience, **sales to SSP groups are not efficient as SSPs end up competing for use of pump.**



D&S's warehouse in Nairobi, Kenya

D&S leverages its partnership with certified service providers to ensure efficient after-sales in deep rural areas

Delivery model

Sales & Installation

The pump sales are made:

- **directly through their 90 branches in Kenya and EA (60%)**
- **through D&S network of 1,500 resellers in Kenya**, including contractors, distributors, and service providers. Most of the surface pumps are sold through distributors, representing about 40% of the revenue. D&S customers include NGOs which represent a sizable segment, about 40% of D&S customer base. D&S has an ongoing partnership with SNV for group training of SSPs.

D&S uses branches as local sales hubs in each county. All are in-house except for Ethiopia where the company is required to have a local partner. **Each branch has its own P&L and gets weekly reorders from the central warehouse.** Logistics in country are fully integrated, and each branch has its own engineers to carry out large installations. D&S has no issue recruiting skilled technicians in Kenya.

D&S has invested in the **standardisation of their indirect sales** (90% of pump sales):

- **Ensuring coherent retail prices:** they adapt their pricing structure and margins to resellers of different sizes so that the target retail price is respected, especially for small pumps. For example, they give a high margin to resellers of a \$450 pump so that they can still be profitable if they sell within a 20km radius.
- **Building capacity:** D&S has built an online training platform for **its irrigation resellers which must all be trained and certified** (some of its largest resellers are former D&S staff which have established their own business). The training also covers basic agronomic notions. D&S has developed an **app to facilitate site visits and sizing of irrigation needs** used either by branch installers or resellers.

After-sales service

D&S' after-sales process starts with a remote diagnosis, following which the SSP can bring the pump to the nearest workshop or have a technician over if the pump is not removable. Most of the pumps sold under their brand Dayliff are **locally designed but manufactured abroad.** A quality control is performed for external products, which can be removed from the catalogue if their breakdown rate is bigger than the firm average of between 5 and 10%.

D&S plans to leverage both its branches and resellers to offer financing solutions, including PAYG.



D&S's shop in Kigali, Rwanda, credit: D&S

D&S is investing in PayGo to reach the smallest farmers and offer complementary services



Impact & economic sustainability

With **over \$100m in revenue** and as an established regional market leader, **D&S grows organically and with limited risk-taking**. Its family ownership favours long-term interest vs. short-term returns, and runs many CSR programs around WASH.



D&S's demonstration farm, with solar pump, water tank and drip lines



Scale

- **D&S is structuring its PAYG innovation under an external JV** to limit the risk to the core business, and attract investment from partners with complementary expertise. In its current partnership with 4RDigital (4RD), D&S is providing the technical knowledge, distribution network and G&A support, while 4RD is bringing its expertise in PAYG systems and asset-financing. They are actively looking for a third value-add partner e.g. in impact investing.
- D&S is aiming to include a **finance charge on the instalments for SSPs PAYG, which will be comparable to the market rates** (commercial loans to established businesses such as themselves currently already sit at 18% interest). They plan to adapt this charge to loan durations and reward regular payments.
- Complementary partnerships with Sprout (weather information) and other fin/agrotechs are in development to **provide information and advice on the Daylipa app**. **Carbon finance is also being explored** (with Cavex) as a way to lower the cost by \$10-15 per pump.

KickStart sells manual pumps as a stepping-stone into irrigation and out of poverty



Short description

KickStart is the **main NGO advocating for and providing access to irrigation for small-scale producers in SSA**. In the past **20+ years**, it has marketed 4 distinct models, and multiple versions, of manual pumps and **sold over 385k pumps across 17 countries**. It has also developed multiple low-cost prototype solar pumps and field-tested hundreds with farmers.

In 2015/16, after reaching a milestone of 1 million people lifted out of poverty, **KickStart pivoted away from its expensive B2C model**, where it imported, warehoused and distributed pumps, sold them to retail shops and hired hundreds of local sales staff. Instead, **KickStart uses a leveraged, cost-effective partnership-based model** and has a wider mission – to “irrigate Africa”. KickStart meets and educates SSPs by partnering with hundreds of local and international NGOs, UN & Govt Agencies, MFIs, CBOs, CoOps and Agri-businesses who are working with, and have trusted relationships with, hundreds of farmers—greatly reducing the marginal cost of meeting with and convincing farmers to start irrigating. **The pivot enabled KickStart to employ fewer but more senior staff and expand its reach from 5 to 17 countries**. In addition, KickStart continues to develop and pilot, new irrigation innovations, including new technologies and ways to reach educate and finance farmers, and it advocates for the ‘system changes’—policies, investments, smart subsidies, etc.—that will enable SSI to be widely scaled.



Key insights

As the lead organisation designing and distributing manual pumps to SSPs (>385k to date), KickStart has demonstrated that these products can be an effective first step to helping subsistence farmers, with reliable access to surface (or shallow ground) water to take a step out of poverty, by introducing them to the benefits of irrigation and unlocking their investment capacity.

- Despite their intrinsic limits—labor intensiveness (like bicycles), 7m suction head (like petrol pumps) and total head of 14m—manual pumps are an **effective stepping-stone to irrigation for resource-poor, risk averse, SSPs** unaware of irrigation’s benefits and/or lacking access to financing.
- SSPs who have benefitted from access to manual pumps and wish to irrigate a wider area are then **able to use their additional income to graduate to motor or solar pumps**, while retaining their manual pumps as a complementary irrigation tool to use on cloudy days and/or when petrol is unaffordable

Shifting from a B2C to a partnership-based model has so far allowed KickStart to reduce its cost/pump by >25% and expand from 5 to 17 countries. With a current team of 27 partnership/sales staff located across 9 countries, KickStart distributes and sells pumps through a network of certified local importer, distributors and retail (agri-vet) shops to ensure the local availability of pumps, spare parts and basic training; and reaches and educates farmers through a network of development partners, helping to ensure widespread uptake and customer satisfaction and avoid negative word-of-mouth.

