IRRIGATION INVESTMENT AND MARKET ANALYSIS STUDY

FINAL REPORT (BACKGROUND PAPER)

JULY 2018

Submitted to

Agribusiness Initiative Trust Uganda Ltd
Umoja House, 2nd Floor, Plot 20, Nakasero Road

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ACRONYMS AND ABBREVIATIONS

aBi	Agricultural Business Initiative
ACF	Agricultural Credit Facility
ASSP	Agriculture Sector Strategic Plan
CICS	Competitiveness and Investment Climate Strategy
DDA	Dairy Development Authority
DWD	Directorate of Water Development
DWRM	Directorate of Water Resources Management
EADD	East Africa Dairy Development
EAS	East African Standards
EPRC	Economic Policy Research Centre
FAO	Food and Agriculture Organization
FAQ	Fair Average Quality
FSD	Financial Services Development
GDP	Gross Domestic Product
GOU	Government of Uganda
GWI	Global Water Initiative East Africa
Ha	Hectare
HDPE	High Density Polyethylene
ITC	International Trade Center
MAAIF	Ministry of Agriculture Animal Industry and Fisheries
MDIs	Micro-Finance Deposit Taking Institutions
MWE	Ministry of Water and Environment
NARO	National Agricultural Organization
NBI	Nile Basin Initiative
NDP	National Development Plan
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
OPM	Office of The Prime Minister
OPV	Open Pollinated Variety
SMEs	Small And Medium Enterprises
TGCU	The Grain Council of Uganda
UBOS	Uganda Bureau of Statistics
UCDA	Uganda Coffee Development Authority
UGX	Ugandan Shillings
UNBS	Uganda National Bureau of Standards
VCD	Value Chain Development
WfAP	Water for Agricultural Production

WFP	World Food Program
WTO	World Trade Organization

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EXECUTIVE SUMMARY

Introduction

The agricultural sector in Uganda faces increasing incidence of prolonged drought and unreliable rainfall attributed to climate change resulting into decline in agricultural productivity and household incomes. However, Uganda has an irrigation potential estimated at about 3,030,000 ha with only less than 1% currently exploited by less than 1% of agricultural households. In addition, access to water for livestock at present is estimated at 48.8%. Lessons learned from the past 8 years indicate increasing importance of irrigation as one of the key factors for increasing productivity, incomes and competitiveness of agribusinesses in both domestic and international markets. Evidence shows that irrigation can increase yields of coffee, vegetables and fruits by 2 to 4 fold stabilize and increase production and enhance product quality. It is against this background that a study was carried out to identify priority areas for enhancing private-sector investment and adoption of irrigation technologies by SMEs and small scale farmers.

In line with the aBi objective of strengthening private sector agribusiness by increasing land and labour productivity, the specific objectives of the study were to:

i) Recommend the most feasible technologies and enterprises for water smart agriculture targeting SMEs and smallholder farmers;
ii) Identify opportunities, risks and challenges associated with identified investment opportunities; and
iii) Develop recommendations for a package of interventions to attract private investments in irrigation and strengthen the capacity of the farmers to demand and pay for irrigation.

2. Situational analysis

Current utilization of irrigation

Currently, the majority of small-scale farmers (~96%) rely on informal irrigation on the fringes of swamps using traditional surface irrigation techniques with focus on rice, vegetable and fruit production systems. Only a limited number of small-scale farmers (< 4%) rely on modern pressurized irrigation techniques. The most common surface irrigation methods are basin irrigation for paddy rice and furrow irrigation for other field crops, while the most common pressurized irrigation methods are drip irrigation kits, drag-hose irrigation, overhead sprinkler, micro sprinklers and rain gun sprinkler system. Use of mechanized irrigation is limited. Center-pivot irrigation is only at a few private farms like Kakira Sugar Limited in eastern Uganda. Greenhouse irrigation is used by commercial farmers engaged in floriculture and high value vegetables concentrated around the Lake Victoria zones. The major water sources for irrigation are river diversions, wetlands, shallow wells, and to a limited extent private valley tanks/dams and underground rainwater harvesting tanks. Water abstraction is usually done using treadle pumps and small petrol engines (up to 7 hp).

Technology use

In the past 5 years or so, rain gun sprinkler irrigation system has dominated the irrigation market followed by conventional overhead sprinkler system, drip irrigation kit and greenhouse irrigation kit. This is largely attributed to: (i) Simplicity and ease of set-up; (ii) Portability making it easy to be moved from once place to another and are thus applicable for an individual farmer or a group of small-scale farmers; (iii) Relatively low cost of irrigation set up due to limited pipe network; and (iv) Can suit farmers in all acreages.

Solar powered irrigation is still a small but growing market in Uganda driven by limited access to electricity and high fuel costs to run the conventional pumps. The market for PV solar power is well established across the country, but not in combination with irrigation.

Irrigation equipment is mainly sourced from Israel, Britain, Turkey, Spain, Belgium, Holland, Kenya, China and India. However, Multiple Industries Limited has started manufacturing irrigation components like pipes and connectors.

There is a rise in distributors with services beginning to open country wide e.g. SIRACO, SolarNow, Holland Green Tech, Balton (U) Ltd, Multiple Industries, Davis and Shirtlif, AgroMax etc. Distributors provide a broad scope of technical services to farmers, from project design, to equipment supply, installation, maintenance and after-sale assistance, to farmer training and irrigation management.

Enterprises currently irrigated

The leading enterprises being irrigated are vegetables (pepper, tomatoes, cucumber, colliandra, cabbage, African egg plant, lettuce, amaranths, carrot, cauliflower, kale, cucumber, Spinach, French beans), fruits (citrus, apples, mangoes, passion fruits), rice and coffee. Hot pepper/chillies and vanilla are mostly for the export market.

Locations where irrigation is mainly used

Irrigation of horticulture is concentrated in Eastern Uganda (Busoga region, Teso region, Bukedi, region, Elgon region-Mbale, Kapchorwa), Central Uganda (Luwero, Nakaseke, Wakiso, Mukono, Mubende, Lake Victoria Basin areas) and Western Uganda (Kabale, Kasese, Rukungiri), West Nile region (Nebbi, Packwach) and most peri-urban and urban areas. Irrigation of rice is concentrated in Eastern Uganda (Busoga region and Bukedi region). Irrigation of coffee is emerging in Central Uganda (Masaka, Mpigi) and Western Uganda (Kasese, Kamwenge, Ibanda).

Key national Legislative Framework on water resource development and utilization

Abstraction of water that is required for irrigation of the crops is regulated by the *Water Act, Cap 152*. According to Section 6 of the Act, no person acquires rights to use water, or to construct or operate any works unless authorized under Part II of the Act. In addition, no person is allowed to sink any well or use any water without a permit to undertake works or a water permit.

The National Environment (Water Resources) Regulations, 1998 requires that all developers of water supply for commercial irrigation, livestock development and fish for which the abstraction rates exceed 400 m^3/day from motorized water pump which whether temporarily or permanently, pumps water from a borehole or waterway boreholes shall apply for a permit for water abstraction. A permit is also required where there is a weir, dam, tank or other work capable of diverting or impounding an inflow of more than 400 m^3/day. The threshold translate to anyone who at least irrigates 4 ha with 10mm of water per day in the growing season.

The National Environment (Wetlands, River Banks and Lakeshores Management) Regulations, 2000 provide principles for sustainable use and conservation of wetlands, riverbanks and lakeshores. The regulation requires that any person, community or organisation must be granted wetland resource use permit to undertake any regulated activities within wetlands. The regulations defines "drainage of wetlands" as the removal or exclusion of water from a wetland by pumping, excavation of channels, planting in a wetland fast growing non wetland trees or plants, abstraction of water from a river entering a wetland, channeling, reclamation and drainage itself.

The National Environment Act, Cap 153 requires projects such as “dams, rivers and water resources including storage dams, barrages and weirs, river diversions and water transfers between catchments and flood control schemes”) to undertake an Environmental Impact Assesment (EIA) to ensure compliance with environmnetal protection.

Irrigation financing and business models

There are four business models currently being used by financial institutions and suppliers of irrigation technologies and services:

- *Retail model*

In the retail model farmers buy directly from the providers either using their own money or loans from the banks. Most of the financial institutions in Uganda offer the retail model which entails lending directly to SMEs and small scale farmers. Lending is done against a collateral. This model allows for a segmented approach to agricultural SMEs. For example, smallholders are served only with small credits, whereas growing farmers can apply for investment financing as well. Lending is done against a collateral. Farmers are prone to dealing with fake suppliers and diversion of loans to non irrigation related activities.

- *Whole sale model*

Wholesale model is based on a financial institution lending indirectly to smallholders through an aggregator organization, such as a farmer-based organization or cooperative. A classical example is that of aBi Finance Clean Technology Fund. aBi Finance offers clean technology fund that is interest free in the range of UGx. 300 million to UGx. 4 billion. For grants, there is no interest but cost-shared grants where the beneficially must contribute at least 20%. For loans, interest rate depends on the Implementing partners who are financial Institutions. The target beneficiaries are associations/groups with strong business case which has been in operation for at least 3 years promoting agribusiness with potential to increase income and jobs as well as impact on the community where the project will be. They can also be individuals through banking institutions with strong business case promoting agribusiness with potential to increase income and jobs as well as impact on the community where the project will be. The potential beneficially must not be targeting only one line of business but diversification is key.

- *Irrigation credit scheme model*

The irrigation credit scheme entails lending indirectly to farmers through partnership with an irrigation service provider. This scheme has been pioneered by Centenary Bank in partnership with Balton Uganda (BU). A similar arrangement is currently being developed between BU and DFCU and UDB. The client with interest in an irrigation system gets a quotation from an irrigation service provider and then presents it to a bank in form of a loan request. The client would have to ensure that at least 30% of the cost of the total cost of the irrigation system is deposited on his/her account). The Bank would then purchase the irrigation system and irrigation service provider does the installation, and works with the farmer for given period say three months.

- *Equipment credit financing model*

Farmers obtain the irrigation technology with a down payment of an agreed percentage. The remaining money is paid in installments over an agreed period of time. A classical example is that of Solar Now Uganda.

3. Opportunities and challenges

Market and investment opportunities

The key market and investment opportunities identified in the literature review and stakeholder consultations are:

i. *High demand for off season production targeting both the domestic and export market for horticultural products*. Off-season vegetable and fruit supplies are currently inadequate to meet the demand. This is manifested in increased off season prices. For example off season price for tomatoes, mangoes and passion fruits increase by even over 100% in comparison to rainfed dependent seasons.
ii. *High price premium for increased quality due to irrigation*. Vegetables and fruits are demanded in their fresh form whose quality is enhanced though irrigation in terms of size, succulence, and taste.
iii. *The demand for water to prevent crop failure at critical growth stages and to increase/stabilize yields for high value crops (supplementary irrigation) and to sustain all year round production for processed products*. Water stress at critical stages of crop growth e.g. flowering for vegetables, fruits and coffee can result in total crop failure or substantial reduction in yields depending on the sensitivity of the crop to water stress. Currently, Britania can only meet 1/3 of its demand for mangoes due to low production and inconsistency in supply.
iv. *The growing demand for irrigation equipment and technical support.* All irrigation distributors testify to increased sales volumes of irrigation equipment over the past 5 years or so. A classical case is that of SolarNow, a new company in Uganda which started its operations in 2015. SolarNow sold its first solar pump in December 2015 from their pilot Kenya project. In 2016, sales were 2-4 pumps/month and the total

pumps sold at the end of that year was 15. In 2017, their sales were about triple the 2016 sales.

v. *Abundant water sources*: Over 15% of Uganda's surface area is covered by fresh water resources. Even the driest areas of Uganda receive an average minimum of 600 mm per year, which can be harnessed for irrigation. However, what is missing is infrastructure to facilitate irrigation and awareness creation among farmers to facilitate adoption of irrigation. The present utilization rate of the internal renewable water resource[1] is low (2.8%). The utilization rate of the entire renewable surface water resources stood at 0.01% as of 2013. If the full irrigation potential was to be exploited, the demand for water would be increased by over 400% by 2030 translating into a utilization rate of renewable surface water resource of 0.05%.

vi. *Local agricultural lending financial institutions*. Over the past few years, financial institutions in Uganda have increasingly shown interest in providing agricultural credit to small-scale farmers. Examples of financial institutions offering agricultural loans are DFCU Bank, Centenary Bank, Uganda Development Bank, Housing Finance Bank, Opportunity Bank, Post Bank, Pride microfinance, and Finca Uganda Ltd. A classical example is that of Centenary Bank whose loan portfolio stands at Shs520 billion with 17% of this going to agriculture compared to 6% of the entire banking industry. Lending to the agriculture sector has been on a steady rise because Centenary Bank is cognizant of the fact that agribusiness is the leading source of wealth creation in Uganda and Africa as a whole. In 2016, Centenary Bank disbursed approximately Shs88 billion to 26,700 farmers compared approximately Shs66 billion to over 21,000 farmers in 2010.

An Agricultural Credit Facility (ACF) was set up by the Government of Uganda (GoU) with the aim of facilitating the provision of medium and long term financing to projects engaged in Agriculture and Agro processing, focusing mainly on commercialization and value addition. By 2015, the Government of Uganda (GoU) contribution to the ACF totaled UgX 119.07 billion. Loans for irrigation and greenhouse facilities as of 2015 constituted 2.71%. The other shares were to: agro processing machinery (58.3%), farm expansion 16.46% and Tractor and farm equipment at 13.82%;

vii. *Enabling environment*: An Explicit national irrigation policy and commitment of resources for implementation. The Uganda National Irrigation Policy is focused on promoting public and private investments in irrigation.

Imported irrigation equipment is exempted from customs duties and VAT, making irrigation an attractive investment opportunity.

viii. *Partners*: Development partners willing to invest in irrigation by providing loans, grants and subsides. The major partners include World Bank, African Development, Japan International Cooperation Agency (JICA), FAO, Islamic Development Bank and International Fund for Agricultural Development (IFAD).

[1] The sum of the external and internal renewable surface water resources (the average annual river flow generated from precipitation) in Uganda amounts to 43.3 billion cubic meters per year, while the dependence ratio (proportion that originates outside the country) was about 69% as of 2013.

Challenges

Irrigation has been a major national intervention for increasing agricultural production since the 1960's. Small scale farmers mainly targeted wetlands as an opportunity for irrigation. It was not until the last 10 years that it was realized exploitation of wetlands is not sustainable and it is necessary to focus on sustainable irrigation interventions particularly to address climate change. Hence, the focus on climate smart agriculture. According to findings from stakeholder consultations, the major challenges to access and use of irrigation are:

(i) Small growing market not yet large enough to attract investors;

(ii) High risk/uncertainities associated with returns on investment in irrigation;

(iii) High initial cost of irrigation set-up and maintenance exacerbated by high energy costs: Most small-scale farmers do not have the financial capacity to invest in irrigation due to the high initial cost of irrigation set up. Operation and maintenance of irrigation systems is high due to rising fuel and electricity costs and shortage of farm labour as a result of increasing rural-urban migration and rising rural wages;

(iv) Influx of fake irrigation products threaten the market credibility even for genuine suppliers. For example in some instances, farmers find costs of genuine products rather high causing them to turn to what they think are cheap genuine products only to turn out to be fake products. This ends up discouraging them from taking up irrigation technologies all together. Regulations on irrigation equipment standards and enforcement are lacking;

(v) The bulk of water resources are locked up in large water bodies and reservoirs which do not attract private investment in water abstraction and commercial supply for lack of tailored enabling environment. In addition there is physical water scarcity in some areas attributed to lack of/limited water sources and seasonality of water sources while in other areas there is economic water scarcity attributed to lack of investment in water infrastructure and to high cost of water abstraction;

(vi) The risks associated with predictability of rainfall to guide investment planning and management of irrigation systems;

(vii) Inadequate technical knowledge and skills on irrigatio*n*. There is lack/limited knowledge among farmers and SMEs about the financial and economic viability of irrigation and lack of specific recommendations on what, where and how to use irrigation. Farmers lack knowledge of crop and climate responsive irrigation schedules, on-farm water application techniques, agronomic practices, and application rates of agrochemicals, resulting in poor water-use efficiency and reduced crop water productivity.

(viii) Fragmented markets for irrigation services and equipment service providers. Most distributors of irrigation equipment are located in Kampala which makes access to irrigation equipment, spare parts and repair services difficult and costly for rural farmers. It is common to find irrigation equipment in rural areas often breakdown and are rendered unusable due to lack of after sales services.

(ix) High interest rates. Currently, the interest rates on agricultural loans are high (18-25% p.a) making borrowing very difficult for small scale farmers.

(x) Un-favorable loan repayment schedules. Repayment of loans is hampered by seasonality of cash flows from farming with earnings concentrated in certain times of the year. This calls for customized loan products where agricultural credit may need to be repaid in "lumpy installments," sometimes over multiple seasons.

(xi) Collateral: Farmers usually lack the collateral traditionally required by banks. In addition, financial institutions don't accept irrigation system as a collateral.

(xii) Lack of access to technical and market information. Besides the shortage of extension workers, there is a lack of an effective streamlined extension structure to coordinate and provide advisory services and technical backstopping on irrigation to farmers from the local level to the national level. Information on where to buy irrigation equipment and market prices is not readily available to farmers.

3. Irrigation Investment Options

Water source options

The most common sources of water for irrigation include rivers, reservoirs and lakes, and groundwater (Table A.1). Reservoirs can be in form of runoff water harvesting in valleys or underground water storage tanks.

Table A.1: Recommended water sources for privately owned small and medium scale irrigation

No.	Water source	Description/technical considerations	Investment cost ($/ha)
1.	Rivers	• Natural water systems • Extraction of water is done through a bank-mounted motorized, solar or human-powered pump. • At least a discharge of 1.5 to 2 L/s is needed to irrigate 1 ha. • Over-extraction of water can deprive downstream water users.	Depends on the system of river diversion /water abstraction
2.	Underground water storage tanks	• A water storage structure constructed below the ground. • Have volumes ranging from 20 to 150 m^3. • They collect and store runoff from open grasslands, hillsides, home compounds, roads, footpaths, paved and unpaved areas, roofs and river diversions. • The tank can be lined with HDPE Dam liner to conserve water. The lined underground tanks range from 50,000 L-500,000 L though they can be as large as 1,000,000 L. • Usually fusion and extrusion welding is carried out to join the lining material to the required measurements. • Can be used to irrigate maximum of 0.25 acres. • Irrigated area is bigger underground water storage tank is considered as night storage reservoirs fed by a stream/spring	• HDPE Dam lined underground tanks cost between 3 to 5 US $/m^3$ of water storage. • A 50,000 L tank costs Ugx. 5 million including HDPE lining material. 1 mm thick HDPE costs Ugx. 25,000-27,000/m^2. • O&M cost: 1-2% of the investment cost per annum • Life span: 15 to 20 years for HDPE Dam lined tanks

3.	Valley tanks	• An excavation in the valley that can store between 5,000 - 20,000 m^3 of water
		• Extraction of water from the reservoir can be done through:
		  o A sump (well reservoir) in natural ground at the side of the reservoir, supplied by gravity from a screened inlet and pipe through the bed and side of the reservoir;
		  o A bank-mounted motorized, solar or human-powered pump.
		• Suited for a watershed area of at least 2 km^2 catchment.
		• At least 12,000 - 15,000 m^3 of water storage is need to irrigate 1 ha per season if storage is based on rainwater harvesting.
		• Irrigated area is bigger if the valley tank is considered as night storage reservoirs fed by a stream/spring
			• US$ 2 to 4 per m^3 water storage
			• O&M cost: 1-2% of the investment cost per annum
			• Life span: Depends on maintenance and level of environmental degradation (siltation)

4.	Shallow wells	• Shallow wells draw water from an unconfined aquifer or shallow groundwater table/ unconsolidated formation, i.e. the regolith. • Depths of hand-dug wells range from about 5 metres deep, to over 20 metres deep. • Stable soil structure for wells without lining. Well stabilization by lining required for unstable soils (sand).Sandy soils require lining of the well for depth > 2 m. The pits are lined with concrete rings, bricks or stone masonry, allowing groundwater to be sourced from greater depths. • Extraction of water from the reservoir can be done through bank-mounted motorized, solar or human-powered pump. • Abstraction should be at low discharges of the order of 0.5 m^3 up to 2 m^3/hr. • Can irrigate small areas (0.1 to 0.3 ha)	• The costs for open wells can vary considerably depending on the well's depth and the equipment required for drilling; • Costs may vary between US$500 and 1 500 per open well fitted with concrete lining. • O&M cost: • Life span: 5 to 10 years
5.	Deep wells (Boreholes)	• A well sunk through an impermeable stratum to draw water from a relatively deep, confined aquifer. • Boreholes depth ranges from 15 m – 90 m. • Average maximum yield is ~ 5-7 m^3/hr varying with location. • Used in conjunction with a suction hand pump, solar pump or submersible electric pump • A well with yield of 7 m^3 per hr can command 1-2 ha per day.	▪ Investment cost: (~US $5,000 USD to 20,000 depending on the depth of the well. ▪ investigations ▪ O&M cost: 2% of the investment cost. ▪ Life span: 10 to 15 years depending on the maintenance

Recommended irrigation technologies and suitable enterprises

A feasible climate smart irrigation technology should be affordable, available, adaptable to existing setting, enhance farming profitability, water efficient, easy to operate, repair and maintain, and environmentally and socially acceptable. The choice of an irrigation system is site specific and depends on: (i) Type of crop; (ii) Relative position of water source to the irrigation field; (iii) Type and characteristics of water source (quantity and quality); (iv) Energy source; (v) availability of equipment, spares, and maintenance facilities; (iv) Labour costs, level of skills and availability (v) Type of soil, (vi) investment costs; (vii) Availability of credit and (viii) Land size.

The recommended climate smart irrigation options for small-scale farmers and SMEs are: (i) Solar-powered drip irrigation system; (ii) Conventional drip irrigation system; (iii) Rain gun sprinkler irrigation system; (iv) Conventional overhead sprinkler irrigation system (Table A .2).

The recommended options for small-scale farmers and SMEs diary production are: (i) Lined underground water tank with motorized abstraction, (ii) Borehole with solar powered abstraction (Table A.3).

***(i) Solar powered irrigation*:**

Solar pumps allow small scale farmers and SMEs to circumvent the constraint of absence electricity and high fuel costs for conventional motorized pumps. In irrigated agriculture, water is most needed during the hot sunny days, when solar energy is at its optimum.

Solar systems are rapidly gaining popularity as PV irrigation pump sets are becoming available at affordable prices. This, in combination with rising fuel prices, point towards favorable conditions for a shift to solar energy. The market for PV solar power is well established across the country, but not in combination with irrigation.

The main constraints for solar powered irrigation is the limited energy outputs of solar panels hence low discharge. In most cases a solar-driven electric pump may irrigate an acreage of 0.3 to 1 ha.

The considerations for commercialization of solar powered irrigation are: (i) Adequate sunshine (8 to 12 $KWh/m^2/day$); (ii) Solar panels and suitable pumps commercially available; (iii) Construction of a reservoir for 2 to 3 days storage to increase discharge and cater for period of low sunshine; (iv) Competent technical advisory services for design and installation; and (v) Low pressure pipe system or drip irrigation.

(ii) Conventional pumped irrigation (rain gun sprinkler, overhead sprinkler and drip irrigation):

Conventional pump sets are still relatively cheap to buy, available in most regional capitals and maintenance can be assured by rural mechanics; pump sets can be shared by a group of small-scale farmers. These pump sets are reliable provided that adequate maintenance of pumps is undertaken and spare parts are available. Portability of pumps enables farmers to take the pump sets home, avoiding the risk of theft.

The technology is suitable for an individual farmer or a group of small-scale farmers. Individual farmers may extend their garden plots to irrigate a larger area as a result of the motorized pump, while groups of farmers can irrigate a common or collective area.

Rain gun sprinkler irrigation systems are in particular easy to set-up, portable making it easy to be moved from once place to another and are thus applicable for an individual farmer or a group of small-scale farmers, relatively low cost of irrigation set up due to limited pipe network; and can suit farmers in all acreages.

