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Food loss analysis: causes and solutions

The Republic of Uganda

Beans, maize, and sunflower studies



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Abbreviations and acronyms

A4NH	Agriculture for Nutrition and Health
AATF	African Agricultural Technology Foundation
ABi TRUST	Agricultural Business Initiative Trust
ACE	Audit Control Expertise
ACIAR	Australian Centre for International Agricultural Research
AEATRI	Agricultural Engineering and Appropriate Technology Research Institute
AFSRT	Agency for Sustainable Rural Transformation
AIPs	Agricultural Innovation Platforms
ASSP	Agricultural Sector Strategic Plan
BOU	Bank of Uganda
CAADP	Comprehensive Africa Agriculture Development Programme
CAIIP	Community Agricultural Infrastructure Improvement Programme
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Center for Tropical Agriculture
CLP	Critical Loss Point
CODEX	Codex Alimentarius – International Food Standards
COMESA	Common Market in Eastern and Southern Africa
CIMMYT	International Maize and Wheat Improvement Centre
CRS	Catholic Relief Services
DSIP	Agricultural Sector Development Strategy and investment Plan
DRC	Democratic Republic of Congo
DSIP	Agricultural Sector Development Strategy and investment Plan
EAC	East African Community
EACBTB	East Africa Cross Border Trade Bulletin
EAGC	East Africa Grain Council
Engr	Engineer
EPRC	Economic Policy Research Centre
ESAP	Economic Structural Adjustment Programme
FAO	Food and Agricultural Organization of the United Nations
FEWSNET	Famine Early Warning Systems Network
FGD	Focus Group Discussions
FICA	Farm Input Care
FSC	Food Supply Chain
GAP	Good agricultural practices
GDP	Gross Domestic Product

GHP	Good handling practices
HACCP	Hazard analysis and critical control points
IDEA	Investment for Developing Export Agriculture
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IGAD	Inter-Governmental Authority on Development
ITC	International Trade Centre
IFDC	International Fertilizer Development Centre
ISO	International Organization for Standardization
LLP	Low Loss Point
MAAIF	Ministry of Agriculture Animal Industry and Fisheries
MAFAP	Monitoring African Food and Agricultural Policies
MC	Moisture content
MFPED	Ministry of Finance, Planning and Economic Development
MTCS	Medium-Term Competitive Strategy
NAADS	National Agricultural Advisory Services
NaSARRI	National Semi Arid Resources Research Institute
NaCRRI	National Crops Resources Research Institute
NARL	National Agriculture Research Laboratories
NARM	National Resistance Movement
NARO	National Agricultural Research Organization
NDP	National Development Plan
NEPAD	New Partnership for Africa's Development
NRM	National Resistance Movement
NSS	National Statistical System
OPV	Open Pollinated Variety
OSCA	One Stop Centre Association
OSSUP	Oil Subsector Support Platforms
OWC	Operation Wealth Creation
PFA	Prosperity for All
PHH-AP	Post-Harvest Handling and Agro-Processing
PICS	Purdue Improved Crop Storage
PO	Producer Organization
PRDP	Peace, Recovery, and Development Plan
QMS	Quality Management System
R&D	Research and Development
SAARI	Serere Agricultural and Animal Production Research Institute
SACCO	Savings and Credit Cooperative Organizations
SADC	Southern Africa Development Cooperation
SIMLESA	Sustainable Intensification of Maize-Legume cropping systems for food Security in

Eastern and Southern Africa	
SPIA	Standing Panel on Impact Assessment
SPS	Sanitary and phytosanitary
SSHI	Semi-structured household interviews
TW	Threshing and Winnowing
UBOS	Uganda Bureau of Statistics
UCA	Uganda Census of Agriculture
UGX	Uganda Shillings
UNBS	Uganda National Bureau of Standards
UNECE	United Nations Economic Commission for Europe
UOM	Unit of measure
UOSPA	Oilseeds Producers and Processors Association
USA	United States of America
VAT	Value-Added Tax
VEDCO	Volunteer Efforts for Development Concerns
VSLA	Village Savings and Loan Association
VODP	Vegetable Oil Development Project
WEMA	Water Efficient Maize for Africa
WFP	World Food Programme

Executive summary

IMPORTANCE OF MAIZE, SUNFLOWER AND BEANS FOR FOOD SECURITY AND LIVELIHOODS

Maize is a major food crop both from the viewpoint of food security and income-generation. It forms a major part of the diet for both rural and urban communities. Maize is also used as a key input in the animal feed industries and for local brewing. The maize subsector contributes to the livelihoods of over 3.6 million farm households, 1 000 traders/agents and 600 millers nationwide by providing them with employment and income. Maize is cultivated in at least 50 districts on about 1 million hectares of land across all agro-ecological zones, representing about 46 percent of the area under cereal crops in the country. Production dramatically increased from 1.1 million tonnes in 2000 to 2.7 million tonnes in 2013, when maize ranked third in production after banana and cassava. This rapid growth was mainly attributed to both yield increases and expansion of the area under maize. In 2006, maize topped the list of food exports. In 2013, Uganda's formal maize export was valued at over USD 42.3 million. In addition, Uganda supplied about 90 percent (over 654 000 tonnes) of the informally traded maize in the region. As a result of its importance, the Government of Uganda selected maize as a strategic commodity for priority public investment.

Sunflower was introduced to Uganda in the 1920s and by the 1960s it was widely grown throughout the country. It is one of the oilseed crops identified by the Government of Uganda and several donors as a prospective poverty-reduction crop. Furthermore, the increasing domestic demand for vegetable oils makes sunflower essential oil crop for substituting the importation of vegetable oils. The demand for sunflower has been growing at a rate of 3 percent per annum. Annual production was registered as up to 245 000 tonnes in 2014 from 79 000 tonnes in 2000. Uganda is ranked twentieth in sunflower production in the world with a share of 0.6 percent.

Beans are a staple crop that are consumed by most households across the country. Beans are prepared and consumed fresh as well as when they are dry. In Africa, the leading producers of beans are Tanzania, Uganda and Kenya whose production volumes in 2010 were estimated at 950 000 tonnes, 455 000 tonnes and 390 598 tonnes respectively. In 2010, Uganda was ranked second producer of beans after Tanzania in the East Africa Community Region. Beans are the second most important crop in Uganda after maize, in terms of number of agricultural households involved in cultivation, consumption and marketing. About 40 percent of agricultural households in the country cultivate beans. Bean production in Uganda is slightly above 1 million tonnes per annum and the average yield is 1.5 tonnes/ha.

THE SELECTED MAIZE, SUNFLOWER AND BEANS SUPPLY CHAINS

A food loss analysis study was undertaken along the maize, sunflower and beans supply chains in Uganda.

The **maize supply chain** (grain and flour) and the **sunflower supply chain** (grain, oil and seed cake) selected are those found in Apac and Lira districts, in the Lango subregion, northern Uganda. More specifically for both supply chains, the study was conducted in Ibuje and Akokoro subcounties (Apac district), and in Amac and Barr subcounties (Lira district) from February 2015 to May 2015.

Both districts were chosen because of the intensity of maize production, the presence or availability of agroprocessing and marketing services. Apac district is one of the leading producers of maize in northern Uganda and Lira district is the main trade and processing hub.

The sunflower was chosen because of its importance as a raw material for vegetable oil in Uganda and for its position as a commercial crop. Of the total oil seed produced in Uganda 49.9 percent comes from the northern region. Sunflower processing is mainly concentrated in the Lango subregion. Lira and Apac districts are the major producers of sunflower however Lira is the oil-processing hub. The study focused on the production and post-harvest handling of sunflower grain up to the

bulking points in the selected subcounties and the processing of sunflower grain into oil and seed cake in Lira.

The study also covers the beans supply chains in Oyam district of Northern Uganda. It was conducted from October 2015 to February 2016 in Oyam Town Council, and Loro subcounty. The supply chain studied was for dry whole bean grain.

The bean supply chain was selected because of its importance to the food security and economy of Ugandans. The study follows the bean FSC from primary production, on-farm post-harvest handling and producer sales in Loro subcounty to the trading activities in Lira district. The beans are stored and sold in the dry form.

A replication study was then conducted along the beans supply chain from October 2016 to February 2017 in Oyam district.

The bean FSC in the study area has one final product, which is whole dry bean and was considered for further analysis in the first study and its replication.

The differences highlighted in Table 3 between the first study and the replication study in terms of district and household level production and district level area under cultivation can be explained by the fact that seasonal variations in production are common in Uganda and can be big for many reasons. The rural population lives hand to mouth and can change how much of a particular crop to produce in a given season depending on how much income is expected from another among other things.

TABLE 1
Food supply chain in the maize subsector in Apac and Lira districts (2015)

Geographical location	Final product	Volume of final product (tonne/ year)	Number of people involved in production	Market of final product	Acreage (acre)	Varieties	Percentage of on farm consumption / Percentage of marketed production
District level							
Apac	Maize grain	45 730*	41 920 men 43 915 women°	Villages, Lira and Apac towns and other parts of the country		Open pollinated variety (OPV) Longe 5	34.3 / 40.5
Apac	Maize flour	>15 090**	<100 men <20 women°°				
Lira	Maize grain	17 160*	32 995 men 35 800 women°				34.3 / 40.5
Lira	Maize flour	>9 060**	<500 men <50 women°°				
Subcounty level							
Barr, Amach, Akokoro and Ibuje	Maize grain	5 520 (in one subcounty)	32 280 (in the 4 subcounties) 1 278 households (in one subcounty)	Villages, Lira and Apac towns and other parts of the country		OPV Longe 5	
Household level							
2 growing seasons per year	Maize grain	4.32			1.8	OPV Longe 5	80°°°

* 2012 Statistical Abstract. Uganda Bureau of Statistics (UBOS, 2012).

** Assumes 40 percent of district production was sold, and 80 percent of the grain is milled (UBOS, 2010b).

° The population data used is that of National Population Housing and Census (UBOS, 2014b).

°° Estimated values

°°° The field study has shown that more than 80 percent of households lack proper storage facilities for maize grain. Therefore, to avoid damage caused by storage pests and other infestations, the grain is mostly sold within one month of harvesting to primary bulkers.

TABLE 2
Food supply chain in the sunflower subsector in Apac and Lira districts (2015)

Geographical location	Final product	Volume of final product (tonne/year)	Number of households involved in production	Market of final product	Average area under cultivation (ha)	Varieties	Percentage of on farm consumption / Percentage of marketed production
District level							
Apac	Sunflower grain	17 551	46 680	Villages, Lira, Kampala and other parts of the country	29 407	PAN 7351 and Sunfola	100%
Lira	Sunflower grain	21 791	57 960		36 513		100%
Subcounty level							
Barr, Amach, Akokoro and Ibuje		7 841 (in the 4 subcounties)	21 015 (in the 4 subcounties)	Villages, Lira, Kampala and other parts of the country		PAN 7351 and Sunfola	100%
Household level							
1 growing season per year	Sunflower grain	0.376		Villages, Lira, Kampala and other parts of the country	0.64	PAN 7351 and Sunfola	100%

TABLE 3
Food supply chain in the beans subsector in Oyam district (2015 and 2016)

	Geographical location	Final product	Volume of final product (tonne/ year)	Number of households involved in production	Market of final product	Average area under cultivation (ha)	Varieties	% of on farm consumption / % of marketed production
District level (Oyam)								
First study (2015)	Oyam	Whole grain	63 101	65 889		22 601	NABE series	
Replication (2016)	Oyam	Whole grain	16 655	65 000		4 870		
Subcounty level (Loro)								
First study (2015)	Loro	Whole grain	8 824	9 214	Loro TC and Lira	3 160	NABE series	
Replication (2016)	Loro						Mixed varieties of medium (K131, K132, yellow beans) and small seeded beans of various colours	
Household level (Loro) ***2 growing seasons per year***								
First study (2015)	Loro	Whole grain	0.958		Loro TC and Lira	0.343	NABE series	30 / 70
Replication (2016)	Loro		0.256		Loro T/C	0.34		30 / 70

Maize supply chain

Actors - In both districts, maize is transported from the primary producers to the consumers through several players: local produce dealers, millers, wholesalers and retailers.

Stages in the supply chain - The harvest seasons occur between July-August and December-January. Subsistence farmers are widespread. They cultivate maize on less than 1 ha and use traditional farming methods. Maize is harvested in piece meal by plucking and heaping cobs with sheaths in the field or removing sheaths and carrying them home right away. Farmers use knives and nails to remove the husks from the maize ears and either throw the cobs on uncovered ground, in basins or onto tarpaulins. Generally the crop is transported from the field to the homestead using bicycles and head portage. Some farmers leave the crop to dry in the field before harvesting and storage followed up by subsequent periodic re-drying on uncovered ground. Maize is dried at home, normally on uncovered ground. A few farmers use tarpaulins to dry maize. Sticks are used to shell the maize. Shelling is done quickly but spillage and breakage is high. Maize is mainly stored in the main dwellings and the remaining is stored in cribs and cane granaries. The storage period usually lasts up to three months. In a few cases, famers use storage pesticides such as Malathion dust 2 percent and phosphine fumigant to reduce weevil damage. Where phosphine is used, it is applied unprofessionally and thus exposes users to the dangers of pesticide poisoning.

Marketing - As a result of the lack of a central collection place and inadequate on-farm storage facilities, the marketing of maize grain is conducted individually (none, or very little collective marketing). The farmers do not usually have a large selection of buyers, who often set the prices. The grain is sold at home or at the village markets to rural households and primary bulkers. The cost of transactions increase with the distance. To avoid damage caused by storage pests and other infestations, the grain is mostly sold within one month of harvesting. At the point of sale, primary bulkers store the maize in polypropylene bags and sell it to medium-sized millers directly or to rural traders and agents, who will sell the stock of maize grain to medium and large-sized millers. Medium-sized millers sell maize flour to urban and rural households, retailers and institutions. The grain is occasionally stored for clients. Large millers sell the flour to urban retailers and traders.

Sunflower supply chain

Actors - Actors in the sunflower supply chains comprise of farmers, large miller agents, local traders, millers, wholesalers, retailers, and consumers.

Stages in the supply chain - Harvesting occurs from July to December but a few farmers may be found harvesting in January. Sunflower is harvested by cutting the heads off using knives, or by breaking the heads off the stalks using the hands. The harvested heads are either thrown on uncovered ground, on tarpaulins, into large saucepans or basins. The heads collected are then transported and poured on a tarpaulin. The sunflower heads are threshed in the field on tarpaulins by beating the heads with sticks until all the seeds have been extracted or by hand scrubbing. Threshing occurs soon after harvesting before the grain is transported to the household. Some winnowing takes place to remove the dust and chaff before the grain is packed into bags and taken home for drying and winnowing. Transportation from the field to the home is commonly by bicycles and head portage. Sunflower is dried at home, on tarpaulins, unimproved, stabilised (using mud or cow dung) and cemented surfaces. Sunflower is stored in the house for less than a month. There is indeed the concern about the rapid loss of moisture that occurs in sunflower during storage, which results in loss of weight and therefore loss of income. The second reason is the lack of proper storage facilities. Farmers who bulk and sell through cooperatives may store up to 1 to 3 months after harvesting.

Marketing - Farmers sell sunflower seed to large miller agents at collection points, local traders at farmgate or a store, through cooperatives and a few directly to millers. Most farmers sell the grain within 1 to 2 weeks after harvesting. A few households may retain three basins of sunflower (20 kg) to mill oil for home consumption. The local traders collect sunflower grain, once they have bulked a quantity to sell

to local millers. The seed is then processed at the millers. The oil is sold to retailers in Lira and traders from other cities such as Kampala. Mukwano takes the crude oil to the refinery in Kampala. The refined oil is sold to wholesalers and is exported. The seed cake is sold to feed mills in Uganda or is exported to regional markets.

- Some farmers have formed producer organizations or cooperatives through which they bulk and sell to millers. A cooperative may handle up to 120 tonnes of sunflower per season. A few cooperatives mill in addition to bulking and selling sunflower grain.
- Farmers produce sunflower independently or under contract with a large processor mainly Mukwano. Farmers under contract sell the entirety of their product to Mukwano (ITC, 2016), selling through agents or site coordinators who work on commission. The seeds are sold prior to the start of the planting period, the farmers are monitored and the seeds are collected when the farmers harvest and deliver to Mukwano.

Bulking - Agents, traders and cooperatives operate stores (rooms in houses, shops or stores). Once the seeds have been received, operations may include weighing, checking moisture content, dismantling the bags, re-drying and cleaning (winnowing). The sunflower is held for periods ranging from one week to three months. Most traders kept the grain for no more than one month. The traders may handle up to 10 tonnes of sunflower per season.

Milling/Crushing – There are 86 mills in Lira. Of the 86 mills, three are categorised as large processors, processing at least 50-tonnes/day. The rest are small-scale processors handling 1 to 8 tonnes per day. The large mills operate throughout the year but the smaller mills from 6 to 7 months a year. Millers occasionally stock grain for their use but try to avoid longer storage periods because of the loss of moisture content and thus volume of the crop. The millers produce oil and its by-product seed cake.

Beans supply chain

Actors - Actors in the sunflower supply chains comprise of farmers, aggregators/agents, bulkers, produce dealers (wholesalers) and retailers at the trading centres, and the consumers. The system includes support services from transporters, input suppliers and the local government.

Stages in the supply chain - Beans are grown in two seasons March to June and August to October. The harvested beans are tied into bundles and carried to the homestead on the head, bicycle, motorcycle or vehicles. Those with larger farms (e.g. 4 to 5 acres) reported using hired vehicles such as a 2-tonne diesel dumper. Women and children mostly carry the crop on their heads and men use bicycles. The un-threshed beans are heaped on an open surface, tarpaulin or on the veranda. The storage period is not long about 2 to 4 days until the remaining leaves fall off easily during drying. Sticks are used for threshing while the bean pods are spread on the ground, or on stabilised or cemented drying yards or tarpaulins. After threshing the beans are winnowed by hand, mainly by women who use a winnower in small portions. The grains are dried on a tarpaulin, uncovered ground, mats, concrete surface and rocks. Farmers generally put beans in polyethylene bags and store them in their houses.

Marketing - As a result of pest problems, and immediate demand for money, farmers tend to sell most of their beans within three months of harvesting. Farmers typically sell the grain to fellow farmers in the village markets, which are generally located at the trading centres, agents/aggregators and bulkers. Farmers buy from fellow farmers or retailers to bridge household food deficits. Rural bulkers sell to produce lines in Lira and to traders from Kampala.

Rural bulking - The rural bulkers are usually located in the townships and operate stores having a 30 tonne capacity. These traders handle up 20 bags of beans per day purchased from farmers or agents. They store grain for up to six months during which time they may re-dry grain that has been kept for long. But generally they have a high turnover with grain being sold very quickly. The rural bulkers practice minimal quality checks at purchase. The grain is bitten to check the moisture content. The cleanliness of the grain is also checked and it is turned away if it has too much stone, sand or dust particles until the farmer cleans it sufficiently.

Wholesale - The wholesalers (produce dealers) work individually or as associations comprising of 30 to 150 members operating numerous stores. An individual produce dealer may handle up to 100 bags of beans a day and the entire produce-line 45 tonnes. Most of the grain is purchased from agents and bulkers. Price depends on moisture content, presence of rotten grains and contamination with dust and stones. Handling includes transportation, loading and off-loading, re-drying (when the moisture content is too high) and storage. The grains are fumigated to manage pest and rodent problems.

METHODOLOGY

The assessment of post-harvest losses used the 'food loss analysis' case study methodology developed by FAO under the Save Food Initiative (FAO, 2016). The methodology followed included a *preliminary screening* of food losses based on secondary data, documentation and expert consultations; a *survey* which provided some indicative levels of food losses based on observations and analysis of current practices, direct measurements and responses from sampled supply chain actors; a *load tracking and sampling assessment* to measure actual quantity and quality losses before and after one or more events by collecting samples at these various stages of the supply chain, weighing them and conducting laboratory analysis for mechanical damage, discolouration, moisture content, presence of debris and insects, and aflatoxin contamination; and *solution-finding (synthesis)* so as to develop target interventions to address the observed food losses.

The methodology also takes into account gender and environmental, social and food safety aspects that enable the formulation of well-packaged solutions to mitigate the losses. In particular, the involvement of men, women and children in various activities along the value chain is discussed.

STUDY OBJECTIVES

The food loss assessment study aimed to identify the critical loss points in the selected supply chains, the key stages at which food losses occur, why they occur, the extent and impact of food losses and the economic, social and environmental implications of the food losses. Furthermore, these studies also proposed mitigation measures and evaluated the feasibility of potential interventions to reduce food losses and waste.

The objective of the replication of the beans study in the same study area and during the same harvest season is to obtain time series indicative data and a better understanding of causes and extent of losses that are related to incidental factors/events (e.g. irregular climate conditions, insect invasion, or unexpected event in the supply chains such as a temporary blockage to access to the usual markets) vs. more structural causes, hence a better formulation of recommendations on solutions and strategies to reduce losses. The changes that may occur and the reasons for variations in the causes and deviations in the level losses (increase or decrease) from one year to the other is analyzed and taken into consideration.

In addition, because of time constraints, the researchers were unable to complete load tracking along the bean supply chain during the first study. Load tracking was therefore conducted at the time of the replication study.

STUDY FINDINGS AND RESULTS

Critical loss points (CLP)

Maize supply chain

Harvesting (3.3% quantitative losses), **on-farm storage** (10% quantitative losses and up to 50% qualitative losses) and milling (5% quantitative losses) were identified as the critical loss points.
The **drying** and **shelling** steps are also considered critical. Inefficiencies at these stages promote the deterioration of the product at later stages such as storage. Estimated levels of quantitative losses are 3% at drying and 4% at threshing (Table 5).

Harvesting losses arise because of delayed or incomplete harvesting and high spillage, which may be caused by poor supervision, or simply lack of appreciation of the magnitude of the losses that occur, as well as insufficient knowledge of good harvesting practices. Some farmers leave their maize to dry in the field before harvesting and storage. Delayed harvesting results in pest introduction at the field level. Farmers threw maize on uncovered ground during harvesting, thus predisposing the grain to contamination. Further, high humidity in the field increases discolouration, especially in the first season.

TABLE 4
Field work methodology for each selected supply chain

Maize supply chain	Sunflower supply chain
Survey • Focus group discussions and key interviews with farmers, processors and other pertinent actors. **Load tracking and sample collection** • At harvesting: plots were measured (4x4m) and farmers were allowed to harvest normally. Then the grain that was split and discarded during the harvesting process was collected carefully, weighed and compared to the total harvest to obtain the percentage of losses at harvest. • At home storage (n=18 homes), traders and aggregation points (n=10): collected samples were dried, threshed and stored. The quality was tracked across three and four months of storage, at both farmer and primary bulkers' points respectively. Aflatoxin levels were assessed, using rapid aflatoxin kits. • At mills (n=+6): stored maize were collected and analysed. Laboratory: National Agricultural Research Laboratories (NARL)	**Survey** • Supply chain stages observed: primary production, harvesting, threshing, transport to the household, drying and winnowing, storage, producer sales, bulking and milling. • Semi-structured interviews involving 70 sunflower producing households. • Interviews with farmers, millers, extension, and other pertinent stakeholders. **Load tracking and sample collection** • At harvesting: 35 fields were randomly sampled and 3 quadrants (4x4m) were harvested from each field, threshed and weighed. • At aggregation points at the village level and from farmers (n=20): collected samples were analysed for the level of impurities and aflatoxin presence. Laboratory: NARL
Beans supply chain (first study)	**Beans supply chain (replication study)**
Survey • Supply chain stages observed: primary production, harvesting, transportation of bean stalks to the household, threshing and winnowing, drying of bean grains, on-farm storage, and producer, bulker and wholesale sales. • Focus group discussions (n=45; 25 male and 20 female) and key informant interviews (n=20 respondents, including farmers, traders and agricultural officers). **Load tracking and sample collection** • From farmers and traders (n=22): collected samples were analyzed across 2.5 and 4 months of storage. Laboratory: NARL	**Survey** • Supply chain stages observed: drying, threshing, winnowing and storage. • Interviews with farmers, bulk traders, wholesalers and retailers. **Load tracking and sample collection** • At the farm level (harvesting, transportation, threshing, winnowing, drying and storage) - Harvesting: 24 fields were randomly sampled and 1 quadrant (4x5m) was harvested from each field by the family and a measurement was taken. The researchers combed for any unharvested or uncollected beanstalks left in the field or actual beans left because of shattering of the pods. Harvested beans plus those collected by the research team were transported to the homestead, threshed and weighed separately. - Threshing and winnowing: one half was threshed and winnowed in the traditional way and the other half, as a control, was threshed by hand. The output from the two processes were weighed and compared to estimate the grain loss from employing the traditional method. - On-farm storage: 10 kg were bought from five farmers. A sample of 2 kg from each 10-kg lot was collected and taken to the laboratory for analysis of quality parameters. The rest (8 kg) were stored in a polypropylene bag and left with the farmer to store among their produce. 3 months later, the bean sample was retrieved from the farmers and 2 kg removed, which were taken to the laborary for analysis. • At the bulk trader level (aggregation, transportation, drying and storage) • At the urban consumer level (household): an owner of an eatery purchased 2 kg of beans from a retailer and took it to her kiosk for preparation. The beans were cleaned and the research team took measurements of what had been sorted out. Laboratory: Kawanda Agricultural Research Station

Drying - Maize is dried on uncovered ground, at times spread on wet courtyards, at the farm level, which causes grain discolouration, contamination with foreign matters, termite damage, mould and debris. Farmers lack proper drying facilities for grain such as cribs and tarpaulins. In Apac district, most farmers bring the grain from the field after it has been dried in the field. This exposes the grain to high losses resulting from mould contamination, since it usually rains during the first season at the time of field drying. Some grain will be thrown away but, in most cases, it is mixed with clean grain.

TABLE 5
The maize supply chain, stakeholders, operations and loss points

Supply chain level		Farm / production	Village market / trading center	Town (market)
Actors		Farmers Input suppliers Local transporters	Rural households Primary bulkers Rural traders and agents Small-scale millers Rural retailers Transporters	Rural traders and agents Medium-sized millers Large-sized millers Urban retailers Urban traders Urban households Institutions Wholesalers
Operations		Harvesting / field drying Drying Shelling Farm storage Transportation	Farmers sales (to rural households and primary bulkers) Storage Rural retailing Small-scale milling Transportation	Sales Milling Urban retailing Wholesale
Critical loss points		Harvesting Drying and shelling On-farm storage		Milling
Quantitative loss (%)	Apac	Harvesting: 1.9% (spillage) Drying, shelling, on-farm storage: 26.8%* (weevil damage, mould, breakage)		Milling: 5% (leakage from machinery, poor status of machines)
	Lira	Harvesting: 4.7% (spillage) Drying, shelling, on-farm storage: 7.2%* (pest damage, mould, breakage, rodents)		Milling: 5% (leakage from machinery, poor status of machines)
Qualitative loss (%)	Apac	On-farm storage (after 3 months): % of samples positive with aflatoxin (>10 ppb): 50%		
	Lira	On-farm storage (after 3 months): % of samples positive with aflatoxin >10 ppb: 30%	Storage at rural trader (after 4-month storage): % of samples positive with aflatoxin >30 ppb: >70%	

* Mean values for both districts: Drying: 3%; Shelling: 4%; On-farm storage: 10%
NB- Marketing systems:
Farmers sell maize grain to primary bulkers and rural households.
Primary bulkers sell maize grain to rural traders, agents, and medium-sized millers.
Rural traders and agents sell maize grain to medium and large-sized millers.
Medium-sized millers sell flour to urban and rural households, retailers and institutions.
Large millers sell the flour to urban retailers and traders.

Threshing - Threshing using knives (for small quantities) and sticks (for greater quantities), breaks the grains, which further eases the infestation of grain by weevils and mould. As the grain is threshed some is spilled and scattered and, in many cases, cannot be recovered. Although there are a few shellers in Lira, most of the farmers interviewed had not accessed them.

During **on-farm storage**, it was found that losses are caused by insect damage, mould and aflatoxin contamination, insect frass, debris accumulation, rodent infestation, termite attack and discolouration related to poor drying, inadequate storage conditions (temperature, high humidity, long storage period, etc.) and lack of storage capacity. For example, many farmers store grain on the uncovered floor, mix the maize grain with other products and fail to place maize bags on pallets. Where an attempt is made to use pallets, either they are insufficient, or are placed very close to the walls and roof. In many cases, no space is left for air circulation within the pallets resulting in the grain moulding and a faster proliferation

of insect pests. Losses are also high during storage due to the aggregate effect of inadequate drying and threshing processes.

After 3 months' storage at the farm, 40 percent of samples were contaminated with aflatoxin at over 10 ppb (the minimum standard).

Rural bulking - The rural traders mainly face challenges regarding the quality of the grain received from farmers, especially in relation to high moisture content, high levels of impurities, unfilled and broken grains. Rural traders do not have appropriate storage for maize. Maize is stored in polypropylene bags, which are roughly stacked in the stores. Stores have poor ventilation and thus expose grain to low air circulation and result in the grain becoming contaminated with mould. Indeed, samples from these stores are heavily infested with weevils after 4 months' storage and have high levels of aflatoxin contamination.

Samples from rural traders' stores are heavily infested with weevils after 4 months' storage and have high levels of aflatoxin contamination. Over 70 percent were infested at over 30 ppb.

Milling - Losses are mainly due to spillage. This is the result of broken parts at maize mills, which are the result of failure or the reluctance of the proprietors to carry out regular service and maintenance. This reason may be because such losses do not directly affect the millers, but instead are borne by their clients. Qualitative losses are also possible, especially when different quality products pass through the same machines without being cleaned. Also, in order to facilitate the removal of the husk during milling, millers mix the grain with water on dirty concrete floors. This predisposes the grain to contamination and results in contaminated flour.

Sunflower supply chain

The critical loss points identified occur at **harvesting** (2.46% quantitative losses), **threshing** (2.4% quantitative losses), **drying** (3% quantitative), **farmer storage** (2% quantitative), **bulking points** (1.8% quantitative) and **milling** (6.5% quantitative and qualitative) (Table 6).

Harvesting - The causes of the loss were identified as: Spillage; Harvested heads left in the field without removing the grain (partly because of non-uniform crop maturity); Dust stuck to the heads that are dropped on the ground upon harvesting.

Threshing - The loss is a result of: Grain scattering and being spilled on the ground because of the impact of the sticks on the sunflower heads in the process of threshing (grain is lost as a result of the rudimentary technology used for threshing); Some of the grain may break, leaving a portion of the grain on the head, while the other falls out; Some of the grain does not dislodge and remains on the head.

Drying - The losses are attributed to: Spillage because of the lack of proper drying facilities such as cribs and tarpaulins; Domestic animals eating the sunflower as the crop is left out to dry (this is a result of drying at ground level); Insufficient drying time (1 to 2 days instead of the recommended 4 days), farmers dry their sunflower to contain from 14 to 15% moisture content instead of the advised 12%.

Household storage - The key informants attributed the losses to: Spillage, caused by the grain scattering and becoming stuck in crevasses when not stored in bags and secure containers; Rodents eating the grain when the sunflower is not stored in secure containers; Lack of knowledge about appropriate storage techniques and practice; Lack of proper storage equipment (hermetic bags and plastic silos); Ignorance of food safety and how it may be compromised by farmers' actions; Lack of concern about losses that have been caused by farmers but are incurred by others in the food supply chain.

- Local Trader/agent bulking/cooperative bulking - The factors resulting in losses at the bulking storage points are: Debris; Spillage as bags are moved, opened for drying and cleaning; Excessive moisture (occurs because of farmers' improper drying practices, some traders do not have moisture meters and others do not care); Mould resulting from storing improperly dried sunflower and poor storage conditions (most stores were constructed for use as shops); Rodents.

TABLE 6
The sunflower supply chain, stakeholders, operations and loss points

Supply chain level	Farm / production	Selling point (farm gate, commercial store, collection point, cooperative)	Town (market)
Actors	(1)* Contract farmers (2) Independent farmers (farmers, farmer groups, cooperatives) Input suppliers Transporters	(1) Large miller agents (2) Local traders	(1) Large-scale millers Refinery Wholesalers (2) Small-scale millers Retailers Traders (1 & 2) Feed mills
Operations	Harvesting Threshing Transportation from the field to the home Drying Winnowing Household storage	Farmer sales Bulking and storage (local traders / agents / cooperatives)	Milling/crushing Small-scale milling Large-scale milling Storage Wholesale Retail
Critical loss points	Harvesting Threshing Drying On-farm storage	Bulking points (drying, cleaning, storage)	Small-scale miller storage and milling
Quantitative loss (%)	Harvesting: 2.5% (un-harvested crop, spillage) Threshing: 2.4% (spillage) Drying: 3% (spillage, eaten by domestic animals) Farmer storage: 2% (spillage, rodents)	Bulking points: 1.8% (spillage, mould, rodents)	Small-scale milling: 5% (evaporation, un-extracted oil)
Quantitative and qualitative loss (%)	Samples collected at bulking points at the village level and from farmers: Aflatoxin contamination levels of 30 ppb in 53.5% of the samples		Drying, cleaning, storage (at small-scale millers): 1.5% (spillage, mould, rodents)

*Figures (1) and (2) illustrate the marketing relationship and flow between the different actors: who sells to whom.
Farmers sell sunflower seed to large miller agents, local traders, and millers.
Local traders sell to local millers.
The crude oil is sold to retailers and traders.
The refined oil is sold to wholesalers and is exported.
The seed cake is sold to feed mills or is exported to regional markets.