KickStart’s MoneyMakerMax treadle pump, credit: KickStart



Key data

- Date of registration: 1991
- Promoting irrigation since: 1999
- Countries of operation: 17 in SSA, inc. Kenya, Tanzania, Malawi, Zambia
- Model: Manual pumps
- SSPs reached: > 385k
- Average irrigated area: ¼ - ½ acre



KickStart targets the poorest SSPs and leverages its partners to show them the multiple benefits of irrigation



Value proposition

Product offering and target customers

- KickStart currently sells 2 models of manual pumps, under its MoneyMaker brand: its best-selling **MoneyMaker Max treadle pump**, and the **MoneyMaker Starter Pump**, a hip pump. KickStart's manual pumps are **easy to use and affordable** and require no tools to maintain. But they are **labour-intensive** and **require access to surface or shallow ground water** (<7m).
- Such pumps **target subsistence SSPs**, who irrigate small plots with an average irrigated area between ¼ and ½ acre, and who have no prior irrigation knowledge or are irrigating micro-plots with buckets. **Buying a manual pump is often for them the first step towards resilience**. After several harvests, they realize the full benefits of irrigation and can save enough money to invest in a petrol or solar pump. After graduating to a petrol or solar pump, most SSPs keep their manual pumps to use on cloudy days or when they cannot afford fuel.
- KickStart currently **sells ~90% of its pumps to local importers/distributors** who on-sell ~30% of the pumps to local agro-dealer retail shops (> 250 shops) and sell the rest to KickStart's institutional/NGO partners (> 350 partners), which incorporate irrigation into their broader programmes. Some 10% of the pumps are currently sold directly from KickStart to partners.
- Some **low-quality copycat pumps** (even the same colour) are manufactured in India and **sold in retail shops in SSA**—some customers buy a counterfeit believing it is a KickStart pump. These poor-quality pumps **pose a risk to** the reputation of KickStart's MoneyMaker brand, and **the reputation of human-powered pumps in general**, as none offer guarantees or local support.

Commercial sales

- **KickStart sells its pump together with spare parts** to local importer/distributors in SSA who most often bundle them with locally-sourced hosepipes, and on-sell them to local retail shops and/or partners. **Bundled Treadle Pumps retail for \$170-\$230 and Starter Pumps for \$75-\$100** depending on the country, location, local tax regime and distributor/retailer mark-ups.
- **KickStart partners with multiple MFIs across SSA** including with VisionFund, and most recently with Tupande (formerly One Acre Fund Kenya) who **provide loans to qualified borrowers**, or groups of borrowers, generally with a small downpayment, a payment holiday (while crops are growing), and then the loan and interest (between 30% and 50% APR) being fully paid off within 5-7 months.

Institutional sales

- **KickStart partners with and trains a wide range of institutions** who purchase pumps from local importer/distributors and who, with KickStart's help, deliver pumps and training on pump use and maintenance, and agropreneurship (irrigated farming as a business) to SSPs. While historically many of these partners distributed pumps for free to vulnerable SSPs, an increasing number are insisting that SSPs have skin-in-the-game, and **KickStart is educating partners about the importance of not distorting markets with free distribution** but rather to focus on helping SSPs co-finance the pumps.
- **KickStart and its partners work to introduce irrigation to empower the most vulnerable SSPs**: e.g. enabling cast-out widows to make a living through the sale of vegetables with the Nyanam project and partnering with UCSF medical school to empower and improve the health of HIV positive families in Western Kenya; partnering to resettle IDPs with ActionAid in northern Mozambique and with CRS and ICRC in northern Nigeria; and **promoting youth and women employment with the Rent-to-Try-&Buy model in Kenya** (see box below).
- **KickStart implements regular in house, and donor outsourced impact studies to measure the multifaceted impacts of irrigation** including: improved year-round resilient livelihoods; improved food and nutritional security; reduced stunting of children; improved mental health, reduced marital violence and less risky sexual behaviour by teenage girls.

KickStart focuses on easing the pump maintenance and use to limit the need for after-sales service

Delivery model

Design

KickStart has an **in-house R&D team who is currently developing a low-cost submersible solar pump** (targeting \$250 retail price), suitable for irrigating ~½ acre with a maximum flowrate at 3 meters head of 0.35 litres/sec and a maximum head of ~12m with a flow rate ~0.1 litres/sec. While this development is taking longer than expected, and KickStart has produced and tested many dozens of prototype low-cost solar pumps over the last 4 years, **KickStart is now expecting the new pump to be available in Kenya by mid-2024**. KickStart is striving to overcome challenges faced by most currently available solar pumps: e.g. they are expensive, hard to maintain and repair, don't pump dirty water, and can't pump water on cloudy days. **KickStart says its pump will be easily repairable with fully replaceable plug-and-play spare components**. It will work with dirty water, have an optional extra panel to enable pumping in low-light conditions, and **be modular, allowing two pumps to be easily connected in series to double the pressure head**—which will all be unique features on the market.

Distribution and training

- **KickStart outsources its manufacturing through an intermediary in China**, who selects and trains the best factories and provides in-factory QC services on all pumps. The pumps are shipped directly from China to appointed importer/distributors across SSA. **KickStart staff perform random quality checks to help ensure the quality.**
- **When selling through partners, KickStart staff typically train partner's staff and 'lead SSPs'** to in-turn train SSPs on pump use and maintenance. In direct sales, KickStart staff train retailers who then train customers.