However, fuel costs and access to fuel for running conventional pump sets constitute a constraint for small-scale farmers. For group irrigation of 5 to 200 ha, farmers need to be organized into water users associations (WUA) to ensure adequate operation and maintenance (O&M).

The considerations for commercialization of conventional pumped irrigation systems are: (i) Adequate surface or groundwater sources in the vicinity of irrigated areas (water level not to exceed 7m at pump site); (ii) Assurances for good management and cooperation of farmers in pump users group; (iii) Access to regular supply of fuel at affordable price; (iv) Access to markets for produce; and (vi) Technical advisory services on selection, installation, field irrigation practices and maintenance.

Table A.2: Irrigation options, their configuration, costs per ha, suitable water sources and recommended enterprises

Technology, method	Configuration	Costs per ha	Water sources	Recommended enterprises
Solar-powered drip irrigation system	Solar water pumping system (solar panel, controller unit and motor-pump), a pipeline network (main transmission line to storage tank and distribution line fitted with screen water filter), an overhead storage tank and a network of drip lines.	Investment costs: 14,500 US$ (52,200,000 Ugx) Annual operation & maintenance costs: US$ 800 (2,880,000 Ugx) for maintenance.	Shallow wells, deep wells, valley tanks , underground water storage tanks	Vegetables (Cabbage, tomatoes, onion, hot, okra, green pepper, french beans, Nakati, Kale, Spinach, Lettuce). Fruits (passion fruit, citrus, pineapple, mango, avocado, apples), Spices (hot pepper/chili, vanilla and ginger), Coffee
Conventional drip irrigation system	An engine-driven pump usually petrol pump (3 to 7 hp), a pipeline network (transmission line to storage tank and distribution line fitted with screen water filter), an overhead storage tank and a network of drip lines	Investment costs: 9500 US$ (34,200,000 Ugx) Annual operation & maintenance costs: US$ 3,250 (11,700,000 Ugx) consisting of 1200 US$ (4,320,000Ugx) for energy, 1100 US$ (3,960,000 Ugx) for labour and US$ 950 (3,420,000 Ugx) for maintenance.	Rivers, valley tanks, shallow wells (<7m deep) , underground water storage tanks	Vegetables (Cabbage, tomatoes, onion, hot, okra, green pepper, french beans, Nakati, Kale, Spinach, Lettuce). Fruits (passion fruit, citrus, pineapple, mango, avocado, apples), Spices (hot pepper/chili, vanilla and ginger), Coffee
Rain-gun sprinkler irrigation system	An engine-driven water pump transmits water through a pipeline network connected to a movable sprinkler (rain-gun sprinkler). It is a long range system where water is sprinkled at least 30 m radius.	Investment costs: 4500 US$ (16,200,000 Ugx) Annual operation & maintenance costs: US$ 3200 (11,520,000 Ugx) consisting of 1200 US$ (4,320,000Ugx) for energy, 1600 US$ (5,760,000 Ugx) for labour and US$ 400	Rivers, valley tanks, shallow wells (<7m deep) , underground water storage tanks	Vegetables (Cabbage, tomatoes, onion, hot, okra, green pepper, french beans, Nakati, Kale, Spinach, Lettuce). Fruits (passion fruit, citrus, pineapple, mango, avocado, apples), Spices (hot

	It is a high pressure system requiring more than 5 bars and has discharge rate of 5,000 to 10,000 L/hour. This system is semi-portable with a fixed main/submain and movable and lateral and rain gun.	(1,440,000 Ugx) for maintenance.		pepper/chili, vanilla and ginger), Coffee Groundnuts, Climbing beans, upland rice and coffee-robusta
Conventional overhead sprinkler irrigation system	Consists of an engine-driven pump usually petrol pump (~ 7 hp), a pipeline network (transmission and distribution), and overhead sprinklers placed on riser pipes fixed at uniform intervals along the length of the lateral pipe. It is a short range system where water is sprinkled up to 15 m. It can operate with a pressure of 1 to 1.5 bars for low-pressure sprinklers and 3 to 5 bars for conventional sprinklers. and has discharge rate of 5,000 to 10,000 L/hour.	Investment costs: 6000 US$ (21,600,000 Ugx) Annual operation & maintenance costs: US$ 3400 (12,240,000 Ugx) consisting of 1400 US$ (5,040,000Ugx) for energy, 1400 US$ (5,040,000 Ugx) for labour and US$ 600 (2,160,000 Ugx) for maintenance	Rivers, valley tanks, shallow wells (<7m deep) , underground water storage tanks	Vegetables (Cabbage, tomatoes, onion, hot, okra, green pepper, french beans, Nakati, Kale, Spinach, Lettuce). Fruits (passion fruit, citrus, pineapple, mango, avocado, apples), Spices (hot pepper/chili, vanilla and ginger), groundnuts

The watering options for privately owned small and medium scale dairy production, their configuration, associated costs and recommended enterprises are shown in the Table A.3.

Table A-3: Recommended watering options for privately owned small and medium scale dairy production

Technology, method	Configuration	Costs per ha	Water sources	Recommended enterprises
Borehole with solar powered abstraction system	Borehole, solar water pumping system (solar panel, controller unit and motor-pump), a main pipeline network (transmission line to storage tank and distribution line), an overhead storage tank and a network of watering points.	Investment costs: 32,500 US$ (117,000,000 Ugx) Annual operation & maintenance costs: US$ 600 (2,160,000 Ugx) for maintenance.	Deep wells	Semi-intensive dairy farming (20 to 25 animals).
Lined underground water tank with motorized abstraction	Lined underground water tank., an engine driven water pump (7 hp), a main pipeline network (transmission line to storage tank and distribution line), an overhead storage tank and a network of watering points.	Investment costs: 13,500 US$ (48,600,000 Ugx) Annual operation & maintenance costs: US$ 1250 (4,500,000 Ugx) for maintenance	Roof catchment and surface run-off	Semi-intensive dairy farming (20 to 25 animals).

Profitability of enterprises

Profitability of enterprise for the irrigation options depends on the type of crop (variety) and level of agronomic practices. Overall, annual incremental benefit with irrigation is highest for fruits (apples, mangoes, citrus, passion fruits) followed by coffee, vegetables (hot pepper, tomatoes, cabbage and onions), groundnuts, climbing beans and upland rice.

The annual incremental benefit in Ugx with irrigation per ha is shown in the table 4 below.

Table A.4: Annual incremental benefit with irrigation per ha for different enterprises

No.	Enterprise	Solar Powered drip irrigation system	Rain gun sprinkler irrigation system	Conventional drip irrigation system	Conventional overhead sprinkler irrigation system
1	Apples	54,452,500	45,812,500	45,632,500	45,092,500
2	Mangoes	41,619,600	32,979,600	32,799,600	32,259,600
3	Citrus	38,066,750	29,426,750	29,246,750	28,706,750
4	Robusta Coffee	33,292,000	18,684,000	18,504,000	17,964,000
5	Passion fruits	27,862,500	19,222,500	19,042,500	18,502,500
6	Hot Pepper	26,530,000	17,890,000	17,710,000	17,170,000
7	Tomatoes	24,012,000	15,372,000	15,192,000	14,652,000
8	Cabbage	22,612,000	13,972,000	13,792,000	13,252,000
9	Onions	21,998,000	13,358,000	13,178,000	12,638,000
10	Groundnuts	20,238,180	11,598,180	11,418,180	10,878,180
11	Climbing beans	16,020,000	7,380,000	7,200,000	6,660,000
12	Upland rice		5,788,000		5,068,000

Note: Benefit for fruits and coffee considers peak production

Dairy

For semi-intensive dairy (20 animals), the net annual incremental benefit is Ugx. 58,950,000 per year using HDPE lined underground tank with motorized abstraction and Ugx. 61,290,000 per year using Borehole with solar powered abstraction system. The net annual incremental benefit for dairy is higher than for irrigation of crops.

Feasibility of irrigation

a) Internal Rate of Return

For annuals (vegetables, groundnuts, upland rice, climbing beans) and passion fruits, rain gun sprinkler irrigation system has the highest IRR followed by Conventional overhead sprinkler irrigation system. For perennials (fruits and coffee), Rain gun sprinkler irrigation system has the highest IRR followed by Solar Powered drip irrigation system.

Table A. **5**: The IRR for different irrigation options and enterprises

Enterprise	Rain gun sprinkler irrigation system	Conventional overhead sprinkler irrigation system	Solar Powered drip irrigation system	Conventional drip irrigation system
Hot pepper	110%	79%	51%	52%
Tomatoes	95%	68%	46%	44%

Enterprise	Rain gun sprinkler irrigation system	Conventional overhead sprinkler irrigation system	Solar Powered drip irrigation system	Conventional drip irrigation system
Cabbage	86%	61%	43%	40%
Onions	82%	58%	42%	38%
Groundnuts	71%	50%	39%	33%
Passion fruits	71%	53%	41%	37%
Climbing beans	45%	30%	30%	19%
Upland rice	35%	22%		
Apples	28%	25%	27%	22%
Mangoes	28%	25%	27%	22%
Robusta Coffee	27%	22%	27%	19%
Citrus	23%	20%	23%	17%

Dairy

For semi-intensive dairy (20 animals) using HDPE lined underground tank with motorized abstraction has an IRR of 35% while an IRR of 17% was obtained using Borehole with solar powered abstraction system.

b) Return on Investment

At 15% interest rate , Rain gun sprinkler irrigation system has the highest Return on Investment (ROI) followed by Conventional overhead sprinkler irrigation system. For annuals (vegetables, groundnuts, upland rice, climbing beans) and passion fruits, For perennials (fruits and coffee), Rain gun sprinkler irrigation system has the highest ROI as a result of relatively low initial investment. However, Operation and Maintenance cost is high due to energy cost for high pressure. Due to the agronomic advantage of minimizing fungal inventions, drip irrigation is recommended for tomatoes although sprinkler irrigation has a higher ROI. For coffee and citrus, Solar Powered drip irrigation system has a higher ROI in comparison to Conventional drip irrigation system due to lower operation and maintenance costs even though the initial investment cost is higher.

It should be noted that the final choice of an irrigation system is site specific and is dictated by other factors such as type and characteristics of water source (quantity and quality); availability of spares; level of skills and type of soil.

Table A. **6**: ROI at 15% interest rate for different irrigation options and enterprises

Enterprise	Rain gun sprinkler irrigation system	Conventional overhead sprinkler irrigation system	Conventional drip irrigation system	Solar Powered drip irrigation system
Hot pepper	550%	368%	324%	203%
Tomatoes	458%	298%	255%	174%
Passion fruits	416%	267%	223%	161%
Cabbage	406%	260%	216%	158%

Onions	384%	243%	199%	151%
Apples	347%	215%	172%	140%
Mangoes	328%	201%	158%	134%
Groundnuts	319%	194%	151%	131%
Robusta Coffee	202%	106%	63%	122%
Citrus	188%	96%	52%	90%
Climbing beans	164%	78%	35%	83%
Upland rice	105%	34%		

Dairy

For semi-intensive dairy (20 animas), using HDPE lined underground tank with motorized abstraction has a ROI of 114.8% at 15% interest rate. At this interest rate, using Borehole with solar powered abstraction system produced a ROI of 11.6%. The initial investment cost for Borehole with solar powered abstraction system is too high and calls for grants to justify the investment.

4. Recommended production areas for irrigation adoption and value chains

Investment in small-scale irrigation is promising in areas endowed with adequate infrastructure and markets, such as Urban and peri-urban areas. Other promising areas are those already doing high value crops. The other potential areas for irrigation adoption are those already practicing informal irrigation. Irrigation is considered 'informal' when farmers spontaneously develop systems without planning and with little or no technical assistance. Often the technology used is basic and sometimes inappropriate. Farmers raise the water level of the river using self-made local weirs with bags of sand and wooden poles. Water is diverted in simple non-lined channels from which it is accessed by breaching the banks every time to allow it to flow into the furrows of the lower lying farms. The majority of informal irrigated areas in Uganda are located on the fringes of swamps mostly in eastern Uganda around streams flowing into Lake Kyoga.. The area under informal irrigation increased from 23,000 ha in 1945 to 53,000 ha in 2005 with focus on irrigating rice, vegetable and fruit production systems. Although urban and peri-urban informal irrigated agriculture covers a small percentage of the total irrigated area, it accounts for between 60 and 100% of the consumed leafy vegetables in the urban areas depending on crop and season. Table A.6 shows the regions earmarked for the different enterprises.

Table A. 6: Potential areas of irrigation adoption for different value chains

Value chain	Enterprise	Agricultural production zone*									
		I	II	III	IV	V	VI	VII	VIII	IX	X
Horticulture	Vegetables			√		√	√	√		√	√
	Passion Fruits						√	√		√	√
	Citrus					√					
	Mangoes			√		√					
	Apples										√
Coffee	Coffee			√	√		√	√		√	√
Cereals	Rice						√				
Oil seeds	Groundnuts		√	√	√	√		√			
Pulses	Climbing beans										√

Value chain	Enterprise	Agricultural production zone*									
		I	II	III	IV	V	VI	VII	VIII	IX	X
Diary	Diary						√	√	√		√

Adapted from MAAIF (2016): (I) North Eastern Dry lands, (II) North Eastern Savannah Grasslands, (III) North Western Savannah Grasslands), (IV) Para Savannahs), (V) Kyoga Plains, (VI) Lake Victoria Crescent, (VII), Pastoral Rangelands (VIII) Western Savannah Grasslands, (IX) South Western Farmlands and (X) Highland Ranges.

5. Strategic Framework for Irrigation Development

The Strategy is aligned with the aBi goal and development objectives. It is therefore designed to achieve specific targets in the aBi Business Plan 2019-23, which dovetails into the overall Danida country program strategy under UPSIDE (2019-23).

The Goal of the irrigation strategy is to increase incomes from target enterprises by 50% by 2023. The purpose of the strategy is to increase the utilization of irrigation from the current 1% of cultivated area to 15%. This will target approximately 10% of farmers, mainly involved in high value commercial farming targeting markets for off-season vegetables and fruits, coffee, and Dairy. In order to achieve the goal and purpose, aBi and partners in intervention under 4 strategic pillars:

i. Increasing Access to Irrigation Technologies and Services
ii. Promoting Financial Inclusion for Irrigation investments
iii. Increasing Productivity and Production of Target Enterprises
iv. Capacity building for sustainable management of irrigation

Table A. **1**: Strategic Framework for Irrigation Development

No.	Intervention Area	Expected results	Recommended interventions/strategies	Key actor (s)
1.	Increasing Productivity and Production of Target Enterprises	♦ Increased sales volumes ♦ At least 100% increase in yields ♦ At least 100% increase in output from target enterprises	♦ Testing and validation of technologies (Proof of concept, demonstrations) ♦ Training of Irrigation extension experts and farmers on CS-Irrigation ♦ Promotion of access to inputs (seed, fertilizers, pesticides, etc) ♦ Promotion of Quality Management systems	Government (Universities, research organizations) Media
2.	Increasing Access to Irrigation Technologies and Services	♦ Increase in % of area irrigated from 1% to 15% ♦ At least one supplier/service provider per district ♦ Increased demand for irrigation	♦ Support to establish service centers/outlets ♦ Facilitating linkages between suppliers and producers ♦ Support water source development ♦ Market development (Promotion, demonstration of irrigation technologies)	Irrigation service providers e.g., Holland green Tech, SIRACO, SOLARNOW, BALTON etc
3.	Promoting Financial Inclusion for	♦ Increased loan portfolio for irrigation	♦ Irrigation Financing (Clean Technology Fund, Lines of Credit, etc)	Suppliers, farmers/FOs, SMEs Financial Institutions

No.	Intervention Area	Expected results	Recommended interventions/strategies	Key actor (s)
	Irrigation investments	♦ At least 10% farmers access loans for irrigation	♦ Facilitating linkages between suppliers, FIs and producers ♦ Support development and dissemination of knowledge on irrigation and financial inclusion	
4.	Capacity building for sustainable management of irrigation	♦ Enhanced knowledge and adoption of Laws and Regulations ♦ Increased Capacity to provide extension services ♦ Increased adoption of climate smart irrigation-practices and GAPs ♦ Capacity of watersheds/ aquifers sustained	♦ Dissemination of laws and regulations ♦ Establishment/strengthening of common property institutions, & Farmer institutions ♦ Training of Irrigation extension experts, local artisans and farmers ♦ Establishing a Center of Excellence (co-funding)	Farmers, District Local Government, CBOs Suppliers, SMEs & Financial Institutions Research Institutions, NEMA Media

5. Risks and mitigation measures

Table A. **9**: Expected risks and mitigation measures

	Risk	Mitigation Measure(s)
1.	Exchange rate fluctuations	♦ Insurance, export financing ♦ Export promotion
2.	High interest rates discouraging FDI and demand for loans	♦ Support development of tailored products ♦ Support FIs to strengthen client appraisal systems ♦ Promote group lending and savings
3.	Market distortions due to unfair subsidies and handouts	♦ Lobby and advocacy ♦ Close collaboration with government to anticipate policy direction
4.	Escalating energy prices (fuel, electricity)	♦ Development of alternative energy sources e.g. solar energy
5.	Limited availability and high costs of fertilizers	♦ Investment in local manufacture of fertilizers ♦ Fight fake fertilizers
6.	Increased supply of fake products and inputs on the markets	♦ Establish traceability systems ♦ Direct procurement from proven sources
7.	Pest and disease epidemics – reducing returns t investment	♦ Use of forecasting systems ♦ Include mitigation pest and disease epidemics as part of the irrigation package
8.	Low commodity prices	♦ Enterprise selection (High value enterprises with fairly stable prices) ♦ Invest in Quality Management targeting niche markets

	Risk	Mitigation Measure(s)
		♦ Invest in storage and value addition ♦ Contract farming ♦ Crop insurance

1 INTRODUCTION

1.1 Background

The agriculture sector in Uganda remains dominantly rainfed. However, increasing incidence of prolonged drought and unreliable rainfall in the last 10 years or so has catapulted irrigation[2] to the top of the agricultural development agenda. Water for agricultural production (WfAP)[3] is among the priority investments in the Agriculture Sector Strategic Plan (ASSP) 2015-2020. Recent research estimates that loss and damage caused by prolonged drought and rainfall unreliability accounted for 2.8 trillion Uganda Shillings (US$1.2 billion) in 2010 translating into about 7.5% of the country's GDP (EPRC, 2014; OPM, 2012).

While improved planting materials, fertilizer application, and other related crop and animal husbandry practices may lead to increased production; they will not be sufficient due to lack of substantial investment in irrigation for intensification and increased production levels necessary for social economic transformation of Uganda through agriculture.

Uganda's irrigation potential[4] is estimated at about 3,030,000 ha (Nile Basin Initiative, 2012) though less than 1% of this has been exploited and less than 1% of agricultural households practice irrigation in Uganda (UBOS 2010; MAAIF 2011; Wanyama et al., 2017).

In addition, access to water for livestock at present is estimated at 48.8% (NDP II, 2015). Therefore, there is still an opportunity to exploit the irrigation potential, which would ensure that Uganda is not only food secure but also an exporter of agricultural products. Significant progress has been achieved in establishing the enabling environment: The National Irrigation Policy, institutional and budget frameworks are in place and various seed projects have been funded over the last decades. However, efforts need to be directed at securing more financing, improving institutional coordination and active promotion of irrigation.

1.2 Objectives

The overall objective of the study was to identify priority areas for enhancing private -sector led investment and adoption of small and medium scale irrigation technologies by SMEs and small scale farmers in the six (6) supported value chains (horticulture, coffee, oilseeds, diary, pulses and cereals).

In line with the aBi objective of strengthening private sector agribusiness by increasing land and labor productivity, the specific objectives of the study were to:

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2 Irrigation is the artificial application of to crops meet the crop water requirement

3 Water for agricultural production refers to the supply and utilization of water for crop (irrigation), livestock and aquaculture production.

4 Irrigation potential refers to the total area which is technically, socially, economically and financially feasible as well as environmentally acceptable that can be brought under irrigation.

i. Recommend the most feasible technologies and enterprises for water smart agriculture targeting SMEs and smallholder farmers;
ii. Identify opportunities, risks and challenges associated with identified investment opportunities;
iii. Develop recommendations for a package of interventions to attract private investments in irrigation and strengthen the capacity of the farmers to demand and pay for irrigation.

1.3 Justification

In view of the current challenges to agriculture, investment in irrigation is a necessary condition for the country to achieve substantial and sustainable growth in agriculture. Available evidence indicates that use of irrigation can increase crop yields by up to four times, stabilize and increase production and enhance quality (Hagos et al., 2009). Agricultural Business Initiative (aBi) Trust is a multi-stakeholder entity co-founded in 2010 by the Government of Denmark and Uganda with an objective of promoting private sector agribusiness development to enhance wealth creation in Uganda, specifically to achieve the objective of the Government of Uganda's Competitiveness and Investment Climate Strategy (CICS). The mandate of aBi Trust is to support private sector to increase their contribution to the agricultural sector by increasing land and labour productivity, and market competitiveness. This is achieved through investments in Financial Services Development (FSD) and Technical Assistance in Value Chain Development (VCD) to agribusiness and other value chain actors in six value chains (Coffee, Cereals, Pulses, Horticulture, Diary and Oil seeds). Increasing access to water for production has become a major priority for achieving aBi objectives. Hitherto, aBi trust has offered grants to support utilization of water for agricultural production. In addition, aBi finance has initiated the clean technology fund to finance sustainable land management initiatives, efficient energy solutions, the use of renewable, environmentally friendly waste management, efficient water use and soil moisture management, and other climate practices for the value chains it supports. The success of aBi initiatives as well as achieving the country's target for irrigation development requires a stronger public-private partnership to increase investments, enhance coordination of actors, develop and enhance promotion of irrigation technologies, and strengthen implementation of key elements of the policy and regulatory environment. It is against this background that an irrigation investment and market analysis study was conducted to identify priority areas for enhancing private-sector led investment and adoption of irrigation technologies by SMEs and small scale farmers. The findings of this study will among others inform the design of an irrigation financing strategy to increase utilization of irrigation in the agribusiness sector.

1.4 Structure of the report

This report is structured as follows: Chapter 1 covers the introduction highlighting the background, objectives of the study and justification. Chapter 2 presents the situation analysis. Chapter 3 presents challenges to access and use of irrigation and presents opportunities to increase access and use of irrigation. Chapter 4 presents the feasible irrigation options and enterprises. Chapter 5 presents the enterprise market analysis. Chapter 6 presents the recommended intervention areas. Based on the outcomes of the study, Chapter 7 presents recommended interventions and Chapter 7 presents the risks and mitigation measures. Finally, the bibliography and the annexes are presented.

2 SITUATIONAL ANALYSIS

2.1 Current utilization of irrigation

Currently, the majority of small-scale farmers (~96%) rely on informal irrigation on the fringes of swamps using traditional surface irrigation techniques with focus on rice, vegetable and fruit production systems (FAO, 2015). Only a limited number of small-scale farmers (< 4%) rely on modern pressurized irrigation techniques. Traditional irrigation schemes are characterized by poor infrastructure posing difficulty in overall water management resulting to low water use efficiencies.

The most common surface irrigation methods are basin irrigation for paddy rice and furrow irrigation for other field crops, while the most common pressurized irrigation methods are drip irrigation kits, drag-hose irrigation, overhead sprinkler, micro sprinklers and rain gun sprinkler system. Use of mechanized irrigation is limited. Center-pivot irrigation is only at a few large private farms like Kakira Sugar Limited in eastern Uganda. Greenhouse irrigation is used by commercial farmers engaged in floriculture and high value vegetables concentrated around the Lake Victoria zones. The major water sources for irrigation are river diversions, wetlands, shallow wells, and to a limited extent private valley tanks/dams and underground rainwater harvesting tanks. Water abstraction is usually done using treadle pumps and small petrol engines (up to 7 hp).

2.2 Technology use

In the past 5 years or so, rain gun sprinkler irrigation system has dominated the irrigation market followed by conventional overhead sprinkler system, drip irrigation kit and greenhouse irrigation kit. This is largely attributed to: (i) Simplicity and ease of set-up; (ii) Portability making it easy to be moved from once place to another and are thus applicable for an individual farmer or a group of small-scale farmers; (iii) Relatively low cost of irrigation set up due to limited pipe network; and (iv) Can suit farmers in all acreages.