Quality tests showed aflatoxin contamination levels of 30 parts per billion (ppb) in 53.5 percent of the samples from aggregation points at village level and from farmers.

- Small-scale milling/crushing - The key informants attributed the losses to: Debris because of the poor cleaning practices at the farmer level; Excessive moisture (the intense competition for sunflower means that some millers buy grain even at 15 percent moisture content and higher, while most milling machines require 7 percent moisture content for an optimal oil yield); Mould resulting from storing improperly dried sunflower and poor storage conditions; Rodents; The excessive heat in the oil expeller, which causes some of the oil to vaporize; Processing and handling of the cake (the oil expellers do not extract the oil efficiently, improper storage of sunflower cake causes it to mould and become soggy and in this state it must be discarded: some millers have experienced 100 percent loss of cake because of moisture that came through leaking roofs).
- Large-scale millers - The factors resulting in losses at this level are: Debris (millers mentioned blowing off 20 to 30 tonnes of dust from 2 500 tonnes of sunflower; Excessive moisture in sunflower

because farmers do not dry grain well (millers end up with less than the purchased weight of grain after re-drying).

Beans supply chain (first study and replication)

The critical loss points identified in the first bean study occur at **harvesting** (3.2% quantitative loss); **on-farm storage** (1.8% quantitative and qualitative loss); **threshing and winnowing** (0.97% quantitative loss); and **rural bulking and wholesale stages**. Rural bulking contributed 1% loss, both quantitative and qualitative; and wholesaling contributed 9.8% loss, both quantitative and qualitative. Farmers also consider **producer sales** a critical stage (0.88% quantitative loss) as they incur monetary losses and spillage of grains that are not recovered. The above-mentioned losses are calculated on the basis of estimates made by farmers and traders.

The replication study revealed that CLPs in the dry bean grain FSC were mainly at the farm-level whereby **harvesting** contributed 3.6% quantitative loss, **threshing and winnowing** (4.1% quantitative loss), and **storage** (8.5% qualitative loss). At the marketing level, **bulk traders** identified the CLP during **storage** where the qualitative losses averaged 3%. Quantitative losses at **wholesaling** were an estimated 0.5%.

Analysis of differences in results between the two studies

At the farmer level - The main differences between the loss levels in the two studies are, to a large extent, methodological. In the replication study, in addition to conducting the survey, the researchers completed load tracking and sampling at the stages of harvesting, transportation, threshing, winnowing, drying and storage, which enabled the authors to ascertain the actual quantities of grain lost. In the first study, load tracking was only performed at the storage stage. However, it is important to note that the results obtained during load tracking for samples collected at farm storage (after 2.5 and 4 months of storage) showed that the cumulative quality losses exceeded 7 and 15% after respectively 2.5 and 4 months' storage (because of insect and mechanical damage, debris, other seeds, discolouration), which confirms the results of the second study.

At the marketing level - Load tracking was carried out at the bulk trader level (aggregation and transportation, drying and storage) in the replication study (result presented above). In the first study, load tracking was completed during the storage stage at the trader (bulker), and the quality losses estimated using the load tracking method averaged 10% because of insect damage and discolouration.

The values obtained between the two studies are relatively similar in terms of values and causes of losses (Table 7). Differences occur at the stages of threshing/winnowing and wholesaling. During the validation meeting that took place after the replication study, the attendees (experts, farmers' organizations, researchers, government officials) were more in agreement with the second assessment (replication study) with respect to losses at farmer level. They also agreed that the loss at marketing level was as high as presented in the first bean report (10% and 9.8%). At threshing, the variation in quantity lost was observed to be particularly high for small grain beans. During the replication study, farmers reported that small grain beans remain in the husks because they are encased in harder to split pods. Also, the colour (black, ash-grey, brown) and size of the bean grain also made it difficult to separate the beans from the chaff and to pick up the beans when they were scattered on the ground during winnowing. At wholesale level, in both studies, there is minimal loss by spillage. The differences concern the other losses (e.g. reduction in moisture content, debris, pests). In the replication study, no other losses in volume of a batch were observed while in the first study wholesalers estimated incurring losses resulting from reduced moisture content, debris and insect pests and rodents.

The causes of losses

The researchers reported similar causes in both studies.

Harvesting - The cause of the losses were identified as: Shattering, because the period for drying the beanstalks while still in the field is too long and farmers' deliberate practice; Un-harvested in the field (next most important cause) because beans are hidden by overgrown weeds or careless harvesting; Theft, as hired labourers may steal some of the harvested beans.

Transportation of un-threshed bean - The loss is equally a result of: Theft, which is a result of labourers deliberately throwing beans down during transportation with the intention of picking them up later for consumption; Beanstalks getting stuck in bushes or falling out of the heaps as they are transported from the field (the result of the state of transportation infrastructure, narrow and bushy paths and improperly secured loads).

On-farm storage before threshing - The losses are a result of: Spillage of beans spilling onto the ground from the pods; Grains become contaminated after being dropping on uncovered ground.

Threshing and winnowing - The losses are a result of: Mechanical damage (the impact of the beating action with sticks during threshing damages some of the bean grains, thus increasing their susceptibility to mould and pest contamination and rapid deterioration); Spillage; Weather (on occasion too much wind may blow away some grains during winnowing but farmers said these could be recovered if one was careful).

TABLE 7
The beans supply chain, stakeholders, operations and loss points

Supply chain level		Farm / production	Village market / trading center	Town (market)
Actors		Farmers Input suppliers Transporters	Farmers Agents/aggregators Rural bulkers	Produce dealers (wholesalers) Traders Retailers
Operations		Harvesting Transportation of beanstalks to the household On-farm storage of un-threshed beans Drying of un-threshed beans Threshing and winnowing Drying of bean grains On-farm storage of threshed beans	Producer sales Rural bulking Storage	Wholesale Retail
Critical loss points	**First study**	Harvesting On-farm storage Threshing and winnowing	Producer sales Rural bulking	Wholesale
	Replication	Harvesting On-farm storage Threshing and winnowing	Rural bulking (storage)	Wholesale
Quantitative loss (%)	**First study**	**Farmers' estimations** Harvesting: 3.2% Threshing and winnowing: 0.97% On-farm storage: 1.1%	**Traders' estimations** Producer sales: 0.88% Rural bulking: 1% *(Moisture loss (0.5%) is considered as quantitative and qualitative loss)*	**Traders' estimations** Wholesale: 5.8% *(Infestation by pests (3%) is considered as quantitative and qualitative loss)*
	Replication	**Load tracking** Harvesting: 3.6% Transport: 0.5% Threshing and winnowing: 4.1% On-farm drying: 1.8% On-farm storage: 1.5%	**Load tracking** Rural bulking (aggregation and transport): 0.5% Rural bulking (drying): 1.5%	**Traders' estimations** Wholesale: 0.5%
Qualitative loss (%)	**First study**	**Farmers' estimations** On-farm storage: 0.71% Load tracking On-farm storage: 7-15%	**Load tracking** Rural bulking (storage): 10%	**Traders' estimations** Wholesale: 4%
	Replication	**Load tracking** On-farm storage: 8.5%	**Load tracking** Rural bulking (storage): 3%	

Drying bean grain - It was reported by traders that farmers do not dry grain well. Consequently traders have to dry grain incurring extra costs and grain weight losses. The mould observed in the beans is usually a consequence of contact of the beans with the ground at drying.

On-farm storage of threshed beans - The losses are related to: Spillage (most important cause), which occurs because the polyethylene bags have been perforated; Pests and rodents rendering the grain vulnerable (farmers use their houses as storage, which does not provide the ideal conditions for storing grain); Mould (the grain is susceptible when the sacks are placed directly on the floor).

Producer sales - The losses are caused by: Traders manipulating measuring tools to reflect a lower weight according to farmers (although this does not end up as a food loss in the FSC, it causes the farmer a monetary loss); The use of improper measuring tools by farmers such as basins and other containers (farmers loose money as they are paid less than what he or she should receive); Spillage from beans falling out of containers and perforated sacks.

Rural bulking - The losses are attributed to: Spillage (perforations in the sacks and improperly secured bags); Reduced moisture content of the grain during storage and re-drying.

Wholesale (Produce dealers) - Loss factors reported at this stage in the FSC include: Weight loss in grain resulting from reduced moisture content; Spillage during transportation, loading, off-loading and storage (sacks tearing); Debris; Insect pests and rodents.

THE IMPORTANCE OF GOOD POST-HARVEST HANDLING PRACTICES

The lack of appropriate and feasible technologies coupled with the poor operational skills of users are the main constraints to the reduction of post-harvest losses in the maize, sunflower and beans supply chain in Uganda. Traditional practices during harvesting, drying and on-farm storage result in high levels of post-harvest losses due to spillage, spoilage and grain deterioration. Improper operation and poor conditions of threshing and milling machines result in losses due to spillage, mechanical damage and low milling yield and quality output. More than 80 percent of households lack proper storage facilities for maize grain.

Drying, threshing and winnowing are considered critical stages because of the effect of inappropriate drying and threshing processes on the levels of losses at later stages (e.g. storage). Inadequate processes increase moisture content, mold and pest infestation, and grain breakage, reducing the quality of the grain handled. During drying, grain comes in contact with the uncovered ground where tarpaulins are not used. Debris is added as farmers gather up the grain after drying, causing economic loss to the traders and millers. Improper drying increases the risk of mould when the grain is not properly stored.

Women's roles in post-harvest activities

Gender relations are a primary component of the social and economic context which influences how women and men participate in and benefit from food value chain activities. Gender inequalities in access to and control over productive and financial resources and participation to decision-making process are an underlying reason of the inefficiencies of food value chains and subsequently of food losses.

Socially, both men and women contribute to the value chains studied, although the activities and responsibilities are tilted more towards women and children as a result of traditional norms. Women and children are engaged in most of production and post-harvest activities, carrying the burden of most on-farm activity and working from morning to sunset. Marketing is a male dominated activity; women are mainly involved in selling small quantities of produce at markets to obtain income for domestic use. Most of the retailers are women, who endure financial losses because of fluctuating prices. The proceeds from the sales are, in most cases, not shared equally between men and women, as men control the money and determine the amount to give to the women. Men's greater responsibilities involve negotiating with

TABLE 8
Underlying causes of food losses

Risk factors	Marketing	Equipment and facilities	Knowledge and skills
• Climate change effects leading to unpredictable weather patterns, which tends to delay planting • Damage by pests • Weed infestation • Unreliable input suppliers • High price of certified seed • Lack of quality seed, varietal susceptibility • Failure to prepare land on time	• No incentives to apply proper handling practices and therefore sell clean, well dried grain • Broken market linkages • Lack of structuring of actors	• Lack of post-harvest handling and storage technologies available for individual and collective use	• Lack of knowledge and skills regarding: - agronomic practices - harvesting practices - post-harvest handling practices - the magnitude of the losses incurred during post-harvest handling and the impact of post-harvest losses on household, business and national revenue earnings - quality and safety standards - new technologies coupled with lack of access to technology • Lack of motivation to exercise diligence and carefulness during activities from production to producer sales • Little or no capacity-building of FSC actors • Lack of research on new varieties, methods and technology
National capacities	**Enabling environment**		**Gender**
• Lack of effective extension services	• Lack of enforcement of quality and food safety standards • Lack of credit to support FSC actors to improve/acquire their facilities		• Inequalities between men and women in access to and control over productive and financial resources and participation to decision-making process

buyers and selling the products at the different trade levels along the chain. Among the traders, men own the accounts despite the fact that women sometimes participate in the sales.

The study findings further revealed that most of the valuable assets that would help women minimise food losses such as natural resources, mainly land, water and livestock, physical capital such as agricultural equipment/tools, bicycles and motorcycles are owned and controlled by men. Women and girls usually carry the crop on their heads whereas men and boys commonly use bicycles. In addition, women have limited access to the stocks and to financial services such as for credit and extension services.

It was also noted that most women (except the traders or retailers) were less involved in production and marketing organizations, some must first seek permission from their husbands to join these groups, which further limits their capacity for collective bargaining and active involvement and roles in minimising losses in the FSC.

The underlying causes of losses can be summarized in Table 8.

IMPACT OF POST-HARVEST LOSSES

In anticipation of the losses incurred during household storage, farmers are usually forced to rush the sale of their produce soon after harvest. This reduces the quantity of food available to the household that will cost more later in the season. In addition, just after harvest, the prices are very low, thus resulting in loss of stable incomes at the household level. Financial losses incurred by quantitative and qualitative losses when the product cannot be sold or at a lower price, lead to loss of livelihoods and contribute to food insecurity at the household and community level. For the part of product intended to be consumed by the household, the losses impact negatively on the quantity of product available, thus threatening the household's food security. The presence of aflatoxin poses serious risks to the health of consumers.

It is possible to estimate potential losses (volume and economic value) at different levels of the supply chain (Table 9). The results that are presented below show that food loss reduction measures should be given high priority to raise incomes of smallholder famers and other actors (traders and millers) and improve food and nutrition security in Uganda.

TABLE 9

Impact of food losses in maize, sunflower and beans supply chains (indicative levels) at farm household, subcounty and district levels

		Volume of marketed/ milled product (tonne)	Value of marketed product (USD/an)	Percentage loss	Annual weight loss (tonne)	Economic loss (USD/year)	Selling price (USD/ tonne)
Maize	Farmer level	3.46	650	Threshing: 4%	0.14	26	187.5
				Drying: 3%	0.10	19.4	
				Storage: 10%	0.35	65	
	Subcounty level	4 417	828 190	Threshing: 4%	177	33 130	
				Drying: 3%	133	24 850	
				Storage: 10%	442	82 820	
Sunflower	Farmer level	0.376	86.5	Harvesting: 2.46%	0.01	2.1	230
				Threshing: 2.4%	0.01	2.1	
				Drying: 3%	0.01	2.6	
				Storage: 2%	0.008	1.7	
	District level	39 340	9 million	Harvesting: 2.46%	968	219 600	
				Threshing: 2.4%	945	214 380	
				Drying: 3%	1 180	267 930	
				Storage: 2%	788	178 770	
	Bulking point (storage)	49	17 050	Storage (bulking point): 0.8%	0.39	136	347.9
	Small-scale miller	270	93 930	Storage (small-scale milling): 0.8%	2.2	750	
Beans (first study)	Farmer level	0.958	508	Harvesting: 3.19%	0.03	16.2	530
				Storage: 1.77%	0.02	9	
				Threshing: 0.97%	0.009	4.9	
				Producer Sales: 0.88%	0.008	4.5	
	District level	63 101	33.5 million	Harvesting: 3.19%	2 010	1 066 850	
				Storage: 1.77%	1 120	591 950	
				Threshing: 0.97%	612	324 400	
				Producer Sales: 0.88%	555	294 300	
	Trader level	4 680	3.8 million	Storage: 1.4%	33	26 320	803.5
Beans (replication)	Farmer level	0.256	110	Harvesting: 3.6%	0.009	3.9	425
				Threshing: 4.1%	0.01	4.5	
				Drying: 1.8%	0.005	2	
		0.128	54	Storage: 8.5%	0.01	4.6	
	District level	16 655	7.1 million	Harvesting: 3.6%	600	254 820	
				Threshing: 4.1%	683	290 210	
				Drying: 1.8%	300	127 410	
		8 330	3.5 million	Storage: 8.5%	708	300 920	
	Bulk trader	3 330	1.7 million	4.5%			501

Maize supply chain

In the study area, the average production of maize is about 2 160 kg per season and per household. If we assume that farmers sell 80 percent of their produce within one month, each household would then be able to sell a quantity of 3 455 kg of maize per annum, which represents a potential earning of USD 650 per annum. As a result of critical losses at farm level, a total of 590 kg of maize is lost in a year. That food loss translated into a financial loss of USD 110.

At the level of the subcounty, accumulative financial losses along the maize supply chain exceed 140 000 USD.

Sunflower supply chain

The impact (loss) is arrived at by calculating the annual sunflower output for Apac and Lira districts multiplied by the potential percentage of product lost at the critical loss points in the food supply chain.

Each producer household can sell a quantity of 0.376 tonne of sunflower per annum in Apac and Lira districts, which represents a potential earning of USD 86.5 per year. As a result of critical losses at farm level, a total of 38 kg of sunflower is lost in a year. That food loss translated into a financial loss of USD 8.5.

At district level (Apac and Lira) as a result of critical losses at farm level, a total of 3 882 tonnes of sunflower is lost in a year. That food loss translates into a financial loss of USD 880 680.

The average amount of sunflower grain handled at a bulking point per season is 49 tonnes. The loss at trader/cooperative bulking points as a result of storage factors (excluding spillage) is 0.8%, equivalent to an economic loss of 135.7 USD/year.

The average amount of sunflower grain milled (at a small-scale miller) per year is 270 tonnes. The loss from storage factors (excluding spillage) is 0.8%, equivalent to 751 USD.

Beans supply chain

First study

Each producer household can sell a quantity of 0.958 tonne of beans per annum in Oyam district, which represents a potential earning of USD 508 per year. As a result of critical losses at farm level, a total of 67 kg of beans is lost in a year. That food loss translated into a financial loss of USD 34.6.

At district level, as a result of critical losses at farm level, a total of 4 300 tonnes of beans is lost in a year. That food loss translates into a financial loss of USD 2.3 million.

The average amount of produce handled by a produce line per year is 4 680 tonnes. The loss at the trader level as a result of storage factors is 1.4%, equivalent to an economic loss of 26 323 USD per year.

Replication study

Each producer household can sell a quantity of 0.256 tonne of beans per annum in Oyam district, which represents a potential earning of USD 110 per year. As a result of critical losses at farm level, a total of 34 kg of beans is lost in a year. That food loss translated into a financial loss of USD 14.5.

At district level, as a result of critical losses at farm level, a total of 2 290 tonnes of beans is lost in a year. That food loss translates into a financial loss of USD 973 360.

The average amount of produce going through bulk trader level (drying and storage) per year is estimated 3 330 tonnes (20% of total produce). The loss at the trader level as a result of storage factors is 4.5%, equivalent to an economic loss of USD 75 100 per year.

RECOMMENDATIONS

Based on the results of the studies, recommendations were formulated, which are summarized in Table 10. For the three commodities, in order to achieve the objectives of loss reduction and to inscribe the recommended interventions in the long term, it is necessary to carry out actions at the technical, structural and political levels.

Producing good quality grain is crucial for farmers to easily access the markets and sell their produce. Interventions are needed to ensure grain is of good quality prior to its storage and to address losses at storage. Thus, there is need to ensure proper drying of grain and address the issue of grain breakages at threshing. Besides, several storage technologies can be deployed depending on the availability of the equipment at local level: plastic silos, metal silos, grain safe bags and stores for community grain storage

TABLE 10
Summary of the recommendations

Organization and marketing	Equipment and facilities	Knowledge and skills
• Facilitate group formation (farmer field schools) so farmers can assist each other during harvest periods • Strengthening of producer organizations or cooperatives, through which farmers can be trained and linked to markets, in terms of structure, governance, transparency, business handling, collective infrastructure and equipment and marketing. • Establish a post-harvest coordination platform/forum that brings together key stakeholders in government, development/non-governmental organizations and the private sector to promote, among others, food loss reduction • Advocating for price differentiation for different grades (in terms of quality as a result of post-harvest handling)	• Train and assist local artisans to construct storage facilities • Involvement of the private sector to improve the distribution network and accessibility of silos. • Government to build market and road infrastructure • Provision of simple technologies to aid transportation and drying of grain • For actors involved in bulking: build or rent proper stores and manage them well, following the set standards and law • Setting and managing demonstration and validation technology sites hosting tarpaulins, pallets, drying yards and racks, mechanical threshers, cleaners, hermetic bags, and plastic/metal silos among others • Promote and encourage the adoption of post-harvest equipment at the different levels of the FSC • Improve access to appropriate technology, equipment and facilities for smallholder farmers	• Training of farmers in appropriate harvesting and post-harvest handling techniques • Sensitisation and capacity-building of all actors (producers, millers and traders) on improved grain handling and storage • Train farmers and traders in the effective and efficient use of fumigants/pesticides for protection of grain against infestation by storage insects • Awareness-raising and training for producers in harvesting and post-harvest handling practices • Training of traders (bulkers, wholesalers, retailers) in storage management, product quality assurance and use of fumigants for protection of grain • Training in available technologies for food loss reduction • Sensitisation to create awareness about losses, causes and mitigation measures • Use deterrent measures such as turning away any grain that does not meet the minimum standard requirements
National Capacities	**Enabling Environment**	**Gender**
• Re-tooling extension workers for post-harvest management • Improving availability of extension services and facilitating their service delivery • Training extension workers at the district level in appropriate preproduction, harvesting and post-harvest handling techniques. • Reinforce the capacities of the local government (district) to organize sensitization and capacity-building activities to the benefit of the different actors in the FSC • Support participatory and inclusive research to improve traditional storage structures.	• Support the review of agricultural policies and strategies • Support government in the streamlining of policy for marketing and storage by the private and public sector • Formulation of a national food loss reduction policy • Formulation of national standards for harvesting, post-harvest handling, storage and bulking, and adopting them as district-wide by-laws, popularising the standards and monitoring their enforcement • Facilitate linkages and access to markets, financial services (credit, insurance, credit, co-sharing, cash basis, potential suppliers and delivery system to farmers) and proper post-harvest handling, storage and milling technology • Engage the financial sector partners to bridge the credit gap for accessing post-harvest technologies • Encourage cooperative to thrive and grow	• Address persistent gender discrimination by giving women the same access to agricultural technology, equipment and productive resources • Address gender inequity in terms of access to and control over economic and financial resources to enabling rural women's economic empowerment, improving food security and improving life in rural communities

enterprises. Among the benefits of these technologies is the generation of modified atmosphere in an environmentally safe and sustainable manner.

Adoption of these technologies will be done on a case-by-case basis. It is important to work out their economic costs with farmers. Having technologies readily available is important to farmers, as such it is important to work with local agrodealers or other private sector players that can keep promoting, distributing, and making technologies available.

The interventions directed to the reduction of food losses should not be implemented as standalone. Rather, they should be formulated as part of the existing national strategies for food security, agriculture, natural resources and/or economic development. This will eliminate duplication of effort and investment of financial and non-financial resources towards crosscutting aspects of national interventions.

While farmers are expected to use the proposed technologies and practices, sensitisation and capacity-building over a prolonged period of time is advised for which the cost is not borne by the farmer, but by another level such as the local government (district) establishment or projects. A sustained approach is recommended to bring about a shift in the mind-set and continued uptake of new technologies and methods. A mix of sensitisation approaches can be used, but the core avenue for delivery of the above should be producer organizations or cooperatives.

Farmers will not be motivated to make any changes or invest in post-harvest technologies as long as they are operating at a loss. Supporting farmers to improve productivity is an important starting point. Farmers are unaware and not bothered about the quality or safety of the grain they send to the food supply chain. Some are likely to view the consistent use of tarpaulins, use of hermetic bags and silos, proper drying as an unnecessary inconvenience and an avoidable cost. This is because of the mind set and failure to make a profit at low output.

Research will be important to adapt existing techniques for smallholder farmer requirements and conditions.

TECHNOLOGICAL SOLUTIONS RECOMMENDED AND COST-BENEFIT ANALYSIS

For each subsector, a cost-benefit analysis was carried out for each recommended technological intervention (Tables 11-14). It is hypothesized that adopting of these technologies will help reduce food losses by 80%-90% over a period of years. The calculations are based on 10 or 20 years of operation of the

TABLE 11
Cost and benefit analysis of interventions at farmer level (maize)

	5-ton maize crib (1 for HH)	Motorized maize sheller (1 per 130 HH)	500-kg metal silos (1 per HH)	3-ton metal silo (1 per HH)	300-kg plastic silo (1 per HH)	Hermetic storage bags (22 bags per HH)	30-tonne community store (1 per subcounty)
	Value/Unit	Value/Unit	Value/Unit	Value/Unit	Value/Unit	Value/Unit	Value/Unit
Product quantity	4.32 tonnes/year	4.32 tonnes/ year	3.6 tonnes/ year	3.6 tonnes/ year	3.6 tonnes/ year	3.6 tonnes/ year	3.6 tonnes/ year
Product value	250 USD/ tonne	250 USD/ tonne	250 USD/ tonne	250 USD/ tonne	250 USD/ tonne	250 USD/ tonne	250 USD/ tonne
Loss rate	3 %	4 %	10 %	10 %	10 %	10 %	10 %
Food loss	0.13 tonne/ year	0.17 tonne/ year	0.36 tonne/ year	0.36 tonne/ year	0.36 tonne/ year	0.36 tonne/ year	0.36 tonne/ year
Economic loss	32.5 USD/ year	42.5 USD/ year	90 USD/year	90 USD/year	90 USD/year	90 USD/year	90 USD/year
Total yearly costs of solution	52 USD/ year	2 USD/year	16 USD/year	45 USD/year	3.8 USD/year	23.3 USD/ year	0.65 USD/ year
Client costs per tonne of product	12 USD/ tonne	0.47 USD/ tonne	4.4 USD/ tonne	12.5 USD/ tonne	1 USD/tonne	6.5 USD/ tonne	0.18 USD/ tonne
Anticipated loss reduction	85 %	80 %	90 %	85 %	90 %	85 %	80 %
Volume of loss reduction	0.11 tonne/ year	0.14 tonne/ year	0.32 tonne/ year	0.31 tonne/ year	0.32 tonne/ year	0.31 tonne/ year	0.29 tonne/ year
Loss reduction savings	27.6 USD/ year	34 USD/year	81 USD/year	76.5 USD/ year	81 USD/year	76.5 USD/ year	72 USD/year
Profitability of the solution	- 24.4 USD/ year	32 USD/year	65 USD/year	31.5 USD/ year	77.2 USD/ year	53.2 USD/ year	71.4 USD/ year

proposed improvements. The loss reduction target is set arbitrarily. For each study, the researchers made specific assumptions. Taking into account the depreciation period and allocating the costs to the number of households concerned, the total yearly/seasonal cost and profitability of the intervention are calculated.

Maize supply chain

It is estimated that the adoption of improved technologies will enable at least a 30 percent increase in maize-related income-generation. In addition, actors' confidence in the quality of the produce in the value chain will increase. Further, better grain quality will also improve the milling outturn.

It is recommended that a maize crib is used to improve the drying of maize. This facility is suitable at the household level and can result in significant reduction of losses at this stage, as well as in the following stages of the supply chain, including storage. In the beginning, it is projected that 30 percent of maize producer households will adopt the use of a crib (first year).

The shellers can be operated as a business, and would result in reduced losses at the farmer group level. Shellers can be fabricated locally by private workshops in Lira town and at the Agricultural Engineering and Appropriate Technology Research Institute (AEATRI) at NARO. The shelling cost of using a stick is USD 0.94 per 120 kg bag. The cost drops to USD O.63 using a motorised sheller.

Numerous storage technologies can be deployed depending on the availability of the equipment at the local level. Recommended solutions can be plastic silos (300 to 400 kg capacity), half-tonne silos, 1 to 3-tonne metal silos, grain safe bags and 30-tonne maize stores for community grain storage enterprises. There is one workshop in Lira where these silos are made. Use of hermetic bags is a choice that would be made by less privileged households that either cannot afford, or may be isolated and find the adoption of cribs, metallic silos and grain safes unsuitable for use in their circumstances.

Adoption of cribs and silos will be on a case-by-case basis. It may be that improvements to a traditional drying and storage structure will be adequate.

While technologies such as drying cribs are appropriate and well advised, the farmer can only profit from the intervention if they improve productivity (yield/ha) and obtain better prices for grain. Calculating the benefits of improved drying and storage for the farmer is not easy. Benefits could be measured in terms of reduced losses and higher selling prices. Improved drying and storage cribs could allow for maize harvested at 30 percent moisture content to be dried on the cob to recommended rates in about six weeks. The price of a new crib (USD 780) may seem very high to farmers and they may be reluctant to make the investment, even though it will benefit them in the long run. It is important to realize that a farmer is not building a crib or a store for just one season. He would be unlikely to get his investment back in one year. A well-constructed crib, regularly maintained, can last for many years (15 years). It is estimated that an additional income of USD 220 per annum would be earned as a result of adopting a crib, as the farmer will be able to sell his maize at USD 250 per tonne, instead of USD 187.5 per tonne. A household's investment in such an equipment would be recovered in around 4 years with the additional revenue earnings. It could also be suggested that two or three producers invest in a crib, and dry and sell their grain together. In this case, the costs related to the investment and maintenance of the crib would be shared between these households.

The additional income earned as a result of the adoption of a 500-kg silo would be sufficient to recover the purchase price of the silo in one year; investment in a one or three-tonne silo could be recouped within around two years.

Sunflower supply chain

At farm level, recommended solutions include appropriate sunflower growing and post-harvest technologies and practices (use of tarpaulins, hiring of a threshing machine, drying on cribs, use of hermetic bags and plastic silos).

While technologies such as drying cribs, hermetic bags and silos are appropriate and well advised, the farmer can only profit from the intervention if they improve productivity (yield/ha), obtain better prices for grain or lower prices for the interventions.

Threshers could be owned by cooperatives or interested service providers (as an investment) and hired out to farmers. This practice is used for maize in some areas and can be adopted for sunflower.

Interventions recommended at the bulking and small-scale milling levels are: consistent use of proper

TABLE 12
Cost and benefit analysis of interventions at farmer level (sunflower)

	Tarpaulin	Hire-sunflower thresher	Drying cribs (1 000 kg)	Hermetic bag (400 kg)	Plastic silo (500 kg)	
	Value/Unit	Value/Unit	Value/Unit	Value/Unit	Value/Unit	Remarks
Product quantity	376 kg/year	376 kg/year	376 kg/year	376 kg/year	376 kg/year	
Product value	0.23 US$/kg	0.23 US$/kg	0.23 US$/kg	0.23 US$/kg	0.23 US$/kg	
Loss rate	3.7 %	2.4 %	2 %	2 %	2 %	
Food loss	14 kg/year	9 kg/year	8 kg/year	8 kg/year	8 kg/year	
Economic loss	3.2 USD/year	2.1 USD/year	1.7 USD/year	1.7 USD/year	1.7 USD/year	
Total yearly costs of solution	0.1 USD/year		0.24 USD/year	8.3 USD/year	2.3 USD/year	Costs of tarpaulin and crib are per square metre
Client costs per kg of product	0.004 USD/kg	0.005 USD/kg	0.01 USD/kg	0.02 USD/kg	0.005 USD/kg	
Anticipated loss reduction	80 %	100 %	80 %	80 %	80 %	
Volume of loss reduction	11 kg/year	9 kg/year	6 kg/year	6 kg/year	6 kg/year	
Loss reduction savings	2.5 USD/year	2.1 USD/year	1.4 USD/year	1.4 USD/year	1.4 USD/year	
Profitability of the solution	1 USD/year	0.30 USD/year	-2.3 USD/year	-6.5 USD/year	-0.39 USD/year	

TABLE 13
Cost and benefit analysis of interventions at farmer level (beans, first study)

	Tarpaulin	Hermetic bag (100 kg)	Plastic silo (500 kg) (above average acreage)	
	Value/Unit	Value/Unit	Value/Unit	Remarks
Product quantity	479 kg/season	479 kg/season	2 303 kg/season	
Product value	0.53 USD/kg	0.53 USD/kg	0.53 USD/kg	
Loss rate	0.53 %	1.8 %	1.8 %	
Food loss	2.5 kg/season	8.5 kg/season	40.8 kg/season	
Economic loss	1.4 USD/season	4.5 USD/season	21.6 USD/season	
Total costs of solution	0.1 USD/season	2.1 USD/season	1.2 USD/season	Cost of tarpaulin is per square metre
Client costs per kg of product	0.003 USD/kg	0.021 USD/kg	0.002 USD/kg	
Anticipated loss reduction	80 %	80 %	80 %	
Volume of loss reduction	2 kg/season	7 kg/season	33 kg/season	
Loss reduction savings	1.1 USD/season	3.6 USD/season	17.3 USD/season	
Profitability of the solution	-0.13 USD/season	-6.4 USD/season	11.9 USD/season	

TABLE 14
Cost and benefit analysis of interventions at farmer level (beans, replication study)

	Tarpaulin	Hermetic bag (90 kg)	Plastic silo (500 kg)	Metal silo (750 kg)	Tarpaulin and hermetic bag	Tarpaulin and plastic silo	Tarpaulin and metal silo
	Value/Unit	Value/Unit	Value/Unit	Value/Unit	Value/Unit	Value/Unit	Value/Unit
Production quantity	256 kg/year	256 kg/year	256 kg/year	256 kg/year	256 kg/year	256 kg/year	256 kg/year
Product value	0.4 USD/kg	0.4 USD/kg	0.4 USD/kg	0.4 USD/kg	0.4 USD/kg	0.4 USD/kg	0.4 USD/kg
Loss rate	1.8 %	8.5 %	8.5 %	8.5 %	10.3 %	10.3 %	10.3 %
Food loss	4.6 kg/year	10.9 kg/year	10.9 kg/year	10.9 kg/year	15,5 kg/year	15,5 kg/year	15,5 kg/year
Economic loss	2.0 USD/year	4.6 USD/year	4.6 USD/year	4.6 USD/year	6.6 USD/year	6.6 USD/year	6.6 USD/year
Total yearly costs of solution	2.8 USD/year	1 USD/year	8.7 USD/year	9.1 USD/year	3.8 USD/year	11.5 USD/ year	11.9 USD/ year
Client costs per kg of product	0.004 USD/ kg	0.006 USD/ kg	0.011 USD/ kg	0.008 USD/ kg	0.009 USD/ kg	0.014 USD/ kg	0.011 USD/ kg
Anticipated loss reduction	80 %	80 %	80 %	80 %	80 %	80 %	80 %
Volume of loss reduction	3.7 kg/year	8.7 kg/year	8.7 kg/year	8.7 kg/year	12.4 kg/year	12.4 kg/year	12.4 kg/year
Loss reduction savings	1.6 USD/year	3.7 USD/year	3.7 USD/year	3.7 USD/year	5.3 USD/year	5.3 USD/year	5.3 USD/year
Profitability of the solution	0.7 USD/year	3 USD/year	2.3 USD/year	2.7 USD/year	3.7 USD/year	3 USD/year	3.4 USD/year

grain store management practices including use of tarpaulins, moisture meters and using deterrent measures such as refusal to buy sunflower that is below the minimum acceptable grade.