KickStart's R&D workshop

After-sales service

- Each pump comes with a **1-year guarantee** and a serial number stamped on its body which enables KickStart to honour the guarantee and track down and correct production problems. **Pumps are also sold with a set of spare parts** (e.g. piston cups and rocker-cables).
- **In the countries of deepest market penetration** (Kenya, Malawi, Zambia, Tanzania, Uganda), KickStart ensures an **effective after-sales service** thanks to dealer staff trained on basic pump operation and trouble-shooting, and with support from its programme staff they ensure availability of spare parts at the dealers' and can also track and correct other/bigger issues.
- **Ensuring proper training, spares and customer satisfaction is more challenging in countries where KickStart has fewer staff** and/or a less dense network of certified retailers.
- KickStart **regularly measures customer satisfaction** through internal and external surveys. A 2019 survey by 60 Decibels measured a NPS at 51 (only 4% detractors), **well above its regional or sector average**

KickStart leverages donor fundings and brand reputation to extend its reach and lift more farmers out of poverty

Impact & economic sustainability

- KickStart has **sold >385k pumps to date**, and it estimates (based on studies) that on-average, 75% of pumps sold enable a family of 5 **to climb out of poverty**, so **~1.5m people to date**.
- In FY22, **33% of KickStart's total revenue came from product sales and donated services**, with **the rest coming as donations** from foundations (48%), individuals (16%) and corporations (3%). The ratio between sales revenue and expenses increased from 24% to 30% between FY20 and FY22, while KickStart's donor income increased by 21% during the same period.
- **KickStart limits its gross margin to 20%** (of its FOB China costs) **to improve affordability**, while distributors and retailers set their own gross margins. KickStart works to limit price gauging by not offering exclusives and by engaging multiple importer/distributors per country.

Scale

The MoneyMaker brand is best established in the countries where KickStart has worked for longest—Kenya, Tanzania and Zambia—but even there, the majority of SSPs need more education on the benefits of irrigation, and access to financing before they purchase pumps. **In some countries, where it has limited staff and large partnership sales** (e.g. Malawi, Nigeria, Mozambique), KickStart can recover all of its local marketing and sales costs from its gross margins, but overall, **KickStart explains that it requires donor funding to**; develop and test its new innovations/technologies; establish local supply chains; recruit and educate partners; reach, educate and drive behaviour-change in SSPs; run marketing campaigns; develop and promote local financing solutions; measure its impacts; advocate for systems changes and ensure that irrigation pumps reach even the poorest, most vulnerable SSPs.

Shamba Maisha – an example of institutional programme leveraging KickStart's pumps to lift SSPs out of poverty

- The **2-year Shamba Maisha RCT** (randomized controlled trial) run by UCSF Medical School in Western Kenya **quantified the impacts of irrigation on families living with HIV**. Agricultural inputs and a MoneyMaker treadle pump on a 12-month bank loan (~\$175 with a required \$20 downpayment and 6-month grace period), along with 8 training sessions on agriculture were provided to 366 randomly selected SSPs out of the 720 registered HHs. The study found **significant increases in food security and in mental and physical health**—reduced depression, women's empowerment, increased social support, lower levels of marital violence, reduced stunting in children, reduced stigmatization and increased self-confidence.
- Notably, **14% of the original applicants (162/1127) were not selected because they did not have access to a year-round source of surface or shallow-ground water**. Other participants had their water source dry-up during an extended period of drought.
- **Even with a very flexible loan, the total repayment rate was low** (c. 25%) even though all SSPs reimbursed part of the loan. External factors including flooding followed by severe drought, and limited motivation to collect the payments (the loans being guaranteed), also influenced repayment rates.



SSPs irrigating with the MoneyMakerMax, credit: UCSF

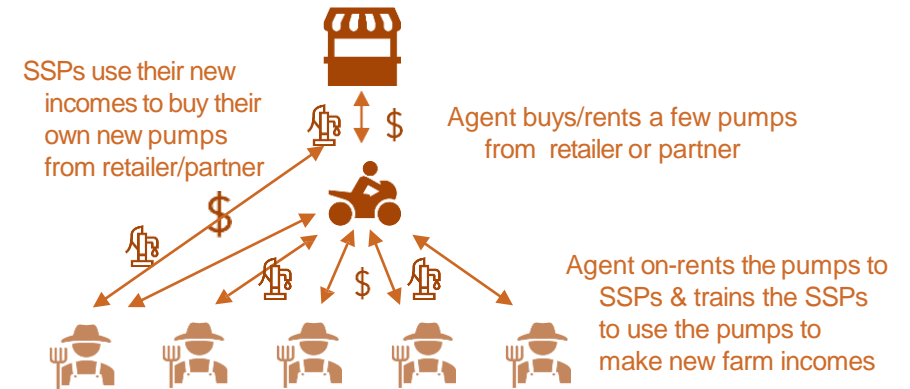
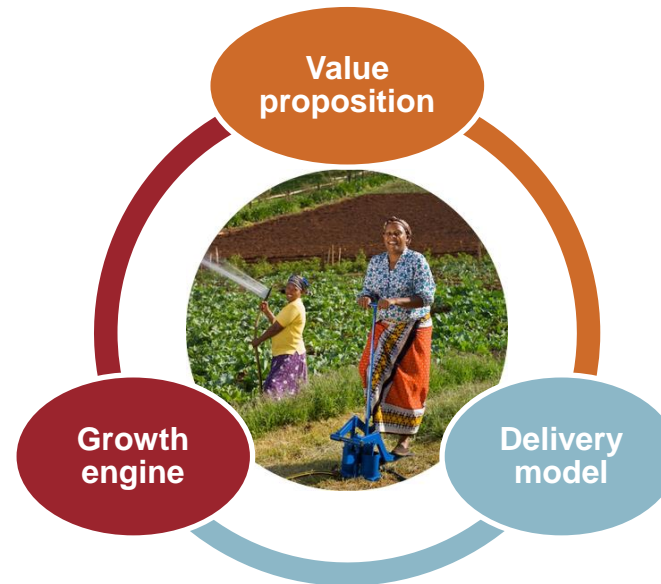
KickStart has recently launched its Rent-to-Try-&Buy (R2T&B) pilot which allows irrigation agents to rent irrigation pumps to SSPs while incentivizing pump purchases