Solar powered irrigation is still a small but growing market in Uganda driven by limited access to electricity and high fuel costs to run the conventional pumps. The market for PV solar power is well established across the country, but not in combination with irrigation.

Irrigation equipment is mainly sourced from Israel, Britain, Turkey, Spain, Belgium, Holland, Kenya, China and India. However, Multiple Industries Limited has started manufacturing irrigation components like pipes and connectors.

There is a rise in distributors with services beginning to open country wide e.g. SIRACO, SolarNow, Holland Green Tech, Balton (U) Ltd, Multiple Industries, Davis and Shirtlif, AgroMax etc. Distributors provide a broad scope of technical services to farmers, from project design, to equipment supply, installation, maintenance and after-sale assistance, to farmer training and irrigation management. The list of irrigation service providers is shown in Annex 1.

2.3 Enterprises currently irrigated

The leading enterprises being irrigated are vegetables (pepper, tomatoes, cucumber, colliandra, cabbage, African egg plant, lettuce, amaranths, carrot, cauliflower, kale, cucumber, Spinach, French beans), fruits (citrus, apples, mangoes, passion fruits), rice and coffee. Hot pepper/chillies and vanilla are mostly for the export market.

2.4 Location where irrigation is mainly used

Privately owned small scale irrigation is scattered all over the country. Irrigation of horticulture is concentrated in Eastern Uganda (Busoga region, Teso region for citrus, Elgon region-Mbale, Kapchorwa), Central Uganda (Luwero, Nakaseke, Wakiso, Mukono, Mubende, Lake Victoria Basin areas)and Western Uganda (Kabale, Kasese, Rukungiri), West Nile region (Nebbi, Packwach) and most peri-urban and urban areas. Irrigation of coffee is emerging in Central Uganda (Masaka, Mpigi) and Western Uganda (Kasese, Kamwenge, Ibanda).

2.5 Key national legislative framework on water resource development and utilization

Abstraction of water that is required for irrigation of the crops is regulated by the *Water Act, Cap 152*. According to Section 6 of the Act, no person acquires rights to use water, or to construct or operate any works unless authorized under Part II of the Act. In addition, no person is allowed to sink any well or use any water without a permit to undertake works or a water permit.

The National Environment (Water Resources) Regulations, 1998 requires that all developers of water supply for commercial irrigation, livestock development and fish for which the abstraction rates exceed 400 m^3/day from motorized water pump which whether temporarily or permanently, pumps water from a borehole or waterway boreholes shall apply for a permit for water abstraction. A permit is also required where there is a weir, dam, tank or other work capable of diverting or impounding an inflow of more than 400 m^3/day. The threshold translate to anyone who at least irrigates 4 ha with 10mm of water per day in the growing season.

The National Environment (Wetlands, River Banks and Lakeshores Management) Regulations, 2000 provide principles for sustainable use and conservation of wetlands, riverbanks and lakeshores. The regulation requires that any person, community or organisation must be granted wetland resource use permit to undertake any regulated activities within wetlands. The regulations defines "drainage of wetlands" as the removal or exclusion of water from a wetland by pumping, excavation of channels, planting in a wetland fast growing non wetland trees or plants, abstraction of water from a river entering a wetland, channeling, reclamation and drainage itself.

The National Environment Act, Cap 153 requires projects such as “dams, rivers and water resources including storage dams, barrages and weirs, river diversions and water transfers between catchments and flood control schemes”) to undertake an Environmental Impact Assesment (EIA) to ensure compliance with environmnetal protection.

2.6 Irrigation financing and business models

There are four business models currently being used by financial institutions and suppliers of irrigation technologies and services:

2.6.1 Retail model

In the retail model farmers buy directly from the providers either using their own money or loans from the banks. Most of the financial institutions in Uganda offer the retail model which entails lending directly to SMEs and small scale farmers. Lending is done against a collateral. This model allows for a segmented approach to agricultural SMEs. For example, smallholders are served only with small credits, whereas growing farmers can apply for investment financing as well. Lending is done against a collateral. Farmers are prone to dealing with fake suppliers and diversion of loans to non irrigation related activities.

Key risk mitigants for this model are: (i) deep knowledge of the farmer and his or her business; (ii) a cap on the exposure to a single farmer; (iii) group lending (collective responsibility); and (iv) integration into a supply chain.

2.6.2 Wholesale model

Wholesale model is based on a financial institution lending indirectly to smallholders through an aggregator organization, such as a farmer-based organization or cooperative.
In the wholesale model, the entire group is the borrower, and therefore group members guarantee each other. In the agent model, the group's organization only administers the loans, and individual group members are the borrowers. The benefits of this approach are savings on costs of creditworthiness assessment and loan administration. The security of the model can be enhanced by cash collateral requirements at the organization level, instead of traditional collateral or claims on harvest proceeds at the individual farmer level, as well as direct integration with input suppliers to reduce the amounts of cash disbursed directly to farmers. Success factors include strength of management, length of history, and commercial orientation of the farmer based organization or cooperative through which the bank will lend.
A classical example is that of aBi Finance Clean Technology Fund. aBi Finance offers clean technology fund that is interest free in the range of UGx. 300 million to UGx. 4 billion. For grants , there is no interest but cost-shared grants where the beneficially must contribute at least 20%. For loans, interest rate depends on the Implementing partners who are financial Institutions. The target beneficiaries are associations/groups with strong business case which has been in operation for at least 3 years promoting agribusiness with potential to increase income and jobs as well as impact on the community where the project will be. They can also be individuals through banking institutions with strong business case promoting agribusiness with potential to increase income and jobs as well as impact on the community where the project will be. The potential beneficially must not be targeting only one line of business but diversification is key.

2.6.3 Irrigation credit scheme model

The irrigation credit scheme entails lending indirectly to farmers through partnership with an irrigation service provider. This scheme has been pioneered by Centenary Bank in partnership with Balton Uganda (BU). A similar arrangement is currently being developed between BU and DFCU and UDB. The client with interest in an irrigation system gets a quotation from an irrigation service provider and then presents it to a bank in form of a loan request. The client would have to ensure that at least 30% of the cost of the total cost of the irrigation system is deposited on his/her account). The Bank would then purchase the irrigation system and irrigation service provider does the installation, and works with the farmer for given period say three months.

Box 1: Centenary Bank Uganda irrigation credit scheme

Centenary Bank in partnership with Balton Uganda unveiled the Irrigation Credit Scheme aimed at providing affordable irrigation equipment to small scale farmers. The irrigation equipment referred to as the *Farmer's Kit* is a complete set of tools comprising of the highest quality farming inputs for growing crops both in the open field and in the green house. It consists of a farmer's green house, drip irrigation system, water tank of 500 liters, farmer's sprayer, seeds, nursery set, fertilizers, agro chemicals as well as training. Customers who wish to acquire the Farmers Kit through the bank, need only Shs9 million to buy the irrigation equipment. customers are able to save up to Shs.3 million if they choose to acquire the *Farmers' Kit* through the Centenary Bank Irrigation Credit Scheme besides accessing credit at a lower interest rate." In addition, Centenary Bank provides extension services and agronomists to each borrower.

2.6.4 Equipment credit financing model

Farmers obtain the irrigation technology with a down payment of an agreed percentage. The remaining money is paid in installments over an agreed period of time. A classical example is that of Solar Now Uganda.

Box 2: Equipment credit financing by Solar Now Uganda

SolarNow is a commercial registered company in Uganda headquartered in Kampala and currently boasts of 47 branches across Uganda. It started six years ago and its mother company is in Netherlands. SolarNow is a new player in the irrigation sub-sector. SolarNow is currently providing one type of irrigation technology-a solar water pump designed for surface water pumping. SolarNow imports this technology from their partners in Kenya-future pumps, who developed this product and had it manufactured from India. SolarNow offers a solid and proven credit model for Solar Home Systems which is replicable for the solar pump, and any other agricultural appliances. This low risk investment solutions in combination with different product packages, allow farmers to professionalize their farming business gradually by upgrading their irrigation system with additional products and services.

Apart from the cash payment model, SolarNow has the following credit financing plans

i. A one year plan of 12 equal installments with a 50% deposit with 3 month grace period
ii. A two year plan of 24 equal installments with a 50% deposit with 3 month grace period
iii.

2.6.5 Subsidy on irrigation technology

Small-scale farmers are able to access irrigation technology through subsidy offered by Development partners. A classical case is that of Clean technology subsidy program with Dutch Embassy and SNV Netherlands program for water for livestock.

Clean Technology **s**ubsidy program with the Dutch embassy enables clients who are part of a cooperative or can proof to be an engaged/established farmer to have a 25% discount. This subside programme ends by close of 2018.

SNV in partnership with Balton Uganda offers subsidy on lined underground water tanks for Dairy production**.** SNV pays for the client 40% as a promotion of the technology and the client pays the remaining 60%

Box 3 Subsidy by SNV

Lined Underground water tanks for Dairy production

Balton Uganda is currently providing water conservation technologies to mitigate the dry season effects on dairy through provision of dam lining technology. The dams lined range from 50,000 L-500,000 L though they are capable and willing to do more than these range depending on the farmer preference (e.g. Up to 1,000,000 L if needed). The type of catchments being exploited are: Roof catchment and Surface run-off. The dam can also collect rain directly especially when the rains are heavy. To ensure good quality of the water from the surface run-off, the channel to the dam is laid with stones to filter off the sediment that would damage the liner and cause an extra cost of having to desilt. The target area is the cattle corridor. A 50,000 L tank costs Ugx. 5 million and 1 mm think HDPE costs Ugx. 25,000-27,000/m^2. Since the project started early 2017, the results/impacts are expected to be quantified/realized at the end of 2017 and early 2018 after the dry spell. It is anticipated that "As more and more people use the technology (a high turnover) then the costs will come down".

2.6.6 Equipment leasing

A lease is a contractual arrangement between two parties whereby a party that owns an asset (the "lessor") lets another party (the "lessee") use the asset for a predetermined time in exchange for periodic payments. Leasing focuses on the lessee's ability to generate cash flow from business operations to service the lease payment, rather than on the balance sheet or on past credit history. This explains why leasing is particularly advantageous for young companies, as well as for small and medium businesses that do not have a lengthy credit history or a significant asset base for collateral. Furthermore, the absence of traditional collateral requirements (such as land) offers an important advantage in countries with weak business environments, particularly those with weak creditors' rights and collateral laws and registries. Because the lessor owns the equipment, it can be repossessed relatively easily if the lessee fails to meet lease rental obligations; this is particularly advantageous in countries where secured lenders do not have priority in the case of default. The leasing entities that do have a focus on the agricultural sector are often linked to manufacturers or distributors of agricultural equipment in one way or another.

Lease financing only partially overcomes the typical constraints to credit financing. Leasing firms often take additional collateral from rural clients in developing countries; this practice is different from the typical lease transaction in developed economies, in which the leased asset itself is considered adequate security. The security deposit or down payment required tends to be higher than typically demanded in developed economies.

This scheme has been pioneered by DFCU.

BOX 4: Equipment leasing by Agriworks Mobile Irrigation Systems (AMIS)

The problem

- -Few solutions suited for plots upslope from water, or for small commercial acreages (1 – 10 acres)
- How to get a farmer from irrigating 1/10 acre to 2 acres? (and from $250 per year to $4,000 per year)

The Solution

Innovative **technology** and **business model**

The Technology

- Mobile: Farmers share the cost
- Modular: Customizable
- Turn-Key: Easy to use and Scalable

The Business Model:

- -Asset-Leasing: Down payment plus 3 repayment installments.
- -Clients match income from equipment with repayments for technology
- -Group Loans: Social capital
- -Lease process: Forms and due diligence done from the village

The Product

Two major selling points that fit the smallholder.

Our systems are **mobile** and **modular**.

Mobile: - 1-6 farmers can share the cost of a system which moves from farm to farm - Store it at home at night to prevent theft

Modular: - Attach more technology to the system as you earn money from it. No need to buy a new system to expand - Pipes, sprinklers, drip-lines, etc...

Turn-key:

- Use it anywhere with surface water within 260 meters - No need for site-specific design - Easy to Use: Learn it in one day

'AMIS-Foundation / AMIS-50 / AMIS-Extra':

A water delivery system that rides on a small motorcycle. It delivers water up to 200 meters+ from a water source and connects to other AMIS components. Also available with a bigger pumps for customers with greater power need ('50' & 'Extra')
Additional Components:
'AMIS Mvua-Kali': Rain gun attachment for up to 6 acres
'AMIS–Impact': Smaller sprinklers for irregular shaped plot & orchards
'AMIS Drip': Drip irrigation set for highly efficient irrigation

The Product

6 fully compatible components

Average Irrigation Requirement:
10 hours per week per acre: $250 - $300 per season. (Can be less than half with rainfall + supplemental irrigation)
Typical Profits per Season with Pressurized Irrigation:
$1,500 - $4,000 per acre
Payback Period:
1 – 2 seasons
Expected 5-year Return on Investment
430.% +

Typical Irrigation Capital Costs

-$4000 – $8000+ per hectare for competing pressurized irrigation systems.

-Less than $800 per hectare with Agriworks Mobile Irrigation

3 OPPORTUNITIES AND CHALLENGES

3.1 Market and investment opportunities

The key market and investment opportunities identified in the literature review and stakeholder consultations are:

ix. *High demand for off season production targeting both the domestic and export market for horticultural products*. Off-season vegetable and fruit supplies are currently inadequate to meet the demand. This is manifested in increased off season prices. For example off season price for tomatoes, mangoes and passion fruits increase by even over 100% in comparison to rainfed dependent seasons.

x. *High price premium for increased quality due to irrigation*. Vegetables and fruits are demanded in their fresh form whose quality is enhanced though irrigation in terms of size, succulence, and taste.

xi. *The demand for water to prevent crop failure at critical growth stages and to increase/stabilize yields for high value crops (supplementary irrigation) and to sustain all year round production for processed products*. Water stress at critical stages of crop growth e.g. flowering for vegetables, fruits and coffee can result in total crop failure or substantial reduction in yields depending on the sensitivity of the crop to water stress. Currently, Britania can only meet 1/3 of its demand for mangoes due to low production and inconsistency in supply.

xii. *The growing demand for irrigation equipment and technical support.* All irrigation distributors testify to increased sales volumes of irrigation equipment over the past 5 years or so. A classical case is that of SolarNow, a new company in Uganda which started its operations in 2015. SolarNow sold its first solar pump in December 2015 from their pilot Kenya project. In 2016, sales were 2-4 pumps/month and the total pumps sold at the end of that year was 15. In 2017, their sales were about triple the 2016 sales.

xiii. *Abundant water sources*: Over 15% of Uganda's surface area is covered by fresh water resources. Even the driest areas of Uganda receive an average minimum of 600 mm per year, which can be harnessed for irrigation. However, what is missing is infrastructure to facilitate irrigation and awareness creation among farmers to facilitate adoption of irrigation. The present utilization rate of the internal renewable water resource[5] is low (2.8%). The utilization rate of the entire renewable surface water resources stood at 0.01% as of 2013. If the full irrigation potential was to be exploited, the demand for water would be increased by over 400% by 2030 translating into a utilization rate of renewable surface water resource of 0.05%.

[5] The sum of the external and internal renewable surface water resources (the average annual river flow generated from precipitation) in Uganda amounts to 43.3 billion cubic meters per year, while the dependence ratio (proportion that originates outside the country) was about 69% as of 2013.

xiv. *Local agricultural lending financial institutions*. Over the past few years, financial institutions in Uganda have increasingly shown interest in providing agricultural credit to small-scale farmers. Examples of financial institutions offering agricultural loans are DFCU Bank, Centenary Bank, Uganda Development Bank, Housing Finance Bank, Opportunity Bank, Post Bank, Pride microfinance, and Finca Uganda Ltd. A classical example is that of Centenary Bank whose loan portfolio stands at Shs520 billion with 17% of this going to agriculture compared to 6% of the entire banking industry. Lending to the agriculture sector has been on a steady rise because Centenary Bank is cognizant of the fact that agribusiness is the leading source of wealth creation in Uganda and Africa as a whole. In 2016, Centenary Bank disbursed approximately Shs88 billion to 26,700 farmers compared approximately Shs66 billion to over 21,000 farmers in 2010.

An Agricultural Credit Facility (ACF) was set up by the Government of Uganda (GoU) with the aim of facilitating the provision of medium and long term financing to projects engaged in Agriculture and Agro processing, focusing mainly on commercialization and value addition. By 2015, the Government of Uganda (GoU) contribution to the ACF totaled UgX 119.07 billion. Loans for irrigation and greenhouse facilities as of 2015 constituted 2.71%. The other shares were to: agro processing machinery (58.3%), farm expansion 16.46% and Tractor and farm equipment at 13.82%;

xv. *Enabling environment*: An Explicit national irrigation policy and commitment of resources for implementation. The Uganda National Irrigation Policy is focused on promoting public and private investments in irrigation.

Imported irrigation equipment is exempted from customs duties and VAT, making irrigation an attractive investment opportunity.

xvi. *Partners*: Development partners willing to invest in irrigation by providing loans, grants and subsides. The major partners include World Bank, African Development, Japan International Cooperation Agency (JICA), FAO, Islamic Development Bank and International Fund for Agricultural Development (IFAD).

3.2 Challenges

Irrigation has been a major national intervention for increasing agricultural production since the 1960's. Small scale farmers mainly targeted wetlands as an opportunity for irrigation. It was not until the last 10 years that it was realized exploitation of wetlands is not sustainable and it is necessary to focus on sustainable irrigation interventions particularly to address climate change. Hence, the focus on climate smart agriculture. According to findings from stakeholder consultations, the major challenges to access and use of irrigation are:

(i) Small growing market not yet large enough to attract investors;

(ii) High risk/uncertainities associated with returns on investment in irrigation;

(iii) High initial cost of irrigation set-up and maintenance exacerbated by high energy costs: Most small-scale farmers do not have the financial capacity to invest in irrigation due to the high initial cost of irrigation set up. Operation and maintenance of irrigation systems is high due to rising fuel and electricity costs and shortage of farm labour as a result of increasing rural-urban migration and rising rural wages;

(iv) Influx of fake irrigation products threaten the market credibility even for genuine suppliers. For example in some instances, farmers find costs of genuine products rather high causing them to turn to what they think are cheap genuine products only to turn out to be fake products. This ends up discouraging them from taking up irrigation technologies all together. Regulations on irrigation equipment standards and enforcement are lacking;

(v) The bulk of water resources are locked up in large water bodies and reservoirs which do not attract private investment in water abstraction and commercial supply for lack of tailored enabling environment. In addition there is physical water scarcity in some areas attributed to lack of/limited water sources and seasonality of water sources while in other areas there is economic water scarcity attributed to lack of investment in water infrastructure and to high cost of water abstraction;

(vi) The risks associated with predictability of rainfall to guide investment planning and management of irrigation systems;

(vii) Inadequate technical knowledge and skills on irrigatio*n*. There is lack/limited knowledge among farmers and SMEs about the financial and economic viability of irrigation and lack of specific recommendations on what, where and how to use irrigation. Farmers lack knowledge of crop and climate responsive irrigation schedules, on-farm water application techniques, agronomic practices, and application rates of agrochemicals, resulting in poor water-use efficiency and reduced crop water productivity.

(viii) Fragmented markets for irrigation services and equipment service providers. Most distributors of irrigation equipment are located in Kampala which makes access to irrigation equipment, spare parts and repair services difficult and costly for rural farmers. It is common to find irrigation equipment in rural areas often breakdown and are rendered unusable due to lack of after sales services.

(ix) High interest rates. Currently, the interest rates on agricultural loans are high (18-25% p.a) making borrowing very difficult for small scale farmers.

(x) Un-favorable loan repayment schedules. Repayment of loans is hampered by seasonality of cash flows from farming with earnings concentrated in certain times of the year. This calls for customized loan products where agricultural credit may need to be repaid in “lumpy installments,” sometimes over multiple seasons.

(xi) Collateral: Farmers usually lack the collateral traditionally required by banks. In addition, financial institutions don't accept irrigation system as a collateral.

Agricultural financial service providers have few instruments at their disposal to manage these various risks; they therefore tend to protect themselves through excessive credit-rationing and by relying heavily on traditional land collateral. However, agricultural borrowers’ assets are less suitable as collateral than for example, urban real estate. In fact, farmers and their producer associations frequently lack the collateral traditionally required by banks for larger and longerterm loans. Due to legal and administrative impediments as well as cultural factors, rural assets are often not registered and consequently may be more difficult to foreclose and sell. Even where these constraints are less binding, collateral is a poor protection against massive defaults due to covariant risks. The result is that required collateral ratios are much higher than they would be otherwise.

(xii) Lack of access to technical and market information. Besides the shortage of extension workers, there is a lack of an effective streamlined extension structure to coordinate and provide advisory services and technical backstopping on irrigation to farmers from the local level to the national level. Information on where to buy irrigation equipment and market prices is not readily available to farmers.

(xiii) Lack of clarity on the irrigation tax incentive

Taxation of irrigation equipment is not clear to most of the irrigation service providers. For example, Uganda revenue Authority (URA) does not categorically refer the irrigation pump provided by SolarNow as an irrigation equipment and hence no tax exemption as it is for equipment listed as irrigation equipment. This has left SolarNow with no much choice but to include the 18% tax levy on the overall cost of their pump and this significantly burdens or deters clients. According to SIRACO, HDPE pipes take 60-70% of the system cost and yet the government gives incentive only on sprinklers only and not the pipe. Some players in the provision of irrigation equipment are charged tax of 18% (VAT) on even equipment meant for irrigation just like any other person buying for non-irrigation purposes. Tax on irrigation equipment whether imported or locally purchased attract 6% (Withholding tax).

According to Holland GreenTech there is no VAT and withholding tax attached on drip lines but import tax has to be paid while - Import tax has to be paid on Connectors and no VAT and withholding tax. So if importation of the above equipment subject to different tax in the same container may result in paying of more tax than stipulated.

(xiv) Inadequate capacity by both the public and private sector to regulate/ enforce and comply with sanitary and phytosanitary standards (SPS) that guarantees the health and safety of consumers, especially for commodities destined to the EU market. The capacity of the private sector to meet market quality standards and public sectors to effectively regulate and enforce quality standards is also limited. For example, most of Ugandan cereals on the market do not meet the agreed EAC grain quality standards, which make it difficult to exploit the regional market yet most of the neighboring countries like Kenya are net grain importers.

4 IRRIGATION INVESTMENT OPTIONS

This section presents the recommended climate and water smart irrigation options for small-scale farmers and SMEs.

4.1 Water source options

The water needed to supply an irrigation scheme is taken from a water source. The most common sources of water for irrigation include rivers, reservoirs and lakes, and groundwater. Reservoirs can be in form of runoff water harvesting in valleys or underground water storage tanks.

Groundwater has proved a reliable and accessible water source for irrigation. However, water depth and variability in depth and quantity can be constraints as the common motorized pump systems do not allow water to be pumped from a depth of more than seven metres. For effective exploitation of shallow groundwater, there is need for capacity building of local craftsmen/local drilling teams and provision of technical advice on suitable sites.

The recommended water sources for privately owned small and medium scale irrigation are described in Table 1.