Beans supply chain

First study

At farm level, recommended solutions include adopting appropriate timing for harvest and harvesting techniques; consistent use of tarpaulins when drying, threshing and winnowing; adopting modern threshing techniques that are scaled-down to the smallholder farmer level and use of intact storage such as hermetic bags and plastic silos.

Interventions at the trader level are: consistent use of tarpaulins when re-drying, use of intact bags and modification of existing storage facilities to proper standards for food storage.

Replication study

The strategies presented in the first study (aforementioned), and in the replication study (below), are in alignment.

At farm level, recommended solutions include tarpaulins for drying and threshing; and hermetic containers such as hermetic bags and plastic silos.

PART 1

Beans value chain 2015-16

INTRODUCTION

Agriculture is the most important sector of the Ugandan economy as it employs 66 percent of the working population aged 10 years and older (UBOS, 2012). The sector contributes up to nearly 20 percent of the gross domestic product (GDP), accounts for 48 percent of exports and provides a large proportion of the raw materials for industry (MAAIF, 2010). Food processing alone accounts for about 40 percent of total manufacturing. The Development Strategy and Investment Plan (DSIP) was aligned and anchored to the National Development Plan (NDP) as one of the drivers of growth. In the DSIP it was noted that the agricultural sector faces several output-level challenges. The most important among them being: low levels of productivity across most enterprises; high losses because of pests, vectors and diseases; failure to comply with increasingly demanding international quality and standards for traded food and agricultural products; and inadequate infrastructure for value-addition processes including marketing, storage and distribution. These challenges are further increased by inadequate access or feeder roads that increase the costs of marketing; multiple policy frameworks that, in some cases, compound investors' uncertainty about the investment environment; the negative consequences of climate change exhibited by prolonged dry seasons, abrupt changes in intensity and shifts in the cessation and on-set of rains. In terms of human nutrition, it has been observed that Uganda's average calorie intake at about 2 066 is still less than the recommended daily calorie intake of 2 300 (MAAIF, 2010).

Post-harvest loss reduction has taken centre stage in the fight against food and nutrition insecurity and the attempt to increase the incomes of smallholder farmers in Africa. Losses are manifested as weight losses (pests, spillage or shrinkage from reduced moisture), quality loss (changes in the grade characteristics of colour, shape, or flavour), nutritional loss, loss of seed viability, and economic loss (lost income as a result of obtaining

lower prices from rushed sales, reduced quantities or poor quality products being presented to the market (MAAIF – SG 2000, 2013).

To address the above-mentioned issues, a food loss assessment study was undertaken along the food supply chain for beans within the framework of a joint project implemented by the United Nations Rome-based agencies: the Food and Agricultural Organization of the United Nations (FAO), the International Fund for Agricultural Development (IFAD) and the World Food Programme (WFP): *Mainstreaming food loss reduction initiatives for smallholders in food deficit areas*, which was funded by the Swiss Development and Cooperation Agency. The overall objective was to improve food security and income-generation opportunities through the reduction of food losses in supported food grains and pulses value chains.

The food loss assessment study aimed to identify the critical loss points in the selected supply chains, the key stages at which food losses occur, why they occur, the extent and impact of food losses and the economic, social and environmental implications of the food losses. Furthermore, these studies also evaluated the feasibility of potential interventions to reduce food losses and waste.

METHODOLOGY

The assessment of post-harvest losses used the 'food loss analysis' case study methodology developed by FAO under the Save Food Initiative (FAO, 2016). The methodology followed included a preliminary screening of food losses based on secondary data, documentation and expert consultations; a survey that provided some indicative levels of food losses based on the observations, direct measurements and responses from sampled actors in the supply chain; load tracking and sampling assessment; and solution-finding (synthesis) for developing interventions to address the observed food losses. The supply chain stages observed were primary production, harvesting, transportation of beanstalks to the household, threshing and winnowing, drying of bean grains, on-farm storage and producer, bulker and wholesale sales. The involvement of men, women and children in various activities along the value chain was discussed.

The bean supply chain of Oyam district in northern Uganda was selected. After the completion of the 'Screening' phase, based on secondary data and expert consultations, a field study was conducted in Loro subcounty of Oyam district from October 2015 to February 2016. Qualitative data were collected during focus group discussions (n=45; 25 male and 20 female) and key informant interviews (n=20 respondents including farmers, traders and agricultural officers). Quantitative data were collected during analyses of samples collected from farmers and traders (n=22) and taken on-station at the National Agricultural Research Laboratories in Uganda for analysis of mechanical damage, discolouration, moisture content, presence of debris and insects. Quality aspects were tracked across 2.5 and 4 months of storage, at both farmer and primary bulkers' points at subcounty and parish level. The percentage losses are all based on estimates provided by actors in the supply chain.

Chapter 1

The beans subsector – Introduction and background

STATUS AND IMPORTANCE OF THE BEAN SUBSECTOR AND DEVELOPMENTS OVER THE LAST 15 YEARS

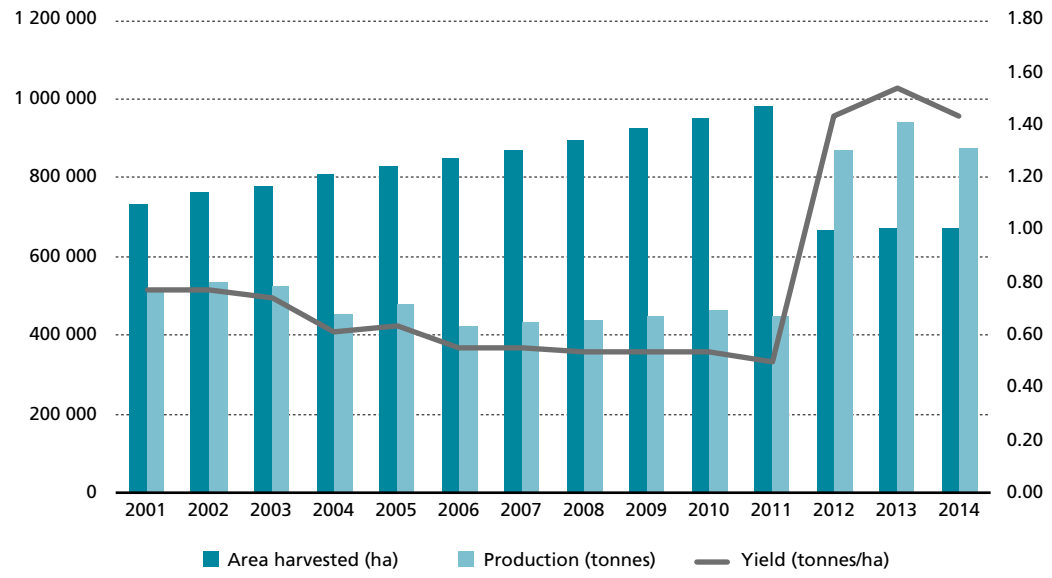
In the Republic of Uganda, bean (*Phaseolus vulgaris*) is the second most cultivated crop after maize. Over 1 million households grow bean and allocate a total of about 1 million ha of land to this crop every year. Bean production has been on the increase in Uganda. Between 2005 and 2011, dry bean production stagnated between 400 000 to 500 000 tonnes. Production rose to 869 606 tonnes in 2012, 941 182 in 2013 and 876 576 in 2014 (FAOSTAT, 2014). This made Uganda the second largest producer of beans in Africa in 2014, after Tanzania. Similarly, productivity increased from 0.5 tonnes/ha in 2011 to 1.4 tonnes/ha in 2013 and declined to 1.3 tonnes/ha in 2014 (FAOSTAT, 2014) (Figure 1.1).

The economic importance of common beans

Dry common beans were traditionally grown for home consumption but are now gaining importance as a commercial crop. From 2010 to 2013 dry bean was the agricultural commodity that was most traded informally after maize and fish (UBOS and BOU, 2013).

Beans earned the country USD 20.5 million, 21.2 million, 22.0 million and 19.3 million in 2010, 2011, 2012 and 2013, respectively (UBOS

FIGURE 1.1
Trend in common bean production and yield in Uganda, 2001-2014



Source: FAOSTAT, 2014

TABLE 1.1
Production information for the bean subsector

	Annual production (tonnes/year)[1]	Cultivated area (ha)	Average yield (tonne/ha)
Raw material (dry beans)	876 5762	674 000[2]	1.3[2]
Annual average growth over the last 10 years (%)	7.40 %[2]	0.70 %[2]	14 %[2]
Average cost of production (USD/acre)	103.4[3]		
	On-farm consumption	**Marketed**	**Other use, e.g. Seed**
Percentage of production	55.9[4]	31.6[4]	12.5[4]
	Volume (tonnes/year)	**Value (USD/year)**	
Market product #1 –fresh beans	8 769[5]	5 315 803[6]	
Market product #2 –dry beans	268 232[4&5]	211 903 482	
Number, gender, age of	**Women**	**Men**	**Total**
Producers	7 500 000	7 200 000	14 700 000

[1] Tonnes per year; [2] FAOSTAT, 2014; [3] Kilimo Trust, 2012 (Cost of production 1 acre is UGX 341 000 converted to USD using USD 1 = UGX 3 298; Tonne = Metric Tonne; [4] UBOS-MAAIF, 2010; [5] Expert opinion that less than 1 percent of beans are sold fresh; [6] Price of fresh beans USD 0.61/ kg and price of dry beans USD 0.79/kg.

FIGURE 1.2
Volume trend and value of dry beans exports from Uganda



Source: FAOSTAT, 2014

and BOU, 2013 – cross-border trade). The crop is mainly exported to the neighbouring countries of Burundi, the Democratic Republic of Congo (DRC), Kenya, Rwanda, and South Sudan (UBOS and BOU, 2013 – cross-border trade). In 2014, the Bank of Uganda (BOU) estimated foreign exchange earnings were 20 665 million for the year 2013/2014 (BOU, 2014). In fact, in January 2014, Uganda exported 74 percent of the beans traded in the region (EACBTB, 2014).

Furthermore, maize and beans were still ranked as the most traded commodities in the East African Region between January and March 2015. By 2015 calendar year, the export value of beans

TABLE 1.2
Importance of the bean supply chain at the national level

FSC #	Economic Importance H/M/L	Employment Provision H/M/L	Generation of foreign exchange H/M/L	Contribution to national food consumption H/M/L	Contribution to national nutrition/ diet H/M/L	Environmental impact H/M/L
Beans	H	H	M	H	H	L

Source: Authors' own analysis based on literature.

was an estimated USD 44.26 million, rising from USD 16.02 million in 2013 and USD 25.12 million in 2014 (http://www.bou.or.ug/bou/rates_statistics/statistics.html).

INVENTORY OF ACTIVITIES AND LESSONS LEARNED FROM PAST AND ONGOING INTERVENTIONS

The National Agricultural Research Organisation (NARO)

The National Agricultural Research Organisation through its work with the National Legumes Research Programme at the National Crops Resources Research Institute (NaCRRI) and National Agricultural Research Laboratories Institute (NARL) at Kawanda conduct research on aspects of post-harvest handling for various commodities including the common bean. Research conducted on post-harvest losses and farmers' coping mechanisms (Ebinu, 2013) indicated that farmers perceive bean bruchids to be the main constraint to storage. In this study, more than 50 percent of the interviewed farmers estimated losses to be higher than 50 percent.

The same study found that farmers practice re-drying, use of botanicals such as red pepper and tobacco leaves to control bean bruchids. The study also confirmed the relative distribution of the two bruchid species, depending on the altitude; *Acanthoscelides obtectus* dominates at higher altitudes in the eastern highlands and southwestern highlands. *Zabrotes subfasciatus* dominates in the mid north, on low, warm land (Lira and Oyam) and central humid lowlands (Mpigi). Ebinu (2013) also screened different bean varieties and found varietal differences in the response to bruchid attack. Based on his study, the programme initiated breeding activities to develop varieties that are resistant to the bruchids.

In addition, research at the NARL has found that metal silo storage reduces losses to below 2 percent after 4 months of storage. Botanical use and hermetic bags (PICS) storage has already been tested on-farm and is being promoted. Storage of beans in metal silos, on the other hand, is still being tested on-farm for wider usage. Research is still evaluating a few hermetic bags, which were perforated by the bean bruchid, *A. obtectus* at high infestation levels. Thus, alternative options for this particular bruchid, including use of the solarisation technique combined with plastic silo storage, are still being evaluated on-station.

The World Food Programme

The WFP has been at the forefront of mitigating post-harvest losses and promoting marketing of key commodities. From August 2013 to April 2014, WFP has conducted an action research trial to illustrate the benefits of improved post-harvest management procedures and the advantages of new storage technologies over traditional farming practices. The research involved the demonstration of five new storage technologies: small (<100 kg) super grain bags; small (<100 kg) zero fly bags, medium (100-150 kg) plastic silos, medium to long (540-1 200+ kg) metal silos, large (1 000+kg) and grain safes. For all participating farmers (200 farm families in Uganda), without exception, the new procedures and technologies enabled food losses to be reduced by more than 98 percent; regardless of the crop and regardless of the duration of storage (Costa, 2014). The results clearly indicated post-harvest crop losses in developing countries could be hugely reduced when appropriate capacity-development and improved farming equipment are introduced.

Following the trial WFP supported 16 600 low-income farm families through training on proper harvesting conditions, drying, threshing, solarisation, on-farm storage and provision of low cost airtight storage equipment to eradicate post-harvest losses (Costa, 2015).

THE PROCESS OF POLICY-MAKING AND CURRENT POLICY FRAMEWORK AND STRATEGY ON FOOD LOSS

The Agricultural Sector Strategic Plan (ASSP) 2015/16-2019/20 is the current guiding policy for

agricultural research and development in Uganda. The ASSP replaces the Agricultural Sector Development Strategy and Investment Plan 2010/11-2014/15 though the priorities do not vary. The priorities of the ASSP are to: increase production and productivity of agricultural commodities and enterprises; increase access to critical farm inputs; improve access to markets and value-addition and strengthen the quality of agricultural commodities; and strengthen the agricultural services institutions and the enabling environment.

Bean is one of the 12 priority commodities that have been targeted by ASSP interventions. The planned activities along the value chains for beans are:

- increase seed production, multiplication and distribution;
- facilitate information and knowledge provision through extension;
- promote mechanisation of bean production;
- promote fertilizer use and sustainable soil management;
- support irrigation technologies in bean production;
- facilitate marketing, post-harvest handling and value addition;
- strengthen the institutions and enabling environment.

The sector targets the production of 10 million tonnes by 2020. Annual exports are projected to increase to USD 63 million.

RELEVANT INSTITUTIONS AND ROLES

The common bean is an important component of agriculture and diet in Uganda. Recognising this importance, governments have increasingly invested in bean research while policy-makers are more and more interested in the impacts of these investments. The policy framework focuses on sustainable development by commercialising subsistence agriculture while ensuring food security remains a critical priority. The agricultural sector investment plans were projected to be realistic, affordable sustainable and efficient.

The Ministry of Agriculture, Animal Industry and Fisheries

The Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) established the National Agricultural Research Organisation as a key player in providing high technologies to farmers to increase agricultural productivity and income. Up until the 1990s, public sector bean research had focused on improving bean yields, but as yields improved, the selection criteria changed to include attributes such as disease-resistance, adaptability to low soil fertility, and high iron content (SPIA BRIEF, 2014). Since 1998, Uganda has released eleven improved bean varieties.

Other research and development institutions

International research centres such as the International Center for Tropical Agriculture (CIAT) and Harvest Plus are also supporting and or conducting research on common bean**.** Harvest Plus is the Consultative Group on International Agricultural Research's (CGIAR) global programme for Agriculture for Nutrition and Health (A4NH) and aims to improve nutrition and public health through development and promotion of bio fortified crops that are rich in vitamins and minerals as well as provision of global leadership on bio fortification evidence and technology. In Uganda, the programme focuses on growing iron beans and Vitamin A sweet potatoes with smallholder farming households.

The National Agricultural Advisory Services (NAADS), Operation Wealth Creation (OWC) and Prosperity for All (PFA)

In the same vein, the National Agricultural Advisory Services was restructured into Operation Wealth Creation under the Prosperity for All programme to provide support in the areas of input distribution and technical advice. Working with OWC, NAADS provides general support to farmers in the District Local Governments and supports strategic interventions through the provision of planting and stocking materials, farm machinery and implements, and equipment for value addition (http://www.naads.or.ug).

Extension services

Farmers are receiving minimal guidance and advice because of changes in extension service delivery. As a result, most farmers have not changed their farming methods and consistently obtain low yields. Apart from the extension services, other provisions such as training, research and related infrastructures are limited.

There are also a number of national and international non-governmental organizations (NGOs) such as Farmgain, CHAIN, CARITAS, etc. which are involved in outreach activities, seed supply and training on recommended agricultural practices including post-harvest handling.

TABLE 1.3
Dry beans grading standard FDUS EAS 46:2013

S/N	Characteristics	Maximum limits			Method of test
		Grade 1	Grade 2	Grade 3	
i	Foreign matter, % m/m	0.5	0.75	1	ISO 605
ii	Inorganic matter, % m/m	0.1	0.2	0.3	
iii	Other edible grains, % m/m	0.1	0.2	0.5	
iv	Pest damaged grains, % m/m	1	2	3	
v	Heat damaged grains, % m/m	0.1	0.2	0.5	
vi	Contrasting varieties %m/m	0.5	1	1.5	
vii	Broken/split % m/m	1	2	3	
viii	Discoloured % m/m	1			
ix	Total defectives grains, % m/m	2	3.5	5.5	
x	Debris, % m/m	0.1			
xi	Moisture, % m/m	14			ISO 24557
xii	Total aflatoxin (AFB1+AFB2+AFG1 +AFG2), ppb	10			ISO 16050
xiii	Aflatoxin B1, ppb	5			
xiv	Fumonisin ppm	2			AOAC 2001.04

NOTE: The parameter, 'total defective grains', is not the total sum of the individual defects. It is limited to 70 percent of the total sum of individual defects.

Source: EAC, 2013

Regulatory bodies

Regarding food quality and safety issues, it is the role of the Uganda National Bureau of Standards (UNBS) to formulate and promote the use and enforcement of standards to protect public health and safety and the environment against dangerous, counterfeit and substandard products; ensure fairness in trade and precision in industry through reliable measurement systems; strengthen Uganda's economy by enhancing competitiveness of local industries and promoting quality exports through standardisation, quality assurance, testing and metrology.

The UNBS has developed a standard for dry beans (Table 1.3). It is identical to, and has been reproduced from, the East Africa Standard EAS 46:2013 (EAC, 2013). This standard specifies requirements and methods of sampling and testing dry common beans (*Phaseolus vulgaris* Linn.) intended for human consumption. The beans are placed into three grades depending on the maximum limits allowable for each grade. Farmers and produce dealers, however, have no awareness of the existence of the standard or its use. Therefore, it is not applied. Most produce dealers use their subjective senses of sight and touch to assess whether the beans meet required moisture content, on which basis they decide what to pay farmers.

Chapter 2

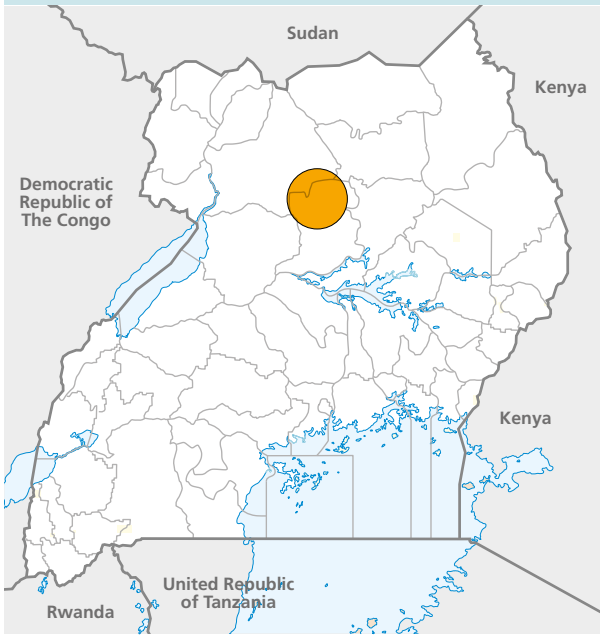
Situational analysis of the bean supply chain

THE STUDY AREA – OYAM DISTRICT

The bean supply chain case study was conducted from October 2015 to February 2016 in Oyam Town Council, and Loro subcounty in Oyam district. It follows the bean FSC from primary production, on-farm post-harvest handling and producer sales in Loro subcounty to the trading activities in Lira district. The beans are stored and sold in the dry form.

Oyam district is located in northern Uganda (02 14N, 32 23E) and is bordered by Gulu district to the north, Pader district to the northeast, Kole district to the east, Apac district to the south, Kiryandongo to the southwest and Nwoya district to the west. The district is comprised of seven subcounties: Acaba, Aber, Ngai, Otwal, Minakulu, Iceme and Loro.

FIGURE 2.1
Map showing the location of Oyam in Uganda



Location of Oyam district in Uganda

Source: UN Map Map No. 3862.1 Rev. 1 (September 2002). Department of Public Information Cartographic Section

THE BEAN SUPPLY CHAIN IN OYAM

Subsistence agriculture and animal husbandry are the main economic activities in the district. Beans are one of the eight major crops grown. According to UBOS, Census 2014, regional reports, the population of Oyam was 383 644 (187 121 men and 196 523 women) in 2014 (UBOS, 2016). Beans are grown by 86 percent[1] of the 76 615 households, who cultivate an average of 0.85 acres (0.343 ha) per household and produce 1 396 kg/ha (565 kg/acre). Total bean production is an estimated 63 098 tonnes annually.

Beans are grown in two seasons March to June and August to October. The main varieties grown include NABE series. Yields are usually 500 kg per acre, although NABE4 has been found to produce up to 600 kg. The main stages in the FSC are primary production, harvesting, transportation of beanstalks to the household, threshing and winnowing, drying of bean grains, on-farm storage and producer sales. The off-farm stages of the FSC include trade by bulkers, wholesalers, retailers and consumption in households. The bean FSC is depicted in Figure 2.2.

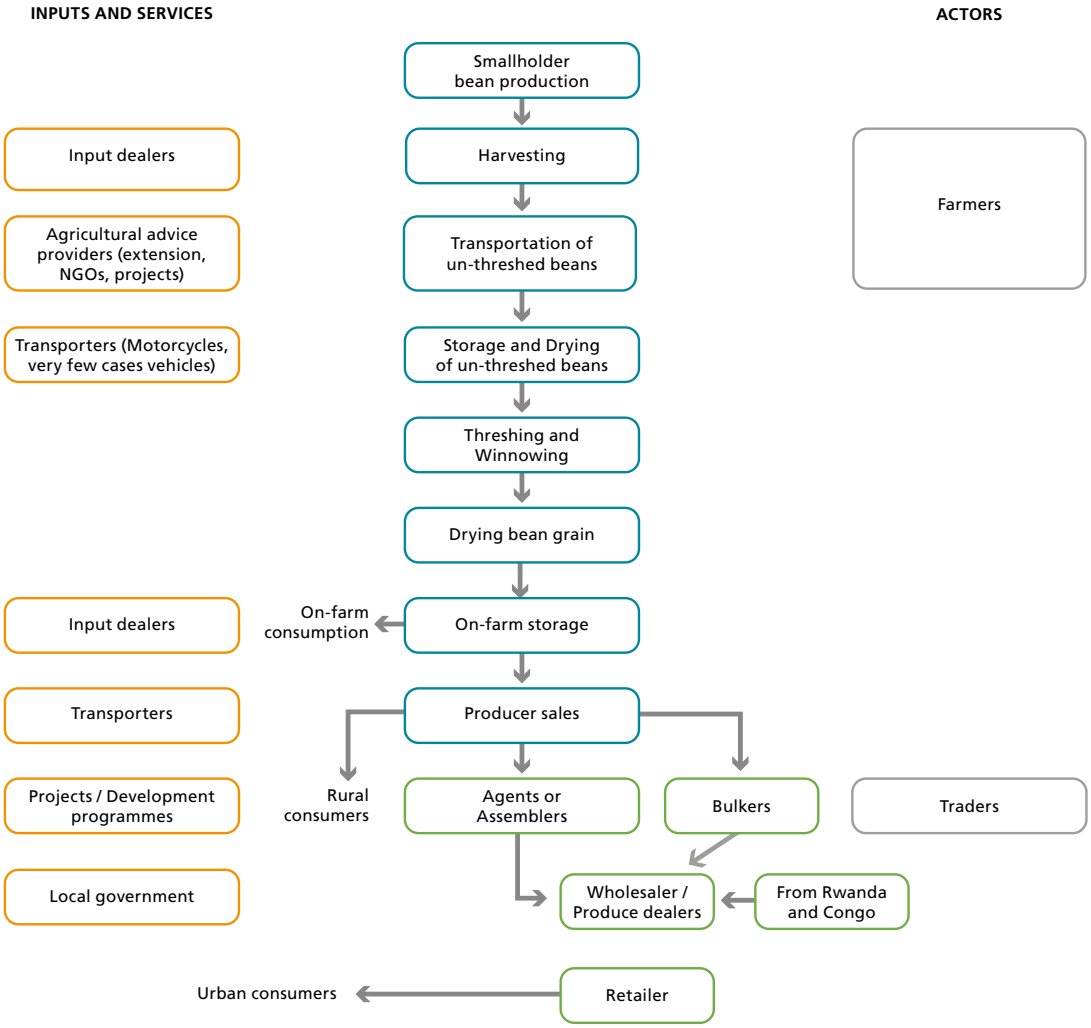
DESCRIPTION OF THE SELECTED SUPPLY CHAIN

Planting

The production activities start with land preparation where oxen are commonly used for ploughing, otherwise men plough. The average cost of ploughing is UGX 85 000/- (USD 25.77) per acre. The main varieties grown include NABE series. This variety is preferred because it has a good taste, matures quickly, is easy to cook, and

[1]Oyam Local Government (2009)

FIGURE 2.2
Oyam district bean food supply chain



Source: Authors' illustration based on literature and key informant interviews.

produces higher yields and there is a ready market. Farmers save seeds for planting or purchase seed at the market and from agro-input dealers. The study did not quantify the proportions of farmers that obtain seed from different sources. The average field size per household is 0.343 ha. Women and children mainly do the weeding and harvesting. Men were reported to do these activities only as hired labour. The average yield was 1 396 kg/ha (565 kg/acre). Farmers reported the following production constraints:

- climate change leading to unpredictable weather patterns, which tends to delay planting;
- infestation of bean by flies; and
- late delivery of seed by agro-input dealers.

Harvesting

Farmers use multiple criteria to judge the maturity of bean and readiness for harvest when most beanstalks have dried and lost their leaves, the pods change colour from green to brown and make a

noise when shaken. In practice, however, farmers tend to delay harvesting until the beanstalks are very dry to minimise the possibility of the grain rotting before threshing and to facilitate threshing. Household labour, predominantly women and children do the harvesting. Hired labour is used where the farm size exceeds 1 acre.

Transportation of un-threshed bean

The harvested beans are tied into bundles and carried to the homestead on the head, bicycle or motorcycle or vehicles (for those with farms with more than one acre). Those with larger farms (e.g. 4 to 5 acres) reported using hired vehicles such as a 2-tonne diesel dumper. Women and children mostly carry the crop on their heads and men use bicycles. Hired labour is also employed at a wage rate of UGX 5 000 (USD 1.51) for a day's labour.

On-farm storage before threshing

The un-threshed beans are heaped on an open surface, tarpaulin or on the veranda. The storage period is not long about 2 to 4 days until the remaining leaves fall off easily during drying.

Threshing and winnowing

Sticks are used for threshing while the bean pods are spread on the ground, or on stabilised or cemented drying yards or tarpaulins. After threshing the beans are winnowed by hand, mainly by women who use a winnower in small portions.

Drying bean grains

The grains are dried on a tarpaulin, uncovered ground, mats, concrete surface and rocks. The households determine when the beans are fully dry and ready for bagging by biting with their teeth, shaking the beans in their hands and listening to the sound the beans make, feeling with their hands, or seeing when the beans change colour, or they break the beans and check if the cotyledon is hard, or they push their hands through the beans in the sack. Household labour, usually women and children are engaged in drying.

On-farm storage of threshed beans

Farmers generally put beans in polyethylene bags and store them in their houses.

Producer sales

Farmers' marketing practices are described in the section on Marketing System.

Rural bulking

The rural bulkers are usually located in the townships and operate stores having a 30 tonne capacity. These traders handle up 20 bags of beans per day purchased from farmers (70%) or agents (30%). They store grain for up to six months during which time they may re-dry grain that has been kept for long. But generally they have a high turnover with grain being sold very quickly. The rural bulkers are men. The job of re-drying grain is hired out to both men and women. The rural bulkers practice minimal quality checks at purchase. The grain is bitten to check the moisture content. The cleanliness of the grain is also checked and it is turned away if it has too much stone, sand or dust particles until the farmer cleans it sufficiently.

Wholesale (Produce dealers)

The produce dealers work individually or as associations comprising of 30 to 150 members operating numerous stores. An individual produce dealer may handle up to 100 bags of beans a day and the entire produce-line 45 tonnes. Most of the grain is purchased from agents (60%) and bulkers at prices ranging from UGX 1 700 to 2 800/- per bag depending on moisture content, presence of rotten grains and contamination with dust and stones. Handling includes transportation, loading and off-loading, re-drying (when the moisture content is too high) and storage. The grains are fumigated to manage pest and rodent problems. Selling prices range from UGX 2 500/- to 2 700/-.

The basics of the bean FSC are summarised in Table 2.1. The following assumptions have been made:

- There were 10 714 households in Loro subcounty in 2014 (UBOS, 2016].
- About 86 percent of the households in Oyam district produce beans (Source: UBOS, 2011).
- The average area under bean cultivation per household in Loro subcounty in 2015 was 0.343 ha (Source: Field Sample).
- The estimated area under bean cultivation for Loro subcounty in 2015 was 3 160 ha per season (Source: 10 714 x 86% x 0.343 ha).
- Average bean yield in Loro was 1 396 kg/ha at the time of the study (Source: Field Sample).
- There are two bean-growing seasons per year.
- The above points imply that the average bean output per household in Loro subcounty in 2015 was 479 kg per season or 958 kg per year (Source: Field Sample).

TABLE 2.1
Details description of the bean supply chain (Loro subcounty – Basics)

Stage in food supply chain	Geographical Location[1]	Months of the year From	To	Main products	Quantity (kg) Per FSC actor[2]	By-products	Quantity (tonne)[3]	Duration/ 1Distance	Equipment & services	Food safety and quality controls applied by this part of the chain
Primary production	Loro	March August	June October					3 months	Seed, fertilizer Oxen Ox Ploughs Hoes Spray pumps	Home saved seed
Harvesting	Loro	June October	August November	Un-threshed Beans	958	Bean trash	8 824	1-2 month	Labour Tarpaulins Polyethylene bags	
Transportation to household	Loro	June October	August November	Un-threshed Bens	927	Bean trash	8 543	< 1 hour	Head portage Motorcycle Bicycle Vehicle	
On-farm storage of un-threshed beans	Loro	June October	August November	Un-threshed Bens	924	Bean trash	8 513	2-4 days	Labour	Beanstalks placed on the ground and some grain is contaminated with dust
Drying of un-threshed beans	Loro	June October	August November	Un-threshed beans	923	Bean trash	8 505	2-4 days		
Threshing and winnowing (TW)	Loro	June October	August November	Beans grains	921	Bean trash	8 482	1-2 days	Labour Sticks Bags Winnower Tarpaulins	Sorting
Drying of threshed beans	Loro	June October	August November	Bean grains	912		8 400		Stabilised surfaces Tarpaulins Labour Basins	Use of tarpaulins, cemented surfaces or rock surfaces

TABLE 2.1
(Continued)

Stage in food supply chain	Geographical Location[1]	Months of the year From	To	Main products	Quantity (kg) Per FSC actor[2]	By-products	Quantity (tonne)[3]	Duration/ 1Distance	Equipment & services	Food safety and quality controls applied by this part of the chain
On-farm storage of bean grain	Loro	July October	December May	Bean grains	895		8 251	1-7 months	Granaries\ uncovered ground, sacks, saucepans Pesticides Labour	Re-drying of grain as deemed necessary
Producer sales	Loro	July October	December May	Bean grains	627		5 776	4-7 months	Polyethylene bags and basins or containers	
Bulkers	Loro	July October	December May	Bean grains	286 240[4]		5 725	4-7 months	Tarpaulins Sampling spears Weighing scales Labour	Re-drying Use of storage pesticides Sorting
Produce dealers (wholesale)	Loro TC & Lira	July October	December May	Bean grains	51 540[5]		5 164	10 months	Labour Tarpaulins Polyethylene bags a	Re-drying Use of storage pesticides Sorting Winnowing

[1] Subcounty where the FSC is located; [2] Output (tonne/year) divided by the number of households in Loro that produce beans; [3] Output (tonne/year) discounted by percentage of loss at this stage of the FSC; [4] Assuming 20 bulkers that work or come into Loro; [5] Assuming 100 produce dealers.