On top of its commercial and institutional sales, KickStart is also innovating and piloting a Rent-to-Try-&Buy (R2T&B) model, in which **entrepreneurial irrigation agents buy or rent** a small number of pumps. The agents **rent-out these pumps to SSPs and train the SSPs** to irrigate crops and make money with the pumps. Some of the SSPs who rent pumps then use their new farming profits to **buy their own new pumps**. The agents earn the **rental fees** and also a commission from the retailer/distributor for every pump that an SSP buys.

KickStart is **piloting the R2T&B model in parallel in Central Kenya** (in partnership with LDRI, a non-profit) **and in Kisumu** (with Tupande by One Acre Fund, in a project funded by the Skoll and Mastercard foundations). Additionally to pump sales, Tupande benefits from this partnership by selling more inputs during the dry season: the agents also earn a commission (5%) on the inputs bought by their SSPs.

SSPs can rent KickStart's manual pumps from irrigation agents, for a **\$1-\$4 per day rental fee**. In the future, agents can also provide other services to SSPs like well drilling, building vertical gardens, etc.

- The model will enable KickStart to sell more pumps, and **empower many more SSPs to irrigate and be trained on irrigation and agricultural practices**, while **promoting youth and women employment** for the agents.
- **At scale, the irrigation agents should be fully profitable** and the partners will earn income from the pump loans/rent and increased sales, but the model requires donor funding to develop and prove, and as yet it is unknown if rental/interest fees can, at-scale, be sufficient enough to cover programme overheads.



- KickStart and partner staff recruit **irrigation agents** aged 18-35 within communities, who **either buy on-credit or rent** (at ~\$17-\$32 per month/pump) 4-6 manual pumps.
- The agent **on-rents the pumps to SSPs** as a trial. The agent earns the **rental fees and also a commission** (~8%) if he/she convinces the SSPs to buy a pump from a partner/retailer. The objective is for **agents to make over \$150** in net monthly income out of this entrepreneurial activity (which is equivalent to that of a moto-taxi).



Short description

SunCulture is a Kenya-based company specializing in solar irrigation. Founded in 2012, the company **has sold more than 40k solar pumps in 6 countries**, with products tailored to SSPs with **farms between 1 and 3 acres**. Thanks to its pioneering use of PayGo, coined as **Pay-As-You-Grow** by the company, which enables the SSP to repay the pump monthly, and integrating installation and aftersales service into the base cost of the systems, SunCulture has become the **market leader for small-scale solar irrigation with financing** in SSA.



Key data

- Date of creation: 2012
- Countries of operation: Kenya, Uganda, Ivory Coast, Togo, Ethiopia, Zambia
- Model: Solar pumps with financing
- SSPs reached: > 40k
- Average irrigated area: 2 acres



SunCulture's pump with sprinklers, Credit: SunCulture



Key insights

By pioneering the use of PayGo financing, SunCulture was able to prove that first-time irrigators are willing to invest into quality solar pumps

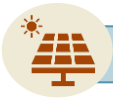
- SunCulture has sold over 40,000 solar water pumps since 2016 (75% since 2020), and has become SSA's leading provider of small-scale pumps with financing
- The vast majority of SunCulture's customers never invested in irrigation before

Reducing the price of the pump by 30% yields a +4x increase in sales, according to market tests done by SunCulture, which is betting on carbon finance and results-based financing to achieve this price reduction without sacrificing its gross margin

The current process for certifying carbon credits from emissions avoided by solar vs. motor pumps is lengthy and expensive (>\$200k per country), creates barriers to entry for new players, and could eventually lead to market distortion

Lack of access to water due to increasingly erratic weather patterns can potentially limit growth, as more and more failed rainy seasons can cause shallow wells to run dry and SSPs to default on their payments

To maximize impact for farmers and improve repayment rates, **SunCulture is building partnerships with other value-chain actors**, such as input providers and off-takers, and plans to leverage its mobile platform as a marketplace to match farmers with other service providers



Value proposition

Product offering and target customers

SunCulture originally designed a **product range as standardized as possible** to reduce costs and streamline installation. Its products are **targeting the typical SSP in Kenya** with a 1.2 acre average farm size. The company is now planning to diversify into a wider range of pumps. **Most clients (84%) are first-time irrigators** (moving from no/rudimentary irrigation); a minority were using motor pumps.

SunCulture offers the below product range and target pricing for cash sales*:

- **ClimateSmart Direct + RainMaker2**, irrigating up to 1 acre with a flow rate of 800 L/h, sold at \$315
- **ClimateSmart Direct + RainMaker 2C Kubwa**, irrigating up to 3 acres with a flow rate of 1500 L/h, sold at \$560
- **ClimateSmart Battery + RainMaker2**, which includes a 15 Ah Li Ion battery with 4 LED bulbs and USB charging ports, sold at \$770
- **TV add-on** sold at \$210
- **500m2 drip kit add-on** sold at \$133

Financing through PAYGrow adds between **30% and 34%** of total interest on top of the cash prices over 24 to 36 months. SunCulture's ability to access **lower cost of capital** would allow the company to **reduce this percentage**.

