



The Growth of Small-Scale Irrigation in Kenya **The Role of Private Firms in Technology Diffusion**

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The Growth of Small-Scale Irrigation in Kenya

The Role of Private Firms in Technology Diffusion

Preface

The UNEP-DTU Partnership, with support from DANIDA, is implementing a three-year project, The Technology, Markets and Investment for Low Carbon and Climate Resilient Development (TEMARIN) in two African countries, namely Kenya and Uganda. This project aims to: 1) analyse successful case studies of market-led interventions and mechanisms in Kenya, and identify key learnings; 2) support technology transfer partnerships in respect of a selected climate mitigation and adaptation technology in Uganda; and 3) understand how domestic climate-technology companies can increase their share of the global value chain and support them in doing so by co-creating knowledge and recommendations in Kenya and Uganda.

This report contributes to the first aim of the TEMARIN project through a study of the market for small-scale irrigation technologies in Kenya. It specifically analyses the strategies and capabilities of irrigation technology suppliers and their role in developing the small-scale irrigation market in the country. This includes outlining recent developments in the sector and providing an assessment of growth opportunities and business models for the diffusion of irrigation technologies to smallholder farmers. The report identifies a growing number of irrigation technology suppliers and the key drivers leading to their market entry. The idea is to improve the understanding of the role of private-sector actors in technology diffusion and market creation regarding climate adaptation of small-scale farming and to identify barriers to further market expansion. The conclusion summarizes the key findings and take-aways of the study.

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1. Introduction

Agriculture is a key factor in reducing poverty, improving food security and driving economic growth in Sub-Saharan Africa (SSA). By 2030, the agricultural sector in SSA could grow to become a USD 1 trillion market, up from USD 313 billion in 2010 (World Bank Group 2019). To realize this potential in a situation where the population is projected to increase from 1.07 billion in 2019 to 2.12 billion in 2050 (UNDESA 2019), the current low levels of agricultural productivity must increase significantly. Towards this end, it is widely believed that irrigation can have positive impacts on agricultural productivity, income and food security (Xie et al. 2018; 2014; Namara et al. 2014; Wichelns 2014; Bjornlund et al. 2017).

For African smallholders, irrigation can be considered a transformational technology for its potential to stabilize, increase and commercialize farm production, resulting in improved productivity and livelihoods. Given its great potential for expansion, it may benefit up to 369 million smallholders in the region (Xie et al. 2014). Irrigation can also reduce smallholder vulnerability to climate change by increasing resilience to drought and long-term changes in precipitation (Batchelor et al. 2018; MALF 2019). Promoting the transfer, diffusion and uptake of irrigation technologies among smallholders is therefore a central factor in addressing poverty and food insecurity in SSA.

Despite the large technical and economic potentials of irrigation, countries in SSA have failed to reap its benefits. Many public projects have underperformed, and rates of the adoption of irrigation technologies are low despite continued donor support (Harrison 2018; Belder et al. 2007; Herbert et al. 2002; Oates et al. 2015; Venot, Kuper, et al. 2017). Several factors may have contributed to the low rates of the diffusion and adoption of irrigation technologies among smallholders. These include financial (high installation costs, poor access to credit), economic (low farm profitability), technical (e.g. poor irrigation infrastructure), knowledge (lim-

ited know-how on the part of end-users, inadequate extension systems), natural (e.g. water scarcity) and market factors (poor farmer access to output and input markets, weak technology supplier base) (Herbert et al. 2002; GoK 2013; GoM 2013; GoT 2017; GoR 2012). As a result, SSA has the lowest share of arable land under irrigation of all developing regions (de Fraiture et al. 2010; You et al. 2011). Against this background, it is important to search for new and better pathways to increase the use of irrigation among African smallholders.

To address this challenge, this report focuses on the role of market factors in smallholder irrigation development, specifically regarding the market for irrigation technologies. Technology suppliers form a direct link between smallholders and the irrigation equipment they need, and they can therefore be expected to play an important role in the diffusion and adoption of irrigation technologies. Aside from delivering agricultural inputs and equipment to the market, technology suppliers have been known to perform important functions in agricultural technology diffusion and uptake, such as technology pricing and marketing, dealing with feedback from end-users, knowledge dissemination, demand articulation, network-building and capacity-building (USAID 2019; Venot and Lejars 2017). They also often have connections to actors across the value chain, such as farmers, equipment manufacturers and exporters, engineering companies, other agribusinesses, government and donors.

Yet despite the central position of technology suppliers in the agricultural innovation system (AIS) (Spielman et al. 2008; World Bank 2006), little research has been conducted on their role in irrigation development in the Global South. In a study from Morocco, Venot and Lejars (2017) showed how the dynamic and evolving network of local retailers of drip irrigation enabled its rapid extension in the Saïss region by translating the technology into the context and needs of the local farmers.

In Kenya, Bosma (2016) demonstrated the importance of technology retailers in increasing the market for petrol pumps for irrigation. And in Burkina Faso, Wanvoeke (2015) confirmed that technology suppliers are important actors that provide important services in addition to retailing equipment, while also stressing that that many of these firms rely on irrigation projects funded and established by development organizations and NGOs.

To enrich this important strand of the AIS literature, this study analyses the strategies and capabilities of irrigation technology suppliers and their role in developing the smallholder irrigation market in Kenya. This includes analysis of recent developments, growth opportunities and promising business models for the diffusion of smallholder irrigation technologies. The broader intellectual aim is to improve understanding of the role of private sector actors in the diffusion and adoption of agricultural technology in low-income and lower middle-income countries (LIC and LMICs). The practical aim is to identify new pathways for the development of small-scale irrigation technologies in SSA given the low level of their diffusion and adoption in the past in spite of large public investments.

Kenya is a suitable case to study, as the market for small-scale irrigation is relatively well-developed for SSA and because an increase in the number of market actors across the supply chain has been observed in recent years (FAO 2016; USAID 2016b) (see section 2.2).

The study is guided by the following research questions:

- How has the market for irrigation technologies developed in Kenya during the last two decades?
- What have been the drivers of the transfer, diffusion and adoption of irrigation technologies in the small-scale segment? What barriers to their further diffusion can be identified?
- How have market actors promoted irrigation technologies in the small-scale segment? Specifically, what have been the trends in, and roles of, Kenyan technology suppliers in providing irrigation technologies and related services?
- What sustainable business models can be identified in the small-scale segment?
- What future development pathways can be identified for the irrigation sector in Kenya, particularly in the small-scale segment?

In the study, we refer to private-sector suppliers of irrigation equipment, services and systems as ‘irrigation technology suppliers’ or simply ‘technology suppliers’, meaning private firms trading in and/or manufacturing equipment used in irrigation, either as their only business activity or as an important part of their businesses. This definition excludes engineering firms and consultants that do not produce or sell irrigation equipment (See section 4.1).

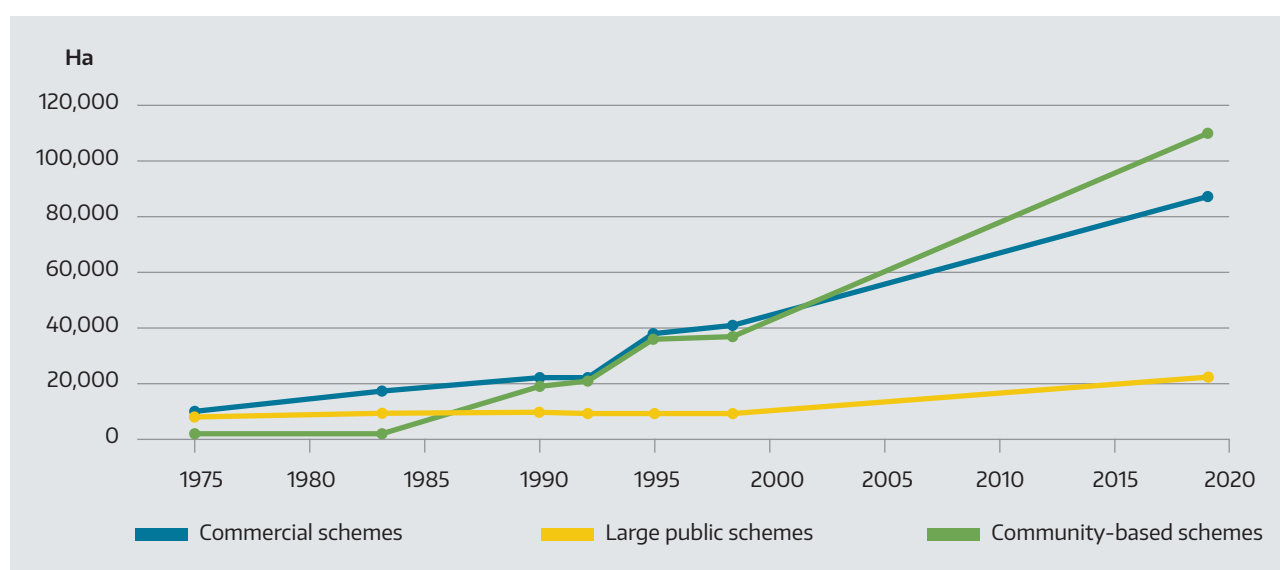
2. Characteristics of and trends in small-scale irrigation in Kenya

This section describes the context for understanding the development of the market for small-scale irrigation technologies in Kenya. This includes a summary of the social recognition of irrigation (2.1), an assessment of irrigation rates and potentials (2.2), an outline of the irrigation technologies we are focusing on and the business opportunities they represent to technology suppliers (2.3), and a breakdown of the end-users of these technologies, i.e. the smallholders (2.4). More background information can be found in the annexes to the report: Annex 1 presents a detailed description of relevant types of irrigation systems and technologies; Annex 2 outlines the components and equipment comprising an irrigation system; Annex 3 reports briefly on the role of irrigation in Kenya's agricultural development; Annex 4 introduces the types of irrigation schemes found in Kenya; and Annex 5 accounts for the status of and trends in irrigation policies and regulations.

2.1. Social recognition of irrigation in Kenya

Irrigation is widely recognized by both private and public actors as a key means to improve food security and livelihoods and foster agricultural transformation in Kenya. The technology is accordingly part of several recent visions and strategies, including Kenya's Vision 2030, the BIG4Agenda, and the Agricultural Sector Transformation and Growth Strategy (MALF 2019). Irrigation is also seen as a technology for reducing vulnerability to climate change (MALF 2017; GoK 2013; 2010). Hence, efforts to develop irrigation in Kenya are likely to receive support from a broad range of stakeholders. See Annex 5 for details.

FIGURE 1. Trends in the area under irrigation in Kenya 1975–2019.



Source: Authors' computation based on data compiled from different sources (Heyer 1976; IDB 1990; Ragwa et al. 1998; Ogombe 2000, Ngigi 2002; MoW 2019).

2.2. Irrigation rates and potential

Irrigation rates and trends

Irrigation schemes in Kenya covered 222,240 ha of land in 2018 (MWSI 2019). Figure 1 shows the trend in the growth of the area under irrigation since 1975. The figure reveals very significant growth in the total irrigated area since the late 1990s. Public or national schemes, (which are large in scale, increased from around 9,000 ha in the late 1990s to 24,240 ha in 2018 (MWSI 2019). The greatest change has occurred in private schemes (mainly large commercial farms) and community-based smallholder schemes, which have increased from around 40,000 ha in the late 1990s to respectively 88,000 ha and 110,000 ha in 2018.

We emphasize that Figure 1 is based on data collected through a review of a number of studies (Heyer 1976; MALF 1990; Ragwa et al. 1998; Ogombe 2000; Ngigi 2002; MWSI 2019), some of which may have used different methods for estimating and grouping the irrigated areas. Data from FAOSTAT, however, confirm that Kenya has increased the proportion of its land under irrigation: in 1990 the share of arable land equipped for irrigation stood at 0.99%, by 2000 it accounted for 1.58%, and in 2017 it reached 2.38% (FAO n.d.).

Irrigation rates by crop type

The current rate of irrigation varies according to crop type. In 2013, about 70% percent of rice production was irrigated (18,000 hectares (ha)), and around 20% of vegetable production (31,000 ha) (FAO 2015a). Other key crops such as coffee, fruit, sugarcane and cotton have even lower irrigation rates.

Irrigation potentials

More than 95 % of Kenya's agricultural output is grown on rain-fed farming systems, yet only 17% of the country's arable land is deemed suitable for rain-fed agriculture, while precipitation in the remaining areas is inadequate to meet crop demands (Water Resources Group 2016). In other words, 83% of Kenya's arable land needs to be irrigated to ensure biologically optimal crop growth.

There have been several assessments over the years of Kenya's irrigation potential, including by the World Bank (1989), JICA (1992; 2013), the Ministry of Agriculture, Livestock and Fisheries (MALF) (1990), the Ministry of Water, Sanitation and Irrigation (MWSI)

(2009), You et al. (2014), the FAO (2015a) and again by MWSI in 2019. The irrigation potential is calculated as the total area that can be irrigated depending on biophysical conditions, including soil properties, the availability of water resources, and water requirements in the contexts of cropping and climatic conditions (FAO 1997). The irrigation potentials estimated by these assessments vary from 200,000 ha to 1,342 million ha, indicating a large scope for expanding irrigation, but also uncertainty about the exact potential. One of the most comprehensive assessments is that in the National Water Master Plan 2030 (JICA 2013), which estimates the irrigation potential to be 765,575 ha without water storage, rising to 1.2 million ha with investments in irrigation water storage.¹

Concerning the irrigation potential of small-scale farms, You et al. (2014) estimated that the potential for investment in small-scale irrigation projects ranges from 54,000 ha to 241,000 ha. The Water Resources Group (2016) is more optimistic, estimating that irrigated smallholder schemes have the potential to grow tenfold in size, from 42,000 ha to 419,000 ha in the case of drip irrigation, and from 14,000 ha to 140,000 ha for sprinkler irrigation. With further infra-structural investments, the irrigated area could grow tenfold to 1.3 million ha (ibid.). FAO (2015a) confirms Kenya's great potential for expanding smallholder irrigation.

2.3. Irrigation technologies for smallholders

Traditional smallholder irrigation practices in Kenya consist of manually fetching water from a river or other body of water, or using gravitational furrow systems. These practices are very labour-intensive, which limits the irrigated area. They also require few materials or equipment, which make them less interesting for technology suppliers. Modern small-scale irrigation technologies, on the other hand, represent more business opportunities for the private sector. These technologies include drip and sprinkler irrigation, as well as enabling components, notably water pumps (solar-, fuel- and grid-powered pumps) and water storage facilities, especially water tanks and dam liners for surface water storage and harvesting.

¹ This assessment is based on a participatory process with key stakeholders in the water and irrigation sector.

In Kenya, sprinkler irrigation was introduced in 1975 with a pilot scheme, the Kibirigwi Irrigation Scheme (Mwangi 1983), and through the 1970s and 1980s irrigation was used on coffee and pineapple plantations (Herbert et al. 2002). Then followed large-scale sprinkler and drip irrigation of vegetables and flowers in the late 1980s and early 1990s. Early activities with small-scale drip irrigation were carried out by Christian missionaries (Good Samaritan) from 1988 onwards. In 1996, the Kenya Agricultural Research Institute (KARI) became involved in small-scale drip irrigation through a community-development program in Eldoret (Sijali et al. 2002). With support from USAID and the World Bank, KARI played the leading role in testing, developing and distributing drip kits during this period (Keller 2014). By 2001, KARI had sold around 5000 kits to smallholder farmers, the majority being supplied to farmers through small-scale irrigation projects involving donors, NGOs and government agencies.

During the 1990s a perception developed among stakeholders in Kenya that drip irrigation was effective in enabling agricultural intensification, saving water and improving incomes (Postel et al. 2001; Burney et al. 2013). This contributed to the creation of a positive agenda for drip irrigation that motivated many donors and NGOs to disseminate drip technologies through projects, especially in the arid- and semi-arid (ASAL) regions of the country (Sijali et al. 2002). A similar development was seen in other SSA countries (Wanvoeke et al. 2017; Garb et al. 2014). The trends in drip-irrigation projects resemble those observed for other small-scale irrigation technologies, in particular sprinkler irrigation and, more recently, solar PV pumps.

Kenya nonetheless has a relatively well-developed market for agricultural irrigation compared to many other countries in SSA. Recent decades have seen an increasing number of market actors entering the supply chain, including many new technology suppliers catering for the small-scale segment (FAO 2015a; USAID 2016b). In the future private agri-business firms are also likely to be important as suppliers of technologies, services and expert knowledge in the small-scale segment. In this regard, the Water Resources Group (2016) estimates that the expansion of smallholder irrigation schemes represents a potential market of USD 236 million and USD 79 million per year for drip and sprinkler irrigation technologies respectively. This opportunity for private-sector investment in small-scale irrigation has been confirmed by FAO (2015a) and USAID (2016b).