Source: Survey data.

- Based on the above, bean output in Loro subcounty in 2015 was 4 412 tonnes per season, which translates into 8 824 tonnes per year.
- The farmgate price for beans in Loro subcounty at the time of the study was, on average, UGX 1 750/kg (Source: Field Study).
- The average currency exchange rate in 2015 was USD 1 to UGX 3 298 (*Source:* Bank of Uganda).

MARKETING SYSTEM

Marketing of beans in Oyam involves farmers, aggregators/agents; bulkers; produce dealers (wholesalers) and retailers at the trading centres and the consumers. The system includes support services from transporters, input suppliers and the local government.

The major sale seasons are June/July to August and September to October with the latter being the peak selling season. As a result of pest problems, and immediate demand for money, farmers tend to sell most of their beans within three months of harvesting. Farmers typically sell the grain to fellow farmers in the village markets, which are generally located at the trading centres, agents/aggregators and bulkers. Farmers buy from fellow farmers or retailers at the trading centres to bridge household food deficits.

The amount of beans sold may be less than 20 kg. This volume of beans is usually sold as piecemeal by women at local markets to obtain money for domestic needs. The beans are usually transported by head portage. Otherwise beans are packaged in 120 kg polyethylene bags and transported using bicycles or motorcycles to bulkers. The cost of transporting a bag of beans by motorcycle is UGX 2 000/= (USD 0.60) per bag. Farmers with larger volumes of produce from 4 to 5 acres hire vehicles.

There is no grading of beans but the buyers may discount the cost of beans by UGX 100/- (USD 0.028) per kg of beans depending on their perception of the quality of the beans. The assessment is made on the basis of the amount of dust and stones in the beans and moisture content, which is often checked by biting the beans or use of sampling spears.

The range of bean prices at the different actor levels at the time of the study have been summarised in Table 2.2. The price of beans is highly influenced by the time in the season. Prices are lowest immediately after harvest when the bean supply is abundant. The farmgate price of beans ranges from UGX 1 600/- to 1 800 /- per kg.

The rural bulkers are often located at the trading centres and buy directly from the farmers or agents. They operate stores having a storage capacity of up to 200 bags of beans and can store grain for up to 6 months. During this time no value is added except to re-dry and at this point the beans may be sorted. Rural bulkers sell to produce lines in Lira and to traders from Kampala.

The central hub for bean marketing in northern Uganda is Lira town. The produce dealers in Lira work individually or in associations of up to 150 members. Other than the beans that come from Oyam, traders in Lira also buy beans from Kitgum, Pader, Kotido, Mbale, Hoima and Kampala and from traders coming from as far away as the Democratic Republic of Congo and Rwanda. Beans are sold from the produce lines to retailers in Lira town, wholesalers from other locations, including Southern Sudan, and finally to consumers in other urban locations.

IMPORTANCE OF THE BEAN FOOD SUPPLY CHAIN TO ACTORS

Farmers and bean grain aggregators rank the common bean highly in terms of income-generation, for transporters and input dealers the value is medium. In terms of consumption, beans are ranked highly by all actors (Table 2.3).

Social structures in the bean food supply chain

The findings on the involvement of men, women and children in the different activities in the bean FSC have been summarised in Table 2.4. Men traditionally plough, and women and children are engaged in planting, weeding, harvesting, transportation, threshing, winnowing and on-farm storage. Men are sometimes involved in weeding, harvesting, and transportation as hired labour. Marketing is a male dominated activity; women are mainly involved in selling small quantities of beans at markets to obtain income for domestic use.

Bean FSC economics

Information was obtained about the FSC actors' costs of operations. The inputs considered include labour, tools, equipment and storage pesticide where applicable. At the trader level rent costs, local government dues and taxes have been considered. Any annual costs have been re-worked to reflect a seasonal cost that was calculated against the volume of produce handled in each season, in each

TABLE 2.2
Price of beans at various market points in November/ December 2015

Selling point	UGX/kg	USD/kg
Farmgate	1 600- 1 800	0.49 - 0.55
Bulk trader	1 800 – 2 200	0.55 - 0.67
Wholesaler	2 400 -2 800	0.73 - 0.85

USD 1 =UGX 3 298

TABLE 2.3
Importance of the beans supply chain for its actors

Actor in FSC #	Actor in FSC	Income-generation	Home consumption
1	Farmers	H	H
2	Bean grain aggregators (bulkers)	H	H
3	Bean grain wholesalers	H	H
4	Transporters	M	H
5	Input dealers	M	H

Source: Authors' analysis based on case study data

category: trader (bulker, wholesaler). The useful life of tools (e.g. pallets and tarpaulins) was calculated according to how many seasons each lasts. The summary of the analysis is provided in Table 2.5. In this analysis farmers' household labour was valued at the market price of hired labour and not assumed to be free. The percentage loss per 100 kg of output was factored into the cost of production. This is because each unit of bean grain lost leads to an increase in the farmers' cost of production. The cumulative cost of production per kilogram was calculated by adding the charges involved in handling a kilogram of beans at one stage of the FSC to the charges incurred at the next stage.

Environment related inputs and factors of the bean FSC

The main tools used in production, post-harvest handling and trading are listed in Table 2.6. The quantities of tools presented in the table are those required to work 0.343 ha, which is the average field size for beans in Oyam. Farmers reported using simple tools for cultivation such as ploughs and hoes. Oxen are used to pull the plough.

TABLE 2.4
Detailed description of the food supply chain – social structures

Steps in the Food Supply Chain	Involvement of women		Involvement of men		Who is mainly involved: women, men, children	Organization level of FSC actors[2]	Gender / social patterns Observations and remarks that explain the chosen qualifiers and/or give additional information
	Girls	Adult women	Boys	Adult men			
	Qualifier[1]	Qualifier	Qualifier	Qualifier			
Primary production	2	2	2	2	Men- Women	Household	Men are in charge of land preparation, women participate in planting.
Harvest	2	2	2	2	Women and Children	Household	Harvesting by women and children. Men may be involved as hired labour.
Transportation to farm	1	1	2	2	Women and Children	Household	Women and children carry harvested beans on the head. When involved men use bicycles.
Threshing, winnowing and sorting	1	1			Women and girls	Household	Women or children mainly use a stick for threshing. Men are involved only when there are large volumes.
Drying and on-farm storage	2	2	2		Women and children	Household	Women and children dry and store on-farm.
Market sales		1		2	Male	Household	Men dominate this stage, however women are involved in piecemeal marketing of small quantities of beans at local markets.
Rural bulkers				2	Male	Individual	Men dominate this activity. Women may be employed when drying of bean grain is required.
Wholesale				2	Male	Individuals	Male dominated activity. Women may be employed when drying of bean grain is required.

[1] Qualification of the equipment, conditions, access to services and training, 4: excellent, 3: good, 2: moderately good, 1: bad.

[2] f.i. Individual/Household level/Cooperative

Source: Survey data

TABLE 2.5
Detailed description of the food supply chain – Economics

Stage in food supply chain	Main product	Cost of activity at stage (UGX/ kg)	Exchange rate (USD 1 to UGX)	Cost of activity at stage (USD/ kg)	Conversion factor	Adjusted cost (USD/kg of final product)	Cumulative cost (USD/ kg)	Remarks
Primary production	Un-threshed beanstalks	92.70	3 298	0.029	-	0.029	0.029	Cost of fertilizer not included
Harvesting	Un-threshed beanstalks	24.20	3 298	0.008	-	0.008	0.037	Cost of labour, bags
Transport to Household	Un-threshed beanstalks	24.70	3 298	0.008	-	0.008	0.045	Labour costs
Storage of un-threshed beans	Un-threshed beanstalks	-	3 298	-	-	-	0.045	
Drying of un-threshed	Dry un-threshed bean grain	38.40	3 298	0.012	-	0.012	0.057	Cost of labour and tarpaulins
TW	Threshed bean grain	70.40	3 298	0.022	-	0.022	0.079	Labour, tarpaulins, bags
Storage of threshed beans	Threshed bean grain	8.95	3 298	0.003	1.00	0.003	0.082	Labour, basins, bags, pesticides
Re-drying	Threshed bean grain	8.95	3 298	0.003	1.00	0.003	0.085	Labour
Producer Trading	Threshed bean grain	16.50	3 298	0.006	1.00	0.006	0.088	Loading and transport costs
Bulker Trading	Threshed bean grain	1 819	3 298	0.552	1.00	0.552	0.640	Loading, transport,
Dealer Trading	Threshed Bean Grain	2 410	3 298	0.731	1.00	0.731	1.37	Incur costs for loading and off- loading, labour for re-drying, fumigation, equipment such as pallets. A pallet is estimated to last 6 seasons. Wholesalers incur rent charges, local government dues. These costs are broken down to a season
Key:								
TW = Threshing, Winnowing								

Source: Survey data

TABLE 2.6
Detailed description of the food supply chain – Environment

Production		**Quantity**	**Unit**
Tools, Equipment, Facilities	Ox-ploughs	1	
	Hoes	1-8	
Materials, Chemicals			
Energy	Sunlight,		
	Animal traction	1	
Water			
Land	Average area	0.343	ha
Storage		**Quantity**	**Unit**
Tools, Equipment, Facilities	Pallets	2	Number
	Polyethylene bags	10	Bags
Materials, Chemicals	Malathion dust	4 tins	Tin (1 tin= 1 bag)900gms)
	Aluminium phosphide		
Energy	Sunlight		
Transportation		**Quantity**	**Unit**
Tools, Equipment, Facilities	Motorcycle	1	Number
	Bicycle	1	Number
	Trucks	1	Number
Energy	Petrol, Diesel	1 (2 tonne)	Number
Processing		**Quantity**	**Unit**
Tools, Equipment, Facilities	Sticks	2	Number
	Winnowing baskets	3	Number
	Tarpaulins	1-2	Number
	Room in the house	1	
	Bare ground		
Materials, Chemicals			
Energy	Sunlight		
	Wind		
Water			
Wholesale, retail		**Quantity**	**Unit**
Tools, Equipment, Facilities	Moisture meters	1	Number
	Weighing scales	2	Number
	Polyethylene bags	30-40	Number
	Sampling spears	3	Number
Energy	Electricity for lighting		

Source: Survey data

TABLE 2.7
Factors considered for the environmental assessment

Factors	Description	Details
Type of production system	Mixed cropping and single cropping system	Farmers intercrop beans
Land preparation practices	Ploughing using hoes or oxen	
Fishing grounds	Not observed	
Soil quality and land degradation	Not observed	
Water regime	Not observed	
Ecosystem impacts	Not observed	
Sources of GHG emissions	Not observed	
Climatic factors	Changes in weather patterns	Delayed first rains in 2015 (mid-April) followed by a dry spell in June, which affected yields. There was a dry spell in the second season, late rains pushing planting to October.
Use of residues in the supply chain	Left in fields. Some feed discarded grains to pigs	
Re-use of food losses		

Source: Survey data

Chapter 3

The bean food losses –study findings and results

CRITICAL LOSS POINTS: TYPE AND LEVEL OF BEAN LOSSES IN THE SELECTED SUPPLY CHAIN

Data collection

The losses presented in the following section are calculated based on estimations made by the farmer and trader and their assessment of the cause of the losses.

Harvesting

Farmers estimated that they lose 3.5 kg out of every 100 kg of the final output (3.5%) during harvesting. The cause of the losses were identified as:

- Shattering (most important cause), because the period for drying the beanstalks while still in the field is too long. Farmers' deliberate practice. While the practice has good intentions, as the beans are handled some pods break open and the grain scatters on the ground during harvesting. Scattering is worse where paid labourers are employed because they do not care about the volume of beans harvested but the size of field covered.
- Un-harvested in the field (next most important cause). Beans are left unintentionally in the field because they are hidden by overgrown weeds or careless harvesting.
- Theft, as hired labourers may steal some of the harvested beans.

Transportation of un-threshed bean

Farmers estimated losses at this stage at 0.71 kg for every 100 kg of final output (0.71%). The loss is equally a result of:

- Theft, which is a result of labourers deliberately throwing beans down during transportation with the intention of picking them up later for consumption.
- Beanstalks getting stuck in bushes or falling out of the heaps as they are transported from the field. The loss is the result of the state of transportation infrastructure, narrow and bushy paths and improperly secured loads.

On-farm storage before threshing

Farmers estimated losses at this level as 0.09 kg of final output (0.09%). The loss is the result of beans spilling onto the ground from the pods. The farmers try to gather some of the grains however a qualitative loss also occurs as bean grains become contaminated after being dropping on uncovered ground.

Threshing and winnowing

The losses at this stage in the FSC were an estimated 0.97 kg for every 100 kg of final output (0.97**%**). The losses are a result of:

- Mechanical damage to the bean grains (most important). The method of threshing is fairly rudimentary (beating with sticks). The impact of the beating action during threshing damages some of the bean grains.
- Spillage occurs as the grain scatters while the crop is being beaten with sticks to release the grains from the pods during threshing. If the scattered grain is not picked up the farmer loses a proportion of the total quantity of final output.
- Weather – On occasion too much wind may blow away some grains during winnowing but farmers said these could be recovered if one was careful.

Drying bean grain

The farmers did not provide an estimate for the losses at drying. During key informant interviews it was highlighted that farmers do not dry grain well.

On-farm storage of threshed beans

Farmers estimated losses at this stage to be 1.8 kg for every 100 kg of final output (1.8%). The losses are related to:

TABLE 3.1
Summary result matrix of food losses

Stage in food supply chain	Cause of loss/reason for low loss	Type of loss Qn/Ql	Percentage lost in this process (Qn)	Percentage of product that incurred quality loss	CLP /LLP	Destination of food loss	Impact on actors in the FSC affected (men/women)	Impact in kg/ ha	Impact in USD	FSC actors' perception of loss (men/ women)	Suggested solutions
Actor: Farmer											
Harvest	Drying for too long, bean pods open when handled and beans scatter on the ground. Some beans are left un-harvested	Qn	3.20%	0%	CLP	Remains in garden	Loss of food and income	44.5	22.2	Attribute to use of hired labour and children	Training in correct agricultural practices for land preparation and correct and timely weeding
Transport from garden to home	Beanstalks are stuck in bushes and others fall out of heaps	Qn	0.35%	0%	LLP	Left along the paths	Loss of food and income	4.90	2.50		
On-farm storage before threshing	Beans spill out of the pods onto the ground. Contamination of beans when they fall to the ground	Ql/Qn	0.04%	0.04%	LLP	Farmer	Loss of income	0.62	0.31		Use of tarpaulins
Threshing and winnowing	Use of rudimentary tools (beating with sticks) that damage grain. Wind effects	Ql/Qn	0.97%		CLP	Farmer	Loss of income	13.6	6.80		Proper drying of beans; proper threshing technology, use of tarpaulins
On-farm storage	Mould contamination	Ql/Qn	1.10%	0.71%	CLP	Waste	Loss of food and income	14.8	7.40		Proper pest management during storage, proper drying, use of tarpaulins, use of pallets. Use of hermetic bags, plastic silos
Sales	Spillage from poorly secured sacs and perforations in sacs	Qn	0.88%		CLP	Ground	Loss of income	12.4	6.20		Use of intact packaging and proper sealing of bags
Actor: Trader											
Bulkers	Spillage, moisture loss (storage and drying)	Qn/Ql	1.00%		CLP	Sorted, sometimes fed to livestock	Loss in income	14	7.00		Use of intact packaging and proper sealing of bags, tarpaulins
Wholesale	Spillage, moisture loss (storage and drying), Debris, pests	QL	9.80%	0.22%	CLP	Waste	Loss in income		0		Proper drying techniques; proper store facilities and store management practices, tarpaulins, price incentives for good quality grain

Note: Qn = Quantity, Ql = Quality.

- Spillage (most important cause), which occurs because the polyethylene bags have been perforated.
- Pests and rodents (0.88%). The farmers' primary concern during storage is to limit the risk of theft and to protect the grain from rain. Farmers use their houses as storage, which does not provide the ideal conditions for storing grain. Rodents easily enter the houses rendering the grain vulnerable.
- Mould – the grain is susceptible when the sacks are placed directly on the floor.

During the focus group discussions (FGDs) farmers indicated that they address these constraints by using storage pesticides such as Malathion dust and one person mentioned aluminium phosphide. Otherwise farmers re-dry the grain when they deem it necessary.

Producer sales

Farmers estimated losses at this stage at 3.3 percent, the highest of their estimations. The losses are caused by:

- Traders manipulating measuring tools (most important cause). Most small-scale farmers cannot afford to buy weighing scales and rely on those provided by the traders. According to the farmers, the traders' scales are often manipulated to reflect a lower weight. Although this does not end up as a food loss in the FSC, it causes the farmer a monetary loss.
- The use of improper measuring tools by farmers (1.10%). Farmers lack weighing scales farmers and use improvised measures such as basins and other containers. The volume of beans claimed using these measures is often not a reflection of the actual weight of the beans being sold and does not represent an actual loss of food in the FSC. Farmers, however, loose money as they are paid less than what he or she should receive.
- Spillage (approximately 0.88 kg out of every 100 kg of final output). The spillage results from beans falling out of containers and perforated sacks.

For subsequent analysis, only the effect or loss from spillage is considered as the actual food loss.

Rural bulking

The rural bulkers estimated food loss at this level at 1 kg for every 100 kg of grain handled (1%).

- The losses are attributed to spillage (0.5%), which is caused by perforations in the sacks and improperly secured bags.
- Storage losses (0.5%) arise from reduced moisture content of the grain during storage and re-drying associated with the storage process.

Wholesale (Produce dealers)

Farmers reported the overall loss as 9.8 kg out of every 100 kg handled (9.8%). Loss factors reported at this stage in the FSC include:

- Weight loss in grain resulting from reduced moisture content (2%);
- Spillage (0.8%) during transportation, loading, off-loading and storage, which occurs during off-loading; re-bagging (some sacks tear and have to be replaced); movement of bags in and out of the store when re-drying and sacks tearing;
- Debris (4%);
- Insect pests and rodents (3%).

LOAD TRACKING AND SAMPLING METHODS

In this case study load tracking was completed at the storage stages for both the farmer and trader. On spot quality checks were made for farmers' samples stored for 2.5 months (n=7) and 4 months (n=11) from harvest. In the case of traders, load tracking was done by taking the weight (100 grams) of a grain sample and returning after eight weeks and taking the weight of the same samples and observing the changes that occurred.

Farmer level: Storage

All farmers' samples were infested with *A. obtectus* weevils at 2.5 months of storage (Table 3.2). Most farmers still stored the grain in polybags. In order to protect the grain from weevil damage some farmers mentioned they did not winnow the grain and preferred to store the beans in their husks as a method of pest management. This however, might be the cause of the observed discolouration of the grain after a few months.

Quality of trader samples after two months load tracking

The mean weight loss after two months was 2.8 percent, which indicates that traders seem to incur significant losses from grain spillage (Table 3.3). The moisture content was within the acceptable range but the level of grain discolouration was high.

TABLE 3.2
Quality of farmers' stored grain after 2.5 and 4 months of storage

Parameter	2.5 months storage	4 months storage
	Percentage of loss	Percentage of loss
Insect damage	1.4	6.3
Mechanical damage	1.2	1.5
Debris	0.3	0.4
Other seed	0.1	-
Discolouration	4.5	7.6
Moisture content	12.4	11.9
Germination	42.6	36.5

Source: Sample analysis

TABLE 3.3
Quality of traders' samples after 2 months load tracking

Quality of traders samples after 2 months load tracking	Percentage of loss from 100 grams
Mean weight loss after 2 months	2.8
Mean insect damage	2.4
Discoloured grain	8.1
Insect damage	2.4
Moisture content	12

Source: Sample analysis

CRITICAL LOSS POINTS AND IMPACT OF THE LOSSES IN THE FSC

Tables 3.4 and 3.5 summarise the study findings for the critical loss points in the FSC as analysed for Loro subcounty in Oyam. The figures indicated have been adjusted based on the definition of quantitative and qualitative food loss[2] to exclude all factors mentioned by farmers that do not qualify as a food loss according to that definition. For example, the percentage loss at harvesting was discounted from 3.5 percent to 3.20 percent, excluding loss resulting from theft of 0.31 percent. While theft represents an economic loss to the farmer it does not qualify as a food loss. Losses from threshing and winnowing are considered a critical loss point because of the effect of inappropriate threshing processes on the levels of losses at later stages (e.g. drying, storage). As already mentioned, the use of sticks for threshing breaks the grains, thus increasing their susceptibility to mould and pest contamination and rapid deterioration. Farmers also consider producer sales a critical stage as they incur monetary losses and spillage of grains that are not recovered. Moreover, losses come close to 1 percent at these two stages. Based on the farmers' estimation it was concluded that drying emerges as a low loss point (Table 3.1, Summary result matrix of food losses). This can be attributed to farmers' not being sensitive to the food safety and qualitative aspects of food losses. Traders reported that farmers do not dry beans well. Consequently traders have to dry grain incurring extra costs and grain weight losses. The mould observed in the beans is usually a consequence of contact of the beans with the ground at drying. There were no low loss points reported at the trader level.

[2] Quantitative food losses refer to the decrease in edible food mass available for human consumption throughout the different segments of the supply chain. A qualitative loss occurs when food products deteriorate in quality, leading to a loss of economic and nutritional value (FAO, 2016).

TABLE 3.4
Critical loss points at the farmer level

Stage in FSC	Cause of loss	Percentage of loss from 100 kg	Type of loss
Harvesting	Shattering	2.80	Quantitative
	Un-harvested crop	0.40	Quantitative
	Subtotal	**3.20**	
Threshing and Winnowing	Damage	0.44	Quantitative
	Spillage	0.35	Quantitative
	Wind effect	0.18	Quantitative
	Subtotal	**0.97**	
Storage	Pests	0.88	Quantitative
	Mould	0.71	Qualitative
	Spillage	0.18	Quantitative
	Subtotal	**1.80**	
Producer sales	Spillage	0.88	Quantitative
	Subtotal	0.88	Quantitative

Source: Farmer estimates

TABLE 3.5
Critical loss points and causes at the trader level

Cause of food loss	Percentage of loss all stages	Type of loss
Actor: Bulker		
Spillage	0.50	Quantitative
Moisture Loss	0.50	Qualitative & Quantitative
Subtotal	**1.00**	
Actor: Wholesaler		
Spillage	0.80	Quantitative
Moisture Loss	2.00	Quantitative
Debris	4.00	Qualitative
Pests	3.00	Qualitative & Quantitative
Subtotal	**9.80**	

Source: Trader estimates

THE IMPACT OF THE LOSSES

Extrapolation of sample findings to Oyam district

Findings of the field studies were extrapolated to obtain the overall scenario of the FSC losses for Oyam district. The following assumptions were made to estimate the district scenario.

- There were 76 615 households in Oyam district in 2014 (Source: UBOS, 2016).
- About 86 percent of the households in Oyam district produce beans (Source: UBOS, 2011).
- The average area under bean cultivation per household in Oyam district in 2014 was 0.343 ha (Source: Field Sample).
- The estimated area under bean cultivation for Oyam district in 2014 was 22 601 ha per season (Source: 76 615 x 86% x 0.343 ha).
- Average bean yield in Oyam district was 1 396 kg/ha in 2015 (Source: Field Sample).
- There are two bean-growing seasons per year.

TABLE 3.6
The impact of loss

Stage in food supply chain	Type of loss	Percentage of loss	Percentage of product that goes through this stage	Percentage loss in the FSC	Seasonal weight Loss (Tonne)	Annual weight Loss (Tonne)	USD Loss
Actor: Farmer							
Harvesting	Quantitative	2.80	100	2.80	880	1 760	933 900
	Quantitative	0.40	100	0.40	126	252	133 720
Subtotal		**3.20**			**1 006**	**2 012**	**1 067 620**
Storage	Quantitative	0.88	100	0.88	280	560	297 150
	Qualitative	0.71	100	0.71	224	448	237 720
	Quantitative	0.18	100	0.18	65	130	68 980
Sub-total		**1.80**			**569**	**1 138**	**603 850**
Threshing and winnowing	Qualitative	0.44	100	0.44	140	280	148 575
	Quantitative	0.35	100	0.35	130	260	137 960
	Quantitative	0.18	100	0.18	56	112	59 430
Sub-total		**0.97**			**326**	**652**	**345 970**
Producer sales	Quantitative	0.88	100	0.88	325	650	344 910
Actor: Bulker							
		0.50	70	0.35	111	222	117 800
		0.50	70	0.35	111	222	117 800
Subtotal		**1.00**			**222**	**444**	**235 600**
Actor: Wholesaler							
		0.80	70	0.56	177	354	187 840
		2.00	70	1.40	442	884	469 070
		4.00	70	2.80	884	1 768	938 145
		3.00	70	2.10	663	1 326	703 610
Subtotal		**9.80**			**2 166**	**4 332**	**2 298 670**
Total loss					**4 614**	**9 228**	**4 896 610**

Note: All beans that are harvested go through the farmer level stages but 70 % is sold while 30 % is retained at household level.
Losses are calculated against the volume of product that goes through the stage of the FSC.

- The above points imply that the average bean output per household in Oyam district in 2015 was 479 kg per season or 958 kg per year (Source: Field Sample).
- Based on the above, bean output in Oyam district in 2015 was 31 550 tonnes per season, which translates into 63 101 tonnes per year.
- The farmgate price of beans in Oyam district in 2015 was, on average, UGX 1 750/kg (Source: Field Study).
- The average currency exchange rate was USD 1 to UGX 3 298 for 2015 (*Source:* Bank of Uganda).

The impact of loss

The seasonal impact (loss) is computed by calculating the population of Oyam that grows beans (76 615 x 86%) multiplied by the average output per household per season multiplied by the percentage of product lost at that stage in the FSC. The findings show that through critical losses (from farmer to wholesaler), a total of 4 614 tonnes of beans is lost in a season and 9 228 tonnes in a year. This food loss translates into a financial loss of USD 4 896 610 (Table 3.6).

Chapter 4

Food loss reduction interventions, strategy and cost implications

SUMMARY OF OBSERVATIONS

The critical loss points identified during the study in Oyam district occur at harvesting (3.20%); threshing and winnowing (0.97%); storage (1.80%); producer sales (0.88%); bulker (1.00%) and wholesaler (9.80%) stages. Any losses resulting from theft, manipulation of scales and improper weighing tools were not included in these values because they do not result as a loss of food in the food supply chain. The food is transferred to another party at a loss to the farmer in terms of income. It is more important to consider the cause of losses in the food supply chain than the stage they occur. Considering the stage in the food supply chain and the cause of loss increases the possibility of drawing up effective interventions to reduce the food losses. After consideration of the critical loss points and the causes, it was observed that the real causes of food losses were as follows.

- **Inappropriate harvest practices** – farmers deliberately wait until beanstalks are extremely dry before they harvest. At this point bean pods easily break open, which results in bean grains spilling onto the ground in the field.
- **Inappropriate growing practice** – recurrent observation of bushy fields at harvest time identified that this is the result of poor ploughing before planting. Poorly ploughed fields compel farmers to weed earlier than the recommended time to prevent weeds from choking the bean plants. Second, farmers often weed the bean fields only once.
- **Inappropriate post-harvest techniques and practice** – farmers use a rudimentary technique to thresh beans from the stalks. The bean stalks are set on the uncovered ground and beaten hard with a stick to thresh out the bean grain. This causes the beans to scatter so that some grain cannot be gathered from the dust; some break beyond usefulness and the quality of the beans is compromised by contact with the unprotected ground.
- **Inappropriate storage techniques and practice** – farmers mostly keep their bean produce in their houses, which are often susceptible to pests and rodents, they are poorly ventilated resulting in dampness. Farmers also use open containers or broken plastic bags that result in easy spilling.

Further verification of the foregoing techniques and practices (through interactions and observation of farmers and traders) leads to the underlying causes.

- Lack of motivation to:
  - prepare fields well;
  - adequately care for crops especially for timely weeding.
- Inadequate understanding as to the correct time for harvesting.
- Lack of motivation to apply the necessary effort to the very end of the crop cycle.
- A general lack of concern about the quality of work and its effect on the quality or safety of food travelling through the supply chain. There is also a lack of awareness about harvesting practices, post-harvest handling and storage technologies that are available for individual and collective use.

It was noted that some of the underlying causes mentioned above are linked to broader aspects that lie beyond the agricultural sector and may not be effectively solved by limiting actions to the agricultural sector alone. For instance:

- Improving poor storage is not simply a matter of lacking the ability or there being a shortage of equipment or materials that could be used. The real matter lies in how the population generally perceives storage, which is limited to having a space to keep out thieves and inclement weather, particularly rain. People, therefore, generally ignore the use of storage to preserve quality and prevent loss to pests, rodents and spillage.

- Farmers and traders also mentioned that organizations have provided training support in the past. Some already know what should be done but seem to lack the motivation to practice what they know. Being careful and innovative to solve basic challenges without external assistance appears implausible to them.

The field study findings in Oyam district were also considered together with reviews and synthesis of assorted literature on agriculture, particularly beans, with the aim of verifying the food losses. The pattern in Oyam district is closely related to the national outlook in Uganda as a whole. For this reason, the interventions for reducing food loses in the following section are suggested to be considered with all the above.

SUGGESTED INTERVENTIONS FOR REDUCING FOOD LOSSES

The proposed interventions to reduce the identified food losses and improve FSC efficiency are summarised in Table 4.1. The loss reduction target of 80 percent is set arbitrarily. But an 80 percent reduction in critical losses in the FSC will result in a financial saving of USD 3 917 295.

IMPLEMENTATION OF FOOD LOSS INTERVENTIONS

General approach to food loss interventions

The interventions directed to reduction of food losses, as suggested in Table 4.1, should not be implemented as standalone. Rather, they should be formulated as elements to be integrated into existing national strategies for food security, agriculture, natural resources and/or economic development. This will eliminate duplication of effort and investment of financial and non-financial resources towards crosscutting aspects of national interventions. For the purpose of quick and easy visibility, the interventions are discussed in the subsections below from the level of the farmer up to the national level. Each of the interventions is placed at the level the cost will be met, even when the eventual effect is at a different level.

Implementation of food loss interventions at farmer level

Intervention

Interventions for reduction of food losses to be implemented at farmer level include:

- Adoption of appropriate harvest timing and harvesting techniques.
- Consistent use of tarpaulins when drying, threshing and winnowing.
- Adoption of modern threshing techniques scaled-down to the level of smallholder farmer.
- Use of intact storage such as hermetic bags and plastic silos.

Strategy

Small-scale farmers could afford to consistently use tarpaulins and intact storage. Scaling-down modern threshing techniques to the level of the smallholder farmer will require research to adapt existing technologies to the farmers' conditions.

Farmers are generally unconcerned about the quality or safety of the food they eat and send to the food supply chain. Some may perceive the consistent use of tarpaulins as an unnecessary inconvenience and an avoidable cost. Second, farmers do not clearly appreciate the loss incurred during storage. Proposed storage interventions may therefore be deemed as unnecessary. The sought for reduction in food losses will not come automatically. Repeated sensitisation, or awareness-raising, is advised over time to bring about a shift in perception.

Cost implication

It is important to note that while the farmer should implement interventions directed towards reducing food losses at harvest, this will require awareness of this situation to be raised. These costs should not be borne by the farmer, but by another level such as the local government (district) establishment or project. The cost implications and profitability of interventions where the cost is borne by the farmers are presented in Table 4.2. The following assumptions were used to compute the values in the Table.

- Household production per season is 479 kg. Given that there are two growing seasons per year, then the annual household output is 958 kg.
- Average producer price of beans in Oyam district is USD 0.53 per kg.
- 0.53 percent of bean produce is lost at threshing and winnowing to spillage and the wind blowing the grain.
- Use of tarpaulins can mitigate 80 percent of the losses.
- 1.80 percent of bean produce is lost to pests, rodents, mould and spillage during storage.