Table 2: Recommended water sources for privately owned small and medium scale irrigation

No.	Water source	Description/technical considerations	Investment cost ($/ha)
1.	Rivers	• Natural water systems • Extraction of water is done through a bank-mounted motorized, solar or human-powered pump. • At least a discharge of 1.5 to 2 L/s is needed to irrigate 1 ha. • Over-extraction of water can deprive downstream water users.	Depends on the system of river diversion /water abstraction
2.	Underground water storage tanks	• A water storage structure constructed below the ground. • Have volumes ranging from 20 to 150 m^3. • They collect and store runoff from open grasslands, hillsides, home compounds, roads, footpaths, paved and unpaved areas, roofs and river diversions. • The tank can be lined with HDPE Dam liner to conserve water. The lined underground tanks range from 50,000 L-500,000 L though they can be as large as 1,000,000 L. • Usually fusion and extrusion welding is carried out to join the lining material to the required measurements. • To ensure good quality of the water from the surface run-off, the channel to the tank is laid with stones to filter off the sediment that would damage the liner and cause an extra cost of having to desilt. • Can be used to irrigate maximum of 0.25 acres.	• HDPE Dam lined underground tanks cost between 3 to 5 US \$/m^3 of water storage. • A 50,000 L tank costs Ugx. 5 million including HDPE lining material. 1 mm thick HDPE costs Ugx. 25,000-27,000/m^2. • O&M cost: 1-2% of the investment cost per annum • Life span: 15 to 20 years for HDPE Dam lined tanks

		• Irrigated area is bigger underground water storage tank is considered as night storage reservoirs fed by a stream/spring	

3.	Valley tanks	• An excavation in the valley that can store between 5,000 - 20,000 m^3 of water
		• Extraction of water from the reservoir can be done through:
		  ○ A sump (well reservoir) in natural ground at the side of the reservoir, supplied by gravity from a screened inlet and pipe through the bed and side of the reservoir;
		  ○ A bank-mounted motorized, solar or human-powered pump.
		• Suited for a watershed area of at least 2 km^2 catchment.
		• At least 12,000 - 15,000 m^3 of water storage is need to irrigate 1 ha per season if storage is based on rainwater harvesting.
		• Irrigated area is bigger if the valley tank is considered as night storage reservoirs fed by a stream/spring
			• US$ 2 to 4 per m^3 water storage
			• O&M cost: 1-2% of the investment cost per annum
			• Life span: Depends on maintenance and level of environmental degradation (siltation)

4.	Shallow wells	• Shallow wells draw water from an unconfined aquifer or shallow groundwater table/ unconsolidated formation, i.e. the regolith. • Depths of hand-dug wells range from about 5 metres deep, to over 20 metres deep. • Stable soil structure for wells without lining. Well stabilization by lining required for unstable soils (sand).Sandy soils require lining of the well for depth > 2 m. The pits are lined with concrete rings, bricks or stone masonry, allowing groundwater to be sourced from greater depths. • Extraction of water from the reservoir can be done through bank-mounted motorized, solar or human-powered pump. • Abstraction should be at low discharges of the order of 0.5 m^3 up to 2 m^3/hr. • Can irrigate small areas (0.1 to 0.3 ha)	• The costs for open wells can vary considerably depending on the well's depth and the equipment required for drilling; • Costs may vary between US$500 and 1 500 per open well fitted with concrete lining. • O&M cost: • Life span: 5 to 10 years
5.	Deep wells (Boreholes)	• A well sunk through an impermeable stratum to draw water from a relatively deep, confined aquifer. • Boreholes depth ranges from 15 m – 90 m. • Average maximum yield is ~ 5-7 m^3/hr varying with location. • Used in conjunction with a suction hand pump, solar pump or submersible electric pump • A well with yield of 7 m^3 per hr can command 1-2 ha per day.	▪ Investment cost: (~US $5,000 USD to 20,000 depending on the depth of the well. ▪ investigations ▪ O&M cost: 2% of the investment cost. ▪ Life span: 10 to 15 years depending on the maintenance

	• A well with yield of 5 m^3 per hr can command 0.5 ha (~1 acre) per day when operating for maximum of 6 hrs per day.

4.2 Recommended irrigation options and suitable enterprises

A feasible climate smart irrigation technology should be affordable, available, adaptable to existing setting, enhance farming profitability, water efficient, easy to operate, repair and maintain, and environmentally and socially acceptable. The choice of an irrigation system is site specific and depends on: (i) Type of crop; (ii) Relative position of water source to the irrigation field; (iii) Type and characteristics of water source (quantity and quality); (iv) Energy source; (v) availability of equipment, spares, and maintenance facilities; (iv) Labour costs, level of skills and availability (v) Type of soil, (vi) investment costs; (vii) Availability of credit and (viii) Land size.

The recommended climate smart irrigation options for small-scale farmers and SMEs are: (i) Solar-powered drip irrigation system; (ii) Conventional drip irrigation system; (iii) Rain gun sprinkler irrigation system; (iv) Conventional overhead sprinkler irrigation system (Table .1).

***(i) Solar powered irrigation*:**

Solar pumps allow small scale farmers and SMEs to circumvent the constraint of absence electricity and high fuel costs for conventional motorized pumps. In irrigated agriculture, water is most needed during the hot sunny days, when solar energy is at its optimum.

Solar systems have a long lifespan of up to 25 years and are rapidly gaining popularity as PV irrigation pump sets are becoming available at affordable prices. This, in combination with rising fuel prices, point towards favorable conditions for a shift to solar energy. The market for PV solar power is well established across the country, but not in combination with irrigation. Solar energy is clean energy with carbon foot print of zero.

Solar pump system results in savings in manpower due to low labor requirement. In addition solar systems can be put to multiple purposes, e.g. to charge batteries which supply electrical power for other uses.
The main constraints for solar powered irrigation is the high cost of solar panels and limited energy outputs of solar panels hence low discharge. In most cases a solar-driven electric pump may irrigate an acreage of 0.3 to 1 ha. One 150 Watt solar module can irrigate over 1000 m^2 (0.1 ha);
As the PV panels are expensive, durable and versatile (can be used for applications like battery charging for light or television), the market value for second hand panels is high. This makes the panels very much prone to theft and applications with stand-alone systems in African countries usually need to be guarded during the night. Regularly taking the components home is not always easy as the panels are often >1m^2, plus the pump;
There is currently no recorded field data regarding the actual performance and lifetime of the complete system or its components. The lack of field data makes it difficult to estimate the

lifetime and thus the annual cost of these systems. Another threat is the presence of fake panels on the market.

The considerations for commercialization of solar powered irrigation are: (i) Adequate sunshine (8 to 12 $KWh/m^2/day$); (ii) Solar panels and suitable pumps commercially available; (iii) Construction of a reservoir for 2 to 3 days storage to increase discharge and cater for period of low sunshine; (iv) Competent technical advisory services for design and installation; and (v) Low pressure pipe system or drip irrigation.

(ii) Conventional pumped irrigation (rain gun sprinkler, overhead sprinkler and drip irrigation):

Conventional pump sets are still relatively cheap to buy, available in most regional capitals and maintenance can be assured by rural mechanics; pump sets can be shared by a group of small-scale farmers. These pump sets are reliable provided that adequate maintenance of pumps is undertaken and spare parts are available. Portability of pumps enables farmers to take the pump sets home, avoiding the risk of theft.

The technology is suitable for an individual farmer or a group of small-scale farmers. Individual farmers may extend their garden plots to irrigate a larger area as a result of the motorized pump, while groups of farmers can irrigate a common or collective area.

Rain gun sprinkler irrigation systems are in particular easy to set-up, portable making it easy to be moved from once place to another and are thus applicable for an individual farmer or a group of small-scale farmers, relatively low cost of irrigation set up due to limited pipe network; and can suit farmers in all acreages.

However, fuel costs and access to fuel for running conventional pump sets constitute a constraint for small-scale farmers.

- Requires financing of fuel costs at 1 -2 L of fuel per hour for 3 to 7 hp power.

Other constraints are the short life span of the pump sets (4 to 6 years). In addition, use of fuel contributes to CO_2 emission and air pollution.
For group irrigation of more than 5 ha, farmers need to be organized into water users associations (WUA) to ensure adequate operation and maintenance (O&M). Caution should be taken to avoid mismatch between pump capacity and water needs and well yields of smallholder farmer resulting into high fuel consumption

The considerations for commercialization of conventional pumped irrigation systems are: (i) Adequate surface or groundwater sources in the vicinity of irrigated areas (water level not to exceed 7m at pump site); (ii) Assurances for good management and cooperation of farmers in pump users group; (iii) Access to regular supply of fuel at affordable price; (iv) Access to markets for produce; (vi) Technical advisory services on selection, installation, field irrigation practices and maintenance, and (vii) Availability of pumps, spare parts, and services (like trained mechanics).

The irrigations options, their configuration, costs per ha, suitable water sources and recommended enterprises are shown in the Table 2 below.

Table 3: Recommended irrigation options for privately owned small and medium scale irrigation

Technology, method	Configuration	Costs per ha	Water sources	Recommended enterprises
Solar-powered drip irrigation system	Solar water pumping system (solar panel, controller unit and motor-pump), a pipeline network (main transmission line to storage tank and distribution line fitted with screen water filter), an overhead storage tank and a network of drip lines.	Investment costs: 14,500 US$ (52,200,000 Ugx) Annual operation & maintenance costs: US$ 800 (2,880,000 Ugx) for maintenance.	Shallow wells, deep wells, valley tanks , underground water storage tanks	Vegetables (Cabbage, tomatoes, onion, hot, okra, green pepper, french beans, Nakati, Kale, Spinach, Lettuce). Fruits (passion fruit, citrus, pineapple, mango, avocado, apples), Spices (hot pepper/chili, vanilla and ginger), Coffee
Conventional drip irrigation system	An engine-driven pump usually petrol pump (3 to 7 hp), a pipeline network (transmission line to storage tank and distribution line fitted with screen water filter), an overhead storage tank and a network of drip lines	Investment costs: 9500 US$ (34,200,000 Ugx) Annual operation & maintenance costs: US$ 3,250 (11,700,000 Ugx) consisting of 1200 US$ (4,320,000Ugx) for energy, 1100 US$ (3,960,000 Ugx) for labour and US$ 950 (3,420,000 Ugx) for maintenance.	Rivers, valley tanks, shallow wells (<7m deep) , underground water storage tanks	Vegetables (Cabbage, tomatoes, onion, hot, okra, green pepper, french beans, Nakati, Kale, Spinach, Lettuce). Fruits (passion fruit, citrus, pineapple, mango, avocado, apples), Spices (hot pepper/chili, vanilla and ginger), Coffee
Rain-gun sprinkler irrigation system	An engine-driven water pump transmits water through a pipeline network connected to a movable sprinkler (rain-gun sprinkler). It is a long range system where water is sprinkled at least 30 m radius. It is a high pressure system requiring more than 5 bars and has discharge rate of 5,000 to 10,000 L/hour. This system is semi-portable with a fixed main/submain and movable and lateral and rain gun.	Investment costs: 4500 US$ (16,200,000 Ugx) Annual operation & maintenance costs: US$ 3200 (11,520,000 Ugx) consisting of 1200 US$ (4,320,000Ugx) for energy, 1600 US$ (5,760,000 Ugx) for labour and US$ 400 (1,440,000 Ugx) for maintenance.	Rivers, valley tanks, shallow wells (<7m deep) , underground water storage tanks	Vegetables (Cabbage, tomatoes, onion, hot, okra, green pepper, french beans, Nakati, Kale, Spinach, Lettuce). Fruits (passion fruit, citrus, pineapple, mango, avocado, apples), Spices (hot pepper/chili, vanilla and ginger), Coffee Groundnuts, Climbing beans, upland rice and coffee-robusta
Conventional overhead sprinkler irrigation system	Consists of an engine-driven pump usually petrol pump (~ 7 hp), a pipeline network (transmission and distribution), and overhead sprinklers placed on riser pipes fixed at uniform intervals along the length of the lateral	Investment costs: 6000 US$ (21,600,000 Ugx) Annual operation & maintenance costs: US$ 3400 (12,240,000 Ugx) consisting of 1400 US$ (5,040,000Ugx) for energy, 1400 US$ (5,040,000 Ugx) for labour and US$ 600	Rivers, valley tanks, shallow wells (<7m deep) , underground water storage tanks	Vegetables (Cabbage, tomatoes, onion, hot, okra, green pepper, french beans, Nakati, Kale, Spinach, Lettuce). Fruits (passion fruit, citrus, pineapple, mango, avocado, apples), Spices (hot

	pipe. It is a short range system where water is sprinkled up to 15 m. It can operate with a pressure of 1 to 1.5 bars for low-pressure sprinklers and 3 to 5 bars for conventional sprinklers. and has discharge rate of 5,000 to 10,000 L/hour.	(2,160,000 Ugx) for maintenance		pepper/chili, vanilla and ginger), groundnuts

Water for Dairy Production

The recommended options for small-scale farmers and SMEs diary production are: (i) Lined underground water tank with motorized abstraction; (ii) Borehole with solar powered abstraction.

The details of the watering options for privately owned small and medium scale dairy production, their configuration, associated costs and recommended enterprises are shown in the Table 3.

Table 4: Recommended watering options for privately owned small and medium scale dairy production

Technology, method	Configuration	Costs per ha	Water sources	Recommended enterprises
Lined underground water tank with motorized abstraction	Lined underground water tank., an engine driven water pump (7 hp), a main pipeline network (transmission line to storage tank and distribution line), an overhead storage tank and a network of watering points.	Investment costs: 13,500 US$ (48,600,000 Ugx) Annual operation & maintenance costs: US$ 1250 (4,500,000 Ugx)	Roof catchment and surface run-off	Semi-intensive dairy farming (20 to 25 animals).
Borehole with solar powered abstraction system	Borehole, solar water pumping system (solar panel, controller unit and motor-pump), a main pipeline network (transmission line to storage tank and distribution line), an overhead storage tank and a network of watering points.	Investment costs: 57,500 US$ (207,000,000 Ugx) Annual operation & maintenance costs: US$ 600 (2,160,000 Ugx)	Deep wells	Semi-intensive dairy farming (20 to 25 animals).

4.3 Criteria for investment appraisal

The following irrigation assumptions guided costing of the irrigation project:

i. Average reference evapotranspiration is ~5 mm/day
ii. Complete irrigation targeting offseason
iii. Maximum head difference between water source and the irrigation field is 20m i.e. a pump with head of 50m is sufficient
iv. Water source is close to the irrigation field (<100m) and has substantial volumes of water to support irrigation.

Investment appraisal involved assessing different types of irrigation systems and their feasibility for the target value chains. The investment appraisal was guided by the following assumptions:

i. Analysis period of 15 years;
ii. The discount/interest rate used is the prime lending rate of commercial banks which varies from 18% to 25% as at 1.10.2017. An interest rate of 15% and 25% p.a was considered in the analysis.
iii. The scale of irrigation considered is 1 ha.

The costs considered included capital costs and operation and maintenance costs that cover energy costs, maintenance costs and labour costs. A financial income analysis (profitability analysis) with irrigation and without irrigation to establish the net incremental benefit under various selected irrigation options. analysis considered the variable costs and running costs of the irrigation systems. For each investment irrigation scenario, the Net incremental benefit, Internal rate of return (IRR) and Return on Investment were analyzed.

Sensitivity analysis was done to determine the risks associated with the investment by considering increase in interest rate from 15% to 25%.

4.4 Profitability of enterprises

Profitability of enterprise for the irrigation options depends on the type of crop (variety) and level of agronomic practices. Overall, annual incremental benefit with irrigation is highest for fruits (apples, mangoes, citrus, passion fruits) followed by coffee, vegetables (hot pepper, tomatoes, cabbage and onions), groundnuts, climbing beans and upland rice.

The annual incremental benefit in Ugx with irrigation per ha is shown in the table 4 below.

Table 5: Annual incremental benefit with irrigation per ha for different enterprises

No.	Enterprise	Solar Powered drip irrigation system	Rain gun sprinkler irrigation system	Conventional drip irrigation system	Conventional overhead sprinkler irrigation system
1	Apples	54,452,500	45,812,500	45,632,500	45,092,500
2	Mangoes	41,619,600	32,979,600	32,799,600	32,259,600
3	Citrus	38,066,750	29,426,750	29,246,750	28,706,750
4	Robusta Coffee	33,292,000	18,684,000	18,504,000	17,964,000
5	Passion fruits	27,862,500	19,222,500	19,042,500	18,502,500
6	Hot Pepper	26,530,000	17,890,000	17,710,000	17,170,000
7	Tomatoes	24,012,000	15,372,000	15,192,000	14,652,000
8	Cabbage	22,612,000	13,972,000	13,792,000	13,252,000
9	Onions	21,998,000	13,358,000	13,178,000	12,638,000
10	Groundnuts	20,238,180	11,598,180	11,418,180	10,878,180
11	Climbing beans	16,020,000	7,380,000	7,200,000	6,660,000
12	Upland rice		5,788,000		5,068,000

Note: Benefit for fruits and coffee considers peak production

Dairy

For semi-intensive dairy (20 animals), the net annual incremental benefit is Ugx. 58,950,000 per year using HDPE lined underground tank with motorized abstraction and Ugx. 61,290,000 per year using Borehole with solar powered abstraction system. The net annual incremental benefit for dairy is higher than for irrigation of crops.

4.5 Feasibility of irrigation

a) Internal Rate of Return

For annuals (vegetables, groundnuts, upland rice, climbing beans) and passion fruits, rain gun sprinkler irrigation system has the highest IRR followed by Conventional overhead sprinkler irrigation system. For perennials (fruits and coffee), Rain gun sprinkler irrigation system has the highest IRR followed by Solar Powered drip irrigation system.

The IRR for different irrigation options and enterprises is shown in the table 5 below.

Table 6: Internal Rate of Return for different irrigation options and enterprises

Enterprise	Rain gun sprinkler irrigation system	Conventional overhead sprinkler irrigation system	Solar Powered drip irrigation system	Conventional drip irrigation system
Hot pepper	110%	79%	51%	52%
Tomatoes	95%	68%	46%	44%
Cabbage	86%	61%	43%	40%
Onions	82%	58%	42%	38%
Groundnuts	71%	50%	39%	33%
Passion fruits	71%	53%	41%	37%
Climbing beans	45%	30%	30%	19%
Upland rice	35%	22%		
Apples	28%	25%	27%	22%
Mangoes	28%	25%	27%	22%
Robusta Coffee	27%	22%	27%	19%
Citrus	23%	20%	23%	17%

Dairy

For semi-intensive dairy (20 animals) using HDPE lined underground tank with motorized abstraction has an IRR of 35% while an IRR of 17% was obtained using Borehole with solar powered abstraction system.

b) Return on Investment

At 15% interest rate, Rain gun sprinkler irrigation system has the highest Return on Investment (ROI) followed by Conventional overhead sprinkler irrigation system. For annuals (vegetables, groundnuts, upland rice, climbing beans) and passion fruits, For perennials (fruits and coffee), Rain gun sprinkler irrigation system has the highest ROI as a result of relatively low initial investment. However, Operation and Maintenance cost is high due to energy cost for high pressure. Due to the agronomic advantage of minimizing fungal inventions, drip irrigation is recommended for tomatoes although sprinkler irrigation has a higher ROI. For coffee and citrus, Solar Powered drip irrigation system has a higher ROI in comparison to Conventional drip irrigation system due to lower operation and maintenance costs even though the initial investment cost is higher.

At 25% interest, Rain gun sprinkler irrigation has ROI of more than 100% for hot pepper, tomatoes, cabbage, passion fruits , onions and groundnuts. Conventional overhead sprinkler irrigation system has ROI of more than 100% for hot pepper, tomatoes, cabbage, passion fruits , and onions. Conventional drip irrigation system has ROI of more than 100% for hot pepper and tomatoes. No enterprise has ROI of more than 100% for solar powered drip irrigation.

It should be noted that the final choice of an irrigation system is site specific and is dictated by other factors such as type and characteristics of water source (quantity and quality); availability of spares; level of skills and type of soil.

The ROI at 15% and 25% interest rate for different irrigation options and enterprises is shown in the table 6 and 7 below.

Table 7: Return on investment for different irrigation options and enterprises at 15% interest rate

Enterprise	Rain gun sprinkler irrigation system	Conventional overhead sprinkler irrigation system	Conventional drip irrigation system	Solar Powered drip irrigation system
Hot pepper	550%	368%	324%	203%
Tomatoes	458%	298%	255%	174%
Passion fruits	416%	267%	223%	161%
Cabbage	406%	260%	216%	158%
Onions	384%	243%	199%	151%
Apples	347%	215%	172%	140%
Mangoes	328%	201%	158%	134%
Groundnuts	319%	194%	151%	131%
Robusta Coffee	202%	106%	63%	122%
Citrus	188%	96%	52%	90%
Climbing beans	164%	78%	35%	83%
Upland rice	105%	34%		

Table 8: Return on investment for different irrigation options and enterprises at 25% interest

Value chain	Enterprise	Rain gun sprinkler irrigation system	Conventional overhead sprinkler irrigation system	Conventional drip irrigation system	Solar Powered drip irrigation system
Vegetables	Hot pepper	326%	206%	158%	
Vegetables	Tomatoes	265%	161%	112%	
Vegetables	Cabbage	232%	136%		
Fruits	Passion fruits	224%	130%		
Vegetables	Onions	217%	125%		
Oil seeds	Groundnuts	175%			

Dairy

For semi-intensive dairy (20 animas), using HDPE lined underground tank with motorized abstraction has a ROI of 114.8% at 15% interest rate. At this interest rate, using Borehole with solar powered abstraction system produced a ROI of 11.6%. The initial investment cost for Borehole with solar powered abstraction system is too high and calls for grants to justify the investment.

4.6 Recommended production areas for irrigation adoption

Investment in small-scale irrigation is promising in areas endowed with adequate infrastructure and markets, such as Urban and peri-urban areas. Other promising areas are those already doing high value crops.

The other potential areas for irrigation adoption are those already practicing informal irrigation. Irrigation is considered 'informal' when farmers spontaneously develop systems without planning and with little or no technical assistance. Often the technology used is basic and sometimes inappropriate (FAO, 2015). Farmers raise the water level of the river using self-made local weirs with bags of sand and wooden poles. Water is diverted in simple non-lined channels from which it is accessed by breaching the banks every time to allow it to flow into the furrows of the lower lying farms.

The majority of informal irrigated areas in Uganda are located on the fringes of swamps mostly in eastern Uganda around streams flowing into Lake Kyoga (Carruthers, 1970). The area under informal irrigation increased from 23,000 ha in 1945 (Carruthers, 1970) to 53,000 ha in 2005 with focus on irrigating rice, vegetable and fruit production systems (FAO, 2015). Although urban and peri-urban informal irrigated agriculture covers a small percentage of the total irrigated area, it accounts for between 60 and 100% of the consumed leafy vegetables in the urban areas depending on crop and season (Wanyama et al., 2017).

Table 6 and 7 shows the regions earmarked for the different enterprises.

Table 9. Potential areas of irrigation adoption for different value chains

Value chain	Enterprise	Agricultural production zone*									
		I	II	III	IV	V	VI	VII	VIII	IX	X
Horticulture	Vegetables			√		√	√	√		√	√
"	Citrus					√					
"	Mangoes			√		√					
"	Apples										√
"	Beans			√				√			
Coffee	Coffee			√	√		√	√		√	√
Cereals	Rice						√				
Oil seeds	Groundnuts		√	√	√	√		√			
Diary	Diary						√	√	√		√

Adapted from MAAIF (2016): (I) North Eastern Dry lands, (II) North Eastern Savannah Grasslands, (III) North Western Savannah Grasslands), (IV) Para Savannahs), (V) Kyoga Plains, (VI) Lake Victoria Crescent, (VII), Pastoral Rangelands (VIII) Western Savannah Grasslands, (IX) South Western Farmlands and (X) Highland Ranges.

Table 10. Distribution of agricultural production zones

Zone	Name of Zone	Districts
III	North-western Savannah Grasslands	Adjumani western Nebbi Arua Moyo Yumbe northern Gulu northern Apac western Lira
IV	Para-savannahs	eastern Nebbi southwestern Gulu western Masindi
V	Kyoga Plains	Kayunga Kamuli Iganga northern Bugiri Tororo northern Busia southern Mbale Pallisa Kumi Soroti Kaberamaido southern Lira southern Apac
VI	Lake Victoria Crescent	Kampala Mukono Wakiso eastern Mpigi eastern Masaka eastern Rakai Kalangala Jinja Mayuge southern Bugiri southern Busia
VII	Western Savannah Grasslands	Hoima Kiboga southern Luwero Mubende Kibaale Kyenjojo Kabarole Kamwenge southern Kasese

VIII	Pastoral Rangeland	eastern Masindi Nakasongola northern Luwero central Kiboga southern Mubende western Mpigi western Masaka western Rakai Sembabule eastern Mbarara southern Ntungamo northern Bundibugyo
IX	South-western Farmlands	western Mbarara Bushenyi northern Ntungamo Rukungiri northern Kanungu
X	Highland Ranges	northern Mbale southern Sironko southern Kapchorwa southern Kanungu Kabale Kisoro northern Kasese southern Bundibugyo

5 STRATEGIC FRAMEWORK FOR IRRIGATION DEVELOPMENT

5.1 Interventions

The Strategy is aligned with the aBi goal and development objectives. It is therefore designed to achieve specific targets in the aBi Business Plan 2019-23, which dovetails into the overall Danida country program strategy under UPSIDE (2019-23).