2.4. Farmer stratification in relation to irrigation

To understand properly who are the users of irrigation technologies, that is, the key customers in the market, a breakdown of farmers is needed. We consider two approaches in this regard: farm size, and level of commercialization.

Stratification based on farm size

There is no universal definition of "smallholder"² (FAO 2015b). Farm size is often used as the scale on which to distinguish between smallholders and large-scale farmers, many studies using two hectares as the threshold (Khalil et al. 2017). However, classifying farms according to size varies across countries depending on agro-ecological, technological, economic and demographic conditions. In Kenya, MALF (2019) defines smallholder farmers as those working land between 0.5 and 5 ha. However, socio-economic conditions, levels of commercialization and technological preferences are likely to be very different for a farm of 5 ha than for one of 0.5 ha. Hence, the MALF definition of smallholders gives a very granular picture of Kenyan farmers, a finer scale being needed to classify farmers by their demand for irrigation technologies. According to the World Bank Group (2019), 87 percent of farmers work less than 2 ha of land, 67 percent less than 1 ha. This pattern is reflected in a low average farm size, ranging between 0.47 ha (USAID 2016b)³ and 1.2 ha (FAO 2015b), depending on what source is used. Regionally, average small-scale farms are about half the size of those in two of Kenya's neighbours, Ethiopia and Tanzania, reflecting a high level of fragmentation of Kenya's farmland (USAID 2016b). Based on these figures, it seems reasonable to state that most Kenyan smallholders have farms in the 0.5 – 1.0 ha range, i.e. the lower end of MALF's definition of smallholders.

² In the report, we use "small-scale farmer" and "smallholder" interchangeably, notwithstanding the possibility that the different semantics could imply some difference in their definitions.

³ In Kenya, land is often inherited on a paternal lineage and divided between siblings. Such a land tenure system combined with high fertility rates, explains why Kenya's agricultural land has become increasingly fragmented within a few generations.

In the context of irrigation technology, several interviewees defined smallholders using an upper threshold of 3 ha. The size of the plots irrigated by smallholders is often much smaller than their whole farm. For example, the drip kits sold by the irrigation companies typically cover an area of 1/8 acre (0.05 ha) up to 1 acre (0.4 ha). When referring to small-scale farmers in this report, we are guided by the above figures but do not rely on a strict definition in terms of farm size.

Stratification based on market participation

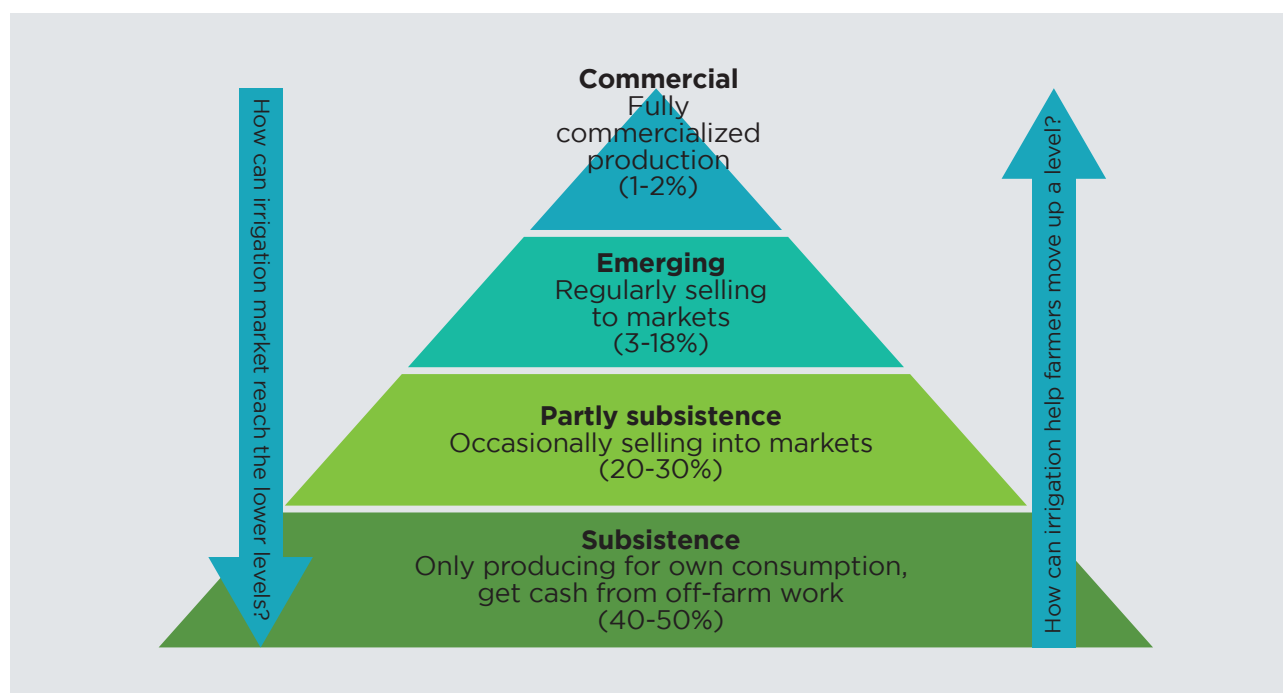
Farmers' demand for irrigation technology depends not only on farm size but also on their participation in agricultural markets. Market participation can provide both the incentive and the ability in terms of income to invest in irrigation, and different irrigation technologies may suit different types of cash crop. Segmenting or classifying farmers for purposes of providing irrigation technology can therefore also be carried out based on indicators of market participation.

In Figure 2 a simple indicator is used, namely how often (or how much of) the production is sold, ranging from subsistence farming (no sales, about half of farmers in SSA) to fully commercial farming (everything sold, 1-2% of farmers). In general, those farmers with

market-oriented production is a more attractive customer segment for technology suppliers (USAID 2016a) than subsistence-oriented farmers who cannot afford irrigation equipment such as solar pumps and drip kits. Yet the framework also illustrates that the largest customer segment for irrigation equipment is not the fully commercialised farmers (possibly medium- and large-scale), but rather the 'emerging' commercial farmers who sell regularly in markets. Part-subsistence farmers with only occasional sales may also be an important customer segment, but they may demand cheaper and less advanced equipment (e.g. small drip kits, hosepipes), although the framework does not make such distinctions.

The framework in Figure 2 may also be used strategically in the development of the irrigation sector, applying two perspectives (illustrated by the vertical arrows). From a business perspective, the question is: How can business models for irrigation technologies be developed that increase sales to less commercial farmers (moving down the triangle)? While from a development perspective, the question is: How can irrigation help farmers become more commercial (moving up the triangle)? We return to these questions in later chapters.

FIGURE 2. Farmer stratification by market participation. The numbers in parentheses refer to the share of farmers who fall into each category and are estimates for Sub-Saharan Africa.



Source: adapted from Seville et al. (2011).



2.5. Summary of characteristics and trends in small-scale irrigation

- The importance of irrigation for agricultural development enjoys broad social recognition, in Kenya and irrigation is part of several recent policy strategies.
- In Kenya, there has been an increase in the area under irrigation since the late 1990s, driven by a growth in large-scale commercial farms, community-based schemes, and to a lesser extent private small- to medium-scale farmers.
- Our interviews revealed that many farmers in Kenya aspire to adopt irrigation technologies. As 8.6 million small-scale farmers using rain-fed agriculture (MALF 2019), which produces the majority of Kenya's agricultural output, the potential for expanding irrigation within this farm segment seems very large. Increasing irrigation would raise agricultural productivity significantly, especially among smallholders, and further develop the market for irrigation technologies.
- Assessments of the irrigation potential reveal a large scope for expanding irrigation in Kenya. Assessments vary from 200,000 ha to 1,342 million ha, with the National Water Master Plan estimating the potential at 765,575 ha (without water storage) and 1.2 million ha (with investment in water storage).

3. Research methodology

This report is based on primary and secondary data collected between November 2019 and January 2020. The focus of the data collection was Kenya, where the irrigation market and the political and institutional frameworks are more dynamic and developed than in many other countries in SSA. Of particular interest is the fact that a growing number of market actors along the supply chain for irrigation technologies and services have been observed in Kenya in recent years (FAO 2015a; USAID 2016b). Kenya is moreover characterized by poor conditions for rain-fed farming, as much of its territory lies in arid and semi-arid regions.

Data collection

Data collection was done in five phases:

First, a desk review of secondary data was conducted to acquire a contextual understanding of the research topic and to refine the problem being addressed, namely how the market for irrigation technologies has developed, as

well as to highlight the associated challenges. Through this assessment we identified the primary data and information needed for the deeper analysis.

Second, the desk review helped identify key stakeholders and informants for subsequent interviews, listed in Table 1 below. We identified five types of stakeholders in the Kenyan irrigation sector. From a value chain perspective (Bolwig et al. 2010), the first two, the end-users and the technology suppliers, are directly engaged in the value chain for irrigation equipment ('value chain actors'), while the other three provide financial, organisational and regulatory resources and knowledge to the value chain ('external actors'). The focus of the data collection was on technology suppliers, farmers and financiers given the market focus of the study. Public agencies and research institutions were also important sources of information, regarding especially the role of the public sector and in terms of getting a broader understanding of irrigation development in Kenya.

TABLE 1. Typology of stakeholders in the Kenyan irrigation sector

No.	Category	Description
1.	End-users	Individual small-scale farmers or farming communities (associations, cooperatives) that acquire and use irrigation technologies.
2.	Technology suppliers	Retailers, wholesalers, manufacturers, consultants and other firms that design, produce, sell, install and maintain irrigation equipment and irrigation systems to and for small-scale farmers (and other farmers).
3.	Financiers	Organizations providing finance to end-users to purchase and maintain irrigation equipment, i.e. commercial banks, donors, NGOs (using donor funds), or micro-finance institutions (MFI).
4.	Public-sector, donor and civil-society organizations	Public-sector and civil-society entities involved with the irrigation sector, policy-makers, regulatory authorities (irrigation authority), implementing agencies, and entities such as donors and NGOs providing capacity-building and other forms of support to farmers. This category also includes water-user associations (WUA) that influence farmers' access to irrigation water.
5.	Research institutions	Organizations and individuals focusing on irrigation research or having significant expertise in the sector.



Third, an interview guide was developed for each type of stakeholder, based on insights obtained from the desk review. The guides were continuously revised as more data were gathered in order to capture more relevant and targeted responses whenever possible.

Fourth, interviews with stakeholders were undertaken by Skype or phone, as well as in-person during a two-week field trip to Nairobi from 12 to 25 January 2020. The interviews were scheduled through email, phone or WhatsApp. In total, interviews with 27 informants were conducted, two online interviews carried out prior to the fieldwork and one afterwards. The remaining 24 interviews were in-person in Kenya. These included 22 semi-structured interviews (including three group interviews) and three informal interviews (conversations with farmers). Annex 6 lists all the interviewees. The semi-structured interviews were recorded and supplemented by notetaking during the interview. Follow-up emails were sent out to some interviewees to clarify issues and collect missing data.

Fifth, nineteen firms providing irrigation technologies in Kenya were identified through a comprehensive snowballing search using document analysis, internet searches and key informant interviews. See Table 5.

Data limitations

It would go beyond the scope of this study to establish a quantitative assessment of the irrigation sector in terms of the respective market shares, revenues and sales of all technology suppliers. The nineteen technology suppliers identified by the study are deemed to include the vast majority of such firms operating in Kenya at present and all of the large firms (six in total).

Data analysis

The interviews were recorded and supplemented by extensive notetaking. The interviews were then transcribed and subsequently analysed to identify patterns, barriers and enabling conditions for irrigation development, to describe how the irrigation market is organized and to identify the factors responsible for the development of the irrigation market and the diffusion of irrigation technologies.

4. Mapping of actors in Kenya's irrigation market

This section provides an overview of the market for irrigation technologies in Kenya based on interviews with stakeholders in Kenya, supplemented with secondary data.

4.1. Actors' roles in developing irrigation schemes

The development of a market for irrigation equipment and services in Kenya has so far been driven mainly by donor- or government-supported irrigation schemes.

Compared to a situation in which a technology provider sells equipment directly to an individual farmer, the establishment of larger irrigation schemes involves several more stakeholders (actors) than just sellers and buyers of equipment. While sales to government- and donor-supported irrigation projects constitute a considerable share of total sales, especially in the small-scale segment, direct sales to farmers are also an important source of revenue for technology suppliers.

Box I: The Karia irrigation scheme: a community-based scheme

At Karia in Kirinyaga County, a group of farmers sought consultation with county irrigation officers in an effort to improve and expand irrigation. The group was advised to register as a member of the local water-users' association so as to be licensed to extract water from the river Rutui, and they were introduced to the small-scale 'Mt. Kenya' irrigation programme, a joint venture between the German development bank (KfW) and the government of Kenya to assist smallholders with irrigation water. In June 2014, 307 members registered the group as the Karia Irrigation Farmer Cooperative Society Ltd. To become eligible for the programme, farmers had to raise 10% of the total project cost, or KSH 36 million. Financing of the project consisted of a 50% grant provided by KfW through the government of Kenya and a 50% loan from Equity Bank at a 12% interest rate and with a five-year payback time and an initial two-year grace period of paying only interest. The project was to construct a conveyance system consisting of the installation of 1.2 km of pipes and valves at each farm. As the implementing agency, the State Department for Irrigation contracted two engineering companies, AH Group (EPC) and Bhundia Associates, to provide the irrigation infrastructure.

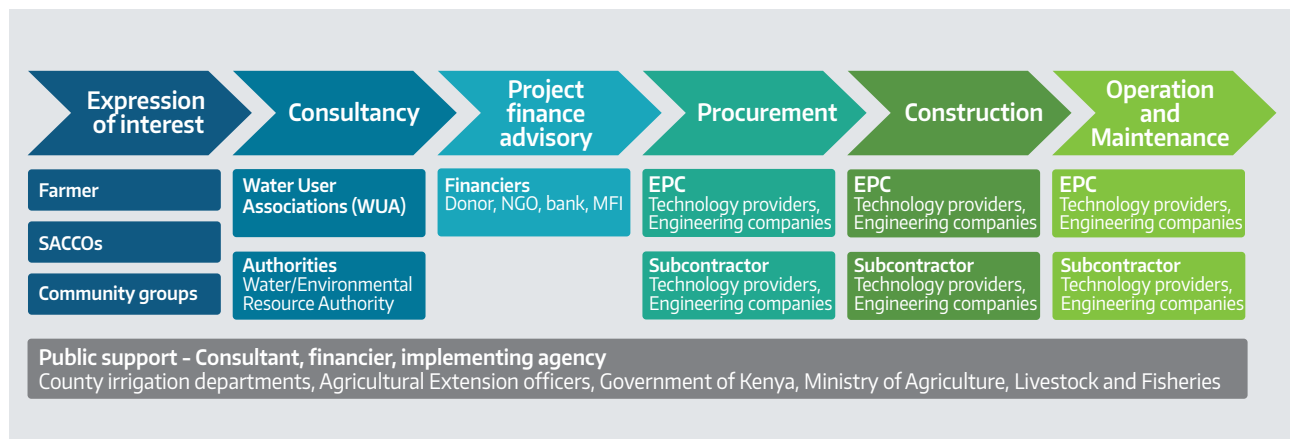
These companies also supported the technical staff who assisted the farmers group to register as a cooperative and trained farmers in the operation and maintenance of the irrigation infrastructure. On the farms sprinklers were installed and delivered by the technology provider Irrico through a tendering process.

The cooperative's committee stated that the scheme has contributed to increasing incomes and jobs and has improved the livelihoods of its members overall. Farmers have developed their farm production from staples such as maize, beans and cassava to horticultural cash crops, including greens, cabbages, bananas and sweet potatoes. Sometimes farmers have problems selling their produce, so they expressed an interest in making a formal contract with a produce buyer to ensure more stable and more reliable market access. This example illustrates the point made in this report, that the effectiveness of irrigation in improving farm productivity and livelihoods depends on the wider agricultural context in which it is applied. By February 2020, the cooperative had paid back its loan with Equity Bank, and the committee expressed an interest in upscaling by introducing a drip irrigation system. However, investment in drip kits and water tanks will require substantial new investments.