TABLE 4.1
Proposed Interventions and targeted loss reduction

Stage in food supply chain	Percentage of loss	Percentage of product at this stage	Percentage of loss in the FSC	Seasonal weight loss (Tonne)	Annual weight loss (Tonne)	USD loss	Cause of loss	Intervention to reduce loss	Loss reduction target	
Actor: Farmer									**Percentage**	**USD**
Harvesting	2.80	100	2.80	880	1 760	933 900	Shattering of pods of stalks	Correct timing of harvesting beans	80	747 120
	0.40	100	0.40	126	252	133 720	Un-harvested crop	Proper and timely weeding	80	106 975
Sub-total	**3.20**			**1 006**	**2 012**	**1 067 620**			**80**	
Storage	0.88	100	0.88	280	560	297 150	Pests and rodents	Proper pest management during storage	80	237 720
	0.71	100	0.71	224	448	237 720	Mould	Proper drying of beans (to correct MC on tarpaulins), use pallets	80	190 180
	0.18	100	0.18	65	130	68 980	Spillage	Use of intact storage packaging	80	55 190
Sub-total	**1.80**			**569**	**1 138**	**603 850**			**80**	
Threshing and winnowing	0.44	100	0.44	140	280	148 575	Mechanical damage	Proper drying of beans; proper threshing technique	80	118 860
	0.35	100	0.35	130	260	137 960	Spillage	Use of tarpaulins	80	110 370
	0.18	100	0.18	56	112	59,430	Effect of wind	Caution to pick up scattered grain	80	47 545
Sub-total	**0.97**			**326**	**652**	**345 970**			**80**	
Producer sales	0.88	100	0.88	325	650	344 910	Spillage	Use of intact packaging and proper sealing of bags	80	275 930
Actor: Bulker										
	0.50	70	0.35	111	222	117 800	Spilling	Use of intact packaging and proper sealing of bags	80	94 240

TABLE 4.1
(Continued)

Stage in food supply chain	Percentage of loss	Percentage of product at this stage	Percentage of loss in the FSC	Seasonal weight loss (Tonne)	Annual weight loss (Tonne)	USD loss	Cause of loss	Intervention to reduce loss	Loss reduction target	
	0.50	70	0.35	111	222	117 800	Moisture loss (drying and storage)	Proper drying techniques; proper store facilities and store management practices	80	94 240
Sub-total	**1.00**			**222**	**444**	**235 600**				
Actor: Wholesaler									**Percentage**	
	0.80	70	0.56	177	354	187 840	Spilling	Use of intact packaging and proper sealing of bags	80	150 275
	2.00	70	1.40	442	884	469 070	Moisture Loss (drying and storage)	Proper drying techniques; proper store facilities and store management practices	80	375 260
	4.00	70	2.80	884	1 768	938 145	Debris	Use of tarpaulins; provide a price incentive to farmer for good quality grain	80	750 520
	3.00	70	2.10	663	1 326	703 610	Pests and rodents		80	562 890
Sub-total	**9.80**			**2 166**	**4 332**	**2 298 670**				
				4 614	9 228	4 896 610				3 917 295

Source: Survey data

TABLE 4.2
Cost and benefit analysis of interventions at farmer level

			Tarpaulin	Hermetic bag (100 kg)	Plastic silo (above average acreage)	
	Cost centre	**Unit of measure**	**Value**	**Value**	**Value**	**Calculation**
a	Production of beans per household	kg/season	479	479	2 303	
b	Value of beans (Farmgate price)	USD/kg	0.53	0.53	0.53	
c	Loss rate	%	0.53	1.80	1.80	
d	Anticipated loss reduction	%	80	80	80	
e	Cost of intervention	USD	0.40	4.20	46.7	Tarpaulin is Per square metre
f	Depreciation period	Seasons	4	2	40	
g	Cost of investment per season	USD/season	0.10	2.10	1.20	e/f
h	Cost of operation per season	USD/season	0	0	0	
i	Total costs per season	USD/season	0.10	2.10	1.20	g+h
ia	Capacity of item	kg	40	100	500	Tarpaulin: grain spread per square meter
ib	Number of loads per season	Loads	1	1	1	(1 load/season)
ic	Throughput of Item per season	kg/season	40	100	500	ia x ib
j	Costs incurred per kg of product	USD/kg	0.003	0.021	0.002	i / ic
k	Food loss	kg/season	3	8	41	cxa
l	Economic loss	USD/season	1.40	4.50	21.6	kxb
m	Loss reduction	kg/season	2	7	33	kxd
n	Loss reduction savings	USD/season	1.10	3.60	17.3	mxb
o	Total cost incurred	USD/season	1.20	10	5.40	axj
p	Profitability of solution/ household	USD/season	-0.13	-6.40	11.9	n-o

This could be mitigated by use of hermetic bags and plastic silos.

Implementation of food loss interventions at trader level

Intervention

Interventions for reduction of food losses to be implemented at trader level include:

- Consistent use of tarpaulins when re-drying.
- Use of intact bagging materials.
- Modification of existing storage facilities to proper standards and use of wooden pallets.

Strategy

Many of the challenges traders face are because of handling practices at the farmer level. Correcting practices at the farmer level will greatly alleviate trader losses. Many traders already use tarpaulins to re-dry produce. This means that the main issue at the trader level is the standardisation of storage practices within the district and sensitisation regarding the correct handling of food and the impacts of practices on food safety. Traders are also unconcerned about the quality or safety of food and are likely to

TABLE 4.3
Cost and benefit analysis of interventions at trader level

			Moisture meter	Pallet	Store	Calculation
	Cost centre	Unit of measure	Value	Value	Value	
a	Volume of beans handled per trader	tonne/season	2 340	2 340	2 340	
b	Value of beans (Selling price)	USD/tonne	803.5	803.5	803.5	
c	Loss rate	%	1.40	1.40	1.40	
d	Anticipated loss reduction	%	80	80	80	
e	Cost of Intervention	USD	15.2	6.10	152	Cost per square meter
f	Depreciation period	Seasons	6	10	20	
g	Cost of investment per season	USD/season	2.50	0.61	7.60	e/f
h	Cost of operation per season	USD/season	0	0	1.50	
i	Total costs per season	USD/season	2.50	0.61	9.10	g+h
ia	Capacity of item	tonne	30	0.70	0.70	
ib	Number of loads per season	Loads	65	65	65	Turnover
ic	Throughput of item per season	tonne/season	1 950	46	46	ia x ib
j	Costs incurred per tonne of product	USD/tonne	0.001	0.013	0.2	i / ic
k	Food loss	tonne/season	33	33	33	cxa
l	Economic loss	USD/season	26 320	26 320	26 320	kxb
m	Loss reduction	tonne/season	26	26	26	kxd
n	Loss reduction savings	USD/season	21 060	21 060	21 060	mxb
o	Total cost Incurred	USD/season	3.00	31.2	468	axj
p	Profitability of solution	USD/season	21 060	21 030	20 590	n-o

view any effort to standardise storage practices as an unnecessary inconvenience. Food safety issues have to be spoken about together with the financial implication of the losses incurred because of improper practices.

Cost implication

The cost implications and profitability of the interventions above are presented in Table 4.3. The following assumptions were made to compute the values in the Table.

- The average amount of produce handled by a produce line per season is 2 340 tonnes. Given that there are two growing seasons per year, then the annual volume is 4 680 tonnes.
- The average trading price of beans in Oyam district is UGX 2 650 000 per tonne (USD 803.5/tonne), which translates into UGX 2 650 per kg (USD 0.80/kg).

There are two aspects pertaining to interventions into food losses during storage at the trader level,

which involve the modification of storage facilities and sensitisation of the traders to adopt proper storage facilities. While the cost of modifying the storage facilities will be borne by the trader, the cost of sensitisation is borne by the local government (district) establishment. Therefore the cost and profitability of the trader's sensitisation concerning the adoption of proper storage is addressed at the district level.

Implementation of food loss interventions at the district level

Interventions

In general terms, interventions to reduce food losses that are to be implemented at the district level are primarily sensitisation and training to address all causes of food losses at the varied points in the food supply chain.

- Sensitisation and training of farmers to encourage adoption of:
  - good harvesting and post-harvest practices and techniques;
  - proper drying and threshing techniques;
  - modern threshing techniques;
  - use of intact storage.
- Sensitisation and training of traders to encourage adoption of:
  - proper storage facilities;
  - proper drying techniques.
- Extension of adopting food loss reduction strategies as a component of agricultural extension services delivered to farmers and traders. To encourage adoption of food loss reduction strategies the extension services package could include:
  - Bringing farmers' to the realisation of losses they have incurred as a result of their practices, prior to, during and after harvest, threshing, drying and storage and how their actions directly affect their progress and income. Farmers will obtain the skills required for good agricultural practices that reduce food losses.
  - Building awareness about existing post-harvest technologies and their benefits.
  - Building the capacity of farmers' groups to facilitate appropriate communal storage, acquisition of post-harvest handling technologies and collective marketing of produce that an individual farmer or household may not be able to afford.
- Strengthening of producer organizations in terms of structuring, collective infrastructure, equipment and group marketing.
- Encouraging the development of service provision using simple techniques. For example provision of transport by means of ox-drawn and motorcycle-driven carts that could transport produce from field to home.
- Encouraging contracting between producers, technology suppliers, local distributers and agro-dealers.
- Encouraging traders who can afford to develop purpose-built grain stores, manage them well and provide good storage service on hire.
- Develop standards for post-harvest handling techniques and adopting them as district-wide by-laws. This borrows from the precedence set by Nakaseke district for maize standards.
- Popularise standards and monitor their enforcement.

Strategy

The suggested format for sensitisation and training includes:

- A 30-minute weekly programme on existing media platforms especially radio and free-to-view television channels. The programme should run for 3 to 5 years. The content of the programme should be built around well-connected story patterns that aim to transform attitudes.
- Monthly community meetings facilitated by focal persons coordinated within the district production office hierarchy.
- Enforcement of by-laws, where necessary, to persuade actors who refuse to adopt the standards.
- A collection of well-defined food loss reduction goals should be set annually based upon the assessment of progress made in each of the selected stages.

As there is the need to transform perceptions (mind-sets and attitudes) at multiple levels of the FSC, an extended capacity-building programme is proposed that combines multiple approaches and tools such as Farmer Field Schools, video and television documentaries, theatre, community radio and technical sheets.

Cost implication

The district should develop the cost implications and profitability of the above interventions. Traders have reported that the District Local Government charges UGX 500/= (USD 0.15) per bag handled by the produce line or wholesale

TABLE 4.4
Cost and benefit analysis of interventions at Oyam district local government level

			Sensitisation	.
	Cost centre	**Unit of measure**	**value**	**Calculation**
a	Volume of beans traded in district	tonne/season	22 093	Overall bean production is reported as 31 550 tonnes a season. But only 70 percent is traded. Local government can only earn revenue from what is traded.
b	Value of beans (Selling Price)	USD/tonne	803.5	
c	Loss rate	%	14.4	
d	Anticipated loss reduction	%	80	
e	Cost of Intervention	USD	0.15	
f	Depreciation Period	Seasons		
g	Cost of investment per tonne	USD/tonne	0.15	e/f
h	Cost of operation per tonne	USD/tonne	0	
i	Total costs per tonne	USD/season	0.15	g+h
ia	Capacity of item	tonne		
ib	Number of loads per year	Loads		Turnover
ic	Yearly throughput of Item	tonne/year		ia x ib
j	Costs per tonne of product Incurred	USD/tonne	0.15	i
k	Food loss	tonne/year	3 176	cxa
l	Economic loss	USD/year	2 551 665	kxb
m	Loss reduction	tonne/year	2 540	kxd
n	Loss reduction savings	USD/year	2 041 330	mxb
o	Total Cost Incurred	USD/year	3 349	axj
p	Profitability of solution	USD/year	2 037 980	n-o

dealers. An annual grain loss of 3 176 tonnes at the critical loss points throughout the food supply chain could cost the local government and revenue earnings of USD 2 551 665.

The cost implications and profitability of the interventions above are presented in Table 4.4. The following assumptions were made to compute the values in the Table.

- The average amount of produce handled by a produce line per season is 2 340 tonnes. Given that there are two growing seasons per year, then the annual volume is 4 680 tonnes.
- The average trading price of beans in Oyam district is UGX 2 650 000 per tonne (USD 803.5/tonne), which translates to UGX 2 650 per kg (USD 0.80/kg).

Implementation of food loss interventions at national level

Intervention

Interventions for reduction of food losses to be implemented at the national level include:

- Formulation of national standards for harvesting, post-harvest handling, and storage of beans covering advisory and extension services.
- Formulation of national food loss reduction policy.
- Adoption of national food reduction policy into national strategic direction.
- Strengthening the technical and operational capacities of the Agricultural Ministry's technical services.

- Strengthening intersectoral coordination at the government level.
- Mainstreaming post-harvest reduction in the formulation of future programmes and strategic frameworks (WFP, IFAD, FAO, WB…).
- Strengthening the technical and operational capacities of UBOS while taking post-harvest losses into account in data collection systems.
- Promoting scientific research (e.g. validation of peasant innovation, varieties, and new technologies).
- Strengthening the technical and financial capacities of the State services responsible for extension and monitoring.
- Strengthening the participation of local experts in knowledge sharing platforms (e.g. Community of Practice on food loss reduction at www.fao.org/food-loss-reduction).

Strategy

It will be necessary to bring together the salient findings concerning food losses for beans along with other crops and agricultural products. This will enable comparison and identification of crosscutting causes that could be addressed as a whole. However, keeping within the boundaries of this study, an overall concept for the mitigation of food losses should be prepared by a select committee at the national level. The concept should contain the strategic elements for reducing bean food losses. Each of the strategic elements should be accompanied by detailed activity sequences. The strategic elements should then be adopted as part of sector-wide national policy. The national policy could be accompanied with enabling laws and standards for implementation.

The food loss interventions in the national strategy should be divided down to district level to be adopted in ways that address the unique challenges at the community level. The district level food loss strategy should be integrated into the overall longer-term and mid-term district strategy and considered in the annual district work plans and budgets.

Cost implications

These costs have not been estimated for this study.

PART 2

Beans value chain

Replication report (2016-17)

METHODOLOGY

The methodology focuses on identifying the symptoms and causes of food loss and finding relevant solutions, using a phased '4S' approach comprising Screening (secondary research from documents, reports) and expert consultations (Annex 2); Survey (making observations and conducting interviews with the actors in the FSC); Sampling (load tracking); Synthesis (root cause analysis and solution finding). The methodology also takes into account gender and environmental, social and food safety aspects that enable the formulation of well-packaged solutions to mitigate the losses. The Survey tool (questionnaire) for farmers (Annex 3), checklist for Focus Group discussions (Annex 4) and check list for key informants (Annex 5) were developed and used. A field Case Study implementation plan was developed and followed (Annex 6).

Load tracking method

Selection of load tracking stage in the supply chain – Load tracking involved physical measurements of food losses through sampling and weighing product lost as a percentage of the total. Sampling was carried out at the farm-level (harvesting, transportation, threshing, winnowing, drying and storage) and the bulk trader level (aggregation and transportation, drying and storage). It was not possible to conduct physical or actual measurements of food losses at the wholesale and retail level of the FSC, as trade (wholesale and retail) is a continuous process whereby load-tracking is less appropriate and interferes with the business operations of the FSC actor. Nonetheless, to ascertain food losses at the wholesale and retail trade level, personal interviews of selected FSC actors were conducted.

Load tracking at farm-level – In Oyam district, load tracking was carried out at the following postproduction stages and processes of the FSC: harvesting, transportation, threshing, winnowing, drying and storage.

Harvesting – Twenty-four (24) fields were randomly sampled in five subcounties for harvest load tracking. In each field a quadrant measuring (4 x 5) m was defined and harvested by the labour provided by the family. The mix of labour included adults from the household, children or hired labour. Once the labourers declared harvesting had been completed, they were asked to collect the harvest from the quadrant and a measurement was taken. Thereafter, the research team went back to the quadrant, combed for any unharvested or uncollected beanstalks left in the field or actual beans left because of shattering of the pods. Thereafter harvested beans plus those collected by the research team were transported to the homestead, threshed and weighed separately and the potential loss was determined.

Threshing and winnowing[3] – Tracking of bean food losses at this stage of the FSC involved first, dividing the beans harvested from the research quadrants into two equal weights. One half was threshed and winnowed in the traditional way and the other half, as a control, was threshed by hand. The output from the two threshing and winnowing processes were weighed and compared to estimate the grain loss from employing the traditional method of threshing and winnowing.

Storage – In order to track bean food losses during on-farm storage, in early November 2016, 10 kg were bought from five farmers in three subcounties of Oyam district. A sample of 2 kg from each 10 kg lot was collected and taken to Kawanda Agricultural Research Station to test for basic properties such as moisture content, grain damage in line with US 46:2003. The rest (8 kg) of the sample of beans were stored in a polypropylene bag and left with the farmer to store among their produce. At the beginning of February 2017, the bean sample was retrieved from the farmers and 2 kg removed, which were taken to Kawanda Agricultural Research Station for analysis.

Urban consumer level (household) – At the urban consumer level, beans are prepared and consumed in homesteads and eateries such as restaurants. Before preparation of beans, they are sorted to remove foreign matter; other grains; shrivelled, mouldy and/or discoloured beans. To understand the level of losses at this level, the beans purchased by an owner of an eatery were tracked from the point of purchase from the retailer to preparing beans into a stew. During the tracking, the restaurant owner purchased 2 kg of beans from a retailer and took it to her kiosk for preparation. The beans were cleaned and the research team took measurements of what had been sorted out.

[3] Ideally, threshing and winnowing are two separate activities. In rural homesteads however, the two activities are jointly carried out and hence difficult to separate and attribute loss of grain to a specific activity. In this study, threshing and winnowing were tracked jointly as a naturally occurring joint activity.

Chapter 5

The bean subsector – Introduction and background

Sustainable food supply and consumption in any country such as the Republic of Uganda necessitates that the system of food production, distribution and utilisation functions seamlessly. Food shortage, hunger, and/or malnutrition in one part of the country or among a portion of the population are indicators of a malfunction in the food supply system or chain. One of the causes of food shortage, besides low production, can be the physical reduction of food (food loss) through various agents, during harvesting all the way to the kitchen. In the process of harvesting, transporting the produce from farm to home, threshing, cleaning/winnowing, drying, storing, transporting to market, wholesaling, retailing or preparing to cook food such as grains (cereals, legumes or oilseeds); some amount of food is undoubtedly lost along the value chain (Abass *et al*., 2014; The World Bank *et al*., 2011; Gustavsson *et al*., 2011; Aulakh, *et al*., 2013). Depending on the type of grain, value-addition level and cause, food losses can be minor or major (Costa, 2014).

There are several kinds of food losses including: weight loss, quality loss, nutritional loss, and economic loss (Hodges, 2012; Gustavsson *et al*., 2011; Hodges *et al*., 2011; Buzby *et al*., 2014). This study considered qualitative as well as quantitative losses simultaneously. Quantitative loss is caused by reduction in the weight of usable grain because of insects, mites, fungi/moulds and bacteria; rodents and birds, and also physical damage and changes in colour (discolouration not related to moulds); moisture content and chemical changes (FAO, 2016). The qualitative loss is caused by reduction in the organoleptic attributes and nutritive value related to attack by insect pests, mites, rodents and birds, or from handling or physical changes or chemical changes such as in fat, carbohydrates, vitamins and protein and contamination of mycotoxins, pesticide residues, insect fragments, excreta of rodents and birds and their dead bodies (Buzby and Hyman, 2012). However, when qualitative deterioration causes the grain to be unfit for human consumption and is rejected, this will amount to a quantitative loss. The quantitative loss in a post-harvest operation, therefore, is the difference between the INPUT and the OUTPUT of that operation, which is often expressed as a proportion or percentage with respect to the INPUT.

Economic loss refers to loss in monetary value of the grains as a result of all the above losses (Fox, 2013). For example, if the product is rejected because of poor quality or if it is sold at a lower price, this leads to an economic loss. Determination of low or critical loss points is an important precursor to the identification of cost-effective interventions to stem losses. This report examines the extent of, cause and solutions of bean food losses in Uganda, taking Oyam district bean FSC as a case study.

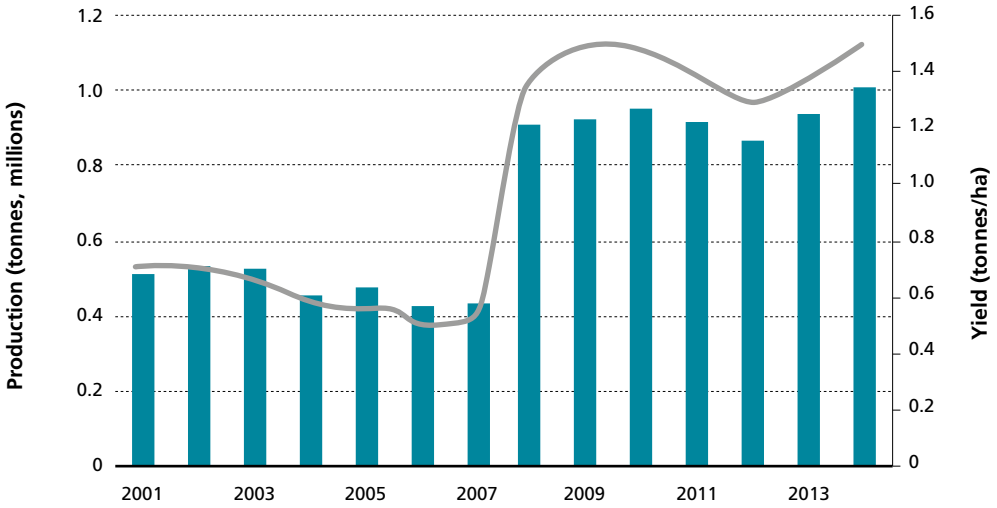
STATUS AND IMPORTANCE OF THE SUBSECTOR

In Africa, the leading producers of beans are Tanzania, Uganda and Kenya whose production volumes in 2010 were estimated at 950 000 tonnes, 455 000 tonnes and 390 598 tonnes respectively (Kilimo Trust, 2012). In 2010, Uganda was ranked second producer of beans after Tanzania in the East Africa Community Region (Kilimo Trust, 2012). Beans are the second most important crop in Uganda after maize, in terms of number of agricultural households involved in cultivation, consumption and marketing. According to the Uganda Census of Agriculture (UCA) 2008/2009[4], about 40 percent of agricultural households in the country cultivate beans.

Statistics from the Uganda Bureau of Statistics (UBOS) indicate that bean production in Uganda

[4] The UCA report was jointly authored by the Uganda Bureau of Statistics and the Ministry of Agriculture Animal Industry and Fisheries in 2010.

FIGURE 5.1
Trend in bean production and yield in Uganda, 2001–2014



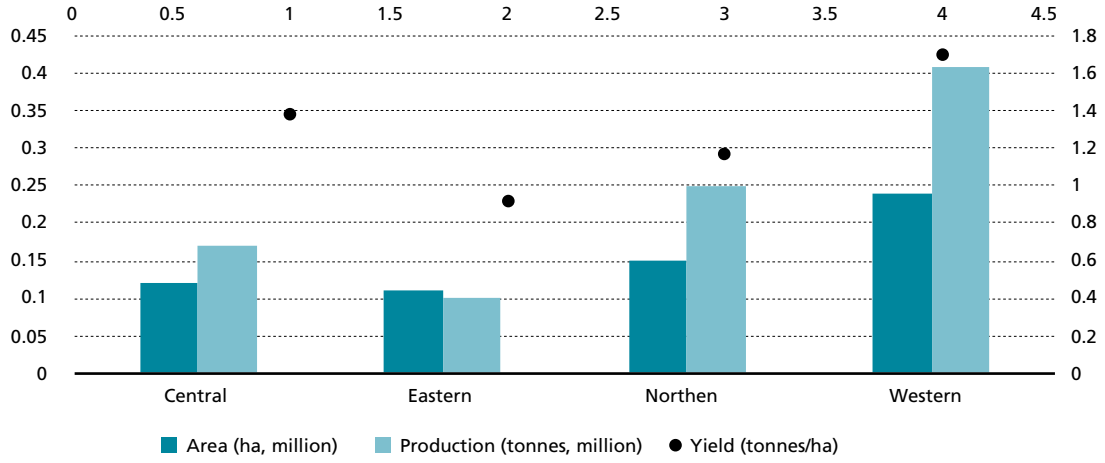
Source: UBOS

is slightly above 1 million tonnes per annum and the average yield is 1.5 tonnes/ha (Figure 5.1). The significant jump in output and yield for beans between 2007 and 2008 follows the revision of production statistics after the Census of Agriculture in 2008/2009 was conducted, which established the actual output. According to the farmers interviewed in the study, the average area under beans production ranged from 0.1 to 4 ha with an average of 0.4 ha per household (UBOS and MAAIF, 2010). NARO has produced several varieties of beans that are being promoted in Uganda. The main bean varieties, and those that are popular, are large-size beans (K131, locally known as Kawula), medium beans (K132, Kanyebwa, yellow beans), and small beans in various colours such as black, brown, white, etc. Beans are grown in two planting seasons: March to June and September to November with the highest output, 59 percent of all the beans in Uganda, being produced during this season (MAAIF, 2010). In terms of regional comparison, northern Uganda – where the case study was based, ties with western Uganda for bean yield 1.7 tonnes per hectare (ha), contributing 0.25 million tonnes (or 27%) to total bean production in the country (Figure 5.2).

Nutritional importance of beans – Beans are a staple crop that is consumed by most households across the country. Beans provide 25 percent of the total dietary calorie intake and 45 percent of the protein in Uganda. They are also a major source of complex carbohydrates, essential micronutrients, dietary fibre, Vitamin B and antioxidants in the nutritionally challenged diets of both the rural and urban poor. Beans are prepared and consumed fresh as well as when they are dry. At the national level, beans are a staple food at national institutions such as schools, hospitals and the security forces (army, police and prisons).

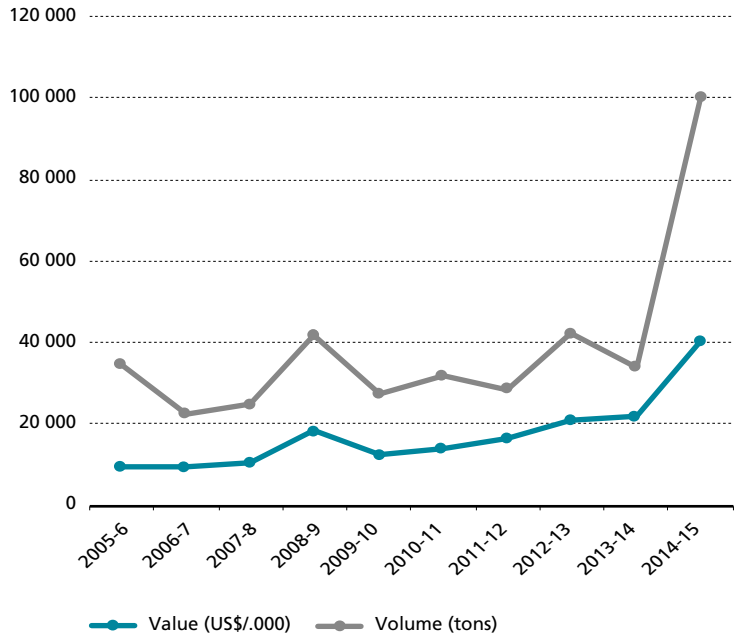
Economic Importance of beans – Beans are the second most important non-traditional export crop in Uganda, after maize. According to the International Trade Centre (ITC) trade map (accessed 26 February 2012), Uganda is a significant net exporter of the common bean and this creates competition for the domestic market and, combined with low production growth, leads to increased prices on the local market. The demand for beans is on the rise against declining production, as the yields are significantly lower than their potential. Figure 5.3 shows the trend for volume and value of dry beans exports from Uganda for the financial years 2000/2001 to 2012/2013. The trend indicates that for the past decade, the export volume and value of Uganda's dry beans has increased consistently. The main export destinations for Uganda's beans are the East African countries: Kenya, South Sudan, Rwanda, Tanzania, Burundi and the DRC (Kilimo Trust, 2012). Kilimo Trust further notes that Uganda exportsabout 20 percent of what is

FIGURE 5.2
Bean production in Uganda by region 2008/2009



Source: MAAIF, 2010

FIGURE 5.3
Trend in volume, value and price of dry beans exports from Uganda

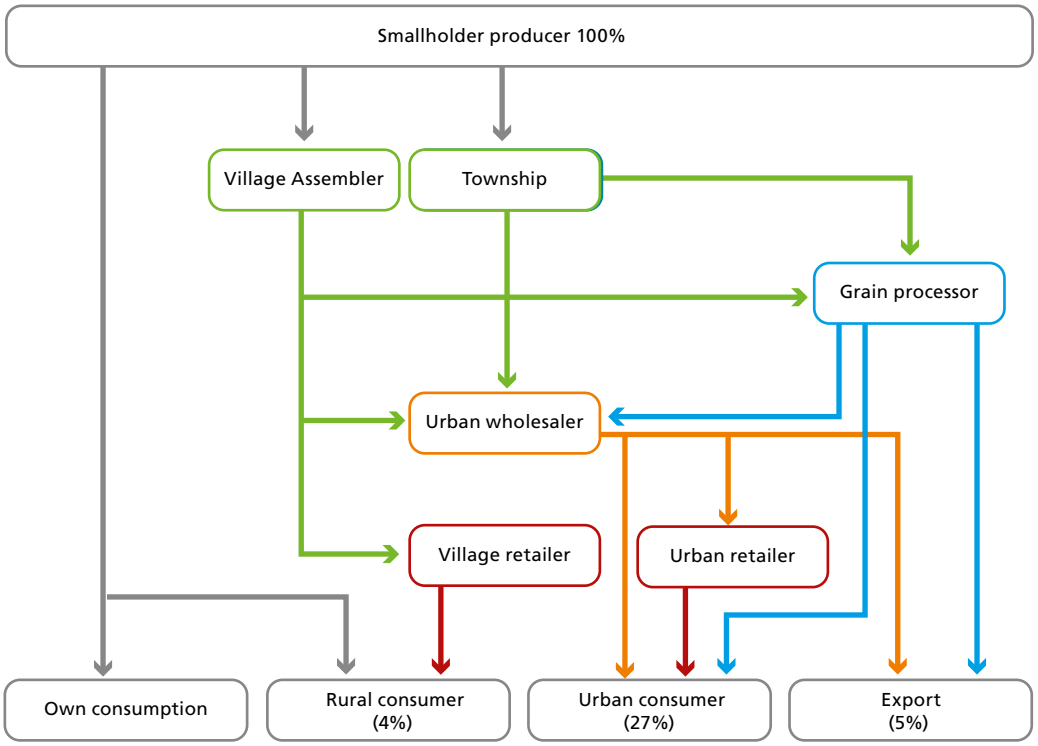


Source: "Background to the budget reports" from 2010/11 to 2015/16 financial years (Retrieved from: www.budget.go.ug/budget/library

produced, meaning that most of the beans are traded and consumed locally.

The flowchart in Figure 5.4 shows two important product 'channels' for the bean supply chain in Uganda, notably the integrated smallholder farmers and traders. It shows the bean value chain path in detail as it moves from producers to the end consumers. The Figure also indicates that smallholder farmers consume almost two-thirds of the beans produced (on-farm consumption). The surplus is sold through three main channels: village assemblers taking the bulk (60%) of the

FIGURE 5.4
Flow chart of the bean food supply chain – actors and product flow in Uganda



Source: Authors' own illustration based on literature and field survey

surplus, township assemblers taking 35 percent and neighbours taking the rest (5%) directly from farmers. Several actors participate in the value-addition process and the role played by each is explained in the following sections.

Farmers/Producers – Farmers who own a land-holding of less than 2 ha are considered as small farmers and the remaining are broadly classified as medium or large farmers. In bean production, about 98 percent of the farmers are small. Most farmers retain about 64 percent of the beans for personal consumption. The bean value chain is fragmented with little horizontal or vertical coordination among the players and, probably, this leads to inefficient marketing of produce and high transaction costs. Farmers sell the remaining produce in an unorganized manner through traders/village/township assemblers. Often farmers sell their produce immediately as they are in need of cash.

Traders – Village and township assemblers are largely speculators who buy from farmers and sell to wholesalers and grain processors for a margin. Village assemblers, at times, also sell small quantities to village retailers. Large wholesalers also contribute to exports. Urban wholesalers sell most of their stock to urban retailers and to the military, hospital and schools (urban consumers). Urban retailers generally supply ordinary urban consumers. In terms of share of consumption, it is estimated that 5 percent of Uganda's total bean production is exported, 27 percent is consumed by urban residents and 68 percent by rural dwellers either directly on-farm or after purchase.

Grain processors – Processors procure raw material through traders and process them into value-added products thus ensuring broad use of the

TABLE 5.1
National production information of beans

Year (2014)	Annual production (tonne/year)	Cultivated area (ha)	Average yield (tonne/ha)
Raw material	1 010 000	670 000	1.5
Annual average growth over the last 10 years (Percentage)	9	-1	15
Average cost of production (USD/tonne)	150		
	On-farm consumption	**Marketed**	
Percentage of production	65	35	
	Volume (tonne/year)	**Value (USD/year)**	
Market product #1 –fresh beans	101 000	25 250 000	
Market product #2 –dry beans	909 000	227 250 000	
Number, gender, age of	Women	Men	Total
Producers	7 500 000	7 200 000	14 700 000
Traders #1 small			
Traders #2 medium	50		
Traders #3 large	5		
Retailers #1 small	NA	NA	NA
Retailers #2 medium	NA	NA	NA

**Data on the number of people working in the Bean FSC that is disaggregated by age is not available

***NA indicates data not available

Exchange rate in 2014: USD 1 = UGX 3 400

**Source:* UBOS and MAAIF, 2010: agricultural census report.

produce. There are over 20 grain processors in the country with facilities that clean and store grains – mainly maize and beans. (The list of grain processors that are members of the East Africa Grain Council (EAGC) is available at http://eagc.org/membership/list-of-members/). Prominent grain processors in Uganda include: Uganda Grain Traders, Ugeri Traders ltd, AFRO-KAI Ltd, Aponye, Export Trading Co (Uganda) Ltd. Grain processors sell most of their stock to institutions such as the military, hospitals and schools (part of urban consumers), wholesalers and for export.