The Goal of the irrigation strategy is to increase incomes from target enterprises by 50% by 2023. The purpose of the strategy is to increase the utilization of irrigation from the current 1% of cultivated area to 15%. This will target approximately 10% of farmers, mainly involved in high value commercial farming targeting markets for off-season vegetables and fruits, coffee, and Dairy. In order to achieve the goal and purpose, aBi and partners in intervention under 4 strategic pillars:

i. Increasing Access to Irrigation Technologies and Services
ii. Promoting Financial Inclusion for Irrigation investments
iii. Increasing Productivity and Production of Target Enterprises
iv. Capacity building for sustainable management of irrigation

The intervention matrix is shown in table 10 below.

Table 11 Recommended irrigation interventions and key actors

No.	Intervention Area	Expected results	Recommended interventions/strategies	Key actor (s)
1.	Stimulate growth for the market for irrigation to supply niche markets	Increased sales volumes	Distance – enhancing retail networks	Irrigation service providers e.g., Holland green Tech, SIRACO, SOLARNOW, BALTON etc
			Awareness creation on climate smart irrigation-mass media campaigns	Uganda National Farmers federation Print and digital media
2.	Attract investment in irrigation	Increased technology adoption	Irrigation Financing	Suppliers/farmers/private sector
				Government
				Producers
3	Capacity building on access and utilization for irrigation	Increased utilization of irrigation	Irrigation extension expertise	District Local Government
			Proof of concept (Irrigation demonstration)	
			Service-enhancing capacity of local artisans	Universities, research organizations)
			Agribusiness skills development	NGOs active in small-scale irrigation e.g. NUCAFE for coffee, District Farmers Organizations, Feed the hungry, Action Aid, World Vision, Caritas.
4.	Research and development	Increased demand for irrigation technology	Adaptive research in Appropriate cost effective and affordable irrigation technology	Government (Universities, research organizations)

5.2 Risks and Mitigation Measures

Expected risks and mitigation measures are shown in Table 11.

Table 12: Expected risks and mitigation measures

	Risk	Mitigation Measure(s)
1.	Exchange rate fluctuations	♦ Insurance, export financing ♦ Export promotion
2.	High interest rates discouraging FDI and demand for loans	♦ Support development of tailored products ♦ Support FIs to strengthen client appraisal systems ♦ Promote group lending and savings
3.	Market distortions due to unfair subsidies and handouts	♦ Lobby and advocacy ♦ Close collaboration with government to anticipate policy direction
4.	Escalating energy prices (fuel, electricity)	♦ Development of alternative energy sources e.g. solar energy
5.	Limited availability and high costs of fertilizers	♦ Investment in local manufacture of fertilizers ♦ Fight fake fertilizers
6.	Increased supply of fake products and inputs on the markets	♦ Establish traceability systems ♦ Direct procurement from proven sources
7.	Pest and disease epidemics – reducing returns t investment	♦ Use of forecasting systems ♦ Include mitigation pest and disease epidemics as part of the irrigation package
8.	Low commodity prices	♦ Enterprise selection (High value enterprises with fairly stable prices) ♦ Invest in Quality Management targeting niche markets ♦ Invest in storage and value addition ♦ Contract farming ♦ Crop insurance

6 BIBLIOGRAPHY

1. MAAIF . 2016. Agriculture Sector Strategic Plan (ASSP) 2015-2020.
2. Chemonics, I. 2010. Uganda coffee supply value chain analysis. Profiling the actors, their interactions, costs, constraints and opportunities. United States Agency for International Development (USAID).
3. Comunicaffe, I.2016. Uganda aims to boost production and domestic consumption. in: Comunicaffe International. Via Dogana, 3 – 20123 MILAN, ITALY.
4. FAOSTAT. 2017. Food and agricultural commodities production. Available at: http://www.fao.org/faostat/en/#data. Accessed 15 July 2017.
5. UCDA.2017. Uganda Coffee Development Authority (UCDA) website, Uganda Coffee Development Authority (UCDA). Kampala.
6. UCDA. 2015. Uganda National Coffee Strategy 2040. Plan for 2015/16 - 2019/20. Uganda Coffee Development Authority (UCDA).
7. Ekou, J. 2014. Dairy production and marketing in Uganda. Current status, constraints and way forward. African Journal of Agricultural Research, 9(10): 881 -888
8. Otto, G., D., Balikowa, D., Kiconco, A Ndambi, T., Hemme. 2008. Milk Production in Uganda: Dairy Farming Economics and Development Policy Impacts
9. Beyssac, B.C., E.,Kamoga. 2012. Oil seeds in Uganda: Combining business led development and multi-stakeholder dynamics in boosting a diverse national sub-sector. SNV
10. Dalipagic, M.I. and Elepu, G., 2014. Agricultural value chain analysis in Northern Uganda: maize, rice, groundnuts, sunflower and sesame. Action Against Hunger (ACF) International.
11. Okello, D.K., Okori, P., Naveen, P., Boris, B.U., Deom, C.M., Ininda, J., Anguria, P., Biruma, M. and Asekenye, C., 2015. Groundnut Seed Production Manual for Uganda. National Agricultural Research Organization, Entebbe, Uganda.
12. EADD. 2008. The dairy Value Chain in Uganda. A report by TechnoServe Uganda for the East Africa Dairy Development Program. Kampala, Uganda.
13. East African Standards. 2006. Raw cow milk Specification. EAS 67:2006 ICS 67.100. Available at: (https://ia801900.us.archive.org/23/items/eas.67.2006/eas.67.2006.pdf. Accessed 14 August 2017
14. Carr, M. 2001. The water relations and irrigation requirements of coffee. Experimental Agriculture 37, 1-36.
15. Balikowa, D. 2011. Diary Development in Uganda. A review of Uganda's Dairy Industry. *MAAIF, FAO, DDA.*
16. MAAIF. 2014. Uganda Training Materials for Coffee production. Trainer's guide. . Ministry of Agriculture, Animal Industries and Fisheries (MAAIF), Kampala, Uganda.
17. Mutua, C. 2016. All about growing French beans for higher returns, Daily Nation. Nation Media Group, Nairobi, Kenya.

18. UBOS. 2007. Uganda national household survey 2005/2006: Report on the agricultural module. Uganda Bureau of Statistics (UBOS), Republic of Uganda. www.ubos.org, Kampala.
19. UNDP. 2012. Value Chain Analysis (VCA) of the Coffee Sub-sector in Uganda. Development of Inclusive Markets in Agriculture and Trade (DIMAT).
20. EPRC (Economic Policy Research Centre). 2014. Enhancing agricultural production and productivity in Uganda through irrigation (2014). CARE International (Uganda), and Global Water Initiative East Africa (GWI).
21. FAO. 1997. Irrigation Technology Transfer in Support of Food Security: FAO Water Report No. 14
22. MWE . 2011. A National Irrigation Master Plan for Uganda (2010-2035). Ministry of Water and Environment (MWE), Final Report, November 2011.
23. Hagos, F., Makombe, G., Namara,R. E. And Awulachew,F.B. 2009. Importance of irrigated agriculture to Ethiopian economy: capturing the direct net benefit of irrigation. Colombo, Sri Lanka, International Water Management Institute. 37p (IWMI Research Report No.
24. OPM (Office of The Prime Minister). 2013. The 2010–2011 Integrated Rainfall Variability Impacts, Needs Assessment and Drought Risk Management Strategy, Kampala.
25. Wanyama, J., Ssegane, H., Kisekka, I., Komakech, J. A., Banadda, Zziwa, A., Oker T. E., Mutumba, C., Kiggundu N., Kato R. K., Mucunguzi D. B., Kiyimba, F. L. 2016. Irrigation development in Uganda: Constraints, lessons learned and future perspectives. *Journal of Irrigation and Drainage Engineering*. DOI:10.1061/(ASCE)IR.1943-4774.0001159. 04017003-1-10
26. Nile Basin Initiative . 2012. Assessment of the Irrigation Potential in Burundi, Eastern DRC, Kenya, Rwanda, Southern Sudan, Tanzania and Uganda. Nile Equatorial Lakes Subsidiary Action Program (NELSAP) of the Nile Basin Initiative (NBI) and the Regional Agricultural Trade and Productivity Project.
27. *Somado, E.A., R.G., Guei and S.O., Keya. 2008.* NERICA: The New Rice For Africa – A Compendium Africa Rice Center (WARDA). pp210.
28. UBOS. 2006-2015. Statistical abstracts
29. UNPII. 2015 . Strengthening Uganda's Competitiveness for Sustainable Wealth Creation, Employment and Inclusive Growth
30. MTIC. 2008. National Trade Policy. Trading Out of Poverty, Into Wealth and Prosperity
31. https://bizna.co.ug/mwesigyes-million-shilling-apple-farm/. Accessed 03 July 2017.
32. Carr, M. K. V. 2013. The water relations and irrigation Requirements of passion fruit (passiflora edulis sims): a review. *Expl Agric*. 49 (4), 585–596
33. Kanyi, J. 2015. Follow these steps to get high yields from passion fruits. Available at: http://www.nation.co.ke/business/seedsofgold/Passion-Fruits-Yields-Crop-Farming/2301238-2637838-x9jjua/index.html. Accessed 27th Feb 2015

34. Passion fruit farming guide. 2017. Available at: http://www.agrifarming.in/passion-fruit-farming/. Accessed 02 September 2017.
35. UNPII. 2015. Strengthening Uganda's Competitiveness for Sustainable Wealth Creation, Employment and Inclusive Growth
36. FIT(U). 2017. Grains subsector analysis report. P.O. Box 24060 Balintuma Road, Kampala.
37. Okello, D. K., M. Biruma, and C. M. Deom. 2010. Overview of groundnuts research in Uganda: Past, present and future. *African Journal of Biotechnology* 9.39 (): 6448-6459.
38. MAAIF. 2012. Uganda National Rice Development Strategy (NRDS) : 2008-2018
39. MoFPED. 2015. Rice Value Chain in Uganda

7 ANNEXES

Annex 1: Pictorial

Figure 1 Solar powered irrigation: A solar powered abstraction adapted on a borehole (top); Future solar water pump distributed in Uganda by SolarNow Services (U) Limited (bottom)

Figure 2 Conventional drip irrigation system

Figure 3 Rain gun sprinkler irrigation system

Figure 4 Overhead sprinkler irrigation system (Source: Mati, 2012)

Annex 2: List of irrigation service providers

No.	Suppliers	Address	Main irrigation equipment and services
1	SOLARNOW SERVICES (U) LIMITED	SolarNow Services (U) Limited Part of SolarNow- The Netherlands Opposite KIU, Kansanga, Kampala P.O Box 10766 Kampala Tel: 0788916600 Email: info@solarnow.eu Web: www.solarnow.eu	Solar pump, low pressure sprinklers, pipes
2	SIRACO IRRIGATION	SIRACO IRRIGATION "Delivering quality" **P.O Box** 2758, Ntinda, Kampala (U) Tel: +256 392 175 835 Mob:+256 758 990 992 Email: info@SIRACOirrigation.com Website: www.SIRACOirrigation.com	Drip systems, Sprinkler **systems, Rain gun systems** *Services:* Design, installation and management of irrigation systems and water harvesting technologies; Agricultural consultancy in agronomy and irrigation Turnkey projects and farm development plans Technologies:
3	BALTON UGANDA	Balton Uganda Plot 47/51 Mulwana Road, Industrial Area, P.O. BOX 852, Kampala, Uganda Tel: +256-752-270100/1/2 +256-312-502300 Email: balton@balton.co.ug **Website**: http://www.baltoncp.com/Uganda	Micro sprinklers, Overhead sprinklers, Misters, Centre Pivot, HDPE Dam liners, greenhouse technology Services: Design ,Supply, Installation, Training , Flushing/cleaning of the installed systems, Infield-nurseries, Growing guides in relation to the products provided Technologies:
4	DAVIS & SHIRTLIF LTD	Davis & Shirtlif Ltd P.O. BOX 22824, Kampala, Uganda Kitgum House TEL: +256(0)414 346337/8 Email: d&skampala@dayliff.com/d&s@ug.dayliff.com Web: www.davisandshirtliff.com/ www.dayliff.com	Manually operated irrigation pumps and solar products, Solar equipment; Solar PV Modules, Hot Water Heaters, Solar water pumps, solar generating systems, street lights; wind generators
5	HOLLAND GREENTECH UGANDA LIMITED	Holland Greentech Uganda Limited "Developing the next step in horticulture in East Africa" Nakibirango road, Off Kironde road, Muyenga, Kampala Email:info@hollandgreentech.com Tel: 0785 389 453/ 0706 230 892	Drip kits, Greenhouse, quality seeds, inputs, soil tests Agricultural advisory service Supply inputs and training on: Irrigation services (drip irrigation) Improved horticultural seeds- Breeding center in Arusha Tanzania Soil analysis and fertilizers (organic), Biological pest control Greenhouse technology
6	MULTIPLE INDUSTRIES LTD	Multiple industries ltd Plot 13/23, 8th Street Industrial Area P.O Box 20166 Kampala-Uganda Tel: 0414236021/2 Email: sales@multipleindustries.com Web:www.multipleindustries.com	Dealers in Rainbird Agricultural Irrigation System- Drip Irrigation, Sprinkler irrigation, Irrigation kits, Movable irrigation system, Automatic Irrigation Systems Manufacturers of HDPE Pipes & Fittings, PVC Pipes & Fittings, Water Pumps and Water Tanks

7	AGROMAX (UGANDA) LIMITED	Agromax (Uganda) Limited Plot 92, Lutette, Gayaza Road Kampala Tel: 0414666030/0756 622464 Email: ronyjoy@agromaxu.com/info@agromaxug.com Web: www.agromaxug.com	Design, installation, consultancy and training Products: Fertilizers and chemicals, Irrigation systems-(drip irrigation, Greenhouse ,Farmer's Kit for Small-Scale Farmers), Pre-sprouted seedlings
8	ADRITEX (U) LIMITED	Adritex (U) Limited Head Office Plot 2-4, 7th Street Industrial Area, Oxford Station 8A P.O Box 22553 Kampala, (U) Tel: +256704569416/+256 414 660937 Email: info@adritexug.com Web: www.adritexug.com	Dealers in Irrigation Equipment, Solar Water Pumps, Boreholes, Solar equipment, water pumps, generators, swimming pools & water treatment
9	NSI.WATER	NSI.Water Retail Sale Office: Behind Shoprite Serome Shop P.O Box 73500 Kampala-Uganda Tel: +256 200 902158 Email: info@nsiwaterug.com Web: www.nsiwaterug.com	Providing a wide range of smart water and energy solutions (Borehole, water treatment, solar water heating, solar pumps, generators, sprinklers & water guns, irrigation fittings & accessories, controls & accessories)
10	CRESTANKS LTD	Crestanks Ltd Plot No. 265, Jinja Rd, Bweyogerere, Wakiso Tel: 0312262015/6, 0772/0752 729560 Email: suresh@crestanks.co.ug/info@crestanks.co.ug web: www.aquasantec.com	Quality tanks for water harvesting and biodigester
11	Agricultural Eng and Applied Technology Research Centre, National Agricultural Research Organization	3 Km off Gulu road at Kawanda stage P.O Box 7144 Kampala, Uganda Tel 041 566 161Kampala Email: aeatri@naro.go.ug	Research and Development of a range of agric product on & processing equipment. Treadle pump, design and installation services for irrigation
12	Makerere University Department of Agricultural Engineering, Makerere University	P.O. Box 7062, Kampala P.O Box 7062, Kampala, Uganda Email: banadda@caes.mak.ac.ug	Trains engineers and technicians in Agricultural Mechanization and Irrigation.

Annex 3: SMEs and small-scale farmers already using irrigation

No.	Name	Contact	Location	Water source	Irrigation technology	Enterprise(s)	Remarks
	Mr . Lugolobi Buhran Sekaggya	0392962736	Lubus mixed farm and information centre Ntooke village, Kayunga Town Council Adjacent to Hopeful future secondary school signpost/Ntooke Mosque Lat: 0.687476, Long: 32.88523, 1091 m a.s.l	Water source: Shallow well (4m deep) with a recharge of a tributary of River Sezibwa	*Description of irrigation system:* High pressure sprinkler system *Main components*: Shallow well, 5bars Pump, 63mm Mainline, 50mm Sub mains & laterals, Rain bird Sprinklers with a throw radius of 15 m *Area covered:* 2 ha (5 acres)	Diary Pastures (Alfalfa, Chloris Gayana), vegetables esp. tomatoes and maize for fodder/silage	Experience: The host farmer is an experienced model farmer with exposure within and outside Africa. Lubus farm is 7 years old since 2008 while the proprietor has spent 17 years in farming. Membership to cooperative society: Bugaga Kwerinda cooperative Society with 150 members Potential: The demonstration also doubles as an information centre. The host farm receives/hosts farmers from within and outside Uganda on the farm
	Mr. Ahimbisibwe Jonathan	0772922754	Katonye Village, Katerera Parish, Katerera Sub-county 36M 0182903 m E, 9981142 m S, 1040 m.a.sl	River Katonye/Mpanga which runs through a network of crater lakes till Lake George	*Type*: High pressure sprinkler system *Main components*: small river impoundment, 10bars Pump, 63mm Mainline, 50mm Sub mains & laterals, RAIN GUN Sprinklers with a throw radius of 35m Hose pipe, overhead sprinklers (0.5 m riser) *Area covered:* 4 acres	Passion fruits (2 acres) Vegetables (tomatoes, cabbage , egg plant)2acres	Group: Katonye fruits and vegetables association Impact on farmers livelihood: Reduction in drudgery and expansion of cropped area. Before the intervention , farmer had to employ laborers to fetch water using watering cans and could only irrigate 1/4 acre. Now the cropped area has been expanded to 4 acres. Increase in income. Before the farmer could earn about 2 million shillings from 1/2 acre. Currently the farmer can earn up to 10 million from 2 acre The farmer is now able to pay school fees without borrowing
	Mr. Peter Masiko	0392548562/0701 548562	Farm owner, Fast Lane Garden Bunyonyi Nyakibande village, Kitumba sub-county 830238.02 mE, 9849146mS, 2104 m a.s.l	Stream from Mt. Nyangorogoro adjacent to Lake Bunyonyi	*Type*: Drip irrigation system *Main components*: Concrete water tank recharged by stream flow, 2 km 63mm main pipeline along the contour to the main tank (20,000L) found at Kiyanga, Rainbird button drip system (2 drippers per apple tree) *Area covered:* 5 acres	Apples (2 acres)/500 trees	Farmer demonstration attempt-Training other farmers *No. of beneficiary farmers:* 1 Nyakibande SACCO Impact of irrigation:-High yields hence high income from apples. With irrigation, the size of the apples increased Farmer has been able to expand the farm from 2 to 6 acres and diverse to other enterprises like forestry, poultry and apiary With irrigation, the frequency of apple trees falling sick and leaves falling off has reduced The farm hosts many visitors and farmers from across the country. At least 20-30 visits per year. Farmers are mainly trained on apple farming
	Kyekidde Youth and Women Farmer's group.	Chairperson Mr. Odongo Anthony 0759/0772 988182, 0779 346558	Butiki village, Buwenda Parish, Mafubira S/county 0559504mE, 0043912mN, 1217 m a.s.l	Shallow well (10 ft deep) with a recharge of perennial stream (River Kyekidde).	*Type*: High pressure sprinkler system *Main components*: Shallow well, 10bars Pump, 63mm Mainline, 50mm Sub mains & laterals,	Indian vegetables (Tindoli, Kalera), local vegetables (tomatoes,	The potential area served by stream under the farmers group stretches 120 m x 4 km Kyekidde Youth and Women Farmer's group. 60 members (36 women and 26 youth)

No.	Name	Contact	Location	Water source	Irrigation technology	Enterprise(s)	Remarks
		Chairperson Youth Mr. Kasolo Bony			RAIN GUN Sprinklers with a throw radius of 35m *Area covered:* 10.5 acres	cabbage , egg plant)	Tindoli: 1 kg of fruit sold at4000 - 7000 /- during dry season. Prices fall drastically to as low as 500/- during the wet season. With irrigation, a farmer can harvest about 25 kgs per week for a period of 4 months. Without irrigation a farmer harvests as low as 8 kg. Tindoli: With irrigation, a farmer can harvest about 25 kgs per week for a period of 4 months. Without irrigation a farmer harvests as low as 8 kg.
	Balikuddembe Godfrey	0774021730	Kalisizo, Masaka District		SolarNow Water pump	Tomatoes, Passion fruits and Hot pepper. coffee irrigation	
	Mrs. Katungye Patience	0754938758	Bisheshe central, Bugarama parish, Bisheshe sub-county /Division 36M 0220272 m E, 9993856 m S, 1403 m a.s.l	Rainwater harvesting tank	*Type*: High pressure sprinkler system *Main components*: runoff water harvesting tank, overhead tank (5000L) , 10bars Pump, 63mm tape for Mainline, 50mm Sub mains & laterals, Drip lines *Area covered:* 1.5 acres	Vegetables (hot pepper, cabbage, tomatoes, onions) Coffee seedlings Nurseries for coffee	Farmers have expanded the runoff harvesting tank to 5 m x 20 m from a pond. Farmer group: Bisheshe Central farmers group (18 members of which 15 are women) Farmers from other neighboring sub counties are trained on the demonstration site on horticultural farming and irrigation

Annex 4: List of Key stakeholders consulted

No.	Name	Designation	Contact
1	Iletu Justine	Farm Manager , Uganda Police- Bugungu- Buikwe	0782698244
2	Okwand Dodaa	Research Officer, NaSSARI/ NARO Serere	0772369125/0750697985
3	Ereu Samuel	Research Officer, NaSSARI/ NARO Serere	0784963092/0706063092
4	Robert Omachi	Senior research, NaSSARI/ NARO Serere	0772690260
5	Nyanzi	Retailer, Nakasero Market	0703325532
6	Stella Nakitto	Retailer, Nakasero Market	077807686
7	Mukangalambe Betty	Retailer, Owino Market	0772498807
8	Dr Musooli Pascal	Senior research officer, National Coffee Resources Research Center (NaCORRI)	0772576446
9	Dr Otim Michael	Senior research officer, National crop resources Institute (NaCRRI)	0772,897,040
10	Harold Nyagamehe/	Managing Director, Aponye Uganda Ltd Plot 6 Wankulukuku	078681553
11	Tukwasibwe Benon	Head Finance, Aponye Uganda Ltd Plot 6 Wankulukuku	0701104254
12	Farmer	Rice farmer, Iganga	078801467
13	Muramira Julius	Vegetable farmer, Muhanga-Rukiga	0782845808
14	Confidence Twinamatsiko	Agronomist, Britania Allied Industries Ltd	0750124582
15	Ivan	tomato dealer, Wakiso	0754768727
16	Namaalwa Harriet	Nursery farmer, Mangajo, Wakiso	0775155020/0704155020
17	Josephat	Agribusiness Specialist , ETG (Fertilizer Division)	0785350326; 0700955352
18	Agronomist	FICA SEEDS	
19	Sales	East African Seed	0772583783
20	Sales	NASECO SEEDS	0751618003
21	Agronomist	Continental Seeds	

22	Sales	Victoria Seed limited	
23	Muwonge David	Deputy Executive Director NUCAFE	0758559218
24	Joseph Nkandu	NUCAFE	0772595030, Joseph.nkanda@nucafe.org
25	Deus Nuwagaba	NUCAFE	0774300628, Dues.nuwagaba@nucafe.org
26	Alvin Asingya	Irrigation Engineer NUCAFE	0703119742, aasingya@nucafe.org
27			
28	Eng Richard Cong	MWE /MD MARS ENGINEERING	0772500697, Richard.cong@mwe.co.ug
29	Kaneema Christine	Agriculturalist MWE	0774312358
30	Ollando Allan	Engineer MAAIF/DAIMWAP	0781573692, ollandoallan@yahoo.com
31	Benon Lwanga	Service Engineer MAAIF	0772892580
32	Silas Ekadu	Senior Engineer MAAIF	0777434129
33	Eng. Dominic Mucunguzi	Senior Engineer MAAIF	0772373337
34	SHUWU P. Michael	Value Chain Officer NAADS	0773075508
35	Evmaly Kamusiime	Agribusiness Analyst PSDU/MFPED	0787818104
36	Wamulimau Robert Paul	MFPED/PSDU	0772516158
37	Peter Ngategize	MFPED	0772824718, Peter.ngategize@yahoo.com
38	Dr. Kalyebara Robert	Heat Technical and Quality Assurance ABI	0772496349
39	Prossy Tumushabe	ABI	0772696825 Prossy.tumushabe@abi.co.ug
40	Davis Ikiriza	ABI Finance	0781314811
41	Peninah Kyariaya	Tech./Ucd ABI	0772616977
42	Victor Komakech	Climate Change Officer HRNS	0772707908 Victor.komakech@hrnstiftung.org
43	Anyangan Andrew Timothy	Supervisor Agric CERUDEB	0703993880

44	Eng. Mubangizi Aloysius	SIRACO irrigation	0701487750, Aloysius@siracoirrigation.com
45	Marianne Namanya Nkore	Balton Uganda	0759330923, balton@balton.co.ug
46	Anita Nelima	Engineer BALTON UGANDA	0773135843/0753333151
47	Peter Huisman	SolarNow	0797583524, peter@solarnow.eu
48	Maarten Hermus	Holland GreenTech	0756074728, maarten@hollandgreentech.com
49	Prem Kumar Reddy	CEO Grow more seeds and chemicals limited	0752222522 ceo@growmoreseeds.com
50	Abama Thomas	Engineer Grow more seeds and chemicals limited	0785540023
51	Komakech Allan	Senior Lecturer, MAKERERE UNIVERSITY	0773205622
52	Sam Cherotich	Research Assistant MAKERERE UNIVERSITY	0773400237
53	Tumutegyereize Peter	Lecturer MAKERERE UNIVERSITY	0782433330

Annex 5: Enterprise Market Analysis

Horticulture value chain

Marketing

Though supermarkets are a growing presence in cities, markets that sell produce in an open environment are still the dominant outlets for horticulture. The main destinations for vegetables include Kalerwe, Wandegeya, St Balikuddembe and Nakawa markets. Besides local market, Uganda's horticultural sector enjoys regional (mainly EAC and COMESA) and international markets (mainly EU) thanks to its ability to produce tasty, fresh and nutritious products. According to UBOS statistical abstracts (2006-2014), formal exports by value from horticulture have shown a tremendous increase from US $ 13.4 million in 2006 to US $ 49.1 million in 2014. This represents over 266% increase in less than 10 years. Currently, there are over 24 registered export companies for horticultural products, most of them exporting fresh products to the EU market.