Figure 3 lists the roles of the different actors at different stages in the development and implementation of a typical irrigation scheme. It can be seen that public-sector organizations, and sometimes NGOs, play important roles in irrigation schemes, i.e. as implementing agency, permitting authority, or technical advisor, or as provider or facilitator of finance to farmers. Engineering, procurement and construction (EPC) companies, as well as subcontracted engineering companies and technology retailers, may enter the scheme's development process in the procurement phase and remain key actors in the subsequent phases. While the

engineering companies are in charge of establishing the scheme's irrigation infrastructure (e.g. the installation of conveyance systems or the preparation of furrows), technology suppliers are responsible for delivering the irrigation equipment used by the farmers, such as low-pressure systems (drip kits and water tanks) or pressurised systems (sprinklers). The case of the Karia irrigation scheme presented in Box 1 is illustrative of this. It should be noted that technology suppliers can also take on the role of an EPC, depending on the size of the scheme and on the firm's capacities.

FIGURE 3. The role of actors at different stages of irrigation scheme development and implementation. Technology suppliers as defined in this report often participate as subcontractors during the last three stages of the scheme's development.



Source: the authors.

This study addresses the market for irrigation technology (meaning physical equipment and related services) and therefore focuses on irrigation technology suppliers and their role in the small-scale irrigation market. We acknowledge that engineering companies and similar consultancy firms may be closely involved in the design of irrigation schemes, including in the choice of type of technology, and so influence the demand for specific technologies. Engineering companies are also central to providing farmers with access to irrigation water, thereby encouraging demand for their irrigation equipment and services. However, these firms were not analysed for this report.

Below we briefly discuss each actor type, following the stakeholder typology in Table 1. We focus on the pri-

vate-sector actors, i.e. the end-users, technology providers and financiers.

4.2. End-users of irrigation technologies (farmers)

Most farmers in Kenya are smallholders, as noted in section 2.4. Some of the technology retailers we interviewed said that their customers might be any smallholder with some commercial production, even if cultivating as little as 1 acre (0.4 ha), and that the majority of customers are farmers cultivating less than two acres. A seller of irrigation equipment may reach the less commercial smallholders (lower part of Figure 2) through delivery to small-scale irrigation schemes or

by selling to farmers' organizations (informal groups or more formal SACCOs) instead of to individual farmers. Hence, the technology supplier may choose to target these intermediaries instead of selling directly to farmers.

4.3. Technology suppliers

The value chain for irrigation equipment and services is well developed in Kenya, with an increasing number of technology suppliers in the market. These are retailers, wholesalers, manufacturers, consultants and other firms that design, produce, sell, install and maintain irrigation equipment and irrigation systems. Chapter 5 provides a detailed assessment of these actors.

4.4. Financiers and mode of financing

Commercial banks and micro-financial institutions

Kenya has a relatively vibrant financial market, with many commercial banks and MFIs offering agricultural loan products. Yet access to bank credit remains a key challenge for the vast majority of smallholders, who cannot pass the risk assessments of the commercial banks especially. Most commercial banks offer agricultural loans in an effort to provide credit to smallholders. The Agricultural Finance Cooperation (AFC), government-owned financial institution, offers Water Development Loans to finance irrigation systems, but with a minimum of five acres, and only for maize and wheat. Some loans are tailored to specific value chains. For example, Family Bank's Majani Plus loans are offered to farmers involved in the production of tea leaves and has a 13.5% interest rate. Others have a broader scope, such as Equity Bank's Farm-Input loan, offering credit for agricultural inputs.

In January 2020, agricultural loan products from commercial banks had an interest rate of around 13%. This rate was the result of the Kenyan government having capped the interest rates chargeable by rural and commercial banks in 2016, compared to previous interest rates of 16-24 % (FAO 2015a). Though the cap was intended to address the problem of the low affordability and availability of credit, it made banks more reluctant to lend. By the end of 2019 the cap had been repealed (Smith 2019), but the rates remained well below the previous levels in early 2020.

Box 2: Risk assessment of farmers by commercial banks

To be eligible for a loan, creditors typically assess the borrower against a set of risk assessment tools. To gauge creditworthiness, Family Bank weighs five characteristics of the borrower to estimate the chance of default and hence the risk of financial loss. This commonly applied tool, known as the "five 5Cs", assesses character (credit history), capacity (depth-to-income ratio), capital (amount of money the borrower has), collateral (assets that can serve as security for the loan) and conditions (loan specifications). Few small-scale farmers meet the criteria for obtaining a loan from commercial banks. For instance, most small-scale farmers have no banking history, limited formal collateral, and limited and seasonal cash flows, leading commercial banks to see the risk of default as a possibility.

MFIs seem to be better suited than banks to provide agricultural loans for the small-scale segment, and especially to tap into the lower level of the small-scale segment (Figure 2). In this regard, Otoo et al. (2018) argue that rural MFIs are most suitable as sources of credit for farmers seeking to invest in individual irrigation technologies. However, our interviews with technology suppliers and farmers revealed that MFIs are often not considered a feasible or attractive way to access credit for irrigation investments due to the high interest rates and unsuitable repayment terms. Hence, while in principle MFIs constitute an opportunity to finance irrigation for smallholders, they are not an option in practice given the current loan conditions, which farmers consider high-risk.

Risk is also considered a major issue by the loan taker. Farmers are risk-averse and are very reluctant to use their main fixed asset, their land, as collateral. Existing loan types offered by commercial banks and MFIs are not aligned with most farmers' needs or capacities. Although loans are packaged as agricultural loans, loan specifications such as grace periods, payback time and lack of mitigation for failed harvests are not aligned with farmers' realities.

Thus, despite a vibrant credit market, banks and MFIs are not able to offer loan products that are accessible or attractive to small-scale farmers. Overcoming the challenge of financing irrigation technologies should therefore focus on reducing or diverting risk from the perspective of both borrowers and lenders.

There are several examples of innovative Fintech⁴ solutions that try to address financing issues in agricultural supply chains using information and communication technologies (ICT). For example, Agri-wallet is a digital wallet (a mobile application) with M-pesa as the currency, providing farmers with a business account they can use to earn, buy and save money for agricultural inputs. Another example is Farm Drive, which aggregates various datasets to assess the credit-worthiness of smallholders in an effort to bridge the gap that prevents financial institutions from lending to creditworthy farmers. These solutions are interesting, as they may help increase transparency across the supply chain and reduce the financial risk to both lenders and borrowers. However, further research is needed to identify their potential for irrigation projects.

SACCOs and community groups

While few smallholders are eligible for a commercial bank loan, they may instead access credit through farmer cooperatives, NGOs, or community-based lending institutions, i.e. saving and credit cooperative organisations (SACCO) and less formal lending struc-

tures such as table banking.⁵ In fact, many small-scale farmers may have access to financial services for purchasing irrigation equipment, for example (New 2017). Based on a survey of 550 farmers spread across five counties in Kenya, Muturi et al. (2019) found that 76% of farmers could access financial services, for example, through mobile money services, SACCOs or informal saving and lending groups. Several of the technology suppliers we interviewed noted that SACCOs and other community-based lending institutions have promise as ways to enhance credit access and accelerate the development of small-scale irrigation projects.

SACCOs have played a key role in agricultural development by mobilizing savings schemes and providing credit to farmers and agri-businesses (GoK 2010).⁶ Hence, the government recognizes SACCOs and other community-based lending organizations as important institutions for increasing lending to small-scale farmers (GoK 2010). For irrigation purposes, the Kenya Union of Savings and Credit Cooperatives (KUSCCO), in collaboration with the Netherlands Development Organisation (SNV), launched a Smart Water Loan facility in 2018 to provide loans to smallholder farmers through their SACCOs at low lending rates.

⁴ The term 'Fintech' (Financial Technology) refers to software and other modern technologies used by businesses that provide automated and improved financial services. Source: <https://www.fintechweekly.com/fintech-definition>

⁵ Table Banking refers to group-based funding systems through which members of the group make continuous contributions to a fund from which members can lend. Source: <https://www.potentash.com/2017/11/01/finances-concept-table-banking-money/>

⁶ In recognition of this, the Kenyan government has made amendments to the Cooperative Societies Act of 2008. This includes formulating a new cooperative development policy (GoK 2010) and expanding the current sharing of credit information to cover SACCOs (GoK 2018) in order to guide and promote the cooperative movement in providing credit facilities.

TABLE 2. Donors active in the Kenyan irrigation sector since 2000

Multilateral	Bilateral
African Development Bank (ADB)	Danish Development Cooperation (DANIDA)
International Fund for Agricultural Development (IFAD)	United States Agency for International Development (USAID)
United States Agency for International Development (USAID)	German Development Bank (KfW)
United Nations World Food Programme (WFP)	United Nations World Food Programme (WFP)
The World Bank (WB)	Department for International Development (DfID) of the United Kingdom
	Embassy of the Kingdom of the Netherlands
	Japan International Cooperation Agency (JICA)

Source: the authors.

International development organizations

International development organizations or donor organizations have contributed significantly to the development of irrigation in Kenya. International donors have promoted irrigation technologies through development projects, such as demonstration projects, that introduce technologies to farmers. This study has identified twelve multilateral and bilateral donors that have funded irrigation-related projects in Kenya over the last two decades (Table 2).

In general, donors have increasingly emphasized a market-oriented approach with a focus on promoting the private sector and entrepreneurship by filling financial, technical and regulatory gaps (Martinot et al. 2002; Kindornay et al. 2013). This is part of a broader turn in international development cooperation towards increased support to the private sector and market-based solutions (Pedersen 2017). The context of irrigation in Kenya richly illustrates this approach. SNV has supported the Smart Water for Agriculture project on accelerating small-scale irrigation development through partnerships. USAID has assisted the private sector to scale and market agricultural technologies as part of the Feed the Future programme, while the German Development Bank (KfW) has supported irrigation schemes and offered credit to small-scale irrigation cooperatives through the Smallholder Irrigation Program Mount Kenya project. A fourth example is Danish Development Cooperation (DANIDA), which funds the Micro Enterprises Support Programme Trust (MESPT) in providing loans to financial intermediaries, specifically micro-finance institutions, for onward lending to agricultural enterprises. It also makes capacity-building grants through which financial institutions are trained in structuring appropriate and innovative financial products for smallholders related to green technologies, including drip irrigation, water-harvesting technologies and solar PV pumps.

4.5. Public-sector and civil-society organizations

The public sector: providing the institutional framework

The public sector in Kenya engages with irrigation development across different scales and sectors. Government institutions formulate and expand the policy frame-

work, manage large national irrigation schemes, build capacity (through extension services and research institutions) and act as facilitators, advisors and sometimes implementers in community-based irrigation schemes. Below the most important institutions at the national, county and local levels are discussed.

The **Ministry of Water, Sanitation and Irrigation** (MWSI) is responsible for irrigation development in Kenya. Nationally the MWSI plays an important role in formulating policies, guidelines and regulations to create an enabling environment for irrigation development. The MWSI also functions as a coordinating body for public-led irrigation development and manages, supports and facilitates irrigation schemes across the country.

The **National Irrigation Authority** (NIA), until recently the National Irrigation Board, was created in 1966 and is the public irrigation service-provider under the MWSI. With a declared vision to "water every irrigable acre", the NIA aims to provide water for sustainable farming through the development of an adequate irrigation infrastructure. A great share of the NIA's work comes under its role as the responsible body for undertaking irrigation development within seven large-scale irrigation schemes, namely the Mwea, Bura, Tana, Ahero, West Kano, Perkerra and Bunyala schemes. The NIA also develops water storage facilities for smallholder irrigation at the household level through the Household Water Harvesting Irrigation Programme, with 2,363 water pans having been completed to date. Moreover, the NIA provides technical and support services, including capacity-building and provision of infrastructure, to private and smallholder schemes through the National Expanded Irrigation Program (NEIP). Since its inception, the NEIP has overseen the development of 160 irrigation projects, placing 127,415 acres under irrigation.

County Irrigation Development Units, which operate under county governments, play an important role in many community-based smallholder irrigation schemes, as the NIA only manages irrigation schemes above a hundred acres. These units oversee these schemes through a management and facilitation role, providing advice and capacity-building for farmers and farmers' groups. They also ensure compliance with national standards, identify new community-based smallholder schemes and implement county irrigation strategies in line with national policies (MWSI 2019).

The **Water Resource Authority (WRA)** was established by the Water Act of 2016 (GoK 2016) and operates as a semi-autonomous institution under the MWSI. The WRA formulates and enforces standards, procedures and regulations in relation to the obstruction and utilization of water resources. It also collects water permit fees and water use charges, permits the use of water resources and determines the amount of water that can be extracted. Hence, the WRA is an important authority when it comes to obtaining access to irrigation water.

The purpose of **Water Resource Users Associations (WRUAs)** is to manage the water resources in a catchment area collectively, with water-users managing and resolving conflicts concerning water use in accordance with the WRA's regulations. WRUAs are community-based organizations consisting of water-users at the sub-basin level. In this regard, it is complementary to the WRA. However, our interviews revealed that individual extractions of water using gravitational irrigation, pumps or shallow wells sometimes occur informally without permits being obtained from the WRA or reporting to WRUAs.

The **Ministry of Agriculture, Livestock and Fisheries (MALF)** is responsible for the economic sector that irrigation schemes ultimately support, namely agriculture. Hence, in the context of irrigation MALF operates as a devolved function, with county extension officers

in place to provide technical support to farmers. MALF also influences irrigation development more generally in its capacity as the main regulator and supporting government body for the agricultural sector.

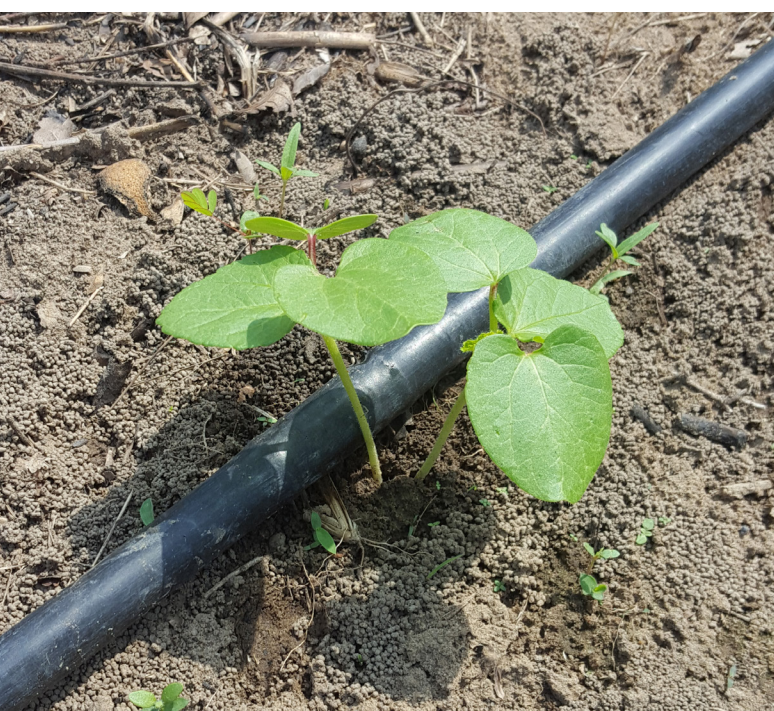
Altogether, there is a well-developed institutional framework at all scales that supports and enables the development of small-scale irrigation. That said, the interviewees observed that the public extension system is inadequate in many places due to a lack of technical capacity in irrigation at the county level. With their technical experts and know-how in irrigation equipment, technology suppliers are in a privileged position to bridge this gap, so they provide a range of support services and schemes to farmers, as discussed in section 5.5.

Civil-society organizations

Non-governmental organizations (NGOs) also play an important role as partners and project leaders on small-scale irrigation projects. NGOs that are active in small-scale irrigation development include World Vision, Care, the Kenya Red Cross (KRC), OXFAM and SNV.

4.6. Research institutions

Many informants considered capacity-building and knowledge-sharing for smallholders as very important instruments in increasing the take-up of irrigation technologies. Training and knowledge dissemination on the feasibility and profitability of irrigation solutions is needed for both individual farmers and farmers' groups. Public research institutions play an important role here. **The Kenya Agricultural & Livestock Research Organization (KALRO, previously KARI)** works to generate knowledge and innovative irrigation solutions for agriculture value chains. KALRO is a prominent agricultural research institution and a good example of how public institutions engage with research-based capacity building within smallholder irrigation. Similarly, the **Kenya Water Institute (KEWI)** is a semi-autonomous institution under MWSI that trains students in irrigation through courses and programmes within the water sector. Research in irrigation is also conducted at several universities, including the **University of Nairobi**, the **Jomo Kenyatta University of Agriculture and Technology** and **Egerton University**. These activities contribute to educating irrigation experts and building the capacities needed to create awareness and assist farmers in devising customized irrigation solutions.