National production information on the bean subsector

Table 5.1 provides an outline of some key information points with respect to bean production in Uganda. Costs involved in land preparation, purchase of inputs, harvesting and threshing are the broad heads covered under the calculation of the average cost of production. The average cost of production cited below is calculated for Uganda during the years 2008 to 2010.

Bean food safety management mechanisms

The major food safety risks are contaminations during processing (drying, threshing) and insects/insecticides during storage. Table 5.2 captures the situation in detail of the food safety mechanisms that are in place at different levels of the bean supply chain in Uganda. While there are defined quality standards that are prescribed at different levels, the quality tests and review procedures on the ground are extremely minimal and are based on sensory inspection. There is a lack of maintenance of basic hygiene standards at the processing level, for example bean drying and threshing is done on uncovered ground thus attracting contaminants and grit. The extension services are almost non-existent, and there are no regular Government audits. This situation is further compounded by the lack of awareness of global standards for processing for example Good Handling Practice (GHP), Good Agricultural Practices (GAP), and Hazard Analysis and Critical Control Points (HACCP), or the East African Standards (UNBS, 2016). Currently, there are no incentives in place to encourage the maintenance of standards of high quality.

TABLE 5.2
Beans food safety/quality management mechanism

Controller	Control	Actual situation in the FSC		Responsible agent
Government regulation and requirements	National food safety/ quality standards	Exists and applies to whole FSC	No	UNBS
		Exists but not rigorous	Yes	
	Frequency of checking (None, Low, Medium, High)	Harvest	None	
		Transport	None	
		Drying	None	
		Threshing	None	
		Storage	None/Low	UNBS, Private firms such as Audit Control Expertise (ACE)
		Market	None/Low	Produce marketing board
	Obligatory registration of food processing/ preparation unit	Exists	No	
		Doesn't exist	Yes	
FSC actors food safety management system	GHP/GAP/HACCP voluntary standards		None	
	Identification and potential hazards		None	

Note: GHP = Good handling practices, GAP = good agricultural practices, HACCP = Hazard analysis and critical control points

INVENTORY OF ACTIVITIES AND LESSONS LEARNED FROM PAST AND ONGOING INTERVENTIONS IN SUBSECTOR LOSSES

There are few examples of activities or interventions that have specifically addressed bean food losses in Uganda. The most distinctive perhaps being the World Food Programme (WFP) project; the seed companies; the grain processors and regional economic bodies. Between 2013 and 2015, the WFP supported over 16 000 farming households in Uganda, especially in northern Uganda; providing them with training (better ways to harvest, dry, thresh, and store crops); and subsidised air and water tight storage technologies to effectively protect against insects, rodents, mould, and moisture and on-farm support. The post-harvest handling storage technologies include: medium (100 – 150 kg) plastic silos; medium and/ large (540 – 1 200+kg) metal silos; small (<100 kg) zero fly or PIC bags; large (1 000+kg) grain safe; and tarpaulins.

There are also grain processors and exporters that buy produce in bulk and fumigate to control pests in a consignment. These include Agroways Ltd, Savannah Commodities Ltd, Afro-Kai Ltd, Aponye (U) Ltd, Produce and Export Ltd, etc.[5]. Uganda enjoys multiple memberships to regional economic bodies that provide opportunities for entry to regional markets where large volumes of beans are purchased before significant losses can occur in storage. The bodies include the East African Community (EAC); Common Market in Eastern and Southern Africa (COMESA); Southern Africa Development Cooperation (SADC); New Partnership for Africa's Development (NEPAD); Comprehensive Africa Agriculture Development Programme (CAADP); and Inter-Governmental Authority on Development (IGAD). The main challenge to the full cooperation of trading blocks still lies in some countries having multiple memberships and weak economies' fear of being flooded with goods from larger economies such as South Africa, Kenya and Egypt.

Uganda has recorded steady progress in bean production for the past 10 years (UBOS, 2001-2014). There has been a substantial increase in the area under the crop, production as well as productivity. Though the crop is grown in all

[5] The full list of companies that export grain from Uganda is available at http://eagc.org/membership/list-of-members/.

FIGURE 5.5
Selected post-harvest technologies promoted by WFP in Uganda



PHOTO 1,2 ©FAO/MIREILLE TOTOBESOLA *©PICS3 PROJECT*

Source: Costa, 2014

districts in Uganda, the districts of western and northern Uganda are dominant (MAAIF, 2010). The principal reason for the increase in production is the introduction of a range of high-yielding and disease/pest tolerant seed varieties including: K131 and K132 (Nambale) with different sizes (short and small-seeded beans) and various colours such as yellow, black, brown, white, which have been developed by NARO and promoted in Uganda. There are also a few seed companies including Victoria Seeds Ltd; East African Seed Co. Ltd; FICA Seeds that produce certified seeds of improved varieties.

With funding from the African Development Bank for Community Agricultural Infrastructure Improvement Programme (CAIIP), the Uganda Government is rehabilitating and constructing rural roads to improve transportation of agricultural products from rural to urban areas. However, poor farm mechanisation, poor collective pest management and marketing, and the absence of warehouse receipt financing systems remain great challenges.

THE PROCESS OF POLICY-MAKING AND THE CURRENT POLICY FRAMEWORK OR NATIONAL STRATEGY ON SUBSECTOR LOSSES

Specific policies are lacking regarding bean production in Uganda. The current policy guiding Uganda's agricultural sector research and development is the five-year Agricultural Sector Strategic Plan (ASSP) 2015/16 – 2019/20. This plan is the successor to the Agricultural Sector Development Strategy and Investment Plan (DSIP) 2010/11 – 2014/15. In terms of strategic focus and implementation structure, the ASSP is not much different than the DISP and is largely an extension. For the 5-year period, the ASSP four priority areas of focus are to a great extent similar to those of the DSIP (Table 5.3).

Specific to the beans subsector, the ASSP medium-term (by 2019/2020) production and productivity targets are to double bean yield from 1.4 to 2.5 tonnes/ha; increase production from 0.9 to 1.5 million tonnes; and increase exports from 35 000 to 100 000 tonnes.

TABLE 5.3
Priority areas for the agricultural sector strategic plan, development strategy and investment plan

ASSP Priority Areas (Current)	DSIP Priority Areas (Predecessor)
1. Increasing agriculture production and productivity.	1. Increasing agricultural production and productivity.
2. Increasing access to critical farm inputs.	2. Increasing access to markets and value addition.
3. Improving agricultural markets and value addition for 12 prioritised commodities including beans.	3. Creating an enabling environment for the private sector in agriculture.
4. Strengthening Institutional capacity of MAAIF and public agricultural agencies.	4. Strengthening agricultural institutions at the centre and in local governments.

Source: MAAIF, 2010, DSIP 2010/11–2014/15 (MAAIF, 2010) and ASSP 2015/16 - 2019/20 (MAAIF, 2015).

Under ASSP Priority Area 3 (Improving agricultural markets and value addition for the 12 prioritised commodities), the Government of Uganda plans to promote collective marketing and establishment of community stores to facilitate commodity bulking to reduce post-harvest losses in general. Nonetheless, there are no specific interventions in the ASSP that are geared towards quantifying food losses, understanding the causes and putting in place interventions to stem losses. The recently concluded DSIP did not include specific interventions to address food losses in general and beans food losses in particular.

However, there are supportive policies, strategies and frameworks but they are generic in nature such as: Prosperity for All (PFA), which is a programme that was derived from the National Resistance Movement (NRM) ruling government manifesto of 2006. The cardinal principle of PFA is to identify and support economic enterprises that will enable households to earn daily, periodic and long-term incomes, with a target of UGX 20 million per household per year. To achieve the PFA vision, all government agencies and local governments must implement existing programmes in an integrated manner and with a high level of efficiency in order to bring about economic transformation, especially in rural areas.

African Heads of State endorsed the **Comprehensive Africa Agriculture Development Programme (CAADP**) in 2003 in the 'Maputo Declaration', which forms the African agenda for agricultural development. The CAADP has four thematic pillars, which are sustainable land and water management; infrastructure and market access; food security and research. Uganda signed its CAADP Compact in March 2010. Doing so commits the Government of Uganda to the principle of agriculture led development as the main strategy for the country; pursuit of a 6 percent average annual growth rate for the agricultural sector; increasing the share of the national budget allocated to the agricultural sector to reach an eventual target of 10 percent.

Other generic policies governing agricultural production in Uganda include the Food and Nutrition Policy; National Agricultural Research Policy; Peace, Recovery, and Development Plan (PRDP); National Land Use Policy; National Water Policy; National Biotechnology and Biosafety Policy; National Policy for the Conservation and Management of Wetlands Resources. Some of the policies still in draft form include those on seed and fertilizer policy and agricultural finance strategy.

RELEVANT INSTITUTIONS AND THEIR ROLE IN TERMS OF POLICY, ORGANIZATIONAL STRUCTURE, MANDATE AND ACTIVITIES IN THE SMALL AND MEDIUM SUBSECTOR INDUSTRY SECTOR

The pertinent institutions and their roles are broadly summarised below:

The Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) is the apex body responsible for national policies and programmes aiming to achieve agricultural growth in Uganda. The current policy steering the sector is the ASSP 2015/16 – 2019/20.

Research institutions – the National Agricultural Research Organization (NARO) and Agricultural Universities – The research institutions focus on improving the complete spectrum of crop sector activities to increase agricultural productivity and income for farmers. The main focus areas include seed varieties, production technologies, farm implements and machinery, the impact of climate change, product development and value-addition and marketing. The Agricultural Universities – Makerere (MAK); Nkozi, Gulu, Kyambogo, Busitema among others; train graduates of agriculture, mechanisation and agribusiness.

The National Agricultural Advisory Services (NAADS) is a grassroots agency commissioned to provide agricultural extension services; assess requirements of agriculture inputs well in advance and to regulate their production and monitor timely supply; perform the statutory functions under various acts and regulations; ensure supply of quality inputs, i.e. seeds, fertilizers and pesticides to farmers. NAADS motivates farmers to organize themselves into production groups, marketing groups and Savings and Credit Cooperative Organisations with the motive of becoming commercial farmers. For the past 15 years, NAADS has been at the forefront of providing advice on technologies to enhance technologies, soil conservation, knowledge and skills development, marketing, storage and agroprocessing.

Plans are in place to cultivate an enabling environment that will encourage increased private sector

TABLE 5.4
Food supply chains in the subsector

FSC #	Geographical area of production	Final product	Volume of final product (tonnes/year)	Number, age and gender of smallholder producers	Market of final product, location, buyers
1	Oyam and all other districts in Uganda	Whole grain	590 850	Total: 14 700 000 Women**:51 % Men**: 49 %	Domestic market; Regional markets: EAC (informal exports to Kenya, South Sudan, Rwanda, Tanzania, Burundi, DRC), COMESA, SADC, NEPAD, CAADP, IGAD

**Data on the number of people working in the bean FSC disaggregated by age is not available

Source: Background to the Budget Reports, 2005/06-2014/15

TABLE 5.5
Importance of food supply chains at national level

FSC #	Economic importance	Generation of foreign exchange	Contribution to national food consumption	Contribution to national nutrition	Impacts on environment and climate change
1	2	2	3	3	1

Legend 1 (low), 2 (medium) or 3 (high)

participation in agricultural value chains and thus increase impact. Development of basic physical infrastructure including roads, rural electrification, communication infrastructure and energy development for improved enabling environment and institutional capacity; removal of critical constraints to private sector growth; support of opportunities to improve market efficiencies; and improvement of incentive environment for the private sector in key value chains (ASSP 2015/16 – 2019/2020).

Uganda National Bureau of Standards (UNBS) is mandated to formulate, promote and enforce the use of standards in production and trade for protection of public health, safety and the environment.

The Uganda Bureau of Statistics (UBOS) was established by an Act of Parliament (1998) and is mandated to develop and maintain the National Statistical System (NSS) and ensure production of quality official statistics.

Besides government agencies, other institutions are involved in bean research and development (R&D) and marketing activities. For example, the International Center for Tropical Agriculture (CIAT) facilitating a seed gene bank at Kawanda Research Institute and the support to the National Crops Resources Research Institute (NaCRRI) for nutritional breeding.

OVERVIEW OF THE MOST IMPORTANT FOOD SUPPLY CHAINS IN THE SUBSECTOR

Food supply chains in the subsector

Table 5.4 presents the FSC characterised by the whole grain as the final product in the bean subsector in Uganda. Kilimo Trust, 2012 noted that Uganda exports about 20 percent of what is produced, meaning that most of the beans are traded and consumed locally.

Importance of food supply chains at the national level

Table 5.5 shows the importance of whole bean grain FSC with respect to the economy, foreign exchange generation, nation's food and nutritional security and its impact on the environment. Beans are a staple crop that are consumed by most households across the country. Beans provide 25 percent of the total dietary calorie intake and 45 percent of the protein intake in Uganda (NARO, 2000). They are a key source of complex carbohydrates, essential micronutrients, dietary fibre, vitamin B and antioxidants in the nutritionally challenged diets of both the rural and urban poor. Beans are prepared and consumed fresh as well as when they are dry. At the national level, beans are a staple food at national institutions such as schools, hospitals and the security forces (army, police and prisons). Beans are the second most important non-traditional export crop in Uganda, after maize. Uganda is a significant net exporter of the common bean and this creates competition

TABLE 5.6
Economic importance of food supply chains for smallholder sectors

FSC #	Gender	Percentage of produce by*		Contribution to income-generation (Percentage share of total annual income)**				
		Small-holders	Others	Farmers	Inter-mediary	Processors (seed processors)	Whole-salers	Retailers
Whole bean grain	Total: 14 700 000 Women: 51 % Men: 49 %	99.5	0.5	80	50 %	NA	7	2

*Data on the percentages of producers that has been disaggregated by smallholder and others is the authors' own estimation based on the literature and field survey

**Data on the percentage of contribution to income-generation (percentage share of total annual income) is the authors' own estimation based on the literature and field survey

for the domestic market and, combined with low production growth, leads to increased prices on the local market.

Table 5.6 shows the importance of the whole dry bean FSC for different smallholder actors in the chain. Most farmers in the study area grow beans in both the first and second seasons. Beans are often intercropped with sunflower, maize or cassava, demonstrating that beans represent a vital crop for farmers. Apart from the above-mentioned crops the household also rears some cattle, goats and chickens, which are sold as need arises to supplement income. Intermediaries are involved in trading whole bean grain by connecting farmers to other traders, and earn as much as 50 percent of their annual income from beans. Apart from the beans they also trade in and handle other commodities such as sunflower, pigeon pea, groundnuts, rice and maize among others. The retailers, on the contrary, handle thousands of other products including cassava flour and thus the contribution of beans to their overall income is minimal.

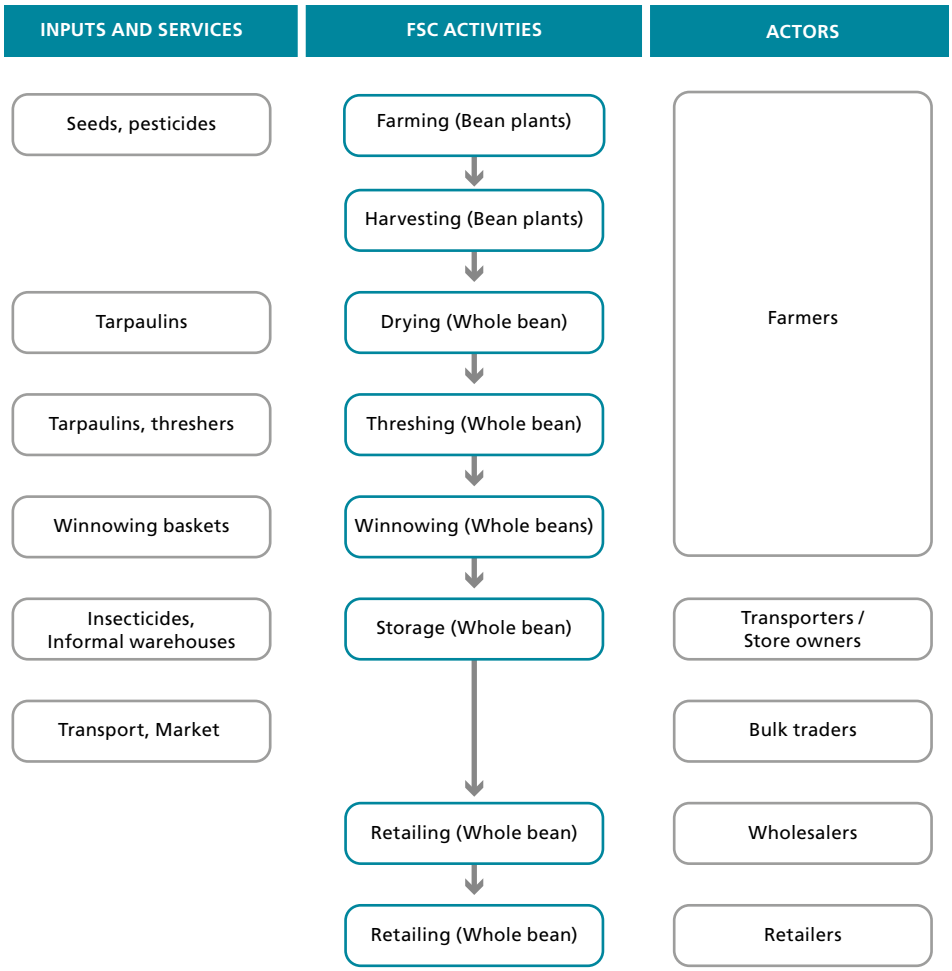
CHARACTERISATION OF FOOD LOSSES IN SELECTED FOOD SUPPLY CHAIN – CRITICAL LOSS POINTS

The Critical Loss Points (CLP) in the Uganda bean FSC, where food losses are highest, having the highest impact on food security, and the greatest effect on the economic result of the FSC is shown in Figure 5.6, which shows the actors, production inputs, and the FSC activities where losses are prevalent.

Farmers/producers – Beans are grown in two planting seasons: March to June and September to November depending on prevailing weather conditions. Land preparations start in February and August and the seeds are planted manually using a hand hoe. Occasionally, the government supplies farmers some subsidised seeds through the 'Wealth creation project'. Women in the household mainly do the weeding, manually. During harvest, the plants are manually hand-pulled and are left spread or stooked in the field to dry for 2 to 3 days. Later the plants are collected, placed on the uncovered ground and the beans are threshed with wooden sticks, of no standard size or weight. The beating helps break the pods thus releasing the grains. Winnowing is manual, using traditional baskets aided by the prevailing wind. The process blows away the chaff and broken pods, which are lighter, while the grains fall to the ground. The bean pods, with the chaff and waste, are taken back to the field. The beans are then placed into an assortment of containers such as gunny bags for storage.

Storage – Depending upon the capacity of the farmer to withhold the grain for a time so as to trade for better prices, small-scale farmers' store the produce at their homes for 2 to 3 months. Farmers normally sell bean grain immediately after threshing and drying to iterant traders and village assemblers or bulk traders. Village and township assemblers and wholesalers normally store in local stores. These are normal buildings with no humidity and temperature controls. After bagging the produce, the village assemblers transport the produce to the wholesalers either in trucks or on motorcycles locally known as *boda-bodas*. Upon receipt of the goods, random samples are taken from different bag consignments, which are collected and checked for the presence of pests and for the acceptable level of moisture content. Based on the checks, the bag consignments are either sent into storage or dried further before

FIGURE 5.6
Flow diagram of the selected FSC



Source: Authors' own illustration based on literature and field survey

storing. In rare cases, bulk traders reject the produce or buy at a reduced price. Few or no regular quality checks and stock maintenance activities are conducted in the stores.

Preliminary screening of food losses in the selected FSC

Despite the importance of bean as the evident economic, foreign-exchange earner, the nation's food and nutritional security and its impact on the environment in Uganda, scanty or no earlier studies were conducted to understand the causes of losses or to seek solutions in the subsector. In all NARO studies, post-harvest losses of grains have not been disaggregated either by cereal and legumes, or by post-harvest operations to identify the critical loss points to design solutions. Therefore, the current study is considered vital for generating critical information on losses in the subsector.

Table 5.7 was completed based on secondary literature from past studies, Internet sources and expert consultations.

TABLE 5.7
Preliminary screening of food losses in the selected FSC

FSC # 1- Whole Bean Grain			
Step in the FSC	**Expected Critical Loss Points (%)**		**Comments /Remarks**
	Qualitative	**Quantitative**	
Harvesting		4.2±0.5	Left in field un-harvested, splitting and spillage
Threshing and Winnowing		3.9±0.5	Spillage, breakage, left in pod thus precipitating food loss
Drying	3.7±0.7		Improper drying on uncovered ground resulting in soil contamination, foreign matter that precipitates food loss
Storage	8.5±0.0	6.5±0.1	Rodents and insect infestation and moulds that precipitate food loss

Data source: authors' own estimation based on literature and field survey

PLANNING THE IMPLEMENTATION OF THE SURVEY, SAMPLING AND SYNTHESIS METHODS

The implementation of this study was based on the terms of reference in Annex 1. Annex 2 illustrates the activities that were undertaken in this study, the location and the study team. For example, Screening illustrates activities involving document review and consultations with subject matter experts. *Survey* and *Sampling* methods focussed on the identified critical loss points of the FSC. The study team took into account the seasonality of production and harvesting, which fall between September to November, to organize meetings with actors in the FSC when the activities to be observed were actually taking place. Before conducting fieldwork initial contacts were made with the community through local officials, community leaders, staff of projects operational in the area, among others. Special arrangements required for interactions and interviews with women were taken into account.

Chapter 6

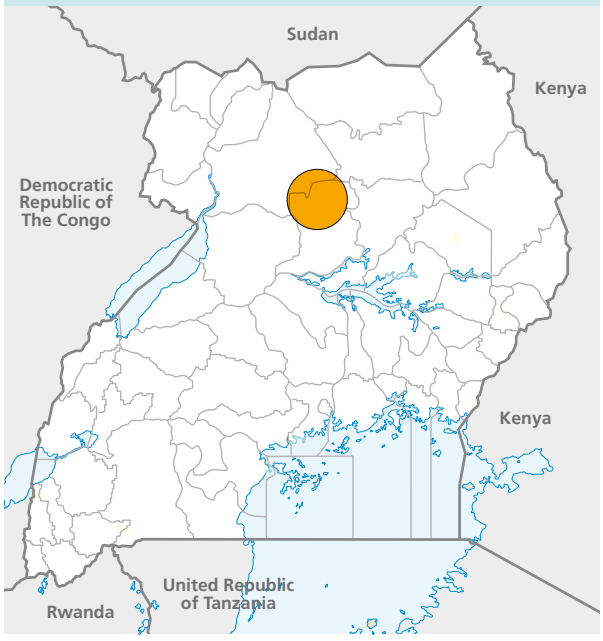
The food supply chain - Situation Analysis

DESCRIPTION OF THE SELECTED SUBSECTOR SUPPLY CHAIN

The bean food supply chain in the study area has one final product, which is whole dry bean and was considered for further analysis. This bean food supply chain case study was undertaken in Oyam district (02°14'N 32°23'E), located in the Lango subregion in northern Uganda. Oyam district is bordered by Gulu to the north, Pader to the northeast, Kole to the east, Apac to the south, Kiryandongo to the southwest and Nwoya to the west (Figure 6.1). The district is composed of seven subcounties including: Loro, Aber, Minakulu, Acaba, Iceme, Ngai and Otwal

The food supply chain is a connected series of activities for producing, transforming and distributing food (FAO, 2016). It includes a number of stages such as production, post-harvest handling, agroprocessing, distribution (wholesale and retail) and consumption. In Oyam district, the focus was mainly on the practices and activities of the postproduction phase. The case study was conducted between November 2016 and February 2017. Based on the findings, the main bean food supply chain stages, which are important in assessing losses include: harvesting; transportation (on-farm and off-farm); drying (on the pods and whole grain after threshing); threshing; winnowing; storage (in-homestead and/or in townships by bulk traders, also called speculative traders); sales (wholesale or retail) and end-use (consumption in eateries or homesteads).

FIGURE 6.1
Map of Uganda



Source: UN Map Map No. 3862.1 Rev. 1 (September 2002). Department of Public Information Cartographic Section

Product transformation and conversion factors – in the postproduction stages of the FSC the products often undergo a transformation. The conversion factor for the whole bean grain final product was determined by taking direct measurements at the different stages that calculated the quantity of the final product. Table 6.1 gives the conversion factors in the FSC.

Primary production: Based on the statistical abstract for Oyam district the population in 2013 was 336 400 (of which 163 200 are men and 173 200 women) and was projected to be 370 000 in 2016 (Oyam District Local Government, 2013). About 86 percent of households in Oyam district cultivate beans on an average of 0.34 ha per household. Bean production in Oyam district, as in many parts of Uganda, is from two seasons. The first season is from March to June and the second from July to November. Farmers in Oyam district cultivate between 0.2 to 0.6 ha of beans using proportionately 10 to 25 kg of local seed that has been kept from the previous season. Cultivation involves the use of traditional equipment such as animal traction or manual labour for ploughing/preparing the land. Plant-

TABLE 6.1
Whole dry bean grain and conversion factors in the food supply chain

Activity in the process	Duration#	Product out	Weight from 100	Cumulative (±%)
Harvesting		Bean plant	100+	-
Drying	2-3 days	Bean plant	100+	-
Threshing		Bean grain	100	-
Storage	4-6 months	Bean grain	100	-

#Only applicable for processes that are determined by a length of time independent of the quantity of product and the amount of labour, such as drying, fermenting, storage, transportation.

Data source: authors' own estimation based on field survey

ing, especially for small and medium bean grains involves family labour (women and children).

Broadcasting of seed and covering with a thin layer of soil, weeding and harvesting also largely involves household labour (women and children). In very few instances, where the head of the family is in formal employment, hired labour is employed for bean cultivation. After harvesting, drying, threshing and winnowing, the average output ranges between 150 to 250 kg with an average moisture content of 16 percent. Before storage, a portion of beans (about 30% of harvest) is set aside for consumption, the remaining beans are cleaned and put in a container such as a pot, plastic bucket or polythene bag and stored. Farmers usually store beans that have been harvested in a given season for a period of 4 to 7 months. Once farmers obtain a new harvest, they usually sell off the stock from the previous season that has not been consumed and store the new harvest. The details are presented in Table 6.2.

DESCRIPTION OF THE EXISTING MARKETING SYSTEMS IN THE SELECTED SUBSECTOR SUPPLY CHAIN, FOR SMALL-SCALE PRODUCERS (FORMAL AND INFORMAL)

In Oyam district, farmers sell beans in small amounts either from their homesteads or at local markets. Farmers sell beans from their homesteads to itinerant traders who use local equipment such as buckets for volumetric rather than gravimetric measurement. Farmers also sell beans to rural retailers and other farmers for consumption or for seed (Figure 6.3). Rural retailers sell beans to food deficit rural consumers. In local markets, farmers sell mainly to bulk traders who also use poor quality equipment for measurement such as containers instead of approved weighing scales. Usually beans are sold to raise money to purchase household basics such as salt, soap or second hand clothes or to pay school fees for children. Figure 2.3 illustrates that the household consumes 64 percent of the beans, 1 percent is sold to other people in rural areas and 2 percent to consumers in the few urban areas of Oyam district. The rest (33%) of the beans produced in Oyam are sold to wholesale traders outside the district. Itinerant traders, who also double as rural assemblers, mainly sell beans to bulk traders in townships.

In other instances, rural assemblers sell beans directly to wholesale buyers who travel around the villages in search of produce. Bulk traders, on the other hand, procure and store beans for a period ranging from 4 to 7 months as they speculate on selling at higher prices when beans are scarce on the market and are in high demand, especially towards the beginning of a school term. Table 6.3 illustrates the price of a kilogram of small seeded beans was USD[6] 0.366 at farmgate and USD 0.508 at retail in urban areas in November 2016. Most of the bulk traders are located in the townships of Loro and Kona-Kamudin in Pader, Lira town in Lira district and Gulu Town in Gulu district.

Once wholesale traders procure beans from bulk traders, there is little or no value-addition to the produce before selling to retailers. In fact the only value-addition provided by wholesale traders is transportation of the produce from rural areas and bringing it closer to retailers and urban consumers.

[6] USD 1= UGX 3 543 as of November 2016.

TABLE 6.2
Detailed description of the food supply chain– basics (n=12 producers, 3 traders)

Stage in food supply chain[4]	Geographical[5] Location	Months of the year[6]		Main Products[7]	Quantity (kg) per FSC actor	By-products	Duration/ Distance[8]	Services and equipment used	Food safety and quality controls applied by that part of the chain
		From	To						
Primary production	Loro subcounty	March July	May August	Bean plant			3 months	Oxen/animal traction	Planting own seeds
Harvesting, threshing and winnowing	Loro subcounty	June October	August November	Bean grains	151	Bean trash	1 -2 months	- Harvesting by hand - Transportation by head portage (women and children)	
Drying	Loro subcounty	July October	August November	Bean grains	145	Bean husks	1 month	Uncovered ground, rarely tarpaulin	There are food safety issues in terms of contamination by dust and grit; chances mould contamination is high, which can result in mycotoxin production
On-farm Storage	Loro sub-county	July October	December May	Bean grains	100		4-7months	- Local pots - Plastic buckets - Polythene bags - Local ash - Malathion dust	There are food safety issues as there is minimum and improper use of pesticides
Storage at bulk trader store	Loro township	July October	December May	Bean grains	25 000		4-7 months	- Polythene bags - Malathion dust - Aluminium phosphate tablets	There are food safety issues as there is inadequate and improper use of pesticides
Wholesale	Loro T/C	July October	December May	Bean grains	2 000		1-10 months	- Weighing scale - Polythene bags	
Retail	Loro T/C	Throughout the year		Bean grains	500		1-12 months	- Weighing scale - Polythene bags	

Data source: authors' own estimation based on field survey

4 If one stage in the FSC has two different features, another row should be inserted, e.g. if there is both crib and warehouse storage in the same FSC.

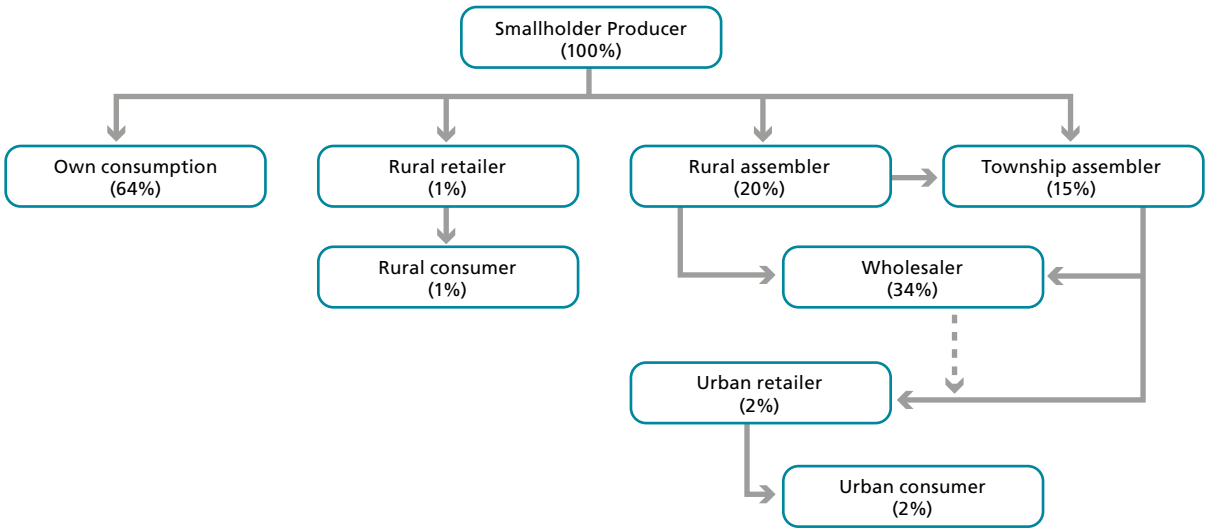
5 Village/town where the FSC stage is located

[6] Timing of the stage of the FSC

[7] 'final' product produced by stage of the FSC.

[8] How long does the process in the FSC stage take/what is the distance (and duration) of transportation.

FIGURE 6.3
Oyam district bean food supply chain



Source: Authors' own illustration based on literature and field survey

TABLE 6.3
Price of beans at various market points in Loro and Lira towns, November 2016 (all prices are in USD per kg)

Type of beans	Farmgate price	Bulk trader price	Wholesale price	Retail price
Small grain	0.366	0.395	0.451	0.508
Medium grain	0.445	0.501	0.529	0.564
Large grain	0.445	0.501	0.529	0.564

Source: Survey data, November 2016. Exchange rate was USD 1 = UGX 3 543

FSC ACTORS' INVOLVEMENT AND THEIR BENEFIT, INCLUDING JOB CREATION AND INCOME-GENERATION; ECONOMIC DATA ON THE FSC; ENVIRONMENT-RELATED INPUTS AND FACTORS IN THE FSC

The bean sector's FSC is dominated by women, where women and children harvest since men assume it is women's work. Women and adult girls are responsible for winnowing since they are 'naturally gifted'. Women and girls transport beans on their heads men and boys use bicycles. Women work from morning to sunset, planting, processing and drying beans. Men rarely help in planting and only help to clear the land.