Supply

The 'vegetable belt' runs through Wakiso in areas around Kakiri, Namayumba and Masulita and skirts around Matugga, Buwambo, Busukuma, Bugema, Busiika, Zirobwe and parts of Kalagi and Nakifuma in Mukono district. The vegetables are grown along the various small rivers and streams that criss-cross these areas. Vegetables in these areas are irrigated with informal means. While there are farmers who grow vegetables, most of them are small scale. The common vegetables are tomatoes, nakati, dodo, bugga, cabbages and green pepper. While many of them own small pieces of land on which they grow the vegetables, most of them simply hire land from other farmers. Supply of vegetables and fruits is highly seasonal due to high dependence on rainfall.

The average cropped area for onions and tomatoes for the period 2006-2014 is 70,146.6±7,146.1 ha and 5074.3±797.0 respectively (FAOSTAT, 2017). From these cropped areas, the average production stood at 277,706.4±28,825.4 tons for onions and 29767.8± 4507.8 for tomatoes. (Table 12) The yields were 3.96±0.01 tons/ha and 5.9±0.1 for onions and tomatoes respectively. A closer look at the trends shows that although the production volumes of both onions and tomatoes are increasing, the yield per ha remains stagnant. This implies that the increase in production is attributed to increase in cropping area. In addition, the yields obtained are well below the potential yields which are 56 – 80 mt/ha and 13 – 19 mt/ha for improved varieties of tomatoes and onions respectively.

Table 13 Production statistics for vegetables (2006-2014)

Year	Onions			Tomatoes		
	Cropped area (ha)	Production (tonnes)	Yield (tons/ha)	Cropped area (ha)	Production (tonnes)	Yield (tons/ha)
2006	57,036.00	224,825.00	3.94	3,831	23,268	6.0
2007	62,124.00	245,133.00	3.95	4,300	25,672	5.97
2008	65,000.00	256,746.00	3.95	4,164	24,500	5.9

2009	73,648.00	291,204.00	3.95	4,766	27,720	5.8
2010	80,208.00	317,473.00	3.96	5,500	31,000	5.6
2011	68,924.00	273,090.00	3.96	5,170	30,000	5.8
2012	71,867.00	285,042.00	3.97	6,000	35,000	5.8
2013	74,796.00	296,968.00	3.97	5,960	35,171	5.9
2014	77,716.00	308,877.00	3.97	5,978	35,579	5.95
Average	70,146.6±7,146.1	277,706.4±28,825.4	3.96±0.01	5074.3±797.0	29767.8±4507.8	5.9±0.1

Source: (FAOSTAT, 2017)

Data on cropped area, production and yield for the different fruits in Uganda is not readily available except that on passion fruit shown in Table 13 for the period 2006- 2014. Over this period cropped area and production volume averaged 7861±77.5 ha and 52,420±341.6 tons respectively. From this, the average yield was 6.7±0.0314 tons/ha. However, though the trend shows slight increases in cropped area, yield remained constant generally at 6.7 tons/ha, which is far below the expected yield of 15 tons/ha under good agronomical practices.

Table 14 Production statistics for passion fruit (2006 - 2014)

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average	STDEV
Cropped area ha	7,789	7,799	7,807	7,816	7,800	7,855	8,000	7,907	7,983	7,862	82.2
Production tonnes	52,249	52,249	52,238	52,236	52,000	52,378	52,500	52,690	53,237	52,420	362.4
Yield (tons/ha)	6.7	6.7	6.7	6.7	6.7	6.7	6.6	6.7	6.7	6.7	0.03

The local market is also supplied by imports of temperate fruits obtained from Kenya and South Africa. The leading imported fruits are apples, mangoes from Kenya and passion fruits from Kenya and Rwanda (ICRAF and Ssemwanga Centre, 2003). Most of the quality mangoes on the market all year round are imported from Kenya. This indicates that local production for these products cannot sustain the local demand and this presents an opportunity to increase. This indicates that local production cannot sustain the local demand. From Britannia Allied Industries Ltd perspective, its demand for mangoes is in shortage by two thirds.

on the basis of an assessment of the citrus growing sub-regions, 10 districts have been selected for strategic interventions in the citrus sector as follows: Teso sub region; Soroti, Kumi. Bukedea, Amuria, Katakwi, Serere and Kaberamaido and in Busoga region; Kamuli, Kaliro and Iganga. The intervention is aimed at promoting production and distribution of quality citrus seedlings tolerant to pests and diseases and with desirable fresh and processing characteristics. MAAIF targets to establish at least 60,000 acres of citrus fields in eastern Uganda.

Demand and current utilization

Generally, most of the vegetables and fruits are consumed in their fresh form in Uganda. With only a per capita consumption of about 12.4 kg/year for fruits and about 50 kg/year for vegetables, Uganda falls way below the WHO/FAO recommendation of 146 kg/year.

A few companies do processing. Vegetable and fruit processing consists extraction of fresh juice, pulp (like by Britania Foods) and concentrates (like done by RECO) for later use.

Market requirements

Export market increasingly require products produced following specified agronomical practices like organically produced and of specific size. For example,

Horticultural product	Market requirement
Cabbage	Varieties that give small heads are preferred to big cabbage heads in most cases.
Citrus	Varieties that are tasty, have minimal seeds or no seed at all, having good peeling properties and have good fruit size.
Mangoes	Varieties that are tasty with flavor, fibre-free, and have good fruit size with high pulp proportion. For the processors, Ngowe variety is preferred followed by tommy Atkins.
Passion fruits	Varieties that are tasty with good flavour and aroma, higher proportion of juice, and have good fruit size. The purple variety is most preferred.
Apples	Each color helps in identifying the type of nutrient content. For example, green apples are rich in vitamin A and C compared to the other colors. Taste is another important parameter in apples and others fruits. Each of the three apple color also tastes different in terms of sweetness.

Price trends and behavior

Prices of horticulture follows seasons of production and other factors like prolonged drought, stability or instability in the neighboring countries and the production levels in other producing countries. Prices rise in the dry season and fall during the rainy season. These fluctuations in prices within the year affect the farmer more than any other actor in the value chain. Price trend of tomatoes, onions and cabbage (2006-2014) is shown in Table 14. Generally, vegetable prices over the years have been on the rise.

Table 15 Price trend of vegetables (2006-2014)

Units: UGX per kg

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average	Std.dev.
Onions	1,117	1,120	1,308	1,503	1,742	1,842	2,855	2,302	2,210	1,778	591
Tomatoes	641	827	998	1,198	1,350	1,639	1,703	1,836	1,923	1,346	461
Cabbage	330	379	378	447	588	530	776	776	676	542	172

For citrus, price trends have been fluctuating over the years as shown in Table 15.

Table 16 Price trends for citrus (2006-2014)

Units: UGX per kg

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average	STDEV
Unit price(UGX/kg)	696	655	757	1,056	958	1,211	1,352	1,268	1,274	1025.22	270.414

Source: Agricultural statistics 2009, 2012, 2015

Horticultural product	Price behavior
Tomatoes	Processor currently pays 2,100-2,300 UGX /kg of tomatoes delivered at the factory. Retailer to consumer prices are dynamic based on the size and number of tomatoes. Normally in peak harvest season, 10 small tomatoes go for UGX 1,000 and when supply decreases, 4 to 6 tomatoes are given at the same amount.
Cabbage	Business is majorly by farmers selling their gardens to the traders. The price of each garden is dependent on size and season whereby during the dry season farmer expects a higher price from his/her garden compared to the rainy season. All in all, the prices cover a wide range from

	UGX 200,000 to 600,000 due to size variations. The final consumer buys one head of cabbage at UGX 500 to 2,000 depending on size, season, market or location.
Onions	selling of onions from the farmer to the final consumer is one that is not standardized. The farmer may sell the garden or harvests and sells in terms of sacks. A sack of onions ranges from UGX 80,000 to 240,000. By the time the onions reach the final consumer, they are being sold in terms of container volumes, heaps or in numbers if not in kilograms for the case of supermarkets, whereby each onion is selling at UGX100 to UGX 500 depending on size and season. Those who sell in heaps, start at UGX 500 for a heap having 4 to 5 onions to UGX 10,000 for a much bigger heap or container. It is a complex chain that cannot allow one determine price changes/behavior given that units of transaction continue changing from one actor to another.
Mangoes	Prices vary between UGX 800 to 1200 per kg for mangoes delivered at the processing factory, the. However, at the farm gate, mangoes are purchased in terms of bags at UGX 20,000- 60,000 or boxes where the quantity within the bag or box is not quantified.
Passion fruits	Prices vary depending on the season as well as at different levels of actors in the value chain. For example when passion fruits are in short supply, the processor pays UGX 4,000 per kg delivered at the factory. At farm gate, the farmer is paid either in terms of a full sack or Ugx 900 per 8 to 12 passion fruits.
Apples	price trends and behavior have remained stable in a range of UGX 500 to 1,000 per apple at the farm gate and supermarket respectively.

Coffee value chain

Marketing

More than 90% of the coffee produced and traded in Uganda is exported to international markets.

Supply

The average cropped area, production and between 2006 and 2014 is respectively 320,096 ± 58,210ha, 189,305,000 ± 28,440,000 mt and 594.6 ± 26.6 kg/ha. Coffee production expanded by 26.9% over the five years (2010 – 2014). Generally, the Table 16 shows a general negative trend in yield. This implies that the observed increase in production is largely due to increase in cropped area as opposed to productivity. The average yields are far below the potential yields of coffee of 5-9 tons/ha. Farmers on average harvest 0.5Kg of coffee per tree, compared to the research station yield of 2 – 3kg per tree per season. National coffee strategy 2040 Statistics from UCDA depict low yields for Robusta at an average of 0.55 kg green coffee per tree or 10 bags of green coffee per ha, in comparison with 25 bags per ha in Brazil and 45 bags per ha in Vietnam. An estimated 70% of coffee trees are old (>40 years).

Table 17 Green coffee production statistics (2006 – 2014)

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average
Copped area (ha)	220,000	285,000	345,000	320,000	269,096	318,311	324,523	397,398	401,536	320,096 ± 58,210
Production ('000 tonnes)	133,310	175,346	211,726	195,871	166,968	191,371	186,125	222,894	220,135	189,305 ± 28,440
Yield (kg/ha)	606	615.2	613.7	612.1	620.5	601.2	573.5	560.9	548.2	594.6 ± 26.6

Source: *(FAOSTAT, 2017)

Table 17 shows that the coffee supply in Uganda has generally increased from 2,175,221 tons in 2005/06 to 3,631,479 tons in 2014/2015.

Table 18 Coffee supply in Uganda over ten year period (2005 – 2015).

Year	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15
Robusta (tons)	93,030	139,558	178,940	156,571	124,593	157,343	133,458	180,286	169,895	170,974
Arabica (tons)	37,483	34,759	30,475	39,002	49,039	38,651	53,404	54,487	49,277	46,915
Total (tons)	130,513	174,317	209,415	195,573	173,633	195,994	186,862	234,772	219,172	217,889

Source: Adapted from (UCDA, 2017)

Demand and current utilization

Consumption of coffee in Uganda is generally low with an estimated per capita consumption of 0.36kg/yr (Comunicaffe, 2016). Sometimes, coffee demand exceeds the supply sometimes by as much as 22% and this is mainly due to unreliable supply from farmers and traders, and low volumes at harvest. Coffee demand for the domestic and export market is shown in Table 18. MAAIF (2016) targets to produce 595,890 mt valued at approximately US$1,153 billion by 2020 (MAAIF, 2016).

Table 19 Coffee demand for export and domestic markets (2007/08 to 2014/15)

Year	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	Average
Export Market (tons)*	192,636	183,221	160,138	188,965	163,575	214,958	209,990	207,351	190,104±19,259.6
Domestic Market (tons)	16,779	12,352	13,495	7,029	23,287	19,814	9,182	10,538	14,060±5,178.2

*Source: Adapted from UCDA (2017)

Table 20. Coffee targets over 5 and 25 years

Subject	**Baseline (2014/15)**	**5 years (2019/20)**	**25 years (2039/40)**
Production (60 kg bags)			
Robusta	2,844,139	4,617,000	11,510,000
Arabica	801,919	1,252,000	3,499,000
Total	3,646,058	5,869,000	15,009,000
Export Volume (60 kg bags)	3,455,852	5,282,100	12,007,200
Export revenues (US $ Billions)	0.410	1,100	2,520
Market positioning (%)			
Commodity/volume	97%	57% (incl. soluble)	20% (incl. soluble)
Sustainable incl. speciality	3%	43%	80%
New coffee trees planted	17,020,000	225,000,000	
Density (trees/ha)			
Robusta	Less than 1,100 tress /ha	1,100 tress/ha	1,900 trees/ha
Arabica	Less than 1,600 trees/ha	1,600 trees/ha	1,760 trees/ha
Yield per tree (green coffee)			
Robusta	0.55 kg/tree	1.1 kg/tree	2.1 kg/tree
Arabica	0.31 kg/tree	1 kg/tree	1.7 kg/tree
Yield Yield per ha			
Robusta	600 kh/ha	1,200 kg/ha	4,000 kg/ha
Arabica	500 kg/ha	1,600 kg/ha	3,000 kg/ha
Certified (%)	2%	15%	50%
Value addition (% roasted and soluble)	1%	5%	20%
Coffee rejuvinated (% per year)	1%	10%	-
Domestic consumption (average per capita consumption per year)	0.36 kg	0.5 kg	1.5 kg
Coffed farmers belonging to an organization	15%	40%	90%

Source: (UCDA, 2015)

Market requirements

Uganda coffee is mainly exported as FAQ based on different grades and coffee types as specified by the coffee regulations of 1994. These grades are based on variety, bean size, quality or place of origin. Robusta variety is mostly exported as Screen 15. Other forms include; washed Robusta, Org. Robusta, Screen 18, Screen 17, Screen 15, Screen 14, BHP 1199 and other Robustas. On the other hand, Arabica is exported as drugar, Bugisu AA, Organic-Bugisu, Bugisu AB, Mt Elgon, Rwenzori, Okoro A, Organic Okoro, Bugisu Supremo, Organic Drugar and Wugar. Exporters and different value chain actors identified Organic, 4C (Common Code for Coffee Communities), Fair trade, UTZ certified and Rain Forest Alliance as some of the standards the coffee exports conform to (UNDP, 2012)

Price trends and behavior

The price of coffee and coffee products is set through competitive market forces while the buyer determines the price in other instances. Table 20 shows the trend of farm gate prices from 2006 to 2014.

Table 21 Coffee price trends (2006 – 2014)

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average	Std.dev.
Coffee	850	1,050	1,253	1,075	1,400	1,875	1,875	1,750	1,875	1,445	410

The Table 21 shows the price trend at the different stages of the coffee value chain.

Table 22 Coffee price along the value chain

Variety	**Product price**					
	Coffee Cherries	Kiboko	FAQ	Parchment	Graded coffee (Drugar coffee)	Roast bean
Robusta*	900	2,500	5,500		7,000	30,000
Arabica**	1,500			5000	6,500	
UCDA prices***		2,000 – 2,200	4,700 – 5,300	5,800 – 6,500	6,000 – 6,500	

Sources: *Mpigi Farmers, **Zombo farmers, ***(UCDA, 2017)

Cereals-Rice value chain

Marketing

The internal market for rice is segmented between imported and locally produced rice. Local traders (middlemen) purchase paddy from individual farmers and farmer groups. The primary stage of marketing in Uganda involves transactions and negotiations between the farmers with either rural traders or processor agents. Most often, farmers with small acreages (usually less than 0.5 hectares) sell paddy rice to either rural traders or processors' agents who collect it from their farm stead, while farmers with landholdings of more than 0.5 hectares transport the paddy to the mills and mill the paddy prior to actual sale.

At the secondary stage of marketing, processing takes place. Rice mills are most often located in trading centers of the main rice growing districts. The mills are also marketing centers where negotiations and deals are concluded between rural, traders' processors and urban traders. This stage involves mainly assembling of milled rice and storage as well as selling of processors to the urban traders. Large scale farmers often prefer to absorb transport costs to milling centers and pay for milling charges prior to selling their rice. Also, rural traders who collect threshed rice from farmers typically mill it prior to actual sale to urban traders. A decision by these farmers to incur transport and milling expenses is weighed against the additional benefits accruing from final sale of the milled rice.

The tertiary stage involves large-scale urban traders who are mainly wholesalers and importers who either purchase the milled rice from the processors and farmers on one hand, or import it. These traders are mainly based in Kampala while a few are from other urban centers. Apart from actual purchase of the milled rice these urban traders often engage in rice cleaning, consolidation and bulking. It is after this process that milled rice is passed to retailers for sale to consumers. Due to large capital requirement these are traders at this level.

Exports of Ugandan rice are quite negligible and where they exist in the national trade data, they are mainly re-exports. The main destinations of these exports are Rwanda, Kenya, DRC and Southern Sudan.

Supply

The bulk of rice grown in Uganda is typically produced by smallholder farmers. The average cropped area, production and between 2006 and 2014 was respectively 100,333.3±14590.7 ha, 201,525.9±28261.9 mt and 2.1±0.5t/ha (Table 22). Despite the increase in production, average annual net import is still at about 60,000-125,000 mt. The average yield is however far below the potential yield of 4 -7 mt/ha for the local rice varieties.

Table 23 Production statistics of rice (2006-2014)

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average
Cropped area (ha)	113,000	119,000	128,000	86,000	87,000	90,000	92,000	93,000	95,000	100,333.3±14590.7
Production (tonnes)	154,000	162,000	177,857	205,765	218,111	233,000	212,000	214,000	237,000	201,525.9±28261.9
Average yield (t/ha)	1.4	1.4	1.4	2.4	2.5	2.6	2.3	2.3	2.5	2.1±0.5

Source: FAOSTAT 2017 and UBOS 2009, 2012, 2015

Demand and current utilization

Consumption per capita is about 8 kg. This yields a demand for domestic consumption of 316,561 mt. With the current estimated annual production for 2015 was estimated at 238,193 mt of milled rice, the demand deficit which is left to be met by imports is calculated as 78,368 mt. Thus, over 30% of the rice consumed in Uganda is imported (Chemonics, 2010). Uganda's population growth rate is currently estimated at 3.2% thus the demand for rice is expected to rise.

Rice is consumed more in urban areas, where it is one of the major foodstuffs in homes, schools, hospitals and the army. For paddy rice, the major market is the milling industry. The demand for rice is derived from the demand for milled and polished rice, mostly in the urban areas. therefore, the contribution of rice production to small farmers' income and rural employment is linked to the availability of a thriving market in urban centers and in the regional markets.

Market requirements

The market for rice requires preferring the aromatic to non-aromatic rice, non-sticky to sticky, unbroken to broken and bulging after cooking to rice that does not bulge, white milled rice to brown

Most Ugandan millers do not have destoners, rice polisher and graders; as a result, locally processed rice is largely of poor quality and does not appeal to niche high value local markets. Post-harvest handling must address the quality aspect for Ugandan rice to compete favorably with the imported rice.

Price trends and behavior

Traders use different methods to determine rice prices in Uganda. Negotiating prices is the main approach with buyer determined prices being the least used approach by rice traders. The implication is that although there is some level of competitiveness in the rice market, more needs to be done to boost the bargaining power of producers. Over the years, rice prices have been fluctuating both across the years as shown in Table 15 and within each individual year. There is also variation within each individual year. Rice prices can increase by up to 50% during the off season and fall during the harvesting periods.

Different market outlets/actors charge a variety of prices, which differ a lot depending on processing, quantities offered, distances, and other factors. These factors tend to constrain efficient market exchanges among rice market participants. Farmers are compelled to pursue diversified production strategies to spread risks, thus resulting in small trading crop volumes. Currently the farmer is paid 2.000 UGX/kg of milled rice by the middle man, the middle man sells to a wholesaler at 2,300UGX/kg who sells it to a retailer at 3,200UGX/kg and finally the consumers buys it at 3,400-3,600 UGX/kg of rice.

Table 24 Average rice prices (2006-2014)

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average± STDEV
Farm gate price ($/kg)**	0.76	0.87	1.08	1.21	1.03	1.05	1.35	1.27	1.21	1.21±0.19
Farm gate price (UGX/kg)**	1,392	1,499	1,858	2,456	2,242	2,648	3,380	3,284	3,145	3,145±750
Exchange rate (UGX: US$)*	1831	1723	1720	2030	2177	2522	2504	2586	2599	2599±375.25

Source: * UBOS 2009, 2012, 2015

Oil seeds- groundnuts

Marketing

Owino market located in Kampala is the biggest market receiving over 20,000 tonnes/month. Still within Kampala, Kalerwe and Nakawa markets receive cumulatively an amount of 10,000 tonnes/month (USAID, 2008). Groundnut farmers sell their produce to the rural or urban markets (collection points) where groundnut may be bought directly by rural traders, town traders, or city traders. Rural traders shell the groundnuts before selling to the town traders usually based in main towns. Town traders are involved in both wholesale and retail business. City traders operate in Kampala, with their groundnut supplies coming from various parts of the country.