5. In-depth analysis of irrigation technology suppliers

This section presents an analysis of private-sector irrigation technology suppliers in Kenya. We first account for the increasing number of technology suppliers and point out the potential drivers of this trend. We then provide an analysis of these technology suppliers in terms of their size and activities, geographical coverage, and irrigation equipment sold (type and price). Third, we analyse some key features of how technology suppliers strategize to grow their business.

5.1. Historical development of irrigation technology suppliers

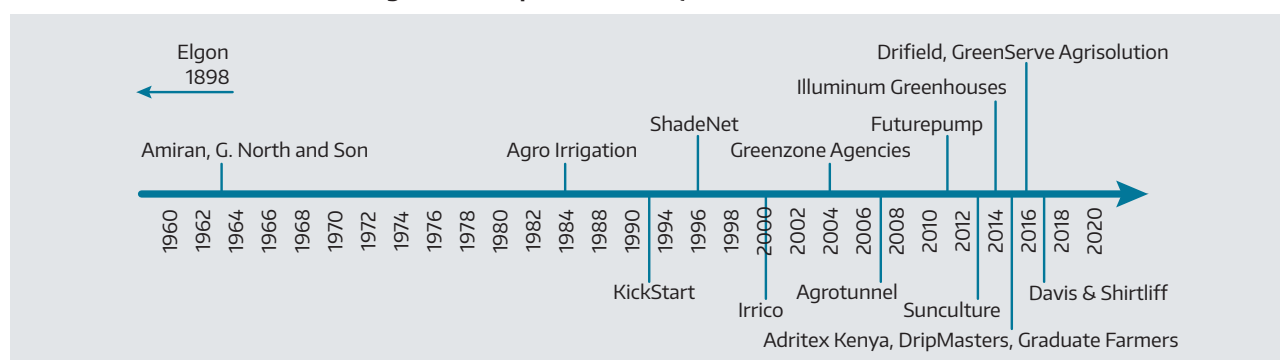
Kenya has seen a significant increase in the number of irrigation technology suppliers, especially since around 2010 (Figure 4). Up to 2000, there were only a few specialised irrigation-trading companies in the market, namely Amiran, G. North and Son, and Agro Irrigation, all of which are large companies, while large agricultural input suppliers sold irrigation equipment as a minor part of their product portfolio (e.g. Elgon Kenya). In addition, there were a few pipe manufacturers (including Shade Net, producing HDPE pipes and drip lines and fittings) and a small producer of manual pumps (KickStart). Since 2000, however, twelve new technology suppliers have entered the irrigation sector, nine of them since 2010. Among these new entrants, nine are SMEs, while two (Davis & Shirtliff

and Irrico International) are large companies. This trend has changed the size structure of the sector in the direction of a higher share of small companies (see section 5.1).⁷

Stakeholder interviews suggest that both market and policy have contributed to the increasing number of technology suppliers just outlined. First, there has been strong growth in the demand for irrigation technologies from several sources: 1) purchases by a growing middle class that is investing in irrigation for urban farming, backyard gardening or rural farming; 2) the demand for equipment and consultancies from donor- or government-supported projects; and 3) demand from smallholders who have access to irrigation water through NIA mediation. Secondly, irrigation has become an increasing political priority in Kenya, where more conducive framework conditions for irrigation investments have evolved in recent years, enabling public investments in infrastructure and projects, as well as the development of dedicated institutions and policies, as noted above and in Annex 5. That said, some informants questioned the efficiency of some policies and regulations, such as import tax exemptions, in creating incentives for private investments in irrigation technologies and infrastructure.

⁷ Our observation that the number of suppliers has increased is confirmed by a comparison with previous studies of irrigation in Kenya (Ngigi et al. 2000; FAO 2015a; USAID 2016b).

FIGURE 4. Timeline of when irrigation companies in Kenya were founded or entered the sector



Source: the authors.

All stakeholder categories we interviewed agreed that the irrigation market is expanding, with a growing number of supply-chain actors. They also observed an increase in competition and that more and more hardware shops are selling irrigation equipment in recognition of the business opportunity it presents. This includes large hardware trading firms like Davis & Shirtliff, which decided to enter the market for small-scale irrigation in 2017. This firm saw how the demand for irrigation products, i.e.

solar PV pumps, was increasing and found that it aligned well with its existing product lines. Regarding suppliers of drip kits, for example, Ngigi et al. (2000) identified three private firms selling them, while this study found eleven firms retailing drip irrigation equipment in 2019.

The last two decades have also seen an expansion in the volume and variety of irrigation equipment in the market. In the case of drip kits, Ngigi et al. (2000) identified five different kits for sale, two of which were being retailed by the public research institution KALRO. This study has found at least eight different drip kits in today's market (Dayliff, JAIN, Power, Rivulus, NETA-FIM, Azud, Eurodrip, Bhavani Drip), as well as a broad range of spare parts and accessories, including fittings, emitters, filters and drip lines with different spacings between emitters.

5.2 Key characteristics of irrigation technology suppliers

Technology suppliers, for whom irrigation is part of their business, include traders in agricultural inputs and/or equipment (e.g. Amiran, Elgon Kenya), pump traders (Davis & Shirtliff), pipe manufacturers (e.g. Agro Irrigation) and agricultural equipment producers (e.g. Shade Net). The definition excludes engineering firms and consultants that do not produce or sell irrigation equipment and are therefore not analysed in depth in this report.

This study identified nineteen irrigation technology suppliers operating in Kenya that fit the above definition (Table 3).⁸ These are large irrigation retailers or wholesalers (trading companies), SME retailers or wholesalers, and equipment manufacturers. Most of the manufacturers also retail their own products, while several of the trading companies sell both retail and wholesale. Many of these firms also provide a range of services in relation to their products (see section 5.5).

⁸The nineteen firms were identified through a comprehensive snowballing search, using document analysis, internet searches and key informant interviews. Due to the comprehensiveness of this search, we estimate that our sample covers the vast majority of such firms operating in Kenya, although no formal listing of them exists. However, we do acknowledge that a number of SMEs, such as rural hardware shops and individual irrigation entrepreneurs, may not be included in this list.



TABLE 3. Irrigation technology suppliers in Kenya and the equipment and services they supply.

Technology supplier	Irrigation equipment (brand or producer in brackets)	Company type and description
Adritex Kenya	Irrigation accessories Solar power for pumps Boreholes and wells	SME retailer Adritex Kenya is a water and energy company that deals with the supply of solar PV systems, water pumps, generators, irrigation accessories, boreholes & wells, solar water heaters, swimming pool chemicals & accessories, and water treatment chemicals & accessories.
Agro Irrigation and Pump Services	Drip kit (Metzerplas) Sprinklers (JAIN) Pipes (own production) Greenhouses (Yamko Yadpaz)	Large manufacturer, wholesaler and retailer Manufacturers of pipes (AgroFlow). Established in 1984, its departments include borehole drilling, pump supply and irrigation. Focused on irrigation, the company serves the agricultural and mining sectors.
Agrotunnel International	Greenhouse (own production) Drip kits Sprinkler (Floppy)	SME retailer and consultant Specialized in the installation of small, portable and affordable greenhouses to medium-income earners in urban areas. Established in 2007, offers consultations and organizes farmer training and excursions.
Amiran	Drip kit (NETAFIM) Greenhouses (own production) Sprinklers	Large wholesaler and retailer Established in 1963, Amiran is part of Balton Group with headquarters in the UK. Catering for Kenyan agribusiness across scale, its portfolio of products includes chemicals, fertilizers, seeds and irrigation, and more recently also telecommunications, water purification, solar energy and generators.
Davis & Shirtliff	Drip kit (Dayliff) Sprinkler (Dirrijet) Solar PV pumps (e.g. FuturePump, Lorentz) Diesel and grid powered pumps (e.g. DAB, Grundfos)	Large pump retailer Davis & Shirtliff is the largest retailer and hardware shop of pumps in East Africa. It has 41 branches in Kenya and 900 employees in total (across all countries). The firm was established in 1946. In 2017, it opened an irrigation department in Kenya.
Drifield Kenya	Drip tapes and lines (Captain Polyplast) Pipes and fittings	SME retailer Nairobi-based retailer of pipes from the Indian manufacturer Captain Polyplast Ltd, a partner in the firm.
DripMasters	Drip kits (Power) Sprinkler Greenhouse	SME retailer Specializes in drip kits for smallholders (1/8 acre to 1 acre).
Elgon Kenya	Drip Sprinkler	Large retailer (leading agri-input trading firm) Caters for the horticultural and floricultural industries in East Central Africa, being one the largest agri-input businesses. Established in 1898.
FuturePump	Solar PV pump (SF1 and S2).	Manufacturer Manufacturer of a leading low-cost solar PV pump designed for farming 1-2 acres. The headquarters is in Kenya, and the factory is in India. Davis and Shirtliff retails and distributes FuturePump's products in Kenya. Established in 2013, the company now has distributors in at least fifteen countries.
G. North and Son	Drip kits (Eurodrip/own assembled) Sprinklers Greenhouses Dam liners	Large wholesaler and retailer Established in 1963, imports and supplies premium technologies for agriculture, irrigation and hospitality
Graduate Farmer	Drip irrigation kits Sprinklers Water pumps	SME retailer and consultant Trains young people in drip irrigation and solar pumps and provides equipment, possibly sourcing equipment from other Kenyan firms. Offers practical training, consultation and information with its products.
Greenserve Agrisolutions	Drip kit Solar pump (Ennos) Hydro pump Water storage	SME wholesaler and retailer Established in 2016. Focuses on farm solutions, especially for smallholder farmers. Greenserve is a newly-established enterprise, looking for partnerships with local and global partners to help reach their users.

Technology supplier	Irrigation equipment (brand or producer in brackets)	Company type and description
Greenzone Agencies	Drip kit (Netafim and Azud) Water pond Greenhouses, polytunnel	SME retailer and consultant Agribusiness company founded in 2004 and located in Kisumu. Specializes in soil and water management technologies. It has a 'sister' community-based organisation (CBO) called Greenzone Agencies, established in 2014. Its main activity seems to be consultancy and project design rather than equipment sales.
Grekkon	Dam liners Drip kits Sprinkler Water pumps (electricity, diesel and solar) Greenhouses	SME wholesaler and retailer Established in Nairobi in 2013. Aside from irrigation, the company specializes in the construction of dryers and the supply of non-soil growing media, seedling trays and mulching papers.
Irrico International	Drip kit (Rivulis) Greenhouses Polytunnels Water tanks Sprinklers Solar pumps	Large wholesaler and retailer. The Hortipro branch caters for the medium and small-scale market, especially with drip irrigation and the construction and assembly of greenhouses. Customizes solutions for customers as well as kits. Reaches small-scale farmers through irrigation projects and partners MALF in holding farmer field days.
Illuminum Greenhouses	Greenhouses Drip kit	SME retailer. Irrigation company based in Nairobi. Offers a wide range of irrigation equipment and agro-inputs; specializes in greenhouses and drip systems.
KickStart	Treadle pump (MoneyMaker Max) Hip pump (MoneyMaker Hip Pump)	SME treadle pump manufacturer Sells pumps through a network of retailers and through irrigation projects.
Shade Net	Pipes Shade nets Drip lines and fittings	Large pipe and drip-line manufacturer (leading firm) Shade Net started manufacturing drip irrigation, HDPE pipes and shade netting in 1996.
SunCulture	Solar PV pumps (own (Rain-marker) and Shakti) Drip kit	SME pump manufacturer and retailer Produces and retails solar PV pumps, often as an integrated system with a drip function. The pumps are exported to many countries. Also retails Shakti pumps for large solar PV irrigation systems.

Source: authors' fieldwork, supplemented with FAO information (FAO 2015a). The companies that were interviewed as part of this study were Amiran, Agrotunnel International, Davis & Shirtliff, G. North and Son, Greenserve Agrisolutions, KickStart and Irrico International.

Categorization of technology suppliers according to size and activity

Table 4 lists the nineteen irrigation companies (listed in Table 5) grouped by size and type. Seven of the firms are large companies, while twelve are SMEs.⁹ Fourteen are trading companies, while five produce equipment. The largest group consists of nine SMEs selling equipment. It is important to note that these stylised categories conceal the diversified nature of most of the firms (see below). Below we describe the groups of large and small firms in turn.

⁹ The term 'SME' as used in this report fits the category of 'small enterprises' in the Micro and Small Enterprises (MSE) Bill 2012 (GoK 2012), denoting 'those firms, trade, service, industry or business activities that post an annual turnover of between Ksh500, 000 and Ksh5 million and have an employee list of 10 to 50'. As we did not obtain detailed information on turnover or number of employees from our interviewees, the categorization is estimated.

TABLE 4. Categorization of 19 irrigation technology suppliers in Kenya according to firm size and firm type

Size of firm	Type of firm (main activity)	
	Trading (retail or wholesale)	Manufacturing
Large	Amiran Davis & Shirtliff Elgon Kenya G.North and Son Irrico International	Agro Irrigation and Pump Services (pipes) Shade Net (HDPE pipes and shade netting)
SME	DripMasters Greenserve Agrisolutions Greenzone Agencies Grekkon Illuminum Greenhouses Graduate Farmer Drifield Kenya Adritex Kenya Agrotunnel International	KickStart (manual pumps) FuturePump (solar pumps) SunCulture (solar pumps and drip kits)w

Large firms

Seven large firms operating in the irrigation sector were identified. Two of them (Agro Irrigation and Shade Net) produce equipment while also engaging in trade, while four (Davis & Shirtliff, Amiran, Elgon Kenya, G.North and Son) are exclusively trading firms. Two firms (Irrico and Davis & Shirtliff) are new entrants to the sector since 2000, although Davis & Shirtliff was established much earlier without a focus on irrigation. In terms of ownership, the only foreign-owned firm is Amiran (UK-based Balton group).

SMEs

As already mentioned, numerous SME technology suppliers have moved into the irrigation market in recent years so that today twelve of the nineteen irrigation firms identified for this study are SMEs, compared to one SME (KickStart) out of the five firms operating before 2000. One of the SMEs (Drifield Kenya) is

partly owned by an Indian pipe manufacturer, while KickStart has its headquarters in the USA. KickStart, SunCulture and FuturePump (all pump manufacturers) have been portrayed as "social enterprises", understood as having a mission beyond economics (e.g., lifting small-scale farmers out of poverty by introducing affordable water pumps). While Kick-Start operates as a non-profit organization, SunCulture and FuturePump are both for-profit. These three companies are all relatively large SMEs, with 16 (KickStart), 19 (SunCulture) and 38 (FuturePump) employees respectively. In addition to the SMEs listed here, we note that several local hardware shops and SME agri-businesses engaged in irrigation may be found across Kenya.

In Box 3 we describe the key characteristics of three large firms and two SMEs to illustrate their diversity and the dynamics of the sector.

Box 3. Profiles of selected irrigation suppliers

Large firms

Davis & Shirliff entered the irrigation market in 2017 by setting up an irrigation department. The company was founded in 1946. It is a fully owned Kenyan firm with branches throughout eastern Africa, as well as in southern Africa and South Sudan. It is the leading hardware trading company for pumps in East Africa and has 41 branches throughout Kenya. It is the largest company in Kenya's irrigation sector in terms of total business volume (which includes many other departments than irrigation). The firm has a wide product portfolio that includes water pumps, swimming pools, generators and water-treatment equipment. Its irrigation department retails its own drip (Dayliff) and sprinkler equipment (Dirrijet). It also sells a range of premium (i.e. DAB, Lorentz, Grundfos) and low-cost water pumps (FuturePump), including diesel, grid and solar-powered pumps.

Amiran is part of the Balton Group, with headquarters in the UK, and it targets both small-and medium farmers, as well as large export farms. The company's product portfolio includes irrigation systems (sprinklers, pivots and drips), as well as household biogas and agri-inputs such as chemicals, fertilizers and seeds. Amiran offers a "Farmer Kit" to small-scale farmers, where a complete drip kit (Netafim) comes with a customized package consisting of agri-inputs, support services and greenhouses. Amiran has agronomists stationed across the different regions of the country to advise and guide farmers' agricultural practices and irrigation technologies. Established in 1963, Amiran is a widely known irrigation company, and the farmers we interviewed about drip irrigation considered to have the best quality products in the market. FAO (2015a) reports that Amiran has 85 % of the drip market for export farms using hydroponics.