Pumps are IoT-enabled so that SunCulture can remotely monitor the usage and water resource levels, with live troubleshooting. Text messaging or the SunCulture mobile app regularly provides **agro-training recommendations** to SSPs. SunCulture plans to integrate weather forecasts, advice for irrigation planning and a marketplace for inputs into its mobile app by 2024.

Financing

SunCulture started offering a **PayGo** option in 2018. SSPs pay a **~10% deposit** and fixed monthly repayments over **24 to 36 months** via mobile money, with a monthly interest rate between **2.5 and 3%**. The company is currently **selling 85% of the pumps through PayGo**.

When payment is overdue for more than 15 days, SunCulture **remotely blocks the pump** and grants the SSP **3 months to resume payments** before a specialized team repossesses the pump. SunCulture reconditions repossessed pumps and sells them cash with a 50% discount and a 1-year guarantee, with demand for these refurbished pumps outstripping supply. The company is planning to better adapt its repayment plan to harvests to limit repayment issues.



Customer satisfaction and impact

Customer feedback is collected through the SunCulture app, and thanks to support from its investors or donors, **60 Decibels** has so far carried out 5 studies of SunCulture customers since 2020, which show that:

- Over 80% of SSPs report improved quality of life and way of farming or increased production and money earned
- 84% of surveyed SSPs in 2022 (vs. 99% in 2020) were accessing irrigation for the first time.

While data from 60 Decibels indicates that most **aftersales challenges are linked to product component issues**, the main issue reported by SunCulture staff is the absence of accessible water for the SSP (for instance as shallow wells run out), which can happen after an extended period of drought and could result in payment default and repossession of the system.

Aquaculture fishpond filled with a SunCulture's pump in Kisumu (Kenya)

*At the time of writing SunCulture had an ongoing a price elasticity initiative which made its retail prices fluctuate. Above pricing was communicated as SunCulture's target, depending on trends in voluntary carbon market and results-based finance.



Delivery model

Prospection

- SunCulture has opened **15 branches across Kenya**, which serve sales and service centers for its distributed customer base. SunCulture's **240+ independent field agents** go door-to-door and organize events with groups of SSPs. To **prevent agents from overselling systems through PayGo to customers who are not credit worthy**, SunCulture only pays upfront 50% of their commission on credit sales whereas the company pays the remainder after 2 months provided their customers have been able to make their first payments.
- **SunCulture encourages word-of-mouth via a referral system** in which current customers are rewarded with a \$8 credit on their repayment after a new buyer they have recommended over phone or through via the SunCulture app has make the down-payment to purchase an irrigation system.
- A 17-staff strong **call center** also follows up with people who indicate interest through social networks, such as Messenger, after hearing about the pumps online (e.g., on media platforms such as Youtube).

Sales & Installation

- Once SunCulture has logged a prospect in its system, a relationship manager performs a **site assessment over the phone**, to assess which product best suits the SSP needs. SSPs are also able to ask for an on-site visit for a small fee (c. \$17). **10 to 30% of SSPs are discarded due to the water source expected to run dry during the dry season.**
- **If the customer applies for financing, the relationship manager first checks the Credit Reference Bureau** (a public database of credit-risk rating) against the customers' biodata and goes through a Customer Data Survey to ensure credit worthiness, then confirms with technical staff the viability of site assessment before approving the loan.
- Once the relationship manager has approved the credit and received the deposit, SunCulture dispatches the product either to the nearest courier site or directly to the farm, for an additional fee. **One of 32 engineers** (17 full-time and 15 part-time) **subsequently visits the farm** to verify that the data provided by the SSP during the initial phone call were correct, install and test the pump, and train the customer on operation and basic maintenance.
- **SunCulture operates directly in Uganda** through a fully-owned subsidiary, and has set up a **joint venture with EDF in Ivory Coast.**
- **In Ethiopia, Zambia and Togo, SunCulture works with distributors** who may themselves offer financing.

After-sales service

SunCulture **guarantees the solar irrigation system for 3 years**, while the add-ons (drip and TV) are guaranteed for 2 years. After the guarantee, after-sales service is freely accessible but SSPs either need to purchase a warranty extension or pay the costs associated with product repairs.



SunCulture's branch in Kisumu (Kenya)

SunCulture is currently fundraising to accelerate its growth



Impact, scale & economic sustainability

- Since 2016, SunCulture has sold more than 40k units in 6 countries; **70% of total sales have been in Kenya**. 75% of these units were sold in the last 2.5 years.
- SunCulture's ongoing **Series B round of fundraising** is aiming to accelerate its growth through **deeper penetration** in existing markets, **opening directly** in new markets, and **establishing partnerships** with new distributors for expansion in new countries.
- **The company also plans to boost its sales by leveraging carbon finance to reduce the pump price**. An in-house pilot allowed to show a **high price elasticity for solar pumps**, after a 30% reduction in price yielded a 4.3x increase in sales. SunCulture has worked with industry standards organization Verra on a methodology to issue carbon credits annually. Based on the current price of carbon credit on the voluntary market (c. 10\$/unit), **this would allow SunCulture to reduce customer prices by at least 17%**. SunCulture benefited from its funders to engage in this lengthy and expensive process for certifying carbon credits (**more than 2 years and >\$200k for only one country, Kenya**). A carbon price of \$30, or a lower carbon price with results-based financing, would allow SunCulture to scale significantly faster.
- The team has also identified **market access** for SSPs as a potential lever for scale and impact, and has started to build partnerships with buyers of produce, and plans to leverage their mobile app as a platform to match SSPs with buyers.