Supply

Table 24 shows the data on cropped area, production and yield for groundnuts for the period 2006-2014. The average groundnut production for the period 2006-2014 was 271,323 ± 31,239.5 mt from an average cropped area of 353,588.9± 73,238.9 ha while the average yield was 0.79 ± 0.11 mt/ha. The cropped area and the production of groundnuts generally increased for the period 2006-2014 while the yields showed a general decline. In addition, the yields obtained are well below the potential yields 2.7 – 3.5 mt/ha.

Table 25. Groundnut statistics (2006-2014) for Uganda

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average
Copped area (ha)	230,000	235,000	280,000	369,000	394,000	409,000	421,000	422,000	422,300	353,588.9± 73,238.9
Production (mt)	230,000	235,000	230,000	258,000	276,000	327,000	295,000	295,306	295,601	271,323 ± 31,239.5
Yield (mt/ha)	1	1	0.82	0.7	0.7	0.8	0.7	0.7	0.7	0.79 ± 0.11

Source: FAOSTAT, 2017

Demand and current utilization

Over 98.8% of the Groundnut production is consumed by the domestic market in Uganda. The period 2006 to 2011 experienced an increase in the domestic consumption while the export volume remained relatively constant and very low compared to the domestic consumption volume (Figure 1). After 2011, groundnut export volume sharply increased until 2013 by over 10 times. In this period, the domestic consumption volume declined marginally but to volumes way above the export volume.

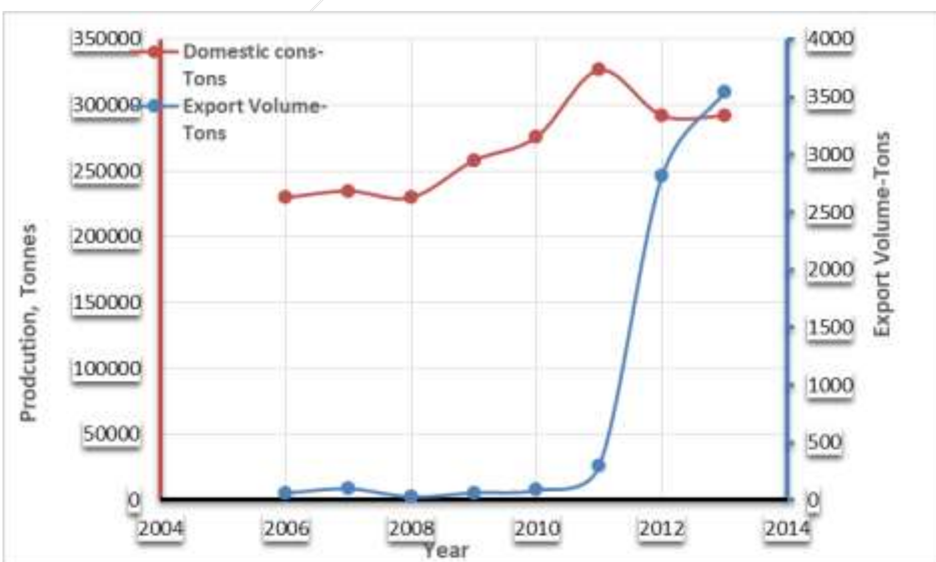

Figure 5 Uganda's groundnut Domestic consumption and Export volume (2006 – 2014).

Although processors exist, currently there is minimal processing of groundnuts because of the high market prices for groundnut grain. Never the less, in the markets visited (Nakasero and Owino markets), the prices of a kilogram of groundnut grain was the same as that of a kilogram of milled groundnut (both paste and powder). Most of the consumers preferred to buy groundnut grain and mill from a miller of their own choice mainly to guarantee quality. The paste or peanut is eaten as a vegetable. As a snack, it is roasted and packaged into varying packages and commonly sold to the consumers through supermarkets, shops, schools, restaurants along the streets etc.

Market requirements

Groundnut is susceptible to mycotoxins development produced by several species of fungi such as *Aspergillus, Fusarium, Penicillium, Alternaria, Cladosporium and Nigrospora species.* Mycotins are toxic substances and there over 200 reported mycotoxins including aflatoxin caused by *Aspergillus.* UNBS set standards for aflatoxin levels in groundnuts based on Kenya standards which apply to the East African Community. The maximum tolerable level of aflatoxin all type of groundnuts and products is 10 ppb. This is a stringent requirement that must be met to penetrate the export market.

Price trends and behavior

For groundnuts, the domestic prices are fairly competitive compared to the international market prices. The huge domestic consumption of groundnuts could be attributed to the flourishing local prices (Figure 2) of over the years.

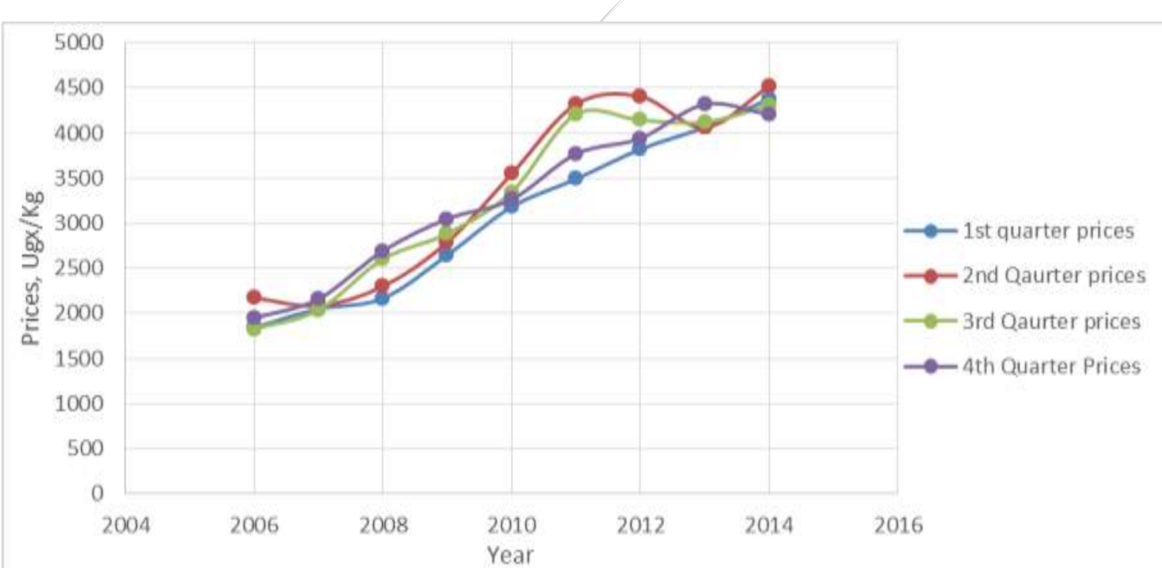

Figure 6 Uganda's Average price fluctuation for groundnuts (2006-2014) in Kampala.

Generally, the prices of groundnuts in Kampala markets over the period 2006 and 2014 have more than doubled. In 2006, the average cost of a Kilogram of groundnuts was Ugx 1946 and in 2014, it cost 4208. The quarterly prices (prices across any given year) show that the 1st quarter prices are lower than the 2nd, 3rd and 4th quarters. The 2nd and 3rd quarter prices declined in 2011 and 2013 while the 1st quarter and 4th quarter remained on an incline trend. A gross margin analysis done by Dalipagic and Elepu (2014) showed that gains were more variable at the producer or farmer level while the other actors (traders, wholesalers and retailers) enjoyed limited gains. A gain is simply the difference between the selling price and buying price except for the producer where a gain is the difference between the selling price and the unit cost of production. The prices and gains below were based on a kilogram of groundnuts. With the Unit cost production varying between Ugx 1203 and Ugx 2522 and at selling price to the local traders varying between Ugx 3000 and Ugx 3333, the margins were between Ugx 478 and Ugx 2130 at the producer level. The local traders link the producers to the market chain. These buy directly from the producers and therefore, the producer selling price is their buying price. The local traders supply the town traders. Their selling price varied anywhere between Ugx 3200 and Ugx 3500, implying that they enjoyed fairly variable gross margins ranging from Ugx 133 and Ugx 500.These are mainly based in the main district markets and are buy from the local traders. This means that the local trader selling price is the town traders buying price. The town traders supply or sell to the wholesalers. The town traders sold to the wholesalers at Ugx 3800 to 4000 bringing their gain to Ugx 500-600. These supply mainly the retailers. The wholesalers sold to the retailers at prices between Ugx 3300-3500 and their gain was Ugx 167-300. These are final links to the consumers and sold the groundnut at Ugx 3800-4000 enjoying a gain of Ugx 500

Dairy value chain

Marketing

In the urban areas of Uganda like Kampala, Entebbe, Mukono and Jinja, small-scale milk mobile traders buy milk directly from farmers and sale to consumers through bicycle or motorcycle delivery. The informal marketing chain dominates the dairy sector. The formal market channel involves large scale processors who are registered and regulated by UNBS and DDA.

Supply

The annual milk production grew from 1,063 Million Litres in 2006 to 1,550 million Litres in 2014. This represents an average growth rate of approximately 4.9%. The highest growth rate (13.1%) was registered between 2007 and 2008 while the least growth rate (2.8%) was in the period 2009/2008. The average quantity of whole fresh cow milk produced for the period 2006-2014 is 1,350± 152 million litres and the production shows a general increase of about 45.8%. Table 25 shows Uganda's fresh milk production from cows for the period 2006 and 2014.

Table 26. Fresh Milk production in Uganda (2006- 2014)

Cow milk (Whole, fresh)	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average
Quantity (Million Litres)	1,063	1,148	1,298	1,334	1,377	1,418	1,461	1,505	1,550	1350.4±152

Sources: UBOS, 20011; UBOS, 2015

Demand and current utilization

Taking a year to be 365 days, the average daily milk production in Uganda is approximately 3.8 Million Litres based on the production of 2006-2014. Factoring a 30% (1.1 Million L/day) for home consumption, it means that the amount available for the market is about 2.6 Million Litres/day.

The amount available for the market flows through two marketing channels (formal and informal market channels). From the formal market channel, the total installed capacity for the formal milk processors is approximately 1 Million Litres/day while the capacity utilization is approximately 0.5 Million Litres/day. The annual per capita consumption for Uganda is approximated to 58 litres/person/annum which is below the WHO recommendation of 200 litres/annum/person. The milk consumption varies across the country with the western milk shed region having the highest consumption of 86 litres/person/annum while the eastern region is at 43 litres/person/annum. Considering that Uganda's population was estimated at about 34.6 million people in 2014, and the per capita milk consumption of 58 litres, then the annual consumption or demand should be about 2.0 trillion litres or 5.5 million Litres/day. Only 33% of the marketed milk in Uganda is processed whereas 67% is marketed raw (MAAIF, 2016). The various processed dairy products available in the markets include; processed milk, yoghurt, cheese, ice cream, butter, flavored milk and milk powder. According to a report by Balikowa (2011), yogurt among the milk products is the most popularly consumed followed by ice cream, butter and ghee. Yoghurt demand and consumption has grown increasingly with consumers from all social classes. Therefore, the yoghurt market in Uganda has a promising potential for more expansion as evidenced by the springing up of various micro-processors some of whom operate in the backyard of residences before registration with relevant authorities or inspection by DDA.

Market requirements

The Dairy Development Authority (DDA) a statutory body borne in 1998 is tasked with a mandate to develop and regulate Uganda's dairy industry. Together with the Uganda National Bureau of Standards (UNBS), the DDA has developed standard specifications for milk products. The standards/the milk quality in the informal market chain are gauged/evaluated by the consumers mainly according to their familiar milk: Colour, Taste, Odour, Etc. These are established before and after consuming the milk. Any deviation (Colour, taste, odour etc) in these pre-established/known customer standards renders the milk to be considered adulterated, poor quality or spoilt. Therefore, the raw milk informal actors build their network of customers through a trust or loyalty to the quality of milk offered. If a consumer finds the milk satisfactory based on their own quality assessment, they will continue buying the milk from the same supplier/vendor/retailer.

Price trends and behavior

In a report by EADD (2008), the milk prices in the informal market from the producer level to the consumer level fluctuated from Ugx 600 to Ugx 1000/Litre depending on the season and the conditions at the individual farmer locations (EADD, 2008). In the formal market, irrespective of the season and the and the region, the milk was sold to the consumers at Ugx 1200/Litre meaning the formal market boasted of gains between Ugx 200 and 600 Ugx (a 20% - 50% gain) as compared to the informal market channel. However, the formal market incurs extra costs of packaging and necessary processing. A typical scenario (of the informal channel) of the milk price variation between seasons (dry and wet) in Kampala is where the milk sold at about Ugx 850/Litre in the wet season and about Ugx 1000/Litre in the dry season (EADD, 2008). A transition from the wet season to the dry season led to a price increase of about 17.6 %. There is therefore an opportunity in the dry period/season for producers who can ensure consistent supply of milk when the majority of the producers are under supplying. This can be done through storing enough feed and water for animals for the dry season

In a report by Balikowa (2011), average farm gate milk price trends (Figure 3) were analyzed for the period for the period 2008 to 2010. It pointed out that milk prices varied across regions and across seasons. In the southwestern region, the average farm gate price was Ugx 600-700/Litre and Ugx 800-1000/Liter in the central region in the months of August and September 2009. This is probably to do with demand driven by population and income statuses.

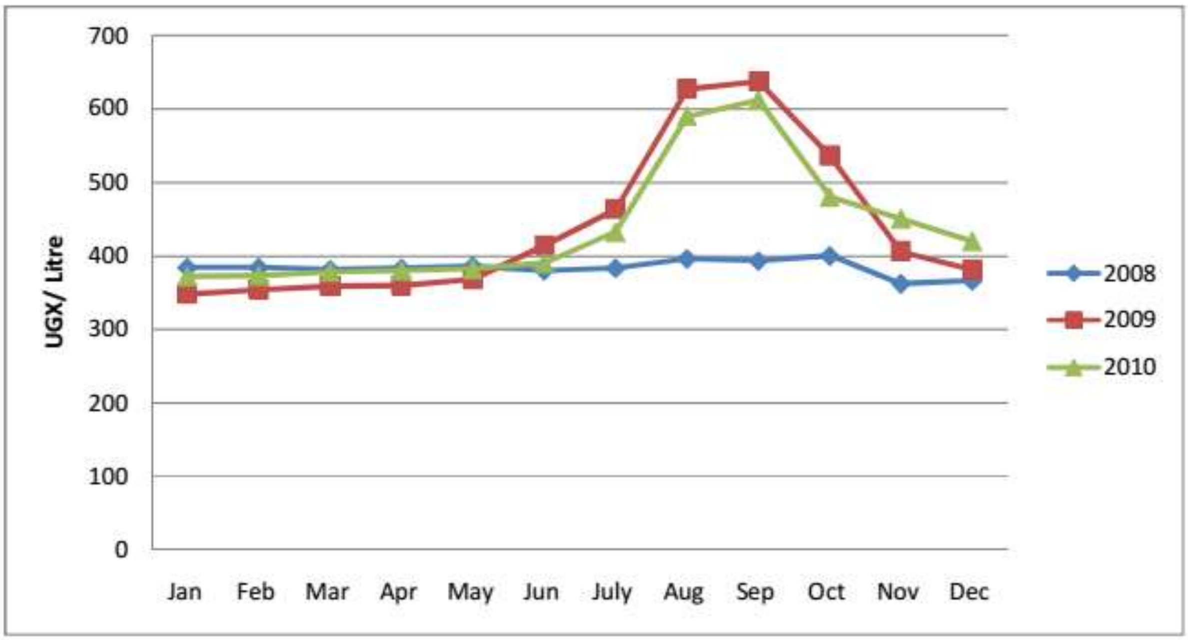

Figure 7 Average Milk farm gate prices from processing Milk companies across given years (2008-2010)

The following can be clearly pointed out from Figure 8:

- In 2009 and 2010, the milk prices were highest (an increase of about Ugx 200) between August and September (dry months) and this was attributed to a severe scarcity of milk according to the report.
- In 2008, milk prices were fairly stable (about Ugx 400/Litre) from January to December as compared to the prices in 2009 and 2010
- The first half (January –June) of the year 2010 had slightly higher prices than the first half of the year 2009. However the second halves saw a price over turn.
- Between 2008 and 2010, the prices were fairly the same at slightly less than Ugx 400/Litre for the first half periods (January-June) of these years.

Annex 6: Farm income analysis

Horticulture-Vegetables value chain

1. Tomatoes

Assumptions

i. Cropping intensity is 200%;
ii. Under rain fed conditions, the average yield of tomatoes is about 30 t/ha. Under irrigation the average yield is ~ 45 t/ha for high yielding variety like commado-F1;
iii. The farm gate price for tomatoes is Ugx 1,000 per kg.

Variable production costs

i. The average land preparation cost is Ugx 150,000 per ha;
ii. Nursery bed preparation and management costs Ugx.100, 000;
iii. Cost of seed is Ugx 900,000 per ha. Planting costs is Ugx. 200,000 per ha
iv. Fertilizer application is Ugx. 534,000 per ha. NPK (17:17:17) is applied during planting at 100kg per ha and top dressing with Urea at a rate of 100kg per ha. NPK costs Ugx 108,000 per 50kg bag while urea costs Ugx 84,000 per 50kg bag. Labour for fertilizer application is Ugx 60,000 per acre. In rainfed farming fertilizer is rarely applied;
v. Weeding Costs Ugx. 200,000 per ha;
vi. Crop protection costs Ugx. 270,000 per ha under rainfed conditions. For pesticide application, winner 72 WP fungicide at 2.5 – 3.5 kg per hectare by mixing 50gms per 20l of water. Each 250gms of the fungicide costs Ugx 10,000. Labour for pesticide application is Ugx 60,000 per acre. Under irrigation, this is likely to double;
vii. The annual irrigation costs are per ha are Ugx 11700000 for conventional drip irrigation system, 2,880,000 for solar Powered drip irrigation system, 12,240,000 for Conventional overhead sprinkler irrigation system and 11,520,000 for rain gun sprinkler irrigation system;
viii. In tomato production staking and pruning are done and this costs Ugx. 400,000 per ha.
ix. Harvesting costs Ugx. 200,000 per ha yield. Harvesting takes 20 man days per hectare. Each man day costs Ugx 10,000;
x. Postharvest activities for include purchasing the sacks (100kg) for unitizing and transporting to a home handling point. All these processes costs Ugx 1000 per unit. On the other hand postharvest activities for tomato involves loading on to crates which costs Ugx 150,000 per hectare;
xi. Transport to market costs 5,000 per 100 kgs.

Annual incremental net benefits

The net annual incremental benefit per ha is Ugx 15,192,000 for conventional drip irrigation, 24,012,000 for solar powered drip irrigation, 14,652,000 for conventional sprinkler irrigation and 15,372,000 for rain gun sprinkler.

2. Onions

Assumptions

i. Cropping intensity is 200%
ii. The average yield of onions is about 8 t/ha under rain fed conditions.
iii. Under irrigation the average yield of onions is about 22 t/ha
iv. The farm gate price for onions is Ugx 1000 per kg.
v. Irrigated production targets off-season or off-sets the normal rainfed production therefore farm gate prices are expected to be 50-60% higher than in rainfed.

Variable production costs

i. The average land preparation cost is Ugx 150,000 per ha;
ii. Nursery bed preparation and management costs Ugx.100, 000;
iii. Cost of seed is Ugx. 160,000 per ha. planting one acre of onion requires 1 kg of seed and the price of 250gm of onion seed is Ugx 40,000;
iv. Planting costs Ugx.200,000 per ha;
v. Fertilizer and its application costs Ugx.534,000 per ha. NPK (17:17:17) is applied during planting at 100kg per ha and top dressing with Urea at a rate of 100kg per ha. NPK costs Ugx 108,000 per 50kg bag while urea costs Ugx 84,000 per 50kg bag. Labour for fertilizer application is Ugx 60,000 per acre. In rainfed farming fertilizer is rarely applied;
vi. Weeding costs Ugx. 200,000 per ha;
vii. Crop protection costs ~ 200,000. For pesticide application, winner 72 WP fungicide at 2.5 – 3.5 kg per hectare by mixing 50gms per 20l of water. Each 250gms of the fungicide costs Ugx 10,000. Labour for pesticide application is Ugx 60,000 per acre. In rainfed farming pesticide application is assumed not to be done;
viii. The annual irrigation costs are per ha are Ugx 11700000 for conventional drip irrigation system, 2,880,000 for solar Powered drip irrigation system, 12,240,000 for Conventional overhead sprinkler irrigation system and 11,520,000 for rain gun sprinkler irrigation system
ix. Harvesting costs Ugx 200,000 per ha yield;
x. Postharvest activities for onions include purchasing the sacks (100kg) for unitizing and transporting to a home handling point. All these processes costs Ugx 1000 per unit.
xi. Transport to market costs 5,000 per 100 kgs.

Annual incremental net benefits

The net annual incremental benefit per ha is Ugx 13,178,000 for conventional drip irrigation, 21,998,000 for solar powered drip irrigation, 12,638,000 for conventional sprinkler irrigation and 13,358,000 for rain gun sprinkler.

3. Cabbage

Assumptions

i. Cropping intensity is 200%;
ii. The average yield of cabbages is about 0.5 kg per head under rain-fed and 1 kg per head if irrigated hence;
iii. the farm gate price for cabbage head is UgX 500, under rainfed conditions and 900 per head under irrigation;

Variable production costs

i. The average land preparation cost for the vegetables is Ugx 150,000 per ha.
ii. Nursery bed preparation and management costs Ugx.100, 000;
iii. Cost of seed is Ugx 450,000 per ha. The average cost of a tin of 10gm of cabbage seeds is Ugx. 18,000. For planting one acre 100gms of cabbage seed are required;
iv. Planting costs Ugx 200,000;
v. Fertilizer and its application is Ugx. 534,000 per ha. NPK (17:17:17) is applied during planting at 100kg per ha and top dressing with Urea at a rate of 100kg per ha. NPK costs Ugx 108,000 per 50kg bag while urea costs Ugx 84,000 per 50kg bag. Labour for fertilizer application is Ugx 60,000 per acre. In rainfed farming fertilizer is rarely applied;
vi. Weeding costs Ugx. 200,000;
vii. Crop protection costs Ugx 270,000 per ha. For pesticide application, winner 72 WP fungicide at 2.5 – 3.5 kg per hectare by mixing 50gms per 20l of water. Each 250gms of the fungicide costs UgX 10,000. Labour for pesticide application is Ugx 60,000 per acre. In rainfed farming pesticide application is assumed not to be done;
viii. The annual irrigation costs are per ha are Ugx 11700000 for conventional drip irrigation system, 2,880,000 for solar Powered drip irrigation system, 12,240,000 for Conventional overhead sprinkler irrigation system and 11,520,000 for rain gun sprinkler irrigation system;
ix. Harvesting takes 20 man days per hectare. Each man day costs Ugx 10,000;
x. Postharvest activities for cabbages include purchasing the sacks (100kg) for unitizing and transporting to a home handling point. All these processes costs UgX 1000 per unit;
xi. Transport to market costs 5,000 per 100 kgs.

Annual incremental net benefits

The net annual incremental benefit per ha is Ugx 13,792,000 for conventional drip irrigation, 22,612,000 for solar powered drip irrigation, 13,252,000 for conventional sprinkler irrigation and 13,972,000 for rain gun sprinkler.

4. Hot pepper

Assumptions

i. Cropping intensity is 200%;
ii. The average yield of cabbages is about 8500 kg per ha under rain-fed and 13,000 kg per ha if irrigated;
iii. the farm gate price for hot pepper is UgX 3500;

Variable production costs

i. The average land preparation cost for the vegetables is Ugx 150,000 per ha.
ii. Nursery bed preparation and management costs Ugx.100, 000;
iii. Cost of seed is Ugx 160,000 per ha.;
iv. Planting costs Ugx 200,000;
v. Fertilizer and its application is Ugx. 500,000 per ha.;
vi. Weeding costs Ugx. 200,000;
vii. Crop protection costs Ugx 270,000 per ha.;

viii. The annual irrigation costs are per ha are Ugx 11700000 for conventional drip irrigation system, 2,880,000 for solar Powered drip irrigation system, 12,240,000 for Conventional overhead sprinkler irrigation system and 11,520,000 for rain gun sprinkler irrigation system;
ix. Harvesting takes 200,000 per ha;
x. Postharvest activities for cabbages include purchasing the sacks (100kg) for unitizing and transporting to a home handling point. All these processes costs UgX 1000 per unit;
xi. Transport to market costs 5,000 per 100 kgs.