Irrico International is a Kenyan irrigation company dealing in irrigation design, installation, maintenance and consultancy for irrigation and greenhouse projects. The company is operative in six African countries, namely Kenya, Uganda, Tanzania, Ethiopia, Zambia and Mozambique. Irrico was incorporated in 2001 and is the only of the large firms reviewed here that specializes only in irrigation. Irrico's Hortipro branch caters for small-scale farmers and offers a range of equipment, drip kits, sprinklers, lawn irrigation, greenhouse constructions and water storage systems. As a specialist in greenhouse systems (integrated with drip kits), Irrico demonstrates the technology at field days organized by MWSI.

SMEs

Greenserve Agrisolutions is a Kenyan company established in 2016 with a focus on technological solutions to small-and medium farmers. Their products range from water pumps (solar (Ennos, FuturePump) and hydro (BarshaPump)), seedlings and agri-input to greenhouses, water tanks and irrigation equipment. With a team of seven staff members, Greenserve Agrisolutions has a somewhat limited capacity to reach farmers across Kenya. Hence, the company works with agents, as satellite branches, in an effort to market and scale its sales. Moreover, it also partners other retailers for equipment they may not have in stock (i.e. green-houses) and gets large firms to stock some of its equipment (i.e. G. North and Son). Accordingly, as a new entrant into the irrigation market, Greenserve Agrisolutions is building up its networks with other stakeholders in the market (financiers, manufacturers, the larger retailers and local agents) to enhance its capacity to reach farmers and be able to offer them a range of technologies and services.

FuturePump is the manufacturer of a low-cost solar PV pump designed for farming 1-2 acres. The two versions of the pump, the SF1 and SF2, are considered to be leading small-scale solar pumps in terms of quality and ICT features (SF2). FuturePump is a for-profit social enterprise with around 38 employees. Its headquarters is in Kisumu, Kenya, and its factory is in India. The company has distributors in at least fifteen countries, thirteen in Africa and two in Asia. Davis and Shirliff, Greenserve Agrisolutions and Graduate Farmer (among others) retail and distribute FuturePump's products in Kenya. Like other solar PV water pumps, SF2 has integrated remote monitoring of the pumps using soil sensors and weather forecasts to advise farmers on the best timing and amount of irrigation to use on their mobile devices. This internet-connected innovation can be operated with remote switch-off, allowing the company to sell its products through a pay-as-you-go payment model (see Chapter 6).

5.3. Types and prices of irrigation equipment in today's market

The irrigation equipment most frequently sold by the firms we surveyed includes drip kits, sprinklers, pipes and fittings, water tanks, greenhouses (integrated with drip systems) and water pumps (diesel, petrol, electric and solar-powered). While each trader focuses on certain brands and products, there is some overlap in their portfolios. The quality of the equipment found in the market varies. The large, well-established trading firms generally have premium irrigation equipment in their portfolios, but an increasing number of sometimes cheaper alternatives have also entered the market.

Five Kenyan firms produce equipment used in irrigation (Table 4). The products include HDPE, PVC and PPR pipes, drip lines and drip kits, solar pumps and manual pumps. Several firms also construct greenhouses that integrate irrigation, and one firm produces shade nets. Several firms produce for export markets, mainly in SSA.

Most of the irrigation equipment sold in Kenya is imported. While imported irrigation products were previously limited to a few premium manufactures, a wide range of qualities and origins are now found in the market. A variety of products are imported from established producers in countries like Israel, India, Italy, Spain, the U.S. and Turkey with large markets for irrigation, as well as cheaper products from low-cost producers mainly China and India. A great variety of drip kits are imported: Amiran retails high-quality drip kits from NETAFIG (Israel), Irrico International sells kits from Rivulis (Israel/Greece), DripMasters from Power (Turkey) and Greenserve Agrisolutions from Bhavani Drip (India), while G. North & Son imports the parts separately, including drip lines from Eurodrip (Greece), and assembles the kits in-house. All large-capacity pumps are also imported. The value of imported products has increased in recent decades to reach USD 74 million in 2011, compared to around USD 25 million in 2005 (FAO 2015a).¹⁰ The dominant categories of imported equipment that year were gate valves (USD 26 million), centre pivots (USD 15 million) and other centrifugal pumps (USD 12 million).¹¹ The remaining USD 21 million covered pipes (HDPE, PVC

and PPR), drip lines, sprinklers, dam linings, irrigation equipment parts (i.e. fittings) and water pumps.

Aside from equipment, Kenyan irrigation firms, both traders and manufacturers, provide significant volumes of technical assistance and other services to farmers and schemes, both within Kenya and in neighbouring countries (see section 5.5). The value of these services is not known but is likely to be significant and to have increased with at least at the same rate as the supply of irrigation equipment.

Prices of irrigation equipment

The prices of irrigation equipment vary widely depending on type, quality, technology segment, and the auxiliary services and products included. This complexity makes it difficult for farmers to assess the costs of an irrigation investment and to choose the most affordable and suitable solution. The prices of drip kits (without pumps) are illustrative of this complexity (based on 2020 prices). At DripMasters, a standard one-acre (0.4 ha) drip kit, including drip lines, filter, fittings, gate valve, emitters and HDPE pipe, retails for USD 755. At Illuminum Greenhouse, a one-acre drip kit costs USD 1400 and includes a 1000-litre water tank and installation, while a kit at Amiran comes with water tank, seeds and fertilizers, as well as installation and training. The cost of a drip system also varies with the crop produced, which affects the spacing between the drip lines. Hence, at Davis & Shirliff drip kits cost from USD 845 per ha for melons (two-meter spacing) up to USD 2400 for onions (0.7-meter spacing).

The prices of water extraction (pumps and boreholes) also varies significantly. Davis & Shirliff retails the FuturePump SF2 (15-meter head, 60V DC, 120W, 3600 l/hr capacity, and solar panel) for USD 660. Within the same price range, farmers can get a diesel-powered pump with a much higher capacity (e.g. 65-meter head, 10 horsepower (HP), and 40,000 l/hr capacity). Manual pumps are cheaper: as the cheapest solution, KickStart retails its manual treadle pump (7-meter head, 3600 l/hr capacity and hosepipe) for USD 170. Several irrigation companies offer borehole drilling services. With prices starting at USD 110 per meter, this technology is obviously very expensive, especially where water tables are low, and so seems out of the reach of small-scale farmers unless a borehole can serve many farmers through a cooperative or similar arrangement.

¹⁰ We could not find more recent statistics on imports of irrigation equipment.

¹¹ Except for the centre pivots, which are only used by large-scale farms, it is not possible to identify the value of imported products used in the small-scale segment.

5.4. Geographical coverage of supply

The majority of the technology suppliers are based in Nairobi, though they use different strategies to cater to the whole country, including distributor networks, local branches, wholesalers and extension agents (see below). While agricultural inputs are widely available across the country through local corner shops, the availability of irrigation equipment is more fragmented. The farmers we interviewed mentioned that they might find assorted pipes, PVC and low-density polyethylene (LDPE), some fittings, sprinklers and occasionally water pumps. However, the variety is limited, and a lot of irrigation equipment is not sold or kept in stock locally. For example, drip kits are rarely found in shops in rural towns.

5.5 Business strategies of technology suppliers

While previous sections have accounted for the growth in technology suppliers and provided a description of them, in this section we explain how technology suppliers strategize to reach end-users and grow their businesses, in so doing contributing to the penetration of irrigation technologies in the small-scale market segment.



The study identified six main dimensions of the business activities and strategies of irrigation technology suppliers:

- Farm segment targeted (scale and type)
- Bundling of technology provision with services and consultancy
- Level of specialization (vs diversification)
- Customers, distribution and marketing
- Partnerships
- Differentiation strategies (broad product catalogue or specific technology segments)

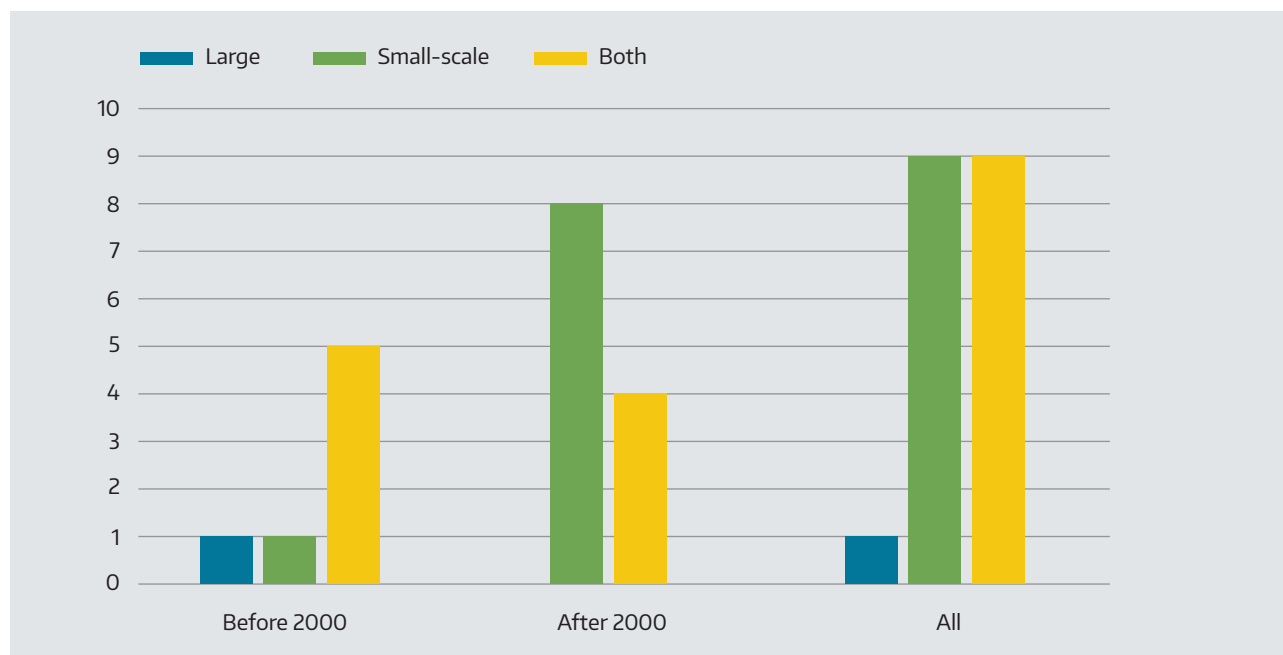
Below we discuss each dimension in turn and outline trends where they can be identified. On this basis we then identify broader differentiation strategies, including the creation of niche advantages by different firms and the extension services offered.

Farm segment targeted

The focus of the incumbent technology suppliers (i.e. those established before 2000) has been on large-scale irrigation, although they increasingly target small-scale farmers as well, while most of the firms established since 2000 have small-scale farmers as their main customer segment (Figure 5). As a result, the smallholder segment appears to be the most important segment (in terms of turnover) for most of the trading companies in today's market.

Large technology suppliers, such as Amiran, Irrico and G. North and Son, target both the small and large farm segments, while SMEs specifically target the small-scale market. This pattern could be explained by the former's greater technical and financial capacities, which enable them to undertake large operations and to serve a broader range of clients. The exception is the large pump supplier Davis & Shirtliff, which only focuses on the small-scale segment, as it finds that this has a much greater potential in terms of turnover. The manufacturers specializing in water pumps for smallholders, SunCulture, FuturePump (solar PV) and KickStart (manual), naturally all target the small-scale market.

FIGURE 5. Number of companies targeting the small-scale and large-scale irrigation market segments according to the period of establishment of the company (before 2000, from 2000 to 2019, and irrespective of year of establishment).



Source: the authors.

Bundling of technology provision with services and consultancy

All the technology suppliers we interviewed offer technical advice and consultancy services related to their products as part of their sales and outreach strategy. These services range from support services delivered during technology provision and after-sales services to broader agricultural services, including crop management, business planning and linking to market (Table 5). This reflects the complexity of irrigation technologies and the need for the careful design of irrigation solutions to fit specific farm conditions and crop needs. Indeed, one technology provider observed that selling irrigation technologies is also about selling know-how, as these technologies are often new to farmers. Hence, aside from informing customers about irrigation products and potentials, the Kenyan technology suppliers offer, to varying degrees, suites of support services, that is, demonstrating, designing, installing and assisting in maintaining and operating the irrigation equipment. To carry out these services, many of the technology suppliers employ staff such as agronomists with strong technical expertise in irrigation, and in some firms (Amiran, Irrico, Davis & Shirtliff, G. North and Son) staff are present at local branches across the country. Other suppliers, such as Greenserve Agrisolutions, use external rural agents to deliver local support services.

Technical expertise and service provision is clearly a means of competing for market share among the technology suppliers, that is, as a key factor in product differentiation. Moreover, interviewees observed that service provision has become increasingly necessary to compete with the growing number of general hardware shops that sell irrigation equipment. Hardware shops sell separate parts and do not keep a broad product line in stock. Packaging irrigation equipment with support services was thus a way of differentiating one's business from these shops. For example, when buying a drip kit at Amiran, it comes with installation, training and an agro-support package for training in drip irrigation practices.

Service provision and technical expertise also allow many technology suppliers to engage in project design and implementation, thereby selling both products and services, and several of the firms we surveyed have such projects outside Kenya (see below).

TABLE 5. Summary of support services undertaken by irrigation technology suppliers in Kenya

Service category	Support services	Description
Financial	Provision of financial services	Access to credit through loan products tailored with and offered through financial institutions, payback arrangements (subject to risk assessment) and pay-as-you-go finance models (offered only through SunCulture and FuturePump).
Technical	Training and demonstrations in irrigation systems	Training in irrigation practices, including operation and maintenance of equipment. Permanent demonstration site showcasing equipment to farmers, as well as participation in agro-fairs to undertake demonstrations.
	Design and installation of irrigation equipment	Customizing irrigation solutions to fit the needs of clients, as well as the installation of irrigation equipment.
	Provision of irrigation operation and maintenance service	After-sale maintenance of irrigation systems in case of operational difficulties or malfunctioning equipment.
Output and input marketing	Provide market information and assist in marketing	Guiding farmers to identify and select the available market options, including linking farmers to buyers (wholesalers and exporters).
	Provision of agri-inputs and training in crop management	Providing farmers with agricultural inputs (e.g. fertilizer and seeds) and training in optimal application with irrigation system (including fertigation and crop management).
Management	Management of farm production and economy	Help farmers develop production and business plans, e.g. training and business advisory services.

Source: authors' interviews with irrigation technology suppliers in Kenya.

Level of specialization

Most of the surveyed firms vary in respect of the terms of the products and services they offer. Many of the trading firms trade in other products than just irrigation equipment, e.g. pumps for other uses (e.g. Davis & Shirliff) or other agricultural inputs (e.g. Amiran). Several companies (e.g. Agrotunnel, Greenserve Agrisolutions, Illuminum Greenhouses and Shade Net) offer irrigation equipment as part of partial or complete greenhouse solutions, reflecting Kenya's large and advanced horticultural industry. Likewise, several of the manufacturing firms (e.g. Agrotunnel and Agro Irrigation) sell products made by other producers that complement their own products in order to be able to offer their customers a complete solution. Hence, only a few firms specialize fully in irrigation products and services. This group is dominated by SME manufacturers (KickStart, FuturePump, SunCulture), all of which also export their products, and some SME trading companies (DripMasters, Grekkon). Irrico International is the only large firm fully specialized in irrigation, although it has also diversified into renewable energy.

Customers, marketing and sales network

Customers

The technology suppliers have a broad range of clients: government institutions (e.g., MALF, MWSI and county governments), international development organizations (e.g., African Development Bank, bilateral donors), NGOs (e.g., World Vision, Care, and International Committee of the Red Cross), retailers and farmers. Two large technology suppliers (G. North and Son, and Davis and Shirliff) reported that the majority of their sales are direct to farmers. While direct sales is the dominant sales channel for the large-scale market segment, it can be difficult and expensive to reach smallholder farmers using it. Indeed, nearly all individual sales to the small-scale segment are to fully or partly commercial farmers or to customers with another main occupation than farming (see also Chapter 6).

Consequently, sales to government- and donor-supported irrigation projects, especially in the small-scale segment, make up a large share of total sales, especially for leading technology suppliers such as Amiran, Irrico and G. North and Son. For example, Irrico has delivered sprinklers to the Karia irrigation scheme (Box 1). Davis & Shirtliff, on the other hand, is reluctant to engage in government-supported projects, because of the risk of the government defaulting on its payments.