The Cizo program in Togo - a successful RBF partnership with BBoxx

Financed by AfDB and EIB (amongst others) and piloted by the Togo government, the CIZO program was extended in 2020 from solar home systems to solar irrigation. The **first phase of the joint partnership between EDF, SunCulture, Bboxx and the Togo government aimed to sell 5k solar pumps with PayGo financing**. The program provides a **50% subsidy on both the deposit and monthly fees**: each 50% payment from a customer registered on the CIZO platform to the distributor (Bboxx) releases an equivalent payment from the government through mobile money.

Over 2 years, SunCulture/Bboxx have installed nearly 4k solar irrigation systems in Togo thanks to this **successful results-based financing program**. Combining RBF and a PayGo platform is an efficient way to ensure that the distributor is 100% focused on scaling its sales and operations (not distracted by administrative tasks), while reducing the risk of corruption and payment delays as **100% of subsidy directly reduces price for the end consumer**.

Flyer SunCulture/Bbox in Togo



Stable Foods offers complete de-risking for farmers, and is extending into market access to guarantee mutual success



Short description

Stable Foods is a Kenya-based company providing irrigation through a fixed solar irrigation system and drip lines connected to several farms, while offering a purchasing agreement to farmers. The company currently operates 3 sites covering 45 acres, with two models: Lease & Operate, for which it leases and cultivates the land, and Irrigation as a service, under which it sells water to SSPs on a subscription basis. Its broader aim is to reduce food insecurity through climate friendly practices.



Key data

- Date of creation: 2021
- Countries of operation: Kenya
- Model: Utility outgrower
- SSPs reached: c. 45 out of 120 target on current sites
- Average farm size: ½ - 1 acre



Stable Foods team, Credit: TechCabal/Stable Foods

Value proposition

Stable Foods is currently offering 2 models:

- **Lease & Operate (L&O)**: Stable Foods leases and cultivates the land for the SSPs. Stable Foods encourages on-the-job agro-training so that farmers can graduate to the laaS model, thereby capturing more of the value while reducing operational costs
- **Irrigation-as-a-Service**: SSPs pay for water (\$42/acre/month) with at least 6 payments per year. Inputs and market access can be provided on demand.

To create the most value for both SSPs and itself, the company has recently launched a third model, **Irrigation Jumla**, in which Stable Foods provides **water and inputs on credit** (20% down payment) and **guarantees crop purchase with a floor price**.



Key insights

By embedding market access in its value proposition, Stable Foods reduces the risk for SSPs, guarantees a high ROI (min. 2-3 times more revenue) and embeds its success with the SSPs'

Stable Foods' model creates a direct incentive for the company to use water as efficiently as possible (all through drip) to connect more SSPs to the same site



Delivery model

- Stable Foods is using its community relation team to find suitable areas for a new site and **convince enough SSPs to subscribe to the model** (minimum of 10 acres in total). The company then installs the irrigation system with a solar pump (surface, or submersible with a borehole) and drip lines on farms of the SSPs who signed off. Each site is protected by a security guard at night to deter theft
- Agronomist visits each farm once a week to ensure cultural activities are done correctly
- The **crops are mainly sold on the local market in 3 owned shops** (highest margin), with surplus sold to agro-buyers via a middle-man.



Impact, Scale & Sustainability

- Thanks to the embedded market access, the **SSPs are ensured to increase their revenue** by at least 2-3 times
- The company is aiming to reduce the proportion of land under the L&O model, by promoting the outgrower utility model (Jumla) which both reduces operational costs and ensures more added value for the SSP
- After closing a pre-seed of \$600k, **Stable Foods is looking to raise \$1.5m** to open 3-4 additional sites in other Kenyan counties in the next 2 years, before replicating the model in neighboring countries

Bibliography (1/3)