Annual incremental net benefits

The net annual incremental benefit per ha is Ugx 17,710,000 for conventional drip irrigation, 26,530,000 for solar powered drip irrigation, 17,170,000 for conventional sprinkler irrigation and 17,890,000 for rain gun sprinkler.

Horticulture-fruits value chain

The gross margin analysis for fruits value chain considered irrigation for production of apples, passion fruits, mangoes and citrus .

1. Passion fruits

Assumptions

i. It is assumed that passion fruit production is 100 % in year one
ii. Vines commence cropping at 6 months of age and reach full bearing in 18 months. Vines have a productive life of 3 to 4 years. New plantings should be made on a continuous 3 year rotation to maintain production. The fruit matures 60–90 days from fruit set. Harvesting occurs throughout the year, but yields vary month by month.
iii. Planting density for 1,100 per ha (spacing of 3 ×3m) or 1660 plants/ha (spacing of 2×3m);
iv. Under rain fed conditions the average yield of passion fruit is 13.4 t/ha;
v. Under irrigation the average yield of passion fruit is 25 t/ha;
vi. The average farm gate prices for passion fruit 3,000 per kg.

Variable production costs

- Cost of seedlings is Ugx 2,750,000 per ha at a cost of 2500 per seedling;
- The average land preparation cost is Ugx. 150,000 per hectare;
- Planting costs are Ugx. 300,000 per ha;
- Fertilizer and its application is UgX 278,000;
- Weeding costs Ugx. 150,000 per ha;
- Crop protection-Pesticide application cost per hectare under irrigation is on average Ugx 1,500,000 The assumption is that pesticide application under rain fed is done in response to an insect attack and is estimated to be half the quantity applied under irrigation (preventive application);
- In passion fruit production trellising has to be done and this costs Ugx. 1,000,000 per ha;

- The annual irrigation costs are per ha are Ugx 11700000 for conventional drip irrigation system, 2,880,000 for solar Powered drip irrigation system, 12,240,000 for Conventional overhead sprinkler irrigation system and 11,520,000 for rain gun sprinkler irrigation system;
- Harvesting of the different fruits costs Ugx. 1,500 per unit (Each unit is a basin of about 20kg);
- Postharvest handling costs includes packaging and packaging material (1000 per bag for 100kg);
- Transport to the market is Ugx 5000 per 100kg bag.

Annual incremental net benefits

The net annual incremental benefit per ha in the second year onwards is Ugx 19,042,500 for conventional drip irrigation, 27,862,500 for solar powered drip irrigation, 18,502,500 for conventional sprinkler irrigation and 19,222,500 for rain gun sprinkler.

2. Apples

Assumptions

i. Depending on the variety, apples start bearing fruits at 1-3 years;
ii. They have an economic life of about 35 years;
iii. It is assumed that apple production is 5% of the potential in the second year, 20% in third year and increases by 10% from fourth year to 7th year and thereafter by 5% till the 18th year;
iv. Apples have two seasons per year;
v. Planting density for apples is 300 plants per hectare;
vi. Apples are grafted and production is in 1-3 years after grafting. Apple trees can have production life of up to 30 years. They are harvested 2 times per year;
vii. Apple varieties grown are: Golden dozzet, Hana, and Winter banana's;
viii. Under rain fed conditions the average yield of apples is about 15 t/ha.;
ix. Under irrigation the average yield of apples is about 30 to 48 t/ha;
    a. at low production stage: 3-5 yrs - 300 fruits per year
    b. at medium production stage (5 to 15 years) -~ 500 fruits per tree.
    c. at full production stage: 800 fruits per tree;
x. The average farm gate prices for apples Ugx 3,000 per kg.

Variable production costs

i. Cost of apple seedlings is 8,500,000 per ha (850 seedlings per ha) at a unit cost of Ugx 10,000;
ii. The average land preparation cost is Ugx. 150,000 per hectare;
iii. Planting costs is Ugx 850,000 per ha at a unit cost of Ugx. 1,000 per seedling;
iv. Total cost of fertilizer is UgX 278,000 per ha. NPK is applied during planting and Urea is applied twice after that, all at a rate of 50kg/ hectare;

v. Fertilizers: 2 types of fertilizers are applied. NPK: 1 kg per tree. 2 times in a year at flowering. Potassium Nitrate. Applied to boost fruits, increase fruit size and avoid abortion;
vi. Weeding costs Ugx. 150,000 per ha;
vii. Crop protection cost per hectare per year under irrigation is on average Ugx 400,000. The assumption is that pesticide application under rain fed is done in response to an insect attack and is estimated to be half the quantity applied under irrigation (preventive application);
viii. The annual irrigation costs are per ha are Ugx 11700000 for conventional drip irrigation system, 2,880,000 for solar Powered drip irrigation system, 12,240,000 for Conventional overhead sprinkler irrigation system and 11,520,000 for rain gun sprinkler irrigation system;
ix. In apple production, bees are required for pollination. Therefore a cost is incurred in installing beehives. The estimated number of bee hives to be installed in a hectare is 20 each costing Ugx. 25,000;
x. Harvesting cost is Ugx. 1,500 per unit (Each unit is a basin of about 20kg).
xi. Postharvest handling cost if Ugx 770,000 per ha yield (activities includes sorting and packaging;
xii. Transport costs to the market are 5,000 per 100kg.

The net annual incremental benefit per ha at full production is Ugx 45,632,500 for conventional drip irrigation, 54,452,500 for solar powered drip irrigation, 45,092,500 for conventional sprinkler irrigation and 45,812,500 for rain gun sprinkler.

3. Mangoes

Assumptions

i. Grafted mangoes are planted and they begin in the 2nd year;
ii. It is assumed that mango production is 6% in the second year, 10% in 3rd year, 25% in 4th year, 55% in 5th year and increases thereafter by 5% till full potential;
iii. Planting density for a mango is 144 plants per ha;
iv. The economic life of mangoes is ~40 years and above;
v. Under rain fed conditions the average annual yield of mangoes 25t/ha;
vi. Under irrigation the average annual yield of mangoes is about 86 t/ha;
vii. The average farm gate prices for mangoes Ugx 700 per kg.

Variable production costs

i. Cost of seedlings Ugx 720,000 per ha at a cost of Ugx 5,000 per seedling;
ii. The average land preparation cost is Ugx. 150,000 per hectare;
iii. Planting costs are Ugx. 1,000 per seedling totaling to 144,000 per ha;
iv. Fertilizer and its application is UgX 278,000 per ha;
v. Weeding costs Ugx. 150,000 per ha;

vi. Crop protection is Ugx 60,000 per ha. The assumption is that pesticide application under rain fed is done in response to an insect attack and is estimated to be half the quantity applied under irrigation (preventive application);
vii. The annual irrigation costs are per ha are Ugx 11700000 for conventional drip irrigation system, 2,880,000 for solar Powered drip irrigation system, 12,240,000 for Conventional overhead sprinkler irrigation system and 11,520,000 for rain gun sprinkler irrigation system;
viii. Harvesting of the different fruits costs Ugx. 1,500 per unit (Each unit is a basin of about 20kg);
ix. Postharvest handling costs includes packaging and packaging material (1,000 per bag for 100kg);
x. Transport to the market is Ugx 5,000 per 100kg bag.

The net annual incremental benefit per ha at full production is Ugx 32,799,600 for conventional drip irrigation, 41,619,600 for solar powered drip irrigation, 32,259,600 for conventional sprinkler irrigation and 32,979,600 for rain gun sprinkler.

Note:

Irregular bearing occurs often with the mango and it is common for some cultivars to bear heavily in one year and sparsely the next. One of the reasons for this phenomenon is that trees over-bear in one year, thus inhibiting adequate flower bud formation the following year.

4. Citrus

Assumptions

i. Grafted citrus are planted and begin yielding in the 3rd year. It is assumed that citrus production yield increases as a percentage of the potential yield in the order of 7.5%, 20%, 60%, 75%, 85%, 90% , 95%, 100%;.
ii. Planting density is 300 plants per hectare;
iii. Under rain fed conditions the average yield of citrus is about 20 t/ha;
iv. Under irrigation the average yield of citrus is about 65 t/ha;
v. The average farm gate prices for citrus are UgX 100 per kg.

Variable production costs

i. Cost of seedling is Ugx 900,000 per ha at a cost of Ugx 3000 per seedling;
ii. The average land preparation cost is Ugx. 150,000 per hectare;
iii. Planting costs are Ugx. 300,000 per ha;
iv. Fertilizer and fertilizer application is UgX 278,000 per ha.
v. Weeding costs Ugx. 150,000 per ha;
vi. Crop protection is Ugx 150,000 per ha. The assumption is that pesticide application under rain fed is done in response to an insect attack and is estimated to be half the quantity applied under irrigation (preventive application);

vii. The annual irrigation costs are per ha are Ugx 11700000 for conventional drip irrigation system, 2,880,000 for solar Powered drip irrigation system, 12,240,000 for Conventional overhead sprinkler irrigation system and 11,520,000 for rain gun sprinkler irrigation system;
viii. Harvesting of the different fruits costs Ugx. 1,500 per unit (Each unit is a basin of about 20kg);
ix. Postharvest handling costs includes packaging and packaging material (1,000 per bag for 100kg);
x. Transport to the market is Ugx 5,000 per 100kg bag.

Note: Citrus farming is largely seasonal with significantly higher variable costs, almost 5 times, incurred in the first season. Material inputs account for roughly half of variable costs, with animal manure and seedlings totaling almost two-thirds of material input costs each season. Labour costs are also significantly higher the first season, with roughly a fifth of family labour resources for harvesting activities.

Net annual incremental benefit

The net annual incremental benefit per ha at full production is Ugx 29,246,750 for conventional drip irrigation, 38,066,750 for solar powered drip irrigation, 28,706,750 for conventional sprinkler irrigation and 29,426,750 for rain gun sprinkler.

Coffee value chain

The gross margin analysis considered irrigation for robusta (clonal) coffee and irrigation for arabica coffee.

Assumptions

i. Arabica coffee: It takes a coffee tree three years to begin producing fruit for harvest. The first harvest after three years is about 50% of the full harvest. This value increases to about 75% of full harvest after four years. Full harvest is realized from the fifth year onwards;
ii. Robusta (clonal) coffee: It takes a coffee tree two years to begin producing fruit for harvest. The first harvest after two years is about 30% of the full harvest potential. This value increases to 50%, 75% and 100% in the 3rd, 4th, and 5th year onwards respectively;
iii. The cropping intensity of coffee is 200% (main crop and fly crop). However, under rainfed conditions, the fly crop yield is usually 20% of the main crop yield. The first harvest is done once at the end of the year;
iv. The economic life of coffee is 40 to 50 years;
v. Under rainfed conditions, the average yield for coffee is 2,500 and 600 kg per ha for robusta (clonal) and arabica coffee respectively;
vi. Under irrigation, the average yield for coffee is 5,500 and 2000 kg per ha for robusta (clonal) and arabica coffee respectively;
vii. The average farm gate price is Ugx. 4,000 and 4,500 per kg of green robusta coffee is and arabica respectively

Variable production costs

i. Land clearing and preparation costs Ugx.410,000 (Ugx 240,000 and 170,000 UgX to plough and harrow one hectare of land respectively). This cost is incurred once in the coffee economic life;
ii. Seedlings cost for robusta is Ugx 1,110,000 per ha at a cost of ~Ugx. 1000 per seedling and planting density 1110 plants per ha. This cost is incurred once in the coffee economic life;
iii. Seedlings cost for arabica is Ugx 1,680,000 per ha at a cost of ~Ugx. 1000 per seedling and planting density 1680 plants per ha. This cost is incurred once in the coffee economic life;
iv. Planting hole preparation costs Ugx 610,500 and 924,000 per ha for robusta and arabica coffee respectively: It costs between Ugx. 300 – 800 to dig each hole. An average value of Ugx. 550 is used in the analysis. This cost is incurred once in the coffee economic life;
v. Manure and its application costs Ugx 1920,000 per ha. 30 tonnes of manure are applied per hectare at a total cost of 1,800,000 UgX including hiring of the track. Application of the manure costs 120,000 UgX per hectare with a basin of manure being applied per hole. This cost is incurred once in the coffee economic life;
vi. Planting costs Ugx.222,000 and 336,000 per ha for robusta and arabica coffee respectively. Planting costs vary between 100 - 300 UgX per plant. For this analysis, a value of 200 UgX will be taken. This cost is incurred once in the coffee economic life;
vii. Fertilizer and its application costs Ugx. 336,000 per ha. Fertilizer is rarely used under rainfed coffee production. Under irrigation, fertilizer is assumed to be applied. Fertilizer is applied at an application rate of 120kg/ha (50kg/acre). The fertilizer normally used is CAN or UREA which costs on average 90,000 UgX per 50kg bag. Application costs 120,000 UgX per hectare giving a total cost of 336000 UgX;
viii. Bending coffee costs 70,000 - 120,000 UgX per hectare. In this analysis, an average value of 100,000 UgX will be used;
ix. Weeding costs Ugx 96,000 per hectare;
x. Crop protection costs Ugx.235,000 per ha. Popular herbicide used is didomin which is applied at an application rate of 1 kg (costs 45,000 UgX) per acre or approximately 2.5 kg per hectare. The cost of application is 50,000 UgX per acre or 120,000 UgX per hectare, giving a total cost of 235,000UgX;
xi. The annual irrigation costs are per ha are Ugx 11700000 for conventional drip irrigation system, 2,880,000 for solar Powered drip irrigation system, 12,240,000 for Conventional overhead sprinkler irrigation system and 11,520,000 for rain gun sprinkler irrigation system;
xii. Prunning coffee costs 120,000 UgX per hectare. Prunning is done from 2nd year onwards;
xiii. Harvesting costs 185,000 per ha. For a seasonal harvest, about five people are employed (per acre) who harvest thrice and are paid UgX 5,000 per person per harvest;
xiv. Post-harvest handling costs vary but for this analysis, an average value of Ugx 720,000 per hectare will be used;
xv. Transport to the market is assumed as 5000 per 100 kg bag.

Net annual incremental benefits for Coffee (Robusta - clonal)

The net annual incremental benefit per ha at full production is Ugx 18,504,000 for conventional drip irrigation, 33,292,000 for solar powered drip irrigation, 17,964,000 for conventional sprinkler irrigation and 18,684,000 for rain gun sprinkler.

Cereals- upland rice

The gross margin analysis considered irrigation for upland rice.

Assumptions

i. NERICA 10 for upland rice. Planting rate is 89kg/ha and maturity 90 (days) and Potential yield (3.5-4.5t/ha);
ii. Cropping intensity for rice is 200%;
iii. The average yield of lowland rice under rainfed conditions and under irrigation is 2,100 and 4,500 kg of milled rice per ha respectively;
iv. The average yield for upland rice under rainfed conditions and under irrigation is 2,200 and 4,500 kg of milled rice per ha respectively;
v. The theoretical milling yield for polished grain is 70%;
vi. The price for upland rice is 3,500 per kg of milled rice.

Variable production costs

i. The average land preparation cost is Ugx. 300,000 per ha;
ii. Under rainfed conditions, cost of seed per ha is Ugx is 89,000. Seed is purchased by farmers at a cost Ugx 1000 per kg;
iii. Under irrigation, cost of seed is Ugx 445,000. Seed is purchased from certified seed companies. e.g. EASEED at Ugx 5,000 per kg;
iv. Transplanting costs for upland rice costs Ugx 200,000 per ha;
v. Fertilizer and its application costs Ugx 460,000 per ha;
vi. Generally it is recommended to apply 100 kg per ha of DAP top dress at planting. When the crop has attained 6 leaves after germination, 100 kg per ha of 46% urea should then be applied. Urea costs 90,000 per 50 kg bag and DAP cost 110,000 per 50 kg bag. The cost of each fertilizer application is Ugx. 30,000 per ha. Under rainfed conditions, fertilizer application is rare;
vii. Weeding rice costs Ugx. 150,000 per ha;
viii. Crop protection costs 75,000 per ha;
ix. The annual irrigation costs are per ha are Ugx 11700000 for conventional drip irrigation system, 2,880,000 for solar Powered drip irrigation system, 12,240,000 for Conventional overhead sprinkler irrigation system and 11,520,000 for rain gun sprinkler irrigation system;
x. Bird control costs 150,000 per ha;

xi. Harvesting rice costs UgX 120,000 per ha;
xii. Postharvest handling costs Ugx.720,000 per ha yield (activities includes threshing, transportation, drying and milling costs. These costs per hectare are Ugx 150,000, 150,000 and 420,000 for threshing, transportation, drying and milling respectively;
xiii. Transport to the market costs Ugx. 5,000 per 100kg bag.

Annual incremental net benefits

The net annual incremental benefit per ha is Ugx 5,068,000 for conventional sprinkler irrigation and 5,788,000 for rain gun sprinkler.

Pulses value chain- beans

Assumptions

i. On average, the common Beans (Phaseolus vulgaris) takes between 80 – 110 days to mature;
ii. The cropping intensity is 200%;
iii. The average yield of bush beans variety under rainfed conditions is 769 kg/ha while for climbing beans varieties, the yield used in the analysis is 1,500kg/ha ;
iv. For irrigated beans (bush varieties), the yield used in the analysis was 2.5 t/ha while for climbing beans varieties, the yield used in the analysis was 6.5 t/ha.
v. Average farm gate price for beans grown under rainfed conditions is Ugx. 1,800/kg and that under irrigation (assumed to be of better quality) is Ugx. 2,000/kg.

Variable production costs

i. Land clearing and preparation costs Ugx 410,000 per ha. It costs on average Ugx. 240,000 and Ugx. 170,000 /ha to plough and harrow respectively;
ii. Seed costs 225,000 per ha at a seed planting rate for both bush and climbing varieties is 45 kg/ha and the cost of seed is Ugx 5000/kg;
iii. Planting costs 120,000 UgX per ha. For climbing beans, wooden stakes are laid down during planting and the cost of stakes that cover 1 ha is about UgX 1,200,000 but stakes are used three times. The labour for staking is Ugx 100,000 per ha. Planting is at a spacing of 60cm by 60cm (2ft by 2ft);
iv. Fertilizer application is Ugx. 600,000 per ha. In rainfed farming it is assumed that farmers do not apply fertilizers. In irrigated beans production, fertilizer application is 200kg/ha of DAP. DAP costs 120,000 UgX per 50kg bag while fertilizer application costs 120,000 UgX per hectare (50,000 UgX per acre)
v. In rainfed beans production, manual weeding is done twice each costing UgX 50,000 per acre (UgX 120,000 per hectare).

vi. In irrigated beans production, the assumption is that chemical weeding is done once followed by manual weeding. Chemical weeding is normally done using glypocel at an application rate of 2.5l per hectare. Each litre costs UgX 20,000 and application costs UgX 120,000.

vii. The most common pest in beans production are the aphids. For their control, cytermethrin is normally applied. About half a litre of the chemical, which costs UgX 15000, is required to spray 1 ha. Chemical applications costs Ugx 120,000 per hectare

viii. The annual irrigation costs are per ha are Ugx 11700000 for conventional drip irrigation system, 2,880,000 for solar Powered drip irrigation system, 12,240,000 for Conventional overhead sprinkler irrigation system and 11,520,000 for rain gun sprinkler irrigation system;

1. Harvesting climbing beans costs UgX 100,000 per acre (UgX 240,000) unlike that of non-climbing beans which costs UgX 72,000 per acre.
2. Post harvest handling includes drying, threshing, winnowing, final drying and storage. The total cost sum of these activities is about UgX 300,000 per hectare.
3. Farmers transport their produce to the market using motorcycles and bicycles. On average farmers spend 5000 UgX per 100kg bag.

Annual incremental net benefits

Beans (Bush varieties)

Irrigation of bush beans is not feasible.

Beans (Climbing varieties)

The net annual incremental benefit per ha is Ugx 7,200,000 for conventional drip irrigation, 16,020,000 for solar powered drip irrigation, 6,660,000 for conventional sprinkler irrigation and 7,380,000 for rain gun sprinkler.

Oil seeds value chain-groundnut

The gross margin analysis considered irrigation for Groundnuts are as follows.

Assumptions

The following information was obtained from an oral interview with NARO Officers Okwand Dodaa and Ereu Samuel based in NASSARI/ Serere during the 2017 Jinja Agricultural show on 19/07/2017. Tel: 0772 369 125 / 0750 697 985 or 0784 963 092 / 0706 063 092

i. Cropping intensity for groundnuts is 200%

ii. A farmer who depends on rain fed system (without irrigation) is characterised with poor agronomic practices (no fertilizer application, no pest and disease control, uses uncertified seed/local seed or seed from previous season)

iii. Optimal yield of Serenut 14 R is: 2700-4,000 kg per ha.

iv. Yield obtained without irrigation was taken as the national average of yield of Groundnut Production (2006-2014) which is 791 kg per ha

v. Farm gate price of groundnuts after harvest range from 150,000-200,000 Ugx per bag where a bag is 40-50 kgs of shelled groundnuts. Therefore cost of 1 kg of shelled groundnuts from at a harvest Ugx. 3,000-4,000

Variable production costs

i. There are two land preparations. 1st and 2nd. They each cost Ugx. 100,000 per acre
ii. Certified seed costs Ugx.200,000 per bag (unshelled groundnuts) and an acre needs 1.5 bags
iii. Planting cost for groundnuts is Ugx.120,000
iv. Application of fertilizer once during planting: TSP or SSP 1 bag per acre at Ugx. 80,000-120,000
v. 1st and 2nd weeding done at each at a cost of Ugx. 120,000 per acre. Application cost is Ugx. 30000 per acre
vi. Crop protection costs Ugx 77,500. Pesticide application. To control thrips and leaf miner, apply Dimethoate 0.5 L/acre. This Applied in 2-3 sprays of 15-20 L knapsacks. Dimethoate costs Ugx. 30,000/L. Labour cost: Requires 5-10 men/ha at Ugx. 4,000 per man
vii. The annual irrigation costs are per ha are Ugx 11700000 for conventional drip irrigation system, 2,880,000 for solar Powered drip irrigation system, 12,240,000 for Conventional overhead sprinkler irrigation system and 11,520,000 for rain gun sprinkler irrigation system;
viii. Harvesting i.e. dig out using a hoe or uproot. Costs Ugx.80,000-100,000/acre
ix. Post-harvest handling:
(a) Plucking and striping: Ugx.700/basin and acre yields 80-100 basins
(b) Drying: Ugx.30,000/yield of an acre
x. Transport to the market costs Ugx 5,000 per 100 kg bag

Annual incremental net benefits

The net annual incremental benefit per ha is Ugx 11,418,180 for conventional drip irrigation, 20,238,180 for solar powered drip irrigation, 10,878,180 for conventional sprinkler irrigation and 11,598,180 for rain gun sprinkler.

Diary value chain

Assumptions

i. Semi-intensive dairy farming (20 to 25 animals).
ii. Exotic breed (70%)
iii. Number of days in lactation is 300 days
iv. Lactation yield of 15L and 30 L of milk per day for non-well watered and well watered animal respectively . A dairy cow requires 5L of water per Litre of milk secreted
v. Current price of a liter of milk at the farm gate is Ugx. 1000 per Litre
vi. The investment cost for each dairy animal is Ugx. 6,000,000.

Variable production costs

i. Veterinary services(vaccination and deworming) = Ugx.200,000/animal/year
ii. spraying =120,000/animal/year
iii. Breeding services (Artificial insemination) = Ugx. 80,000/animal/year
iv. Current price of a litre of milk at the farm gat =Ugx. 1000/L
v. Feeding =150,000/ month under high input use
vi. Average wage of farm labour per hour = Ugx. 150,000 /month

Annual incremental net benefits

For semi-intensive dairy, (20 animals) the net annual incremental benefit is Ugx. 58,950,000 per year using HDPE lined underground tank with motorized abstraction and Ugx. 61,290,000 per year using Borehole with solar powered abstraction system