Marketing

Most irrigation companies participate in farm days, conventions and permanent demonstration sites to market their product and reach farmers. For example, Greenserve Agrisolutions participates in trade fairs organized by the Kenya Livestock Producers Association (KLPA) and Irrico in field days organized by MALF about every second month. At these showgrounds, i.e. around Nakuru, Nairobi or Kisumu, Irrico displays its greenhouses to visiting farmers.

Many technology suppliers advertise regularly in various media, including TV (such as KTN Farmers TV), newspapers and social media, as well as via email and text messaging services. Several companies, for example, SunCulture and Greenserve Agrisolutions, use social media to advertise success stories of farmers adopting their equipment.

Sales networks

Technology suppliers distribute their products locally through different sales networks. Based on the data collected for this report, five types of distribution can be identified (Table 6). Selling to other firms (B2B) can take the form of either i) sales to local hardware shop, or ii) sales to other irrigation companies. Regarding the latter, FuturePump sells its water pumps through other technology suppliers such as Davis & Shirtliff, Greenserve Agrisolutions and Graduate Farmer. Sales directly to the farmer (here denoted as B2C) have three routes: i) through external agents, where the firm, in particular SMEs, uses local agents as sales officers (e.g. Greenserve Agrisolutions); ii) through in-house staff, where agricultural engineers, agronomists or similar act as sales or extension agents for the irrigation company (e.g. Amiran); and iii) in local branches, through which the company retails its products. Only Davis & Shirtliff sells equipment through its own local branches, of which there are 41 throughout Kenya.

TABLE 6. Technology suppliers' sales networks. Sales are divided between business-to-business (B2B) or business-to-consumer (B2C), where a farmer is understood to be the consumer.

Type of sale	Mode of distribution	Description
B2B	Sales to local hardware shops	Technology suppliers sell their products to local hardware shops, such as agri-input corner shops. Equipment includes pipes, fittings, sprinklers and petrol pumps, while more specialized products, such as drip kits, are rarely sold through these shops.
	Sales to other irrigation retailers	Sales between technology suppliers. Primarily from manufacturers to trading companies, but also from larger firms to SMEs, which may only import few products.
B2C	External agents	Technology suppliers using local agents as sales and extension officers to retail their products.
	In-house local agents	Network of local staff, who act as sales agents and extension support. Mainly larger technology suppliers use this type of distribution.
	Local branches (own business)	Irrigation equipment sold through a network of local branches owned by the company.

Source: the authors.

Partnerships

The technology suppliers all have formal or informal partnerships. Indeed, building networks and collaborating with public agencies, NGOs and donors is an important strategy for reaching the small-scale segment. For example, Irrico partners with MALF in the demonstration of greenhouses and involves its staff in the training of drip irrigation systems installed in green-houses. Moreover, the company has signed MoUs with NGOs regarding the supply and installation of irrigation equipment, including drip kits and polytunnels, to different projects.

Many technology suppliers also have agreements with financial institutions. Davis & Shirtliff has MoUs with SACCOs and MFIs to deliver irrigation equipment and services. Especially large irrigation companies collaborate with banks or MFIs. For example, Davis & Shirtliff works with Equity Bank, and Irrico has ties with KCB bank, while SunCulture collaborates with East Africa's largest MFI. These partnerships are part of a strategy to reach farmers by increasing their access to finance.

Some SMEs collaborate with other technology suppliers because they do not have all the necessary equipment in stock to devise customized solutions. For example, Greenserve Agrisolutions works with other technology suppliers to obtain equipment it does not stock. As new entrants to the market, building networks is especially important for SMEs seeking to gain market share. They collaborate with a variety of actors, including government agencies, irrigation equipment manufacturers, large retailers, agricultural input suppliers and local agents (e.g. the "external agents" described in Table 8).

Differentiation strategies: broader product catalogues and irrigation technology segments to create niche advantages

Most technology suppliers offer a comprehensive product portfolio of irrigation equipment to small-scale farmers. However, there are notable differences in the scope of the product types they offer. For many companies, irrigation is not the only or primary business component. For Davis & Shirtliff, it is only one out of seven areas of expertise that make up its energy and water scope. At Amiran, irrigation is part of its overall focus on supporting agribusiness, while G. North & Son offers irrigation along with other agri-

cultural hardware. Other companies, like Illuminum Greenhouse and Agrotunnel, specialize in greenhouse solutions and offer irrigation as an integrated part of these solutions, especially drip irrigation. Manufacturers of specific technology segments such as FuturePump, SunCulture (solar PV water pumps) and KickStart (manual pumps) can also have advantages as experts within specific technological niches. For a number of technology suppliers, including Driffield, Irrico International, DripMasters, Agro Irrigation and Shade Net, irrigation is the main or only business area. Specializing in specific technology segments may be a deliberate part of a business strategy, but in some cases it also results from a firm's limited capabilities, particularly among SMEs.

Some technology suppliers specialize in specific types of irrigation equipment to acquire a market position. For the small-scale farm segment, Irrico specializes in greenhouse systems, which are typically integrated with drip irrigation. Irrico's expertise in greenhouses and polytunnels could be an advantage when targeting farmers wanting to upgrade production from open fields to a controlled environment. Amiran has a well-established reputation as a specialist in premium drip systems and seems to leverage on its position as a market leader. Upon entering the irrigation market, Davis & Shirtliff used its position as a leading pump distributor with branches across Kenya to gain market share and customer trust. Hence, history and a leading market position may give the large technology suppliers an advantage over the SMEs.

As self-declared social enterprises, FuturePump, SunCulture and KickStart differ from the other technology suppliers in the small-scale irrigation market. They work very closely with investors, including grant financing of pilot projects, as angel investors at start-up phase (SunCulture), and debt and equity financing for different business operations. For example, FuturePump and SunCulture have received grants from REEEP (Renewable Energy and Energy Efficiency Partnership) as SMEs offering innovative clean-energy services.

6. Business models for small-scale irrigation

This section applies a business model perspective to identify opportunities and pathways for technology suppliers to market small-scale irrigation technologies. A business model outlines how an entity or company must operate to generate a positive return on investment (ROI) and/or meet its objectives (Chesbrough 2010; Otoo et al. 2018).¹² Therefore, the business models outlined below represent different ways in which technology suppliers in Kenya may develop and grow their businesses.

¹² Return on Investment (ROI) is a performance measure used to evaluate the efficiency of an investment or compare the efficiencies of a number of different investments. ROI tries to directly measure the amount of return on a particular investment relative to the investment's cost. To calculate ROI, the benefit (or return) of an investment is divided by the cost of the investment. The result is expressed as a percentage or a ratio. Source: <https://www.investopedia.com/terms/r/returnoninvestment.asp>



TABLE 7. Business models for small-scale irrigation technologies.

Business model	Direct sales without finance	Technology bundled with finance	Irrigation schemes
#	1	2	3
Value proposition	Cost efficient. Low risk.	Larger customer base than without finance.	Economies of scale.
Possible disadvantages	Limited customer base. Slim profit margins.	Risk of default, farmers walking away from loan. Slim profit margins.	Risk of delayed payments. Susceptible to macroeconomic situation, e.g. hold in government spending or donor priorities.
Customers	Individual farmers.	Individual farmers.	Development organizations, government agencies, SACCO agencies, Agro-food exporters.
Farmer segment targeted	Commercial.	Commercial, emerging commercial.	Subsistence, partly subsistence
Type of financing for farmer	None.	Loans from commercial banks, MFI or SACCO.	Donor grant or loan. In outgrower model, a loan.

Source: the authors.

Business model 1: direct sales without financing

Some irrigation companies, such as Davis & Shirtliff and G. North and Son, stated that the majority of their sales to the small-scale segment consist of direct sales to individual farmers. They also noted that individual purchases are typically made by customers who are not full-time farmers, but who still want to invest in urban farming, backyard gardening or rural farming. A large proportion of Kenyans own land, and there is a strong cultural identity associated with farming, meaning that people with urban jobs also want to invest in it. The other main customer segment that buys irrigation equipment individually is commercial farmers. However, this business model is not suited for the lower levels (emerging commercial and subsistence) of the smallholder segment (Figure 5). Business volumes for direct sales have been expanding, but the customer base remains limited when it comes to smallholders.

While access to credit can be a bottleneck to the adoption of technology, some technology suppliers (Davis & Shirtliff and G. North and Son) argue that direct sales without financing are more attractive to farmers than taking out a loan. This is due to the risk associated with high interest rates, short grace periods, the risk of failed harvests and requirements to provide collateral for the loan. The proposition is that farmers, even those in the lower levels of the segment (Figure 2), can start irrigating with little investment cost if they limit irrigation to a small area, assuming they have easy access to irrigation water.

Business model 2: technology bundled with financing

Technology suppliers can also facilitate access to finance directly for farmers through different market approaches, including: a) providing direct finance (the supplier cooperates with a financial institution); b) lease-to-own (payments in instalments, the farmer owning the equipment after full payment; or c) pay-as-you-go (the farmer makes payments as s/he uses the irrigation equipment).

Several of the large irrigation companies, for example, Irrico, Davis and Shirtliff, Amiran and G. North and Sons, have links with commercial banks and in some cases offer customers a payback arrangement subject to a risk assessment and a review of the farmer's loan

history (see section 5.5). However, these companies do not offer any formal financial packages bundled with their products.

For this business model, the technology provider will need to consider the trade-off between the risk of loan default by farmers and increasing the number of customers within the small-holder segment. For example, Davis & Shirtliff does not offer payback arrangements, as it perceives the risk of default to be too high. Instead, the company has designed a loan product for its solar pumps together with Equity Bank, whereby it creates a project plan together with the farmer, who then takes the offer to Equity Bank for credit. For its greenhouse system, Irrico signed an MoU with KCB bank setting up a buyback guarantee for farmers. In case of default, such as due to a failed harvest, Irrico buys back the irrigation equipment at a lower price to help farmers pay back their loans. This works as insurance for the farmer that mitigates the risks of the investment.

But even if farmers are eligible for credit from the commercial banks or MFIs, loan products are often regarded as unattractive and very risky, as already mentioned. Thus, promoting this business model will require minimizing the costs so that risk levels are also reduced to a minimum. To bridge the gap between the available loan products and farmers' capital needs, revolving funds, credit guarantees from development institutions and government funding were suggested as financial mechanisms by the interviewees.

A promising financial product is the pay-as-you-go business model, which is used by a few irrigation technology suppliers. SunCulture partners with a micro-finance institution as a strategy to reach farmers by increasing their access to finance. Accordingly, SunCulture offers a pay-as-you-go ("pay as you grow") business model that bundles its solar-powered drip system with financing. The loan is designed with a payback time of a number of years and an initial upfront payment of USD 89 (Floy 2019). FuturePump has developed in-built software for its solar pump that allows flexible payments by the farmer, which can be offered through retailers as an add-on (REEEP 2015). These systems build on ICT linked to usage meters enabled by Kenya's well-developed mobile network coverage. Such innovative solutions can be part of an effective business model, as it makes the irrigation equipment financially available to an increased number of small-scale farmers.

Business Model 3: irrigation schemes

Selling irrigation equipment to irrigation schemes, whether private or public, large-scale or community-based, is an important market for technology suppliers, although it is uncertain how large a share of their total revenue this business model represents. The value element of this business model assumes that large quantities will be sold, which increases profit margins due to economies of scale. Our interviews revealed that most of the technology suppliers pursue this business model. However, it is also clear that selling and installing irrigation equipment in larger quantities require a certain firm size and firm capacity. This means that it is especially the large irrigation companies that are able to deliver equipment and support services to irrigation schemes.

Here we outline two variants of the irrigation scheme business model that these technologies suppliers may pursue.

Public and donor-supported schemes

The market for irrigation equipment and services in Kenya has to a great extent been driven by donor- or government-supported irrigation schemes, and the demand for equipment and consultancies from such projects has stimulated the entry of more suppliers (see Chapter 4). This also means that technology suppliers rely strongly on irrigation projects funded and established by government, development organizations or NGOs. This has also been the experience in other countries in SSA (Bolwig et al. 2020; Wanvoeke et al. 2017).

Bundling extension support services with the delivery of technology creates a challenge for technology suppliers in the sense that profit margins from the small-scale market segment are limited. Though the small-scale segment represents a large market potential (as outlined in Chapter 2.2), significant profit will require high sales volumes. When bundling services with technology, profit margins may be challenged, as additional staff and transportation costs are also involved. Therefore, contracts with donors and government agencies may be an effective business strategy due to the achievement of economies of scale in service provision. Clearly, economies of scale are an advantage of this business model, with the cost per unit of sold irrigation equipment and services falling with increasing sales volumes.

Certain potential disadvantages of the business model were also revealed to us in our interviews. First, some technology suppliers have experienced a decline in public support and finance for small-scale irrigation projects within the past two years. Second, delayed payments for technology and service delivery to public irrigation schemes were of concern to technology suppliers. Consequently, one technology provider refrained from pursuing publicly funded contracts. Based on these experiences, we note that socioeconomic conditions such as political priorities and limited public budgets influence how attractive this business model is for the technology suppliers.

Out-grower schemes

Irrigation companies can also deliver equipment and support services to large agri-businesses involved in contract farming. Outgrower or contract-farming schemes are common in Kenya; for example, 60% of Kenya's tea and sugar are produced in outgrower schemes (ActionAid 2015). In such schemes, a large agri-business company or nucleus farm, such as Frigoken, Greenlands or Homegrown, has a contractual agreement with individual or groups of farmers for the supply of agricultural produce at agreed standards and prices. Hence, this business model is based on the agri-business company providing irrigation equipment, e.g. drip kits, sprinklers or solar pumps, to its contracted farmers along with other agricultural inputs and extension support. The out-grower can either pay the agri-business company directly for the irrigation equipment (and other inputs), or the company can cover its costs through the price it pays the farmer for the produce (Otoo et al. 2018). In both cases, the company benefits from receiving higher quality produce or more produce from its outgrowers, but only to the extent that it can prevent outgrowers from side-selling their produce outside the scheme (Bolwig et al. 2009).

This study identified one case illustrating this business model: Frigoken Ltd has trialled and introduced drip irrigation in an outgrower scheme in Murang'a County producing green beans for export. With several thousand outgrowers in Kenya, who typically grow produce for Frigoken on around 200 m² (AKDN 2018), the upscaling of this business model by Frigoken (or similar companies) could have a very large effect on the irrigation sector. Yet a more detailed assessment is needed to determine the general viability of this business model.

7. Discussion: key issues for continued irrigation market development

Our study revealed that the business volumes of irrigation technology suppliers have been growing in recent years, especially for drip kits, greenhouse systems and solar PV pumps. Yet market penetration for many technologies is still low, reflecting the fact that the market has started to grow recently and has focused on certain technologies. This pattern also applies to the smallholder segment, where adoption rates are still very low, despite growth over the past two decades. The adoption of irrigation technology among smallholders has mainly occurred through government-supported projects, while adoption rates outside such schemes seem to have been very low.

The study identified a number of factors that have influenced the development of the small-scale irrigation market in recent decades, and which are important to consider in future efforts to develop the irrigation market in Kenya. We discuss these issues below.

7.1. Availability of technical and systemic knowledge

Irrigation technologies are not plug-and-play solutions but depend on a range of contextual factors to function effectively. These are important factors in the diffusion and adoption of irrigation technologies. For example, whether a solar-powered water pump with sprinklers is an effective technology to irrigate a given crop in a given location depends on whether the supplier correctly designed and dimensioned the system for this particular purpose. But it also depends on the know-how of the farmer who operates it and on the availability of technical expertise and spare parts in case of a breakdown.

Therefore, compared with agricultural inputs such as fertilizers, the widespread and sustained diffusion of irrigation technologies depends on the existence of relatively high levels of knowledge and practical skills

throughout the supply chain, including among system designers, equipment suppliers, craftsmen (e.g. plumbers) and farmers. This view was shared by all the technology suppliers we interviewed, who emphasized that they do not just sell irrigation equipment but also know-how.

The successful diffusion of irrigation technologies also depends greatly on the presence of supporting institutions and organizations, such as the NIA, MWSI, MALF, KALRO and specialized consulting firms. Irrigation can be considered a complex system, so these actors should have expert knowledge of how different irrigation technologies function in a given environment, not just regarding bio-physical factors such as crop varieties and water resources, but also in terms of socio-economic conditions affecting adoption, such as crop markets, access to credit, farm size and land tenure. Such systemic knowledge of the factors of the adoption and performance of irrigation technologies is an important supplement to the technology suppliers' in-depth technical expertise regarding specific equipment.