Authors	Reference name	Year
60decibels	Uses and impact of solar water pumps	2021
Abebe, F. et al.	The influences on farmers' planned and actual farm adaptation decisions: Evidence from small-scale irrigation schemes in South-Eastern Africa	2022
African Union	Framework for Irrigation Development and Agricultural Water Management in Africa	2020
Agula, C. et al.	Enhancing healthy ecosystems in northern Ghana through eco-friendly farm-based practices: insights from irrigation scheme-types	2019
Altchenko, Y. et al.	Mapping irrigation potential from renewable groundwater in Africa—a quantitative hydrological approach	2015
Bacha, D. et al.	Impact of small-scale irrigation on household poverty: empirical evidence from the Ambo district in Ethiopia. Irrigation and Drainage	2011
Bhattarai, M. and Narayanamoorthy, A.	Impact of irrigation on rural poverty in India: an aggregate panel-data analysis	2003
Bjornlund et al	Profitability and productivity barriers and opportunities in small-scale irrigation schemes	2017
Burney, J. A. and Naylor, R. L.	Smallholder irrigation as a poverty alleviation tool in Sub-Saharan Africa	2012
Dabi, N. et al.	Soil and water conservation practices on crop productivity and its economic implications in Ethiopia: A review	2017
Dalberg	Achieving Food Security in Kenya Through Smart Solar Irrigation	2020
de Bont, C., et al.	Neither modern nor traditional: Farmer-led irrigation development in Kilimanjaro Region, Tanzania	2019
DIE	Public-private partnerships in irrigation – how can smallholders benefit?	2020
Dillon, A.	The effect of irrigation on poverty reduction, asset accumulation, and informal insurance: Evidence from Northern Mali	2011
Efficiency for Access	Solar Water Pump Outlook : Global Trends and Market Opportunities	2019
Fan, S., et al.	Investment, subsidies, and pro-poor growth in rural India	2008
FAO	Irrigation Techniques for Small-scale Farmers	2014
FAO	Review of water control technologies in the FAO programmes for food security	2011
FAO/SEI	Investing in agricultural water management pathways to a sustainable future	2022
ILSSI	Annual report FY 22	2022
ILSSI	ILSSI March 2023 symposium Program	2023
Gebreyohannes, T. et al.	Application of a spatially distributed water balance model for assessing surface water and groundwater resources in the Geba basin, Tigray, Ethiopia.	2013
Giordano, M. et al.	Beyond 'more crop per drop'	2017
Grassini, P. et al.	Distinguishing between yield advances and yield plateaus in historical crop production trends.	2013
Growth Research Programme	Farmer-led irrigation in sub-Saharan Africa: building on farmer initiatives	2019
Haile, B. et al.	Hierarchical Modelling of Small-Scale Irrigation: Constraints and Opportunities for Adoption in Sub-Saharan Africa	2022
Haji, J. et al.	Impact analysis of Mede Telila small scale irrigation scheme on house poverty alleviation: case of Gorogutu district in eastern Haratghe Oromia national regional state Ethiopia	2013
Hanjra, M. A., et al.	Pathways to breaking the poverty trap in Ethiopia: Investments in agricultural water, education, and markets (a & b)	2009
Huang, Q. et al.	Irrigation, poverty and inequality in rural China	2005
Huang, Q. et al.	Pump-set clusters in China: Explaining the organization of the industry that revolutionized Asian agriculture	2007
Hussain, I. and Hanjra, M.A.	Does irrigation water matter for rural poverty alleviation? Evidence from South and South-East Asia	2003

Bibliography (2/3)

Authors	Reference name	Year
Hussain, I. and Hanjra, M. A.	Irrigation and poverty alleviation: review of the empirical evidence. Irrigation and drainage	2004
Hussain, I. and Wijerathna, D.	Irrigation and income-poverty alleviation: a comparative analysis of irrigation systems in developing Asia	2004
IDE	Transforming smallholder irrigation – Final Report	2018
IFAD	Handbook for Scaling irrigation systems	2022
IFPRI	Sustainable and equitable growth in farmer-led irrigation in Sub-Saharan Africa: What will it take?	2019
ICBA	Scaling up small-scale irrigation technologies for improving food in Sub-Saharan Africa	2021
IWMI	Sustainable groundwater development for improved livelihoods in Sub-Saharan Africa	2018
IWMI	Improving the Availability and Effectiveness of Rural and “Micro” Finance for Small-scale Irrigation in Sub-Saharan Africa: A Review of Lessons Learned	2018
IWMI	Choice of Irrigation Technology: Opportunities and Constraints for Adoption of Agricultural Water Pumping Technologies by Small Farmers in Cooch Behar District, India	2012
IWMI	Irrigation potential in Ethiopia Constraints and opportunities for enhancing the system	2010
IWMI	Supporting smallholder private pump irrigation in sub- Saharan Africa	2011
IWMI	Water Lifting Irrigation Technology Adoption in Ethiopia: Challenges and Opportunities	2012
IWMI	Increasing access to water for smallholders in sub-Saharan Africa- Irrigation Service Providers A Business Plan	2012
IWMI	Water for food, nature and rural livelihoods	2000
Jambo Y. and Alemu A.	Impact of small-scale irrigation on household food security: evidence from Ethiopia	2021
Kadigi, RMJ	Irrigation and Water use Efficiency in Sub-Saharan Africa	2019
Lefore et al.	Solar for all: A framework to deliver inclusive and environmentally sustainable solar irrigation for smallholder agriculture	2022
MacDonald, A.M. et al.	Quantitative maps of groundwater resources in Africa	2012
Maepa, M. A. et al.	Is the Revitalisation of Smallholder Irrigation Schemes (RESIS) programme in South Africa a viable option for smallholder irrigation development?.	2014
Mhembwe, S. et al.	The contribution of small-scale rural irrigation schemes towards food security of smallholder farmers in Zimbabwe	2019
Mkanthama, J. et al.	Technical efficiency of rainfed and irrigated rice production in Tanzania.	2018
Moyo, T. and Macheche, C. L.	The relationship between smallholder irrigation and household food availability and dietary diversity in Greater Tzaneen Municipality of Limpopo Province, South Africa	2016
Mupaso, N. et al.	Smallholder irrigation and poverty reduction in developing countries: a review	2023
Namara, R. E. et al.	Irrigation development in Ghana: Past experiences, emerging opportunities, and future directions.	2011
Olney, D. K. et al.	A 2-year integrated agriculture and nutrition and health behavior change communication program targeted to women in Burkina Faso reduces anemia, wasting, and diarrhea in children 3–12.9 months of age at baseline: A cluster-randomized controlled trial	2015
PARI Policy Brief	Small-scale irrigation potential in Sub-Saharan Africa: Targeting investments in technologies, locations and institutions	2019
Passarelli, S. et al.	Evaluating the pathways from small-scale irrigation to dietary diversity: evidence from Ethiopia and Tanzania	2018
Pingali, P. L.	Green Revolution: Impacts, limits, and the path ahead.	2012
Ringler C.	From Torrents to Trickle: Irrigation’s Future in Africa and Asia	2021
Shinkai, N. et al.	Impact of irrigation infrastructure development on dynamics of incomes and poverty: Econometric evidence using panel data from Sri Lanka	2007