Therefore, women and children are engaged in most of production and post-harvest activities such as weeding, planting, harvesting and transporting from the field to the homestead. Women do all the drying and threshing and storage, men do most of the marketing. The cause of men being less frequently involved across the bean FSC was observed to be a cultural characteristic. Table 6.4 provides further details on each step.

Away from the household, most of the bean retailers are women, who mostly carry their products on their head and also endure financial losses because of fluctuating prices. The proceeds from the sales of beans are, in most cases, not shared equally between men and women, as men control the money and determine the amount to give to the women. Among the traders, men own the accounts and the money goes directly into their accounts despite the fact that women sometimes participate in the sales. The study findings further revealed that most of the valuable assets

TABLE 6.4
Detailed description of the food supply chain – Social structures

FSC STEPS	Involvement of women		Involvement of men		Who is mainly involved: women, men, children	Organization level of FSC actors[1]	Gender/social patterns Observations and remarks that explain the chosen qualifiers and/or give additional information
	Girls	Adult women	Boys	Adult men			
	Qualifier[2]	Qualifier	Qualifier	Qualifier			
Primary production	2	2	2	2	Men, women	Individual, household	Men prepare the land using pangas and hand hoes. All members of the household are involved in tilling, though women doe the weeding. Pesticides and herbicides are applied by men
Harvest	1	1	2	2	Women, children	Household	Women and children undertake most of the harvesting and transportation of beans from the field to the homestead on their heads. Men and boys may help out using bicycles
Post-harvest, handling (drying)	2	2	2		Women, children	Household	Women and children in most household dry the beans. Women and children transport the beans and lay them on uncovered ground in the morning and remove them in the evening, a laborious task. Very few households dry beans on tarpaulins
Post-harvest, handling (threshing/ shelling)	1	1	1	2	Women, girls, boys	Household	Women and children thresh the beans with limited involvement of men. Beans are threshed on uncovered ground using sticks, the plants are bundled and beaten to split the pods to release the beans. Use of sticks leads to spillage and breakage of the beans
Post-harvest, handling (winnowing)	2	2	-	-	Women, girls	Household	Women and the older girls do the winnowing, because they are 'naturally gifted'. The women winnow using a purpose built traditional basket.
Storage		1		2	Women in household, men in stores	Household, Individual	Women are culturally responsible for storage of the beans at household level. Men apply the pesticides because they are more knowledgeable about pesticides and how they should be applied. Women are said to be unsuitable because chemicals may affect them negatively. Storage conditions are not very good as farmers/ traders use gunny bags that are damaged and can be easily penetrated by pests. The storage chemicals are also misused
Transportation (from house to market)		1		2	Men and women	Household	Men and women may transport but men transport using bicycles and sometimes motorcycles (hired or not). Women may carry a few kilograms to the market by head loading the beans but the
Market sales		2		2	Men and women	Household	Both men are more involved in sales. Both face problem of manipulation of weighing scales by buyers. Men control the proceeds from sales
Wholesale				3	Men and women		Wholesale trade in beans is dominated by men, many of whom have more capital than women
Retail		2			Men and women	Household, Individual	Most of the retailers are women and operate in markets in towns though a few may buy products from farmers. They carry their products to the market by head loading or may hire motorcycles

Note: Individual/Household level/Cooperative

[2] Qualify the equipment, conditions, access to services and training, [4]: excellent, [3]: good, [2]: moderately good, [1]: bad.

that would help women minimise food losses such as natural resources, mainly land, water and livestock, physical capital such as agricultural equipment/tools, bicycles and motorcycles are owned and controlled by men.

Positively, unlike other parts of Uganda such as the central region, where traditional norms prohibit women's use of bicycles, it was observed that women in various parts of Oyam district ride motorcycles and bicycles. This is an opportunity that FAO and its partners can exploit to empower women and minimise the burden of labour across the bean FSC. It was also noted that most women (except the traders or retailers) were less involved in rural bean production and marketing organizations, some must first seek permission from their husbands to join these groups, which further limits their capacity for collective bargaining and active involvement and roles in minimising losses in the FSC.

Detailed description of the food supply chain – Economics

The dry bean grain consumed by people in urban areas starts on the farm, moving through a number of FSC actors including bulk traders, wholesalers and retailers before reaching the consumer. On farms in Oyam district, bean grain production typically involves farmers who use their own resources including land, seed and family labour to produce the grain. To a limited extent, farmers rent land, buy seed and use a hired ox-plough to prepare the land and hired labour for weeding and harvesting. Once farmers produce the bean grain, some is sold to itinerant/bulk traders who travel to homes or stations in small trading centres to buy the grain. Most times, farmers store the grain for a few months for consumption and sale at a future date. At the beginning of the survey (November 2016), the farmgate price of dry bean grain was UGX 1 500 per kg (USD 0.423/kg) (Table 6.5).

When bulk traders buy beans from farm households or itinerant traders, the grain is stored for a period of 2 to 6 months. Most bulk traders hire storage space at trading centres to keep the grain. To keep the grain in good condition, bulk traders use locally available fumigants as pesticides. At the time of the survey, bulk traders were selling beans at an average price of USD 0.561/kg whereas the cumulative cost (purchase cost plus operational cost) was USD 0.501/kg – leading to a trade margin of USD 0.06/kg.

The purchase and operating costs and trade margin for the wholesalers and retailers is also shown in Table 6.5. The trade margins increase as the bean grain moves from the farm to the urban consumers.

Environment-related inputs and factors in the food supply chain

In the present case study, the authors investigated the environment-related inputs and factors in five key activities in the FSC using data from selected producers (n=14). The dry bean supply chain's impact on the environment is very much in line with any farming activity and is environment friendly as compared to other crops. The crop itself is nitrogen fixing and therefore adds nitrogen to the soil. The biomass from threshing is ploughed back into the field.

Production – The main on-farm preproduction inputs are hand hoes, *pangas*, machetes for land preparation and chemicals such as Ambush (a synthetic pyrethroid with 500 g/litre permethrin as the active ingredient) are used to clear weeds. If used inappropriately, Ambush and other synthetic pyrethroids are known to be toxic. Ambush may affect the thyroid and eventually metabolism and protein synthesis in animals such as birds, rodents, fish and amphibians[7]. A few farmers were said to be using animal traction (ox-ploughs) to clear or prepare on average between 0.8 to 2 ha for beans. Bean production is a rainfed agriculture activity. The sun is the commonest source of energy used to dry bean plants.

Storage – A wide range of containers or facilities are used for storage including warehouses, rooms converted into stores, gunny bags, polypropylene bags, PIC bags, silos (plastic and metal) of varying capacities. Farmers reserve a corner of a room in the household where the beans are stored – some even store the crop close to their sleeping areas or beds. The chemicals used in storage and fumigation are predominantly aluminium phosphide (phosphine) and local herbs (e.g. hot pepper powder or organic materials), which are accepted worldwide for storage. It was noted, however, that some farmers applied tablets of aluminium phosphide directly onto the beans, which is not safe. In addition, airtight conditions were not observed. The sun is the commonest source of energy used to control grain moisture and bruchid infestation after spreading the beans out on the ground for re-drying.

[7] See for example *Rattner, B. A. (2009). History of Wildlife Toxicology. Ecotoxicology. 18 (7): 773–783.*

TABLE 6.5
Detailed description of the food supply chain – Economics

FSC stage	Main Products	Cost of operation USD/kg	Cumulative cost USD/kg	Value USD/ kg final product	Value added/ margins USD/kg
Production (farming, harvesting, threshing, drying)	Dry bean grain	0.423	0.423	0.423	N/A
Bulk trade	Dry bean grain	0.056	0.501	0.561	0.060
Wholesale	Dry bean grain	0.028	0.529	0.615	0.086
Retail	Dry bean grain	0.035	0.564	0.705	0.141

Note: average exchange rate as of November 2016 is USD 1 = UGX 3 543

TABLE 6.6
Detailed description of the food supply chain – Environment

Production		**Quantity**	**Unit**
Tools, equipment, facilities	Hand hoes, *pangas*, slasher (land preparation)	5-10	Per ha
Materials, chemicals	Gunny bags	2	No/100 kg
	Ambush	3-5kg	kg/ha
Energy	Human labour – household members	-	-
	Animal traction – sometimes hired	-	-
	Sun light – drying whole bean plants	-	-
Water	Rain fed agriculture	-	-
Storage		**Quantity**	**Unit**
Tools, equipment, facilities	Gunnybags, polypropylene bags, PICS bags, silos (plastic and metal)	0.1-2	Tonnes per container
	Warehouses, informal closed rooms converted into stores (characterised with poor aeration and illumination)	5-15	Tonnes per room
Materials, chemicals	Malathion, 2 % Dust	40-60	gram /100 kg
	Aluminium phosphide (fumigation under sheets)	3-6	Tablets /tonne
	Dudu dust (containing carbonyl 7.5 %)	50-60g	gram /100 kg
	Local herbs (hot pepper powder)	2	kg /100 kg
Energy	Sun light – control moisture pickup and Bruchids infestation	-	-
Transportation		**Quantity**	**Unit**
Tools, equipment, facilities	Bicycle	40-75	kg /3 km distance
	Wheel barrow – hand pushed	50-70	kg /5 km distance
	Motorcycle	75-100	Kg /10km distance
	Head portage,	20-30	kg /3 km distance
	Truck	2-10	tonnes/truck
Energy	Human muscle power	-	-
	Diesel	3-5	Litres /tonne
	Petrol (motorcycles)	3-5	Litres /tonne

TABLE 6.6
(Continued)

Processing		**Quantity**	**Unit**
Tools, equipment, facilities	Flails for threshing	3-5	Numbers
	Winnowing basket	2-3	Numbers
	Tarpaulin	1	Numbers
	Basin	1-2	Numbers
	Brooms	1-3	Numbers
Energy	Human muscle power	-	-
	Solar	-	-
	Wind	-	-
Wholesale, retail		**Quantity**	**Unit**
Tools, equipment, facilities	Shops/outlets, storage containers	8-10	Square meter
	Warehouses/Storage rooms	10-25	Square meter
Energy	Electricity	-	-

Transportation – Head portage is the commonest means of carrying bean consignments. Farmers will also use wheelbarrows, bicycles, motorcycles (*boda-bodas*), while traders use pickups and trucks of varying tonnage.

As for the factors related to the environmental assessment, the authors investigated the production systems, land preparation practices, fishing grounds, soil quality and land degradation, water regime, ecosystem impacts, sources of greenhouse gas (GHG) emissions, climatic factors and utilisation of residues in the supply chain among others (Table 6.7).

Table 6.7 shows that the producers in Oyam district had single, mixed and intercropping bean production systems they said helped to avert risk. Land is prepared using pangas, hoes, axes and sometimes oxen are used. Most producers interviewed in semi-structured household interviews (SSHIs) (75%) said they plant single varieties, although field-level observations revealed that many had intercropped their beans with maize, beans, cassava, cotton and sorghum. Burning of biomass, slash and burn and tree cutting were said to be common in the two subcounties of Oyam and Minakulu, and this could be contributing to land degradation. Deforested and slash and burn areas, resulting from the careless activities of some farmers and some land owners trying to clear land for farming, provide natural sources of GHG emissions. The water regime is such that the water supply changes with the season and farmers complained about a recent long drought that increased water stress and reduced the water available for humans and livestock.

TABLE 6.7
Factors in the environmental assessment

Factors	Description	Details
Type of production system	Single variety, mixed variety and intercropping with sunflower, maize, cassava etc. are common	Farmers have been encouraged to intercrop or plant mixed varieties to mitigate risk. Many have small pieces of land (0.4 to 0.8 ha) they want to use more intensively
Land preparation practices	Burning is still common although many open up or prepare land using machetes, *pangas* and hoes. Land is commonly prepared in the dry season or before the on-set of rains	Burning destroys vegetation and the micro-organisms in the soil, yet these are crucial for the germination of the crops or beans in particular. Farmers in Oyam district should be discouraged from employing this practice
Soil quality and land degradation	Some areas have sandy loams and loam soils. Some farmers leave their land fallow	The loam soils are slightly more erodible than sandy loams depending on the location and other soil characteristics; fallowing, crop rotation and fertilizer application by the farmers could reduce on degradation
Water regime	Changes with season. More water is available after the first rains	It is high in the rainy season and reduces in the dry season Droughts hinder crop yields
Ecosystem impacts	Tree cutting is common and bush burning	Some farmers think that bush burning prepares their land well for the coming season. Tree cutting and bush burning causes deforestation and contributes significantly towards GHG emissions and global warming.
Sources of GHG emissions	Degraded soils, deforested areas and slash and burn areas	Some farmers are said to undertake these practices out of ignorance. Soil degradation causes further deforestation as new land is opened. Soil degradation can also increase the use of inorganic fertilizers, which can release GHGs and pollute water sources.
Climatic factors	Long droughts are common, such as the drought from June 2016 to January 2017	Climate change could be partly caused by tree cutting and bush burning, resulting in the climate variability experienced
Utilisation of residues in the supply chain	Crop residues used on the fields as manure for soil improvement or used as seeds/food	Use of crop residues as manure improves soil quality
Re-use of food losses	Some fed to livestock (goats and pigs), while some is used as seed if still of moderate quality	Use of poor quality seed has a negative effect upon yield and grain quality

Chapter 7

The food losses - study findings and results

DESCRIPTION OF THE FOOD SUPPLY CHAIN: RISK FACTORS

The risk factors reported by farmers in Oyam district that may cause bean food losses at pre and post-harvest production stages are presented in Table 7.1.

At preharvest (farming) stage, the identified risk factors include:

- Cultivation of mixed varieties (size and colour) of beans. Most farmers in Oyam cultivate beans of various sizes/colours, especially the small-seeded black and white beans. Mixed size and/or different coloured beans fetch lower prices compared to beans having single, uniform size and/or colour.
- Intercropping of beans with other crops such as maize and sunflower is also common with farmers in Oyam district. Intercropping affects the yield, output and quality of the crop.
- Poor agricultural practices were also found to be common among some farmers, leading to weed infestation, thereby affecting the yield, output and quality of the crop.

At post-harvest level, the identified risk factors include:

- Farmers' use of rudimentary threshing and drying equipment. It was observed that most farmers dried and threshed beans on uncovered ground leading to the beans becoming mixed with debris and other inedible matter.
- Poor storage practices by both farmers and traders. Most farmers stored beans in ordinary utensils such as pots, plastic basins or polythene bags with no use of insecticides. Many traders stacked bags of beans on the uncovered floor in the store with multiple uses (Figure 7.1)
- Some traders use rudimentary storage equipment, aluminium phosphide for controlling storage pests but lack the proper skill to handle the fumigants.

TABLE 7.1
Food loss risk factors

Variable	Unit	Parameter: Relation to food losses	Value of variable (observed in the case study)
Mixed crop variety	Count	Ideally, farmers should cultivate single variety beans for better quality and market value	Mixed varieties of medium (K131, K132 and yellow beans) and small seeded beans of various colours (white, black, ash-grey) is common
Intercropping	Count	Ideally, farmers should cultivate single bean crop for higher output, quality and market value	Multiple crops per field is common (see Figure 3.1)
Good agricultural practices (GAP)	Y/N	Yes	Poor weed management practices common (see Figure 3.1)
Good post-harvest practices	Y/N	Yes	Farmers use rudimentary threshing, drying and storage equipment. Minimum use of insecticides. Some traders use rudimentary storage equipment, aluminium phosphide for controlling storage pests but lack proper skill to handle fumigants.
Knowledge of FSC actors	Y/N	Yes	FSC actors have inadequate knowledge of good storage practices, prices and markets

FIGURE 7.1
Beans at two bulk trader stores in Oyam district





PHOTO 1, 2 ©MICHAEL OTIM/WILLIAM NANYEENYA/HARRIET MUYINZA

CRITICAL LOSS POINTS: TYPE AND LEVEL OF FOOD LOSSES IN THE SELECTED SUBSECTOR CHAINS, INCLUDING BOTH QUANTITATIVE AND QUALITATIVE LOSSES

Grain quality standards for dry beans in Uganda are controlled by US 46:2013 dry bean specifications, similar to the EAS 46:2013. This standard places dry beans into three grades or categories, based on the characteristics of the bean sample (Table 7.2). The grade of the beans influences the market value. Beans having quality Grade 1, which is ideal, fetch the highest price and Grade 3 fetches a lower price. However, when beans have an unacceptable quality (characteristics above acceptable maximum limits), then they are completely rejected and have little or no market value. A survey of bean traders in Oyam district and Lira town revealed that Grade 3 and Grade 2 beans fetched prices that were up to 40 and 20 percent lower respectively than Grade 1 quality (Table 7.2).

Presentation of load tracking and sampling results

Load tracking – Summary results of load tracking at harvest are presented in Table 7.3. The results indicate that at harvesting farmers experienced 3.6±0.7 percent quantitative loss of beans. The first study reported 3.2 percent quantitative loss level. The two loss levels are comparable. The losses arose in three ways: some beans are left un-harvested; some of the harvested beans are not collected and taken home for threshing and when beanstalks are very dry, some bean pods shatter and the grains scatter during harvesting. It was noted that where children and/or hired labour were involved in harvesting, and the field was infested with weeds, a larger amount of beans were left un-harvested. Furthermore, it was noted that children and/or hired labour tended to overlook and leave some of the harvested beans uncollected in the field.

Transportation of beans from field to homestead is by head portage or bicycle. Harvested beans are usually tied together into an appropriate bundle, using spear-grass, to be carried. During transportation and because of various factors that include transport mode; how well beans are secured in a bundle; the distance between field and homestead; quality of the road; some beans fall from the bundle. To track bean food losses during transportation, the harvested crop was measured in the field and then measured again upon arrival at the homestead and the difference attributed to loss during transportation. To ascertain the actual quantity of grain lost, an equivalent quantity of harvested beans were set aside, hand-threshed and then weighed. The results indicate that farmers lose up to 0.5±0.1 percent of beans during transportation from the field to the homestead (Table 7.3).

TABLE 7.2
Quality scoring of food products

	Description of quality	Score/grade		
	Characteristics	**Grade 1**	**Grade 2**	**Grade 3**
1	Foreign matter, % m/m	0.5	0.75	1
2	Inorganic matter, % m/m	0.1	0.2	0.3
3	Other edible grains, % m/m	0.1	0.2	0.5
4	Pest damaged grains, % m/m	1	2	3
5	Heat damaged grains, % m/m	0.1	0.2	0.5
6	Contrasting varieties % m/m	0.5	1	1.5
7	Broken/split % m/m	1	2	3
8	Discoloured % m/m	1	1	1
9	Total defectives grains, % m/m	2	3.5	5.5
10	Debris, % m/m	0.1	0.1	0.1
11	Moisture, % m/m	14	14	14
12	Total aflatoxin (AFB1+AFB2+AFG1 +AFG2), ppb	10	10	10
13	Aflatoxin B1, ppb	5	5	5
14	Fumonisin ppm	2	2	2
	Percentage reduction in market value	0	20	40

Source: Uganda Bureau of Standards, Uganda Standards -Dry beans specification 2016

FIGURE 7.2
Load-tracking bean harvesting in Oyam district



Quadrant mesurement | Harvesting | Weight taking

PHOTO 1, 2, 3 ©MICHAEL OTIM/WILLIAM NANYEENYA/HARRIET MUYINZA

Threshing and winnowing[8] – In Oyam district, as in other parts of rural Uganda, threshing involves heaping the dry bean harvest on uncovered ground and beating with sticks (threshing) to split/loosen the bean grains from the pods. Threshing beans on uncovered ground leads to quantitative losses because of spillage. Winnowing involves separating the grain from the chaff using the wind. In the process of threshing and winnowing some beans get left in the pods, chaff or on the ground.

[8] Ideally, threshing and winnowing are two separate activities. In rural homesteads however, the two activities are carried out jointly and are hence difficult to separate and attribute loss of grain to a specific activity. In this study, threshing and winnowing were tracked jointly as a naturally occurring joint activity.

FIGURE 7.3
Farmer sun drying, threshing and winnowing beans in Oyam district



Sun drying bean harvest | Threshing beans | Winnowing beans

PHOTO 1, 2, 3 ©MICHAEL OTIM/WILLIAM NANYEENYA/HARRIET MUYINZA

Summary results are presented in Table 7.3, which indicate that up to the traditional method of threshing and winnowing, farmers lose up to 4.1±1.2 percent of beans (quantitative). The first study reported 0.97 percent quantitative loss level. The difference between the two loss levels is, to a large extent, methodological. This particular replication study carried out actual load tracking and sampling. In the first study, load tracking was only performed at the storage stage. The value of 0.97 percent is based on farmers' estimations. The variation in quantity lost was observed to be particularly high for small grain beans. Farmers reported that small grain beans remain in the husks during traditional threshing because they are encased in harder to split pods. Also, the size of grains made it more difficult to separate the beans from the chaff during winnowing. The colour (black, ash-grey, brown) and size of the bean grain also made it difficult to pick up the beans when they were scattered on the ground during winnowing.

Drying – Most farmers spread the bean grain on uncovered ground to dry (see Figure 7.4). Drying beans on uncovered ground leads to quantitative losses because of spillage. The colour and size of the bean grain make it difficult to pick up when it is scattered on the ground during drying. The summary results are presented in Table 7.3.

Storage – There are two harvests a year, and for each harvest storage can last up to six months. Farmers generally keep beans in polypropylene bags or in open plastic containers or local baskets with little or no application of insecticides. Re-drying is a common alternative practice to insecticides.

The detailed results of the on-farm storage load tracking of beans are presented in the summary results presented in Table 7.3 and Annex 8. The results indicate that during the 3 months when the grain was being stored, bean losses were largely qualitative (8.5%) caused by insect infestations because of the limited application of insecticide. Some spillage was observed, although the amount was insignificant. The first study reported 1.77 percent loss level (both qualitative and quantitative) (farmers' estimate). However, it is important to note that the results obtained during load tracking of the samples collected from farm storage (after 2.5 and 4 months of storage) showed that the cumulative quality losses exceeded 7 and 15 percent after respectively 2.5 and 4 months' storage. These losses were because of insect and mechanical damage, debris, inclusion of other seeds and discolouration.

Consumption – almost no beans are discarded in rural homesteads. That is, virtually all beans, including what may be regarded as poor quality (insect infested, shrivelled, mouldy and discoloured), is either consumed by people or cooked and fed to animals (pigs). Poor quality beans are crushed, the grain coat removed and the crushed grains prepared into a dish that is referred to in the local Luo language as *orangaongako* or *orangaogago,* which means crushed beans. Hence the food that would have been lost is put to alternative use.

TABLE 7.3
Summary of mean and standard deviation of bean food losses experienced at each stage in the FSC

Stage in food supply chain stage/Actor	Stage(n)	Quantitative loss (%)	Qualitative loss (%)	Foreign matter (%)	Moisture loss (%)	Moisture level (%)
Farm level	Harvesting (n=15)	3.6±0.7	-	-	-	17.5±0.61
	Transport (n=15)	0.5±0.1	-	-	-	17.5±0.65
	Threshing and winnowing (n=6)	4.1±1.2	-	-	1.5±0.05	16.0±0.55
	Drying	1.8±0.7	-	-	1.0±0.05	15.0±1.03
	Storage	1.5±0.62	8.5±1.5		1.5±0.46	13.5±0.60
Bulk trader	Aggregation and transport (n=6)	0.5±0.07	-	-	-	14.0±0.82
	Drying (n=6)	1.5±0.07	-	-	0.5±0.07	13.5±0.85
	Storage (n=6)	-	3.0±0.07		0.5±0.03	13.0±0.83
Wholesale trader	Marketing (n=6)	0.5±0.07	-	-	-	13.0±0.50
Retail trader	Marketing (n=10)	3.5±0.07*	2.5±0.07*	1.0±0.07	-	13.0±0.27
Urban consumer	Household consumption (n=5)	2.5±0.07*	2.5±0.07*	1.0±0.07	-	13.0±0.25
Potential overall loss		15.1±3.1	10.0±0.07	2±0.07	4.5±0.07	

Notes:

n represents the number of respondents interviewed

Grains removed from a bean batch if broken or other varieties of beans, and/or other grains are considered to be a quantitative loss.

Bean grains removed or lost from a batch because of insect infestation, shrivelling, being mouldy and/or discoloured is considered to be a qualitative loss.

Reduction in amount of grains because of reduced moisture level is considered to be a moisture loss.

Foreign matter is non-edible material such as stones or debris.

* Implies potential food loss at the retail and urban consumer levels. Nonetheless, the food that would be potentially lost is converted into other food dishes and/or fed to pigs.

Bulk trade level – Bulk traders (also called speculative traders) buy beans from village markets, aggregate and transport them to their stores located in townships or in rural areas. They are called speculative traders because they bulk purchase and store the produce during harvest time and sell when there is a scarcity.

The process of produce aggregation at the village market, loading onto the truck, transportation and off-loading from the truck and into the store involves some spillage. Respondents reported that the spillage is higher for small grain beans compared to medium-size grain beans. Before storing beans, bulk traders undertake further drying of the grains to ensure uniform and ambient moisture content (from about 14 to 13 % mc) for storage. From the point of aggregation to drying before storage, estimates indicated that bulk traders lost an average of 2.5 kg per 100 kg bag, i.e. 0.5 percent is lost as a result of spillage during aggregation at the village market; 1.5 percent from spillage while drying; and 0.5 to 1 percent from reduced moisture content. The process of loading onto the truck, transportation and off-loading from the truck involved the minimum loss since most traders aggregated and transported beans in new polypropylene bags. Most bulk traders in Oyam district stored 200 to 500 bags (20 to 50 tonne) of beans and applied aluminium phosphate tablets as insecticide. The storage load tracking results over a 3-month period (Table 7.4), revealed that bulk traders in Oyam district potentially lost up to 4 kg per bag of 100 kg weight of beans, i.e. 4 percent was lost because of infestation by insects and rodents, shrivelling, mould contamination and/or discoloured beans (3%) and reduced moisture content (1%).

To analyse the characteristics of bean grain stored by bulk traders, samples were purchased and taken to Kawanda Research Station, Kampala for analysis. Laboratory analysis revealed that up to 1.5 percent per 100 kg was broken, or contained

TABLE 7.4
Summary of bean losses, causes and solutions in Oyam district

Stage in food supply chain/ Process	Type of loss Qn/Ql	Percentage lost in this process Quant	Percentage of the product that incurred quality loss in this process	Percentage of product goes through this stage	Cause of loss/ Reason for low loss	CLP / LLP	Destination of food loss	Impact/FSC actors affected (men/women)	Loss perception of FSC actors (men/women)	Suggested solutions
On-farm harvesting	Qn	3.6	NA	100	Children of hired labour leaving some bean plants un-uprooted in the field; shattering of pods of some plants	CLP	Remain in field	Lost food / income	Nature of labour used is challenge	Stakeholder training and sensitisation
Transport field to farm	Qn	0.5	NA	100	Batch insufficiently secured for transportation by head portage or bicycle leading to some bean plants falling off	LLP	Left along the road	Lost food / income	Mode of transport is challenge	Stakeholder training and sensitisation
Threshing, winnowing	Qn	4.1		100	Pods of some (small-seeded) beans do not split during threshing; small-seeded beans are challenging to separate from chaff during winnowing. Foreign matter, contrasting varieties, and other edible grains inclusion in the same sample/consignment	CLP	Waste	Lost food / income	Size of beans grains vis-à-vis threshing and winnowing technology is a challenge	Use of tarpaulin
On-farm drying	Qn	1.8		100	Spillage and discolouration while drying on uncovered ground	CLP	Waste	Lost food / income	Loss can be avoided	Use of tarpaulin
On-farm storage	Ql	6.5	8.5	50	Spillage and insect infestation during storage	CLP	Consumed	Lost income	Loss can be avoided	Use hermetic bag, plastic silo
Bulk trader aggregation & transport to store	Qn	0.5	NA	20	Spillage during aggregation in market	LLP	Garbage	Lost income	Little can be done to avoid loss	
Bulk trader drying	Qn	1.5		20	Spillage while drying on bare ground	CLP	Garbage		Loss can be avoided	Use tarpaulin
Bulk trader storage	Ql	NA	3	20	Insect Infestation Shrivelled, mouldy, discoloured	CLP	Part of sale	Lost income	Avoidable loss	Stakeholder training and sensitisation
Wholesale trader	Qn	0.5%	NA	15	Spillage during off-loading and loading on truck	LLP	Garbage	Lost income	Not sure what to do to avoid loss	Stakeholder training and sensitisation

TABLE 7.4
(Continued)

Stage in food supply chain/ Process	Type of loss Qn/Ql	Percentage lost in this process Quant	Percentage of the product that incurred quality loss in this process	Percentage of product goes through this stage	Cause of loss/ Reason for low loss	CLP / LLP	Destination of food loss	Impact/FSC actors affected (men/women)	Loss perception of FSC actors (men/women)	Suggested solutions
Retailer	Qn	3.5%	NA	20	Sorting out broken beans, other varieties of beans, other grains	CLP	Consumed		For premium sale, it's unavoidable loss	Stakeholder training and sensitisation
	Ql	NA	2.5	20	Sorting out insect infested, shrivelled, mouldy beans	CLP	Consumed		Unavoidable loss for premium sale	Stakeholder training and sensitisation
Urban consumer	Qn	2.5%	NA	20	Sorting out broken beans, other varieties of beans, other grains	LLP	Garbage	Lost income	Unavoidable loss for quality meal	Stakeholder training and sensitisation
	Ql	NA	2.5	20	Sorting out insect infested, shrivelled, mouldy beans	LLP	Garbage	Lost income	Unavoidable loss for quality meal	Stakeholder training and sensitisation

other varieties of beans or other grains. This is not considered to be a loss – given that bulk traders do not sort grains before selling.

In the first case study, rural bulking contributed 1 percent loss, both quantitative and qualitative (traders' estimate). Analyses of samples collected at the storage stage (load tracking event) showed that the quality losses averaged 10 percent because of insect damage and discolouration.

Wholesale trade level – At wholesale, bean traders largely make a profit from higher turnover. That is, through buying and selling in bulk, more frequently (market arbitrage). With this kind of business, wholesale traders of beans experience limited quantitative losses from spillage. In this case study, it was observed that most wholesalers of beans from Oyam district were from the adjacent town, Lira, in Lira district.

Wholesale traders buy beans mostly from bulk traders' stores, load on to trucks and transport to their stores. In other instances, and based on agreed terms between the parties, bulk traders deliver beans to wholesale trader's stores. In the process of moving produce from the bulk trader's store to that of the wholesale trader, some spillage occurs while loading and off-loading the truck, though interviewed traders indicated this was insignificant. Estimates from traders interviewed in Lira town indicated that they lost between 0.5 to 1 kg per bag of 100 kg weight, i.e. 0.5 to 1 percent from spillage. No other losses (e.g. reduction in moisture content) in volume of a batch were observed, given that wholesalers buy beans when they are already very dry and sell the batch within a short time.

The first study reported 9.8 percent loss level at the wholesaling level (both qualitative and qualitative).

Retail trade level – At the retail level, traders buy beans from wholesalers and clean them before selling to consumers in smaller quantities. Cleaning involves sorting or removing foreign material, other varieties, other edible grains and poor quality (broken, shrivelled, mouldy, discoloured and contrasting colour) beans. Predominately women, who have been hired by traders, sort and clean the produce in markets. Estimates indicate that up to 8 percent of a batch (e.g. 100 kg bag) of beans bought by retailers from wholesalers was sorted out. The portion sorted out comprised 3.5 percent quantitative loss (broken beans, other varieties of beans, and/or other grains); 2.5 percent qualitative loss (insect infested, shrivelled, mouldy or discoloured beans) and foreign matter (1%). The women, who were hired by the retailers to sort the beans, usually take the residual grains (broken, insect infested, shrivelled, mouldy or discoloured beans; other varieties; other grains) as part-payment. In other instances, retailers retain the residual grains, cook and feed them to livestock, especially pigs. In essence, the residual grains after cleaning are not discarded or 'lost'.

Urban consumer level – The results indicated that up to 6 percent of a batch (2 kg) of beans bought by retailers from wholesalers was sorted and considered as rejects to be discarded. The portion sorted out comprised broken beans, other varieties of beans and/or other grains – quantitative loss (2.5%); insect infested, shrivelled, mouldy or discoloured beans – qualitative loss (2.5%); and foreign matter (1%). Urban consumers who are well off generally do not consume poor quality beans that have been rejected. Peri-urban dwellers, who are no different from rural people, however, will consume the rejects in other forms such as a bean stew *oranga-ongako* or *oranga-ogago*. If they rear animals, peri-urban dwellers sometimes cook the rejected beans and feed them to pigs.

It is important to note that during the validation meeting, the attendees were more in concurrence with the second assessment with respect to losses at the farmer level. It was, however, agreed that the loss at bulkers' points was as high as presented in the first bean report.

Summary of bean losses, causes and solutions in Oyam district – Table 7.4 summarises all the discussion above concerning bean food losses, causes and solutions in Oyam district.

Chapter 8

The food loss reduction strategy – conclusions and recommendations

IMPACT OF FOOD LOSSES IN THE SELECTED FOOD SUPPLY CHAIN

As indicated in Table 3.4 both critical loss points (loss >2%) and low loss points (loss <1%) were observed at various stages of the Oyam district bean FSC. At farm-level, the CLPs were observed at harvesting, threshing and winnowing and storage stages, while at the bulk trader level the CLP was storage. At the retail and urban consumption stage, potential CLPs were observed but the bean food that would potentially be lost was converted into other dishes or livestock feed and hence not regarded as a food loss. Losses were low at other stages of the bean FSC, including transportation from farm to home, drying, transportation from market to store, and wholesale trading.

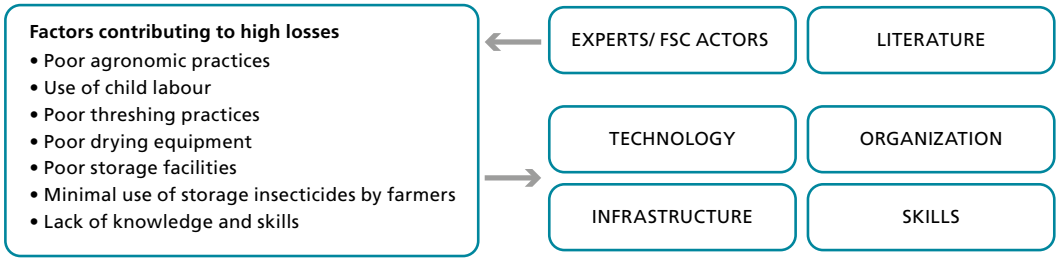
Thus, in this section, Figure 8.1, the cause finding diagram, is used to analyse the reasons for the high losses at the various stages in the FSC. The reasons for the high losses at the different stages observed may be the result of poor practices, limited adoption of improved technologies or lack of infrastructure and policy support for the actors in the FSC. On the other hand, the reasons for the low losses observed at some stages of the FSC may be because of good practices, good infrastructure or policies that could serve as solutions to high losses in other FSCs.

As illustrated in Figure 8.1, many factors contribute to high bean food losses in Oyam district. Expert consultations and stakeholder discussions revealed the following:

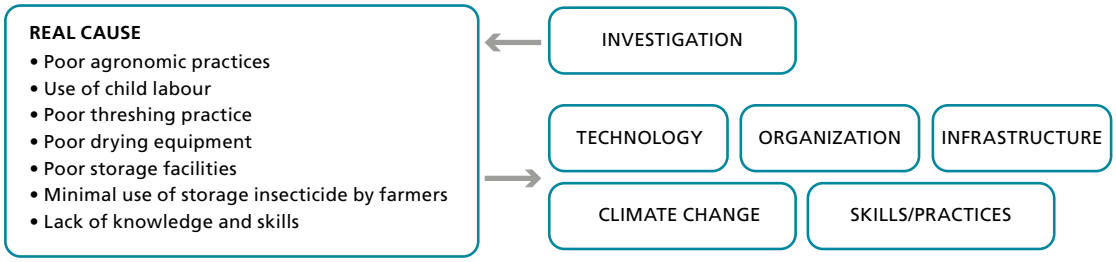
- **Poor agronomic practices –** Farmers in Oyam district, as in most parts of rural Uganda, are subsistence farmers with limited income to adopt appropriate technologies such as use of animal traction for tillage, quality seeds and herbicides for weed control. Some farmers broadcast seed instead of row planting and practice intercropping. These agronomic practices affect proper weeding thereby leading to weed infestation, which affects yield and proper harvesting of the crop.
- **Children as a source of labour** – In Uganda, there is rampant use of children in agricultural production. Employment of children to harvest beans in fields that are infested with weeds affects the complete recovery of the crop from the field as some plants are left un-harvested.
- **Poor threshing, winnowing and drying technology** – In Oyam district most people dry, thresh and winnow crops on dusty uncovered ground – and not on clean, cemented surfaces or tarpaulins spread out on the ground. This practice leads to a high level of spillage into dust and/or grass (quantitative loss). Most farmers do not make the effort to pick up the spilled or scattered beans. The problem is made worse if the beans are small grain with dull colours (black, brown or grey) that cannot be easily recognised. Besides the quantitative loss, bean grains dried on uncovered ground contain foreign matter (sand, small stones, debris), which affects quality. Furthermore there is a high risk of fungal contamination, which might lead to the development of mycotoxins.
- **Poor storage practices and minimum use of insecticides** – Most rural farmers store bean grain in basic utensils such as pots, plastic basins or buckets and polythene bags with minimal application of pest control pesticides. The grain is easily infested with insects, gnawed by rodents and littered with rodents' excreta, thereby affecting quality.
- **Poor grain storage practices by bulk traders** – Most traders package bean grain in 100 kg polythene bags and haphazardly stack the bags in a room. Usually bags filled with beans are stored together with other grains such as maize. Few traders stack bags of grain on pallets. Most traders use aluminium

FIGURE 8.1
Factors contributing to high bean food losses in Oyam district

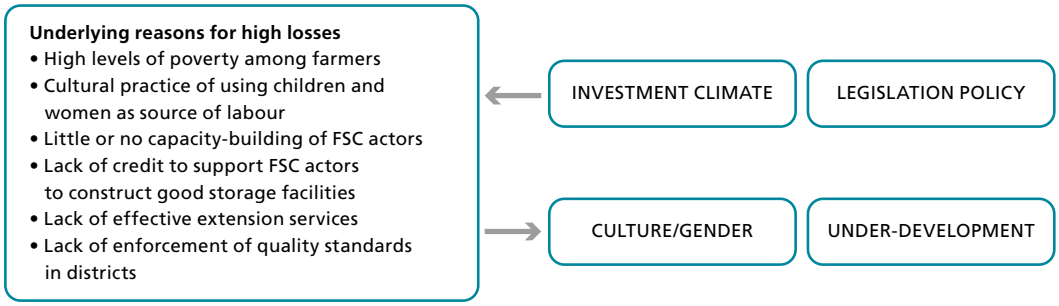
1. The factors contributing to high bean food losses.



2. The *real causes* of food losses.



3. Underlying *reasons* for the cause, why the problem has not yet been solved.



phosphate (readily available) as a fumigant against pests – but they lack the knowledge of its correct application.

- **Lack of knowledge and skills** – Most farmers in Oyam district practice farming without any basic training in agricultural production and marketing practices suitable for the area. The national agricultural extension system in Uganda is fragmented and hence there are limited or no extension services to rural areas to train and sensitise farmers about good farming practices, storage, pest management and access to good grain markets, including for dried bean.

REQUIRED INPUTS AND COST-BENEFIT ANALYSIS OF THE FOOD LOSS REDUCTION MEASURES

The underlying causes of food losses in Uganda, generally and Oyam district in particular, are related to the lack of knowledge and skills about good agricultural practices (pre and post-harvest handling techniques) and lack of appropriate food storage management practices. This particular study revealed that the magnitude of bean food losses experienced, in Uganda in general and in Oyam district in particular, is considerably high, yet there is no nationally integrated strategy to curb food losses. It is critical, therefore, that

TABLE 8.1
Strategies for addressing food losses in the bean food supply chain

Strategy	Role	Cost of intervention
Training extension workers at district level in appropriate preproduction, harvesting and post-harvest handling techniques for beans	MAAIF, FAO, WFP & NARO	160 workers * USD 50*2 times; Thus, USD 16 000
Training of traders (bulkers, wholesalers, retailers) in storage management, product quality assurance and use of fumigants for protection of bean grain	MAAIF, FAO, WFP & NARO	120 traders*USD 50*3 times; Thus, USD 18 000
Training of farmers in appropriate harvesting and post-harvest handling techniques for beans	MAAIF, FAO, WFP & NARO	1 600 farmers*USD 50*2 times; Thus, USD 160 000
Training of machine fabricators in basic designs, operation and maintenance techniques for threshers, cleaners, graders, silo, among others for beans	MAAIF, FAO, WFP & NARO	100 artisans* USD 130*2 times, Thus, USD 26 000 (This includes assorted materials for hands-on practice)
Training of farmers in the effective and efficient use of pesticides for protection of grain against infestation by storage insects	MAAIF, FAO, WFP & NARO	1 600 farmers* USD 50*2 times; Thus, USD 160 000
District local government /policy/by-law makers awareness-raising and consultations on the importance of bean food loss and the different causes; impact and feasibility of proposed solutions	MAAIF, FAO, WFP & NARO	100 officers *USD 50*2 times; Thus, USD 10 000
NGOs awareness-raising and consultations on the importance of bean food loss and the different causes; impact and feasibility of proposed solutions. This is intended for buy-ins	MAAIF, FAO, WFP & NARO	60 NGO representatives *USD 50*2 times; Thus, USD 6 000
Setting and managing demonstration and validation technology sites hosting tarpaulins, pallets, drying yards and racks, mechanical threshers, cleaners, hermetic bags, and plastic/metal silos among others	MAAIF, FAO, WFP & NARO	30 sites* USD 5 800; Thus, USD 174 000
Conduct an inclusive research development action to improve traditional storage structures used for beans	FAO, WFP & NARO	USD 30 000
Establish a post-harvest coordination platform/forum that brings together key stakeholders in government, development/non-governmental organizations and the private sector to promote, among others, food loss reduction programmes	MAAIF, FAO, WFP & NARO	150 officers *USD 50*2 times; Thus, USD 15 000
Facilitate development of an M&E mechanism of food losses reduction programmes and activities in the district	MAAIF, FAO, WFP & NARO	Adopt 67 % of total training cost. Therefore, 380 000 *0.67 =USD 254 600
Total strategy cost		USD 869 600

the Government of Uganda, with support from development partners, formulates strategies to curb food losses. Such strategies should take into account the needs and capabilities of the FSC actors to better implement improved practices. Based on the findings of the current study, the following areas of interventions have been identified in Table 8.1.

The strategy recommended here is in line with that outlined in the first study, there are no major differences.

These strategies are explored further, using a cost-benefit analysis, in the follow up section. To stem bean food losses at the point of drying and storage at the farm in Oyam district, household level and district level budget requirements and profitability of the solution are presented in Table 8.2 and Table 8.3. The determined values in the tables are based on the following assumptions.

- There are two cropping seasons for beans and each household produces an average of 128 kg of dried beans per season for a total of 256 kg per annum.
- The average farmgate price of beans in Oyam district is USD 425/tonne.
- Following training and sensitisation, far-

TABLE 8.2
Budget calculation for food loss reduction at farm level

	Item	Unit measure	Tarpaulin	Hermetic bag (90 kg)	Plastic silo (500 kg)	Metal silo (750 kg)	Tarpaulin and hermetic bag	Tarpaulin and plastic silo	Tarpaulin and metal silo	Calculation
			Value	Value	Value	Value	Value	Value	Value	
a	Production of beans	kg/year	256	256	256	256	256	256	256	
b	Value of beans at farmgate	USD/kg	0.4	0.4	0.4	0.4	0.4	0.4	0.4	
c	Loss rate drying and storage	%	1.8	8.5	8.5	8.5	10.3	10.3	10.3	
d	Anticipated loss reduction	%	80	80	80	80	80	80	80	
e	Cost of item/household	USD	5.6	2.0	86.9	136.0	7.6	92.6	141.7	
f	Depreciation	Seasons	4.0	4.0	20	30	4.0	4 & 20	4 & 30	
g	Cost of investment/season	USD/season	1.4	0.5	4.3	4.5	1.9	5.8	5.9	e / f
h	Cost of operation/ season/ household	USD/season	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
i	Total cost/year/household	USD/year	2.8	1	8.7	9.1	3.8	11.5	11.9	(g + h) x 2
ia	Capacity of item	kg	400	90	400	600				
ib	Number of loads per year	Loads	2	2	2	2				(1 load/ season)
ic	Yearly throughput of item	kg/year	800	180	800	1 200				ia* ib
j	Client costs per kg of product	USD/kg	0.004	0.006	0.011	0.008	0.009	0.014	0.011	i / ic
k	Food loss	kg/year	4.6	10.9	10.9	10.9	15.5	15.5	15.5	c*a
l	Economic loss	USD/year	2.0	4.6	4.6	4.6	6.6	6.6	6.6	k *b
m	Loss reduction	kg/year	3.7	8.7	8.7	8.7	12.4	12.4	12.4	k *d
n	Loss reduction savings	USD/year	1.6	3.7	3.7	3.7	5.3	5.3	5.3	m *b
o	Total cost/year	USD/year	0.9	0.7	1.4	1.0	1.6	2.3	1.9	a *j
p	Profitability of solution/Oyam	USD/year	0.7	3.0	2.3	2.7	3.7	3.0	3.4	n - o

mers can invest in a tarpaulin for drying beans or 90 kg hermetic bag or 500 kg plastic silo or 750 kg metal silo to store beans. Depending on the farmer's income and production capacity, farmers can also invest in a combination of a tarpaulin and hermetic bag; or tarpaulin and plastic silo; or tarpaulin and metal silo.

- 1.8 percent of bean produce is lost during drying, 8.5 percent is lost during storage.
- Investment in a tarpaulin for drying beans can reduce spillage losses by 80 percent and investment in hermetic bag, or a plastic or metal silo reduces storage losses by 80 percent. Investment in a combination of tarpaulin and storage equipment greatly reduces losses.
- Farmers' capacity to produce and store beans varies greatly depending on their socio-economic resources and capabilities. Thus, whereas some farmers can store less than 50 kg per season others can store up to 600 kg.
- Other assumptions, including number of seasons for which the equipment is used for the loss reduction – hence the depreciation rate is shown in the Tables.

Based on the aforementioned assumptions, Table 8.2 shows that farmer investment in a tarpaulin and metal silo or in a tarpaulin and hermetic bag leads to an anticipated food loss reduction savings of 80 percent, equivalent to USD 5,3 per annum, which when aggregated for all households in the district is equivalent USD 274 080 per annum (Table 8.3). It can be seen that the most profitable solution for the individual is a combination of a tarpaulin and hermetic bag. The most profitable solution for the community at large is investment in hermetic bags.

At the bulk trader level, the ideal investment for reducing food losses would be training and continued sensitisation of the traders on the ways and means to minimise pest infestation and hence loss of beans in storage. Further, traders should invest in tarpaulins for drying to reduce loss from spillage. Individual trader returns are likely to be similar to those for farmers as indicated in Table 8.4.

Table 8.4 summaries the critical loss points of bean food, causes and solutions in Oyam district. The determined values in the Table are based on the following assumptions.

- According to Oyam district Production and Marketing Office, in 2016, the area under bean cultivation for season 1 and 2 in the district averaged 4 870 ha.
- Average bean yield in Oyam district based on northern Uganda is 1.71 tonne/ha (UBOS and MAAIF, 2010).
- Based on the first two assumptions, bean output per season in Oyam district in 2016 was 8 237 tonnes and 16 655 tonnes per year.
- According to Oyam district Production and Marketing Office, in 2016, there were about 65 000 households in Oyam district. This implies that on average, each household produced 128 kg of beans per season and 256 kg per annum.
- Farmgate price of beans in Oyam district in November 2016 was as follows: small-seeded beans UGX 1 300/kg and medium and large-seeded beans UGX 1 800/kg. Average price of beans UGX 1 500/kg.
- Exchange rate in November 2016 was USD 1 = UGX 3 530. This translates into average farmgate price of beans at USD 425/tonne.
- Average cost of tarpaulin per year is USD 2.8; hermetic bag is USD 1.0, plastic silo is USD 8.7 and metal silo is USD 9.1.

For example, at harvesting, loss of 3.6 percent of 16 655 tonnes is 600 tonnes per year, translating into USD 254 820 worth of lost food. With USD 50 000 worth of investment in training and sensitisation of farmers, it is expected that there would be 50 percent (USD 127 400) reduction in beans lost at harvesting. The rest of the analysis in Table 8.4 has been undertaken using the abovementioned assumptions and approach.

FOOD LOSS REDUCTION PLAN AND STRATEGY, INVESTMENT REQUIREMENTS

This study revealed that the magnitude of bean food losses experienced, in Uganda in general and in Oyam district in particular, is considerably high, yet there is no nationally integrated strategy to curb the food losses. It is critical, therefore, that the Government of Uganda, with the support of development partners, formulate strategies to curb these food losses. Such strategies should take into account the needs and capabilities of the FSC actors so they are better prepared to implement them.

In this report in particular in Table 8.4, the authors attempted to present what they

TABLE 8.3
Budget calculation for food loss reduction at Oyam district level

	Item	Unit measure	Tarpaulin	Hermetic bag (90 kg)	Plastic silo (500 kg)	Metallic silo (750 kg)	Tarpaulin and hermetic bag	Tarpaulin and plastic silo	Tarpaulin and metal silo	Calculation
			Value	Value	Value	Value	Value	Value	Value	
a	Production of beans	tonne/year	16 655	16 655	16 655	16 655	16 655	16 655	16 655	
b	Value of beans at farmgate	USD/tonne	425	425	425	425	425	425	425	
c	Loss rate drying and storage	%	1.8	8.5	8.5	8.5	10.3	10.3	10.3	
d	Anticipated loss reduction	%	80	80	80	80	64	64	64	
e	Cost of item/household	USD	5.6	2	86.9	136	7.6	92.6	142	
f	Depreciation	Seasons	4	4	20	30	4	4 & 20	4 & 30	
g	Cost of investment/season	USD/season	1.4	0.5	4.4	4.5	1.9	5.8	5.9	e / f
h	Cost of operation/ season/ household	USD/season	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
i	Total cost/ year/household	USD/year	2.8	1	8.7	9.1	3.8	11.5	11.9	(g + h) x 2
ia	Capacity of item	kg	400	90	400	600				
ib	Number of loads per year	/year	2	2	2	2				(1 load/ season)
ic	Yearly throughput of item	kg/year	800	180	800	1 200				ia* ib
j	Client costs per tonne of product	USD/tonne	3.5	5.5	10.9	7.6	9	14.4	11.1	i / ic
k	Food loss	tonne/year	300	708	708	708	1 008	1 008	1 008	c*a
l	Economic loss	USD/year	127 415	300 840	300 840	300 840	428 250	428 250	428 250	k *b
m	Loss reduction	tonne/year	240	566	566	566	645	645	645	k *d
n	Loss reduction savings	USD/year	101 930	240 670	240 670	240 670	274 080	274 080	274 080	m *b
o	Total cost/year	USD/year	58 710	45 800	90 500	62 940	104 510	149 200	121 650	a *j
p	Profitability of solution/Oyam	USD/year	43 220	194 870	150 180	177 730	169 570	124 880	152 430	n - o

TABLE 8.4
Summary table of critical loss points of bean food, causes and solutions in Oyam district per year

Critical Loss Point	Magnitude of losses in the FSC				Cause of loss	Intervention to reduce losses	Loss reduction		Cost of Intervention (USD)	Economic implications	Social implications	Food security implications	Environmental implications
	Percentage	Weight (tonne/ season)	Weight (tonne/ year)	USD/ year			Percentage	USD					
Harvesting	3.6	300	600	254 820	Leaving some plants un-uprooted by children and/ or hired labour, shattering of pods and scattering grains in field	Training of farmers	50	127 410	50 000	Increased output, income	Reduction in child labour, improved welfare	Increased food	
Threshing and winnowing	4.1	341	683	290 220	Manual threshing & winnowing leading to grains remaining in chaff	Training of farmers	50	145 110	50 000	Increased output, income	Improved welfare	Increased food	
Drying on-farm	1.8	150	300	127 415	Drying on bare ground leading to spillage	Use tarpaulin	80	101 930	58 710	Increased income	Reduced drudgery, better welfare	Increased food	
Storage on-farm	8.5	354	708	300 840	Storage in open containers or polybags, limited use of insecticides	Use hermetic bags (90kg holding capacity) or plastic silo (500kg holding capacity)	80 for hermetic bag. 80 for plastic silo	240 670 for either hermetic bag or plastic silo	45 800 for hermetic bag. 90 500 for plastic silo	Increased income	Reduced drudgery, better welfare	Increased food	Reduced pest infestation
Drying at bulk trader	1.5	25	50	25 030	Drying on uncovered ground leading to spillage	Use tarpaulin	80	20 025	10 000	Increased income	Reduced drudgery	Increased food	
Storage at bulk trader	3.0	50	100	50 065	Stored in polybags in store with poor ventilation, uninformed use of insecticides	Training of traders	80	40 050	25 000	Increased income		Increased food	Reduced pest infestation

believe to be the feasible short to medium-term strategies to reduce bean food losses at the various levels of the FSC. Based on findings from the current study, the following areas of interventions were identified:

- Training extension workers at the district level in appropriate preproduction, harvesting and post-harvest handling techniques for beans. The training should be planned and executed by the Ministry of Agriculture, Animal Industry and Fisheries with support from development organizations such as FAO and WFP.
- Training of farmers in appropriate harvesting and post-harvest handling techniques for beans. The training should be planned and executed by the Ministry of Agriculture, Animal Industry and Fisheries and district local governments should be part and parcel of the extension service delivery to farmers.
- Supporting farmers to invest in and use appropriate bean post-harvest equipment including tarpaulins during drying and threshing; and storage facilities such as hermetic bags and plastic/metal silos.
- Training of traders, especially bulk traders about investment in appropriate drying and storage facilities, equipment and application of fumigants/insecticides to stored produce. Training could include moisture meters for grain moisture determination and tarpaulins for fumigation.

Besides the aforementioned strategies, during the national stakeholder validation workshop, held in April 2017 in Kampala, the participants proposed that the Government of Uganda and development partners consider the following to reduce bean food losses.

- Establish a post-harvest coordination platform/forum that brings together key stakeholders in government, development/ non-governmental organizations and the private sector to promote, among others, food loss reduction.
- Improve access to appropriate technology, equipment and facilities for smallholder farmers (animal drawn power, tarpaulins, stabilised drying yards, hermetic silos and packaging materials, among others.
- Train farmers and traders in the effective and efficient use of fumigants/pesticides for protection of grain against infestation by storage insects.
- Support participatory and inclusive research to improve traditional storage structures used for beans.
- Support initiatives that enhance the productivity of beans through increased multiplication of already released high-yielding varieties, promotion of adoption, especially among smallholder farmers, and appropriate use of inputs supported by soil tests to determine specific nutrient needs.
- Support to mechanisation such as promotion of animal draught power, bean threshers and cleaners would significantly decrease drudgery and production costs.
- Support farmer organizations in collective action and adoption, which would significantly improve the situation of bean food losses in the supply chain. The WFP's Warehouse Receipt System has similarly assisted with the aggregation of individual farmers produce and is providing better opportunities for buyers to access large volumes, produced by smallholder farmers.
- Support or encourage women farmers and bulk traders to acquire and use improved storage facilities including metal or plastic silos and hermetic bags, tarpaulins similar to those promoted by WFP, FAO and NARO. Intensification of the horizontal out-scaling of such technologies would significantly decrease post-harvest losses and the extent of the problem of food losses would be well contained.

PART 3

Maize value chain

Districts of Apac and Lira, Northern Uganda

INTRODUCTION

Food losses refer to the decrease in edible food mass throughout the different segments of the food supply chains – production, post-harvest handling, agroprocessing, distribution (wholesale and retail), and consumption. Food losses and their prevention have an impact on the environment, the food security of the poor, food quality and safety and economic development. The exact causes of food losses vary throughout the world and are very much dependent on the specific conditions and local situation in a given country.

During recent decades numerous studies have been undertaken to assess the quantities of food losses and food waste in many countries. Most of these studies were conducted at the national level, and based on a literature review, statistical data and stakeholder interviews.

The research revealed the knowledge gap: we have quantitative estimations of food losses, we know the causes, and we know that food loss reduction will be of great benefit to all actors in the food production and supply chains, in terms of increasing food security for the poor people, and to protecting the environment. However, the most important causes of food losses are not yet known or the impact of solutions or which solutions would be the most viable and cost-effective, in economic, environmental and food security terms. Meaning: the solution to food loss should not be more expensive than the food loss itself, should not place a higher burden on the environment and greenhouse gas emission, should increase the availability of food to the people who need it most, and should be socially and culturally acceptable.

Therefore the 'food supply chain' case studies have been designed, for the most important food subsectors in developing countries. In these case studies primary and empirical data will be generated for the different causes of food losses, and solutions for food losses will be analysed for their feasibility.

A case study is only a recording of one moment of what is happening in a specific food supply chain in a specific season; next season and in a different location the situation may be very different again. Therefore it is important that many case studies in many different locations can be undertaken, so that the multitude of study results can provide significant trends and solutions. Further, the strategy aims to use the results of the case studies to target opportunities for investment programmes and interventions, during which formulation a wider geographical scope and the seasonality will be analysed.

> The objective of this study is to identify and quantify the main causes of food losses in the selected food supply chains, and to analyse the measures proposed to reduce food losses as to their technical and economic feasibility, social acceptability and environmental impact, leading to concrete proposals to implement a food loss reduction programme.

This study was funded by the Food and Agricultural Organization of the United Nations (FAO), the International Fund for Agricultural Development (IFAD) and the World Food Programme (WFP).

METHODOLOGY

The assessment of post-harvest losses used the 'food loss analysis' case study methodology developed by the FAO under the Save Food initiative (FAO, 2016). It involves the collection of data and their analysis, using qualitative and quantitative field methods. Subsequently, solutions to food losses are formulated from the results and conclusions of the assessment. The methodology is described below:

Selection of countries and subsectors

Countries and subsectors are based on existing and ongoing programmes working with, and collaborating with partners in the field. Subsectors are chosen from the important food commodities in the country such as cereals, roots, tubers, fruits, vegetables, oilseeds, pulses, animal products (meat, milk, eggs), fish and seafood.

Identification of consultants

A team of two or three national consultants are engaged in the fieldwork; one is a subsector specialist, who could be an actor in the food supply chain, one agricultural economist and one rural sociologist.

Selection of food supply chains

The main supply chains in the subsectors are ranked by their importance in terms of economic impact and food security, as well as their contribution to national development objectives such as employment, poverty reduction and the generation of foreign exchange. Based on the information obtained, one or two food supply chains (FSCs) in the subsector are selected for an in-depth survey and sampling.

The basic criteria for the selection of FSCs are:

- based on smallholder producers;
- significant scale of food production;
- preferably including agroprocessing and urban markets;
- if possible, included in an ongoing support programme for the subsector.

Uniform methodology

The methodology used for the case studies needs to be uniform for all countries, so that the results are comparable and extrapolation is possible. The methodology was developed specifically for this purpose. It is based on four ('S') elements:

- Preliminary screening of food losses ('Screening') – Based on secondary data, documentation and reports, and expert consultations without travel to the field.
- Survey food loss assessment ('Survey') – A questionnaire exercise differentiated for producers, processors or handlers/sellers (i.e. warehouse manager, distributor, wholesaler, retailer) and other knowledgeable persons in the supply chain being assessed, complemented by ample and accurate observations and measurements.
- Load tracking and sampling assessment ('Sampling') – For quantitative and qualitative analyses at any step in the supply chain.
- Monitoring and solution finding ('Synthesis') – Used to develop an intervention programme for food losses based on the previous assessment methods.

The consultants physically follow the product over four weeks, from the production site to final retail outlet, making direct observations and measurements, and discussing the causes and solutions for food losses with supply chain actors. The consultants draft a proposal for a food loss reduction strategy or plan.

Stakeholder validation

The study results and proposed food loss reduction strategy are discussed and endorsed in a one-day workshop with stakeholders from the public and private sector. A concept is prepared for a programme to finalise and implement the food loss reduction strategy or plan.

Specific information regarding the food loss assessment along the maize supply chain carried out as part of this study

The maize supply chains of Lira and Apac districts in northern Uganda were selected. After the completion of the 'Screening' phase, which was based on secondary data and expert consultations, the field study was conducted in two subcounties. The loss assessment provides indicative levels of losses based on observations, direct measurements and responses from actors in the supply chain.

Qualitative data were collected during focus group discussions and key informant interviews (with farmers, processors and other pertinent actors), and quantitative data were collected by analysing samples collected at various stages in the supply chains and taken on-station at the National Agricultural Research Laboratories in Uganda for analysis of mechanical damage, discolouration, moisture content, presence of debris and insects, and tested for aflatoxin contamination.

Grain parameters were assessed using the grain collected after measuring plots measuring (4 x 4) m and allowing farmers to harvest normally. Then the grain that was split and discarded during the harvesting process was collected carefully, weighed and compared to the total harvest to obtain the percentage of losses at harvest.

Samples weighing 500 grams were collected from 18 homes, and from ten traders and aggregation points. Samples were dried, threshed and stored. The quality was tracked across three months of storage, at both farmer and primary bulkers' points at the subcounty and parish level. The average storage for both crops is three months. Grain is stored until prices rise. Samples of stored maize were also collected from at least six mills. Aflatoxin levels were assessed, using rapid aflatoxin kits, in stored samples of maize from millers and bulker points.

Chapter 9

The maize subsector - introduction and background

STATUS AND IMPORTANCE OF THE MAIZE SUBSECTOR; DEVELOPMENTS OVER THE LAST 15 YEARS

Maize is cultivated in at least 50 districts on about 1 million hectares (ha) of land across all agro-ecological zones (UBOS, 2014; FAO-MAFAP, 2012). The crop is rainfed and represents about 46 percent of the area under cereal crops in the country.

Over the last 15 years, both the maize area and production in Uganda have increased dramatically. The harvested area increased from about 0.4 million ha in 1990 to 0.6 million ha in 2000, reaching 1 million ha in 2013. Similarly, production dramatically increased from 1.1 million tonnes in 2000 to 2.7 million tonnes in 2013, when maize ranked third in production after banana and cassava (UBOS, 2014). This rapid growth was mainly attributed to both yield increases (1.7 tonne/ha in 2000 to 2.7 tonne/ha in 2013) and expansion of the area under maize (FAOSTAT, 2015; UBOS, 2014).

Maize is a major food crop both from the viewpoint of food security and income-generation.

TABLE 9.1
Production information of the maize subsector

National	Figures	Remarks
Raw material annual production (tonne/year)	2 748 000	Data for 2013 (UBOS, 2014; FAOSTAT, 2015)
Cultivated area (ha)	1 000 000	Data for 2013 (UBOS, 2014; FAOSTAT, 2015)
Average yield (tonne/ha)	2.7	Data for 2013 (UBOS, 2014; FAOSTAT, 2015)
Average growth rate over the last 10 years (%)	11	FAO STAT, 2015
Average cost of production (USD/tonne)	167	Dalipagic and Elepu 2014
Percentage of on farm consumption	34.3	Uganda Census of Agriculture 2008/09 (UBOS, 2010)
Percentage of marketed production	40.5	Uganda Census of Agriculture 2008/09 (UBOS, 2010)
Number and percentage of small scale producers	>3.6 million	
Number and percentage of traders	1 000	FAO-MAFAP, 2012
Number and percentage of processors	1 800	Estimated: there are 600 maize mills, each employing at least three people
Maize grain, volume (tonne/year)	2 748 000	Data for 2013 (UBOS, 2014; FAOSTAT, 2015)
Maize grain, value (USD/year)	346 million	Unofficial figure – source: FAOSTAT, 2015
Level of processing operations (S, M, L)	S, M, L	
Level of trading/ wholesale operations (S, M, L)	M	
Level of retail operations (S, M, L)	L	
Export volume (tonne)	103 950	Data for 2013 (FAOSTAT, 2015)
Export value (USD)	42,3 million	Data for 2013 (UBOS, 2014)

Legend: Y/N = yes / no; L/M/H = low / medium / high.

It forms a major part of the diet for both rural and urban communities. The commodity is sold as fresh (green) maize for roasting and boiling, especially in urban areas where it supplements the main meals. The grain is sold to make maize flour. The crop is the number-one staple for the urban poor, and at institutions such as schools, hospitals and the military. Maize is also used as a key input in the animal feed industries and for local brewing.

The maize subsector contributes to the livelihoods of over 3.6 million farm households, 1 000 traders/agents and 600 millers nationwide by providing them with employment and income (FAO-MAFAP, 2012; UBOS, 2014). Smallholder subsistence farmers mainly practice maize production. The latest Uganda Census of Agriculture for 2008/09 estimated that 34.3 percent of the maize was consumed at home; while 40.5 percent of the produce was marketed and 19.3 percent was stored. 3.5 percent of the uses were not specified.

In 2006, maize topped the list of food exports, earning the country over USD 24 million in formal exports (Okoboi, 2010). In 2013, Uganda's formal maize export was valued at over USD 42.3 million (UBOS, 2014). In addition, Uganda supplied about 90 percent (over 654 000 tonnes) of the informally traded maize in the region (EACBTB, 2014). As a result of its importance, the Government of Uganda selected maize as a strategic commodity for priority public investment.

INVENTORY OF ACTIVITIES AND LESSONS LEARNED FROM PAST AND ONGOING INTERVENTIONS IN MAIZE LOSSES

The **Cereals Programme** at the National Crops Resources Research Institute (NaCRRI) of the National Agricultural Research Organization (NARO) has generated and disseminated many maize varieties (both open pollinated and hybrid varieties), dominant among these are the Longe Open pollinated (OPV) and Hybrid series that run from 1 through 12.

Water Efficient Maize for Africa (WEMA) is a public-private partnership project formed in 2008, coordinated by the African Agricultural Technology Foundation (AATF) and funded by the Bill and Melinda Gates and Howard G. Buffett Foundations. The project aims to develop and deploy royalty-free, drought-tolerant and insect protected maize varieties using a combination of conventional breeding, marker assisted breeding and biotechnology techniques and applications (AATF-NARO, 2010).

The **Lira District Strategic Plan** promotes seed multiplication in crops such as rice, maize, cassava and beans to ensure food security in the district. Further, the Production Department conducts staff and farmer study tours, and collects and shares investment information with maize and other farmers. The Department also conducts the improvement and construction of new storage facilities.

The **National Agricultural