7.2. Economic and financial barriers

The existence of economic and financial barriers was highlighted by all the stakeholders we interviewed, who observed that irrigation equipment and support services were too costly for most smallholders. In this regard, access to credit through commercial bank loans were mentioned as a key constraint, though some farmers may have access to finance through SACCOs or more informal types of community lending. Clearly, a constraint on the continued expansion of the small-scale irrigation market is the gap between available loan products and smallholders' capital needs. Moreover, the lack of clarity regarding import regulations for spare parts and import tax exemptions for new products were problems experienced by several irrigation technology suppliers.

7.3. Technical factors

Technical barriers such as limited know-how among farmers and inadequate public extension services were also frequently mentioned as key constraints to the development of small-scale irrigation. However, the latter may have created business opportunities for technology suppliers, as the provision of consultative and support services to irrigation schemes has become a key part of their business. Farmers have limited knowledge of irrigation equipment. In this regard, the concentration of irrigation companies in urban areas is a challenge to further market development, as this means low visibility of and access to irrigation equipment in rural areas.

7.4. Factors related to the broader agricultural system

Finally, the market for small-scale irrigation is confined by the boundaries of the agricultural system it is trying to improve. As irrigation is a component within a broader agricultural context, the irrigation market depends on broader agricultural developments and functionalities across the entire agricultural value chain. Interviewees highlighted a number of systemic issues that constrain the development of irrigation, such as limited access to water resources, a lack of agricultural inputs, low and fluctuating product prices and an insecure offtake of agricultural produce, all of which tend to reduce the profitability, or increase the risk, of investing in new irrigation technologies.



8. Conclusion and recommendations

This report has analysed the small-scale irrigation market in Kenya, including recent developments, the market entry and roles of technology suppliers, and promising business models.

The area under irrigation has shown remarkable growth during the last two decades. In particular, there has been an increase in irrigation by large-scale private farms and community-based irrigation schemes, from around 40,000 ha in the late 1990s to 88,000 ha and 110,000 ha respectively in 2018. There has also been an increasing number of individual small- and medium-scale farmers using irrigation in recent years, though their contribution to development of the market could not be quantified due to a lack of data.

Alongside this development, the period saw a large increase in the number of irrigation companies, referred to as technology suppliers, operating in Kenya. Before 2000, the market consisted of a few specialized irrigation-trading companies, in addition to some large agricultural input suppliers, for which the sale of irrigation equipment was a minor part of their product portfolio, and a public research institution promoting and selling drip kits. There were only two manufacturers of irrigation equipment. Yet since 2000, twelve new technology suppliers have entered Kenya's irrigation sector, nine of them after 2010. This development has not only increased market competition but also changed the size structure of the sector towards a higher share of small companies. The growth in the number of technology suppliers has occurred alongside an increase in the volume and variety of irrigation equipment in the market. Moreover, more and more hardware shops now sell irrigation equipment, which has further intensified competition and made irrigation equipment more readily and locally available to farmers.

All the technology suppliers we interviewed offer technical advice and consultancy services related to their products. They do so to gain or protect market share, as a key factor of product differentiation, and because irrigation

is a complex technology that requires careful design to suit different crop varieties and farm conditions. These services range from support services delivered during technology provision and after-sales services to broader agricultural services, including crop management, business planning and links with output markets.

The technology suppliers' business strategies included several additional features and differentiation strategies. First, different ways of distributing products were used, often associated with the company's size and technical capacity. Second, they created partnerships with public organizations and financial institutions, which were used to reach a greater share of the small-sale segment. Third, many firms specialized in specific types of irrigation equipment, such as drip kits or greenhouses.

The demand for equipment and consultancies from government- and donor-supported irrigation projects or schemes has greatly stimulated the entry of more technology suppliers, sales to such schemes representing an important share of the total sales of many of them. Hence, the development of the small-scale irrigation market witnessed in recent years can in part be attributed to public-sector efforts to expand irrigation. But there has also been increasing demand for irrigation equipment from individual, market-oriented small-scale farmers. This growth is partly driven by investments from a growing non-agricultural middle class in irrigation for urban farming, backyard gardening, or rural farming. Together, the schemes and the individual purchases account for the majority of the demand for small-scale irrigation equipment in Kenya. In contrast, private small-scale irrigation schemes, such as those organized as part of a contract farming scheme, seem to be a minor source of business for the technology suppliers.

Altogether the market for small-scale irrigation is expected to continue to grow, with new business opportunities emerging as the irrigation infrastructure expands and the demand for irrigation solutions from

individual farmers and irrigation schemes continues to grow. In particular, the expansion of irrigation among smallholders who belong to Kenya's many horticultural contract-farming schemes seems to be an opportunity for market growth that warrants more attention.

However, a number of issues need to be considered in the further development of the market for small-scale irrigation. These include innovative financial products

that can make irrigation equipment more accessible and attractive to more small-scale farmers; continued efforts to increase the number of farmers with access to water resources; increased visibility of irrigation equipment and infrastructure in rural areas to improve farmers' knowledge and awareness of the technology; and improved extension support with technical know-how on the design and operation of irrigation systems.

TAKEAWAYS AND RECOMMENDATIONS REGARDING SMALL-SCALE IRRIGATION IN KENYA:

1. The growth in the small-scale irrigation market since 2000 has been driven mainly by the demand for equipment and consultancies from donor- or government-supported schemes, and by demand from a growing middle class wanting to invest in irrigation for urban farming, back-yard gardening, or rural farming.
2. Irrigation companies undertake a range of activities in addition to technology provision, including training, financial packaging and knowledge dissemination, and thus play an important role in irrigation technology diffusion and adoption.
3. There is a need to develop and support innovative financial solutions that enable more small-scale farmers to access irrigation technologies.
4. There is a need for improved import regulations so that tax exemptions also include individual parts and new imports are easier to register for exemptions.
5. There is a need to improve farmers' access to irrigation technologies through the presence of more retailers or other forms of outlet locally, which would also enhance farmers' awareness of the technologies.
6. The opportunity for increasing smallholders' access to irrigation through contract-farming schemes and similar arrangements should be investigated further.

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Annex I. Types of irrigation

Non-manual forms of irrigation can be grouped into the following categories (Brouwer et al. 1990a):

- surface irrigation, in which the entire or most of the crop area is flooded;
- sprinkler irrigation, which imitates rainfall;
- drip irrigation, in which water is dripped onto the soil above the root zone only;
- subsurface irrigation, where water is applied to the root zone by drip pipes or porous pipes placed in the soil;

- sub-irrigation, in which the groundwater level is raised sufficiently to dampen the root zone.

Below we discuss the first three categories, with a focus on sprinkler and drip irrigation, the most relevant types of irrigation for this report. Table A1 provides a brief assessment of the first three categories, with a general description and with respect to their suitability for different crops and farm sizes. It also includes manual irrigation techniques, such as hosepipe irrigation (see Figure A1), which are not covered here.

FIGURE A1. Gravitational-led furrow irrigation (left) and hosepipe irrigation (right).





Surface irrigation

In surface irrigation, either the entire field is flooded (basin irrigation), or water is applied to the crops via small channels (furrows), siphons or strips of land (borders) (see Figure A1). Surface irrigation can be used for all crop types, with some variation depending on the type of system, and it normally requires little equipment and maintenance, unless pumps are used, especially in small-scale schemes. Hence, furrow irrigation can be more attractive for smallholders than drip and sprinkler systems that are more technically complicated. The Water Resource Authority (WRA) is no longer issuing water permits for surface irrigation due to the scarcity of water and the need to reduce the evaporation of irrigation water.

Although surface irrigation continues to be a common practice among medium- and small-scale farmers, it does not require much equipment and thus offers few business opportunities for technology suppliers. As this report focuses on technology suppliers, we will not discuss surface irrigation solutions further.

Sprinkler and drip irrigation

Sprinkler and drip irrigation are mainly used for high-value crops destined for the market due to the capital investments in equipment (power source, pumps, pipes, drip lines, sprinkler heads etc.) that each farmer needs to make individually. Drip and sprinkler irrigation are technically more complicated technologies than surface irrigation, and maintenance requires some technical knowledge. Hence, within the small-scale segment, commercial rather than subsistence farmers are likely to be the most frequent users of these technologies and are whom manufacturers and distributors should target (USAID 2016a), although they can also be a means for subsistence farmers to engage in the production of cash crops such as vegetables.

Drip and sprinkler irrigation have been shown to have significant economic benefits in assessments of demonstration projects and other experience (Otoo et al. 2018; Shah et al. 2014; FAO, n.d.; Gebregziabher et al. 2016). For example, adoption of drip irrigation can save 38% of labour, 45% less water use and increase yields by 110% according to one report (USAID 2016a). Yet it is important to note that to yield such benefits, irrigation solutions must be carefully tailored to the biophysical and socioeconomic contexts in which they are deployed.

TABLE A1. Summary of selected types of irrigation.

Type of irrigation		Description	Crops	Farm size
Drip irrigation		Drip is a localized irrigation method that supplies water through pipes and emitters at very low flow rates directly at the root zone of the individual plant. The technology is water-efficient, as it minimizes over-irrigation and evaporation rates.	The technology is suited for row crops (vegetables, soft fruit), flowers, tree and vine crops, where one or more emitters can be provided for each plant. Generally, only high-value cash crops are considered for this form of irrigation because of the installation costs.	Large-, medium- and small-scale. Drip irrigation can be applied across farm size, though subsistence farmers, who produce crop staples only, are not suitable for the system.
Overhead	Sprinkler	Water is distributed through pipes and sprayed into the air through sprinklers, so it resembles rainfall.	Sprinkler irrigation is suited for most row, field and tree crops, and water can be sprayed over or under the crop canopy.	Large-, medium- and small-scale.
	Centre pivot	Centre-pivot irrigation, also called water-wheel and circle irrigation, is a method of crop irrigation in which the equipment rotates around a pivot, and the crops are watered with sprinklers.	However, large sprinklers are not recommended for the irrigation of delicate crops such as lettuce because the large water drops produced by the sprinklers may damage the crop.	Large- and medium-scale Centre pivots are large, heavy and costly equipment only suited for plot sizes above a certain area.
Manual/"bucket" irrigation		Water is distributed over land through manual labour and water cans. A very labour-intensive system.	Can be applied to all crops, but is mainly used by subsistence farmers on staples as a supplementary to rain.	Small-scale. A system only practiced among subsistence farmers (= small-scale farmers without market production).
Surface	Furrow	Furrows are small channels that carry water down the slope in the land between the rows of crops. Water infiltrates into the soil as it moves along the slope. Siphons are sometimes used to transfer water from furrow to crop area.	Furrow irrigation is best used for irrigating row crops such as maize, vegetables and trees.	Large-, medium- and small-scale
	Basin	Basins are flat areas of land surrounded by low bunds ensuring that the farmed area is flooded.	Paddy rice is always grown in basins. Some cereals, tree crops (i.e. citrus) and a few row crops (i.e. tobacco) can be grown with the basin method.	Large-, medium- and small-scale
	Border	Borders are long, sloping strips of land separated by bunds. Border irrigation can be viewed as an extension of basin irrigation, with free draining conditions at the lower end.	Border irrigation is particularly suitable for close growing crops such as alfalfa, but it can also be used for row crops and trees. This technology is now common in Kenya.	Large scale. Best suited to the larger mechanized farms, as it is designed to produce long uninterrupted field lengths for ease of machine operation.

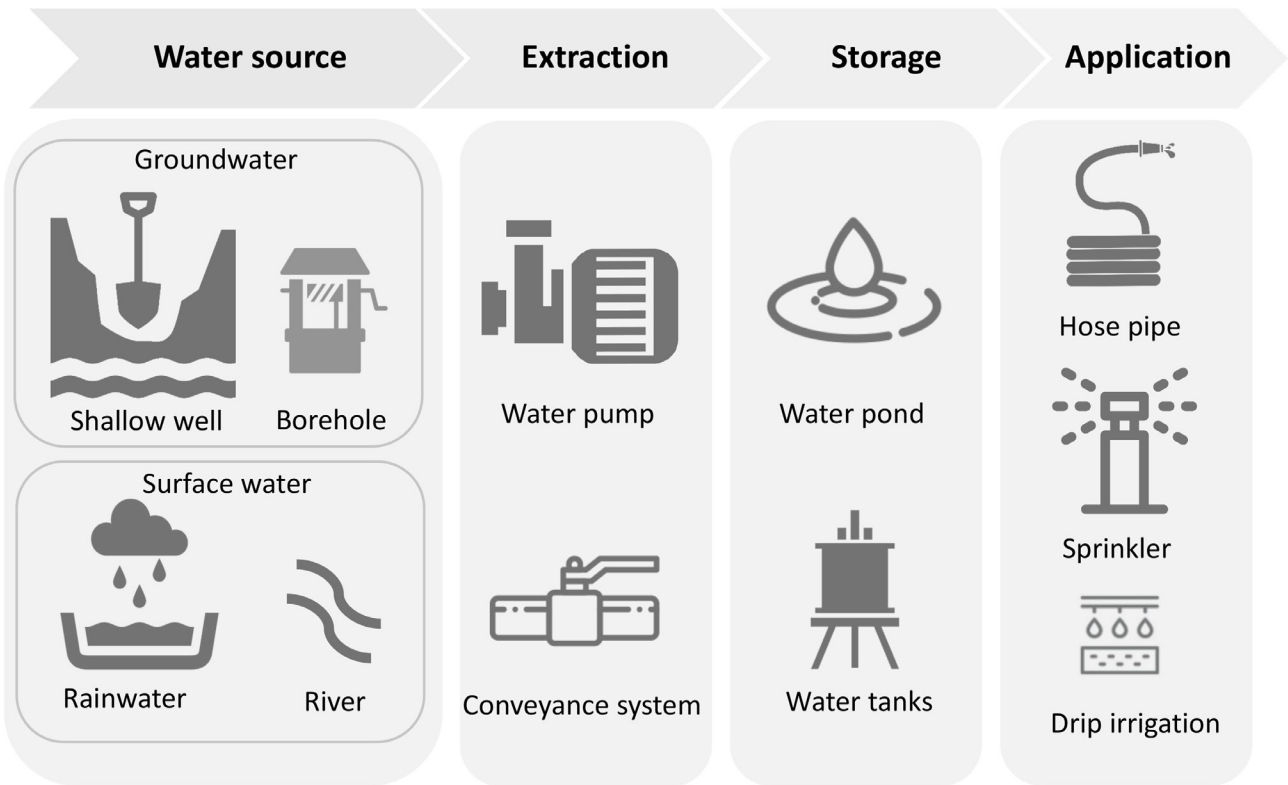
Source: Based on FAO (1986; 2015b) and Brouwer (1990b)

Annex II. Key components in irrigation systems

The physical components and processes in an irrigation system may be categorized into water source, water extraction, water storage and water application (Figure A2). This simple typology applies to irrigation systems of all sizes, but in the present context it provides an overview of how a small-scale irrigation system could be designed and the broad components involved. The

four components make up an integrated system. While a water source, water extraction and water application are all necessary components, water storage is not always needed, though it may improve the efficiency of a system or prolong the period in which it can function into, for example, the dry season, where rivers may dry up or groundwater levels sink. Figure A3 illustrates some of the components.

FIGURE A2. Typology of irrigation system components, consisting of water source, water extraction, water storage and water application.



Source: the authors.

Access to water is obviously a precondition for irrigation. In some regions of Kenya, such as around Mt. Kenya, the topography and the climate allow farmers to irrigate using a gravitational furrow system. If the land is located close to a river, lake or wetland, farmers can use this as a water source. Shallow wells may also be used where the water table is high, but they may not constitute a reliable or continuous water source. Water can also be accessed through boreholes, though establishing a borehole is expensive. Obtaining a permit for irrigation must follow formal procedures, including surveys of hydrological and geological conditions and authorization from the Water Resource Authority.

Extracting the water from the water source normally requires use of a pump powered by diesel/petrol, grid power, or solar PV. The water may be extracted and applied directly to the field or led into a water storage facility such as a water pond or elevated tank, from where it can be applied via gravity or pump. In some large irrigation schemes, water is delivered through a conveyance system with valves allowing each farmer to turn the water on and off. For low-pressure solutions like drip irrigation, water is lifted into a tank, from where it is distributed by gravity through drip lines to the individual plants. The sprinkler application technology requires a higher pressure, which can be generated using a pump or through connection to a large pressurized water-intake system where one exists.

FIGURE A3. Irrigation technology segments: shallow well with grid-powered water pump (top left), solar PV pump (FuturePump S1) (top right), sprinkler (bottom left) and intake valve for the conveyance system (bottom right).