Bibliography (3/3)

Authors	Reference name	Year
Siebert, Stefan, et al.	Groundwater use for irrigation—a global inventory	2010
Tesfaye, A., et al.	The impact of small-scale irrigation on household food security: The case of Filtino and Godino irrigation schemes in Ethiopia.	2008
UNEP	The Growth of Small-Scale Irrigation in Kenya	2020
Unver, O. et al.	Key and smart actions to alleviate hunger and poverty through irrigation and drainage	2016
Wageningen Uni.	Drip irrigation for smallholder farmers	2020
Ward, F. A. et al.	Water allocation rules in Afghanistan for improved food security. Food Security	2013
Wichelns, D.	Investing in small, private irrigation to increase production and enhance livelihoods	2014
Wiggins, S.	African agricultural development: Lessons and challenges.	2014
Williams, T. O.	Reconciling food and water security objectives of MENA and Sub-Saharan Africa: Is there a role for large-scale agricultural investments?	2015
Wondimagegnhu, B. A. and Bogale, B. A.	Small-scale irrigation and its effect on food security of rural households in North-West Ethiopia: a comparative analysis.	2020
World Bank	The Farmer-led Irrigation Development Guide	2021
World Bank	Assessment of Groundwater Challenges & Opportunities in Support of Sustainable Development in Sub-Saharan Africa	2018
Xie, H. et al.	Can Sub-Saharan Africa feed itself? The role of irrigation development in the region's drylands for food security	2018
You, L. et. al.	What Is the Irrigation Potential for Africa?	2011
Zaki, N.A. et al.	An Index-Based Approach to Assess the Water Availability for Irrigated Agriculture in Sub-Saharan Africa	2019
Zaki, N.A. et al.	Monitoring groundwater storage depletion using gravity recovery and climate experiment (GRACE) data in the semi-arid catchments	2018

Stakeholders interviewed

Name	Organisation
Abdisa Desalegn	Oromia Cooperative Bank Ethiopia
About Moeva	Kenya Ministry of Water & Sanitation and Irrigation (MoWSI)
Abraham Salomon	Agriworks
Agatha Thuo	Agriculture Sector Network, Agriculture Sector Board of Kenya Private Sector Alliance (KEPSA)
Amal Talb	World Bank
Amare Hailelassie	CGIAR
Andrew Massaro	Stable Foods
Bancy Mati	Water Research and Resource Center (WARREC)
Belete Bantero	Ethiopian Agricultural Transformation Institute
Boniface Muthusi	Juhudi Kilimo Kenya
Charlie Miller	World Bank
Claudia Ringler	IFPRI
Dagmawi Melaku	CGIAR
Daniel Waldron	Acumen
Elias Awol	Ethiopia Ministry of Agriculture
Evaline Nalwanga	Akvo Int
Festus Ademola	Kickstart
Gabriele Schwarz	Bonergie
Gabriella Izzi	World Bank
Gil Karie	Ignite Solar
Godwin Kuria Githinji	Kenya Ministry of Agriculture, Livestock, Fisheries and Co-operatives (MoALFC)
Grace Muiruri	Kenya Union of Savings and Credit Cooperatives (KUSCCO)
Hack Stiernblad	SunCulture
Hayalsew Yilma	Agriculture and Food Global Practice, World Bank
Henning Bjornlund	UniSA
Henry Davis	Davis & Shirliff
Hizkyas Dufera	Ethiopia Ministry of Irrigation and Lowlands
Hua Xie	IFPRI
Jairus Serede	Kenya National Irrigation Authority (NIA)
Jean Koostra	Kenya SNV Smart Water Agriculture program
Jeffrey Prins	IKEA Foundation
Joel Ogemb	Tupande (One Acre Fund)
Jonathan Denison	Consultant
Joy Busolo	World Bank
Lebeza Alemu	Solar Village
Leesa Shrader	Mercy Corps Agrifin
Lemi Assefa	Rensys Engineering
Lincoln Karani	Kenya Union of Savings and Credit Cooperatives (KUSCCO)

Name	Organisation
Lydia Onditi	Davis & Shirliff
Makena Ireri	GEAPP
Mamadou Dipp	USAID/Connexus (Senegal)
Mark Hemsworth	Rent-to-Own
Martin Fisher	KickStart
Maryanne Wanjiru	Kenya SNV Smart Water Agriculture program
Mekuria Tafesse	World Bank
Mikayla Czajkowski	SunCulture
Nick Brozovic	DWFI
Nicole Lefore	ILSSI
Olamide O. Bisi-Amosun	World Bank
Ollando Allan	Ministry of Agriculture (Uganda)
Oscar Walumbe	Dizengoff
Pape Mbengue	PAMECAS
Pascal Maitha	KickStart
Paul Kamoga	Aptech
Pieter Waalewijn	World Bank
Rajab Namakhola	Ministry of Agriculture (Uganda)
Rianne Teule	SNV
Richa Goyal	<i>IKEA Foundation</i>
Richard Colback	IFC
Robert Kiprotich	Juhudi Kilimo Kenya
Robert Kiteme	Kenya Council of Governors (CoG)
Samir Ibrahim	SunCulture
Sarah Alexander	SNV
Sarah Kanda	GEAPP
Thai Thi Minh	IWMI
Toby Hammond	FuturePump
Trupti Jain	Naireeta Services
Vandana Thottoli	Kenya SNV Smart Water Agriculture program
Vincent Kabuti	Kenya National Irrigation Authority (NIA)
Vincent Sseremnda	Tulima Solar
Winnie Muya	Agriculture Sector Network, Agriculture Sector Board of Kenya Private Sector Alliance (KEPSA)