Annex III. The role of irrigation in agricultural development

Agriculture is the backbone of Kenya's economy, employing 75% of the population and contributing one-third to GDP (MoW 2019). Small-scale farms, with an average farm size of 0.2–3 ha, produce up to 75 % of the country's total agricultural output and 70% of its agricultural market (GoK 2010). Hence raising the productivity of smallholders is key to further development of the sector.

Irrigation can be a central factor here. Irrigated fields occupy ≈2% of the total agricultural area in Kenya, but account for 18% of the value of all agricultural produce and contribute 3% to Kenya's GDP. This suggests that there can be significant economic benefits from raising agricultural productivity through an increase in irrigation (MWSI 2019). In this context, an important fact to consider is that Kenya's farmland is highly fragmented (USAID 2016b), with an average small-scale farm of half the size of its neighbours Ethiopia and Tanzania. This suggests a key role for irrigation solutions that are feasible and profitable on very small scale of, for example, half an acre (2024 m²) and down to 500 m².

Over three decades ago already, the FAO (1986) pointed out that improving the performance of irrigation would require a substantial change in various incentives and capabilities, including long periods of social change, supportive policy frameworks, enhanced return-on-investment rates, substantial international policy and financial support, and the emergence of private-sector agricultural services.

Today, irrigation is recognized by both private and public actors as a key means of improving food security and livelihoods and fostering agricultural transformations in Kenya, the technology being part of several recent visions and strategies, including Kenya's Vision 2030, the BIG4Agenda and the Agricultural Sector Transformation and Growth Strategy (MALF 2019). Irrigation is also seen as a technology for reducing vulnerability to climate change (MALF 2017; GoK 2013; 2010). Hence, efforts to develop irrigation in Kenya are likely to receive support from broad ranges of stakeholder.

Still, as in SSA as a whole, the adoption rate of irrigation technologies has been low among smallholders in Kenya (FAO 2015b), although precise statistics for this farm segment are lacking.

Annex IV. Irrigation schemes in Kenya

In early 1900, formal irrigation schemes emerged with the construction of the Uganda-Kenya railway, and in the 1950s the first large-scale irrigation scheme was built (Ngigi 2002). Independence from Britain in 1963 marked a beginning in Kenya's more formal development of irrigation, which since then, especially for smallholders, has depended strongly on public-sector projects supported by international development finance.

Irrigation schemes in Kenya can be broadly categorized into four groups (with the last not being an actual scheme¹³): large public schemes, community-based smallholder schemes, commercial private irrigation, and individual medium-scale and small-scale irrigators.

Public or national schemes

Public or national schemes are developed on public land and are managed by the National Irrigation Authority (NIA) in consultation with counties and other regional authorities. Public or national irrigation schemes cover an area of 24,240 ha and range in size from 400 ha to more than 12,000 ha (MoW 2019), including the Mwea, Bura, Tana, Ahero, West Kano, Perkerra and Bunyala irrigation schemes. Farmers hold allotment letters to their respective parcels, which often average one acre (0.4 ha), and are organized in geographical or hydrological units that are irrigable from the common source or distribution of water. The NIA and regional authorities provide agricultural inputs, advisory services and irrigation services in operation and maintenance under agency contracts. In a majority of the schemes, the technology is typically furrow irrigation, where water is conveyed and distributed in gravity-fed open-earth channels.

Community-based smallholder schemes

Community-based smallholder irrigation schemes are owned and managed by farmers through a cooperative, a community, an irrigation water-users' association (IWUA) or self-help groups. Over 3600 such schemes exist in Kenya, covering over 110,000 ha (MoW 2019). They produce a large share of domestically consumed horticultural products, as well as export crops, grains and tubers. Farmers often take the initiative to establish these schemes, which are then enabled and implemented with support from public institutions, development partners, NGOs, engineering companies and technology suppliers (see also Box 1).

Commercial schemes

Irrigation by commercial schemes covers an area of 88,000 ha (MoW 2019). These schemes are owned and operated by large-scale, commercial farms using advanced technology to produce high-value crops for the domestic and export markets, specifically flowers, fruits and vegetables. Examples include those owned by the companies Del Monte, Kakuzi, Finlay and Oserian. Some of these large-scale farms work with outgrowers, meaning that they buy crops from smallholders who are able to meet the specific value chain's standards.

Individual medium-scale and small-scale irrigators

Small- and medium-scale farmers often irrigate their crops on an individual basis outside official schemes and thus are not fully captured by irrigation statistics (as in Figure 1). They use a variety of equipments, including solar pumps, water tanks, sprinklers and drip kits. Based on a 2015 survey of household budgets

¹³ An irrigation scheme can be defined as "(...) a group of irrigation farmers who share a hydraulic system that provides irrigation water. A scheme requires collective management of the shared irrigation system" (Africa Union 2020, 6).

by the Kenya National Bureau of Statistics, the World Bank Group (2019) showed that 1-2% of subsistence households and 6-7% of market-selling households use irrigation. As some households may irrigate as part of an irrigation scheme (community-based or public), the exact figures are not known. However, several interviewees observed an increasing number of small- and medium-scale farmers using irrigation in recent years. Accordingly, irrigation development led by small- and

medium-scale farmers may have a substantial effect on the overall development of irrigation, although this remains largely undocumented. Because of the informal nature of their activities, small- and medium-scale farmers are not covered consistently in national statistics, as has also been shown by other studies in SSA (Woodhouse et al. 2017; Beekman et al. 2014). In Kenya the growth may partly be driven by purchases by an increasing middle class wishing to invest in irrigation for urban farming, backyard gardening or rural farming.



Annex V. Policy support and regulatory framework

This annex discusses the policies and regulations that form the evolving policy framework for irrigation in Kenya. It shows how irrigation has become an increasing political priority in Kenya.

The Kenyan government has published a number of strategies, policies, laws and regulations that have influenced the irrigation sector directly or indirectly. In Figure A5 the most important ones are highlighted, focusing on the period after 1999. The first major

law was the Irrigation Act of 1966, which created the National Irrigation Board (NIB). Many laws on forestry, agriculture and industry have been enacted since 1966 that influence the irrigation sector, as shown in Figure 9, but it was not until 1999 that the first comprehensive policy for the Kenyan water sector, the National Policy on Water Resources Management and Development, was created (Huggins 2001). Table A5 provides an overview of selected policies and regulations, as well as their implications for the irrigation sector.

FIGURE A5. Kenya's evolving policy framework, with selected policy documents



Source: the authors.

TABLE A5. Description of selected policies and regulations related to irrigation development

Scope	Name (year)	Description and implications for irrigation development
Overarching policy plans	Big4Agenda (2017)	Action plan to foster economic development of socio-economic issues through four pillars: i) food security and nutrition, ii) affordable universal health care, iii) affordable housing, and iv) enhancing manufacturing. The pillar of food security and nutrition targets a 700,000 acre (283,280 ha) increase in the large-scale production of staple crops, to be grown under irrigation. Moreover, it is a priority to enhance the productivity of smallholders through improved access and reduced prices of locally accessed agri-input, as well as waiving import duties on post-harvest storage equipment.
	Kenya Vision 2030 (2008)	Launched in 2008, Kenya Vision 2030 is a plan for the development of the country until 2030. Improving agricultural development by increasing the area under irrigation, especially in the Arid and Semi-Arid (ASAL) areas of Turkana and the Tana Delta, falls under of the economic and macro pillar.
Agricultural strategies	Agricultural Sector Development Strategy (2010)	Can be applied to all crops, but is mainly used by subsistence farmers on staples as a supplementary to rain.
	Agricultural Sector Transformation and Growth Strategy (2019)	Like ASDS, the Agricultural Sector Transformation and Growth Strategy (ASTGS) is a ten-year sectoral plan aimed to increase the level of food security. One of its overall goals is to increase agricultural production from small-scale farmers as a mean to generate an income and improve livelihoods. A number of actions are proposed to achieve this, including increasing water storage capacity through the construction of dams, supporting farmers with better access to irrigation technology suppliers, promoting new irrigation and water-harvesting technologies, and providing subsidies for rainwater harvesting and small-scale pump systems.
	Kenya Climate Smart Agriculture Strategy 2017-2026 (2017)	The Kenya Climate Smart Agriculture Strategy (KCSAS) outlines how the agri-cultural sector is expected to mitigate and adapt to climate change. The objective is to improve the resilience of agricultural systems while keeping emissions of greenhouse gases low, thus ensuring enhanced agricultural production. KCSAS point water-saving technologies, including sprinklers, drip kits and greenhouses, are measures to improve inefficient irrigation systems, where much of the extracted water is lost.
Water-sector regulations	National Policy on Water Resources Management & Development (1999)	The National Policy on Water Resources Management & Development (NWP) was developed as the first comprehensive national water policy. The NWP sets out the goals and measures for achieving the sustainable development and management of the water sector. Specific objectives include conservation of available water resources, establishment of an efficient and effective institutional framework, and sufficient supplies of water of good quality. Based on the NWP, the Water Act was established in 2002, devolving water and sewerage services to subnational levels, though later, in 2016, the Act was repealed to capture the new paradigm shift on water and food in the contexts of human rights and sustainable development and the management of national water resources (see below).
	National Water Master Plan (2013)	The National Water Master Plan sees to the planning and development of Kenya's water resources and meteorological conditions. The plan will assess and evaluate the availability of the country's water until 2050. It contains an irrigation development plan in which the potential for expanding irrigation and meeting the targets set by Kenya Vision 2030 is assessed for different regions of the country. The plan also emphasizes the importance of water-saving technologies such as sprinkler and drip irrigation, as well as proposing the formulation of irrigation development programmes and financial interventions to improve irrigation infrastructure and human capacities.
	Water Act (2016)	The Water Act provides for the regulation, management and development of water resources. The Water Act recognizes that water-resource management is a shared responsibility between national government and county government. Accordingly, water-resource management nationally is a task of the Water Resources Authority (established under the Water Act 2016), while the local responsibility lies with the Water Resources User Associations (WRUA).
Irrigation laws and plans	Irrigation Act (2019)	The Irrigation Act 1966 was the first comprehensive irrigation law, which provided for the establishment of a National Irrigation Board (NIB). The Act has most recently been renewed with the Irrigation Act 2019, which transforms the NIB into the National Irrigation Authority. The Irrigation Act 2019 makes provision for the development of irrigation in Kenya, including the establishment of irrigation schemes at various levels. The NIA's mandate is to develop and improve irrigation infrastructure and to support medium and smallholder schemes.
	Technological Needs Assessment Programme (2013)	The Technological Needs Assessment Programme is a UNFCCC programme in which developing countries identify key priority sectors and technologies for their mitigation and adaption efforts. Kenya identified drip irrigation as a key technology to increase resilience and climate-proof agricultural production against water scarcities and unreliable precipitation. A number of actions are proposed in the effort to increase the adoption of drip irrigation, including information and awareness campaigns, the training of technical capacities, the provision of low interest credits and enhanced market linkages for farmers.

Source: GoK (n.d.; 2010), JICA (2013) MALF (2017; 2019), Republic of Kenya (2013; 2019; 2016), JICA (2013).

In 2019, the Kenyan parliament approved the Irrigation Act 2019. This law conforms with the conclusion of a recent report from the World Bank (2019), namely that advancing structural reforms is important for stimulating private-sector engagement as a driver of irrigation development. In this regard, the Irrigation Act 2019 transformed the NIB into an authority, the National Irrigation Authority (NIA). Compared to the NIB, the NIA has a broader mandate, with new roles and responsibilities. For example, the NIA is authorized to borrow and lend money. Among its important functions are to "*a) develop and improve irrigation infrastructure for national or public schemes; b) provide irrigation support services to private medium and small-holder schemes; c) provide technical advisory services to irrigation schemes in design, construction supervision, administration, operation and maintenance under appropriate modalities, including agency contract (...)*" (Republic of Kenya 2019, 678). According to researchers at the NIA, the Irrigation Act can potentially strengthen publicled irrigation development as an important step towards improving coordination by public interventions and for irrigation to become a higher political priority.

The new irrigation policy is also aligned well with the Kenyan Agricultural Sector Transformation and Growth Strategy (ASTGS) (MoA 2019). According to the ASTGS, raising the productivity of smallholders in combination with enabling private-sector investments is the key to agricultural transformation and growth. The ASTGS argues that Kenya has a conducive enabling environment for private-sector investment in comparison with other countries in SSA, but it also notes that more transparent investment policies and policy reforms are needed to promote private-sector investments further (MoA 2019).

Irrigation is increasingly recognized as a way of improving food security, livelihoods and agricultural transformation in Kenya, as witnessed by, for example, Kenya Vision 2030, the Big4Agenda and the Agricultural Sector Transformation and Growth Strategy. Irrigation is also seen as important for adaptation to climate change. Irrigation solutions such as drip irrigation have been prioritized in the Technological Needs Assessment Programme, a long-standing programme under the United Nations Framework Convention on Climate Change (UNFCCC), as a key technology to increase resilience and climate-proof agricultural production against water scarcities and unreliable precip-

itation. Similarly, the Kenya Climate Smart Agriculture Strategy 2017-2026 emphasises water-harvesting and water-efficient irrigation systems as climate-smart technologies.

A number of tax-based incentives have been created to promote the development of the irrigation market, mainly exemptions from import duty and valued-added tax (VAT) on irrigation equipment. These exemptions apply only to complete irrigation systems (such as drip kits), some individual parts (e.g. pipes and fittings) being subject to VAT of 16%, as they are not always recognized as being for agricultural purposes. All the technology suppliers we interviewed called for VAT exemptions for all irrigation-related equipment as a measure to reduce retail prices for them. They also pointed out that some spare parts are not accepted as irrigation equipment, and that imports of new irrigation technologies have to be registered through a lengthy process in order to obtain VAT or duty exemptions. Similarly, USAID (2016b) observes that the import and distribution of irrigation equipment is not as efficient as government policy intends due to what in practice is an unclear distinction between what is duty free and what is not.

Annex VI. List of interviewees and interviews

Informant	Stakeholder	Organization	Format	Date
Karia irrigation project society	Farmers	Kahia irrigation society	Group interview	21-01-2020
Mitooini irrigation project society	Farmers	Mitooini irrigation society	Group interview	21-01-2020
Charles	Farmers	Farmer Nyeri	Informal interview/ field notes	21-01-2020
Michael Kironga	Farmers	Farmer Meru	Informal interview/ field notes	21-01-2020
Peter Ngeli	Financier	MESPT	Interview	21-01-2020
Simon Waruingi	Financier	Family Bank	Interview	21-01-2020
Andrew Niljani	Financier	AGGROUP/Endless Africa Lim-ited	Interview	13-01-2020
James	Financier	AGGROUP/Endless Africa Lim-ited	Informal interview/ field notes	17-01-2020
Mica Omato	Financier	AGGROUP/Endless Africa Limited	Interview	17-01-2020
Raphael Wanjogu	Public-sector organization	National Irrigation Authority	Interview	13-01-2020
Jarius Serede	Public-sector organization	National Irrigation Authority	Interview	14-01-2020
Gibson Kiragu	Public-sector organization	Ministry of Water & Sanitation and Irrigation	Interview	14-01-2020
Vincent Koskei	Public-sector organization	MIAD or Mwea Irrigation Agricultural Development Centre	Interview	17-01-2020
Rose Mundia	Public-sector organization	Kerinyaga County	Interview	21-01-2020
David Kimutai and Aris-tophal	Research institution	Kenya Water Institute	Group interview	20-01-2020
Bancy Mati	Research institution	Jomo Kenyatta University of Agriculture and Technology	Interview	17-01-2020
Isaya Sijali	Research institution	KALRO	Skype interview	30-01-2020
Stephen New	Research institution	Financial Transactions and Reports Analysis Centre of Canada (FINTRAC)	Skype interview	09-12-2020
Fred Kizito	Research institution	CIAT	Skype interview	12-12-2019
Vandana Thottoli	Donor and civil society organization	SNV	Interview	16-01-2020
Jay Dave	Technology supplier	Irrico/Hortipro	Interview	13-01-2020
Daniel Muhia	Technology supplier	GreenServe Agrisolution	Interview	15-01-2020
Elijah Mugah	Technology supplier	G. North & Sons	Interview	15-01-2020
Stephen Wambua	Technology supplier	Davis and Shirtliff	Interview	16-01-2020
Oliver Ndegwa	Technology supplier	Agrotunnel	Interview	20-01-2020
Athur Ammi	Technology supplier	Amiran Kenya	Interview	20-01-2020
Tom Opapa	Technology supplier	KickStart International	Interview	20-01-2020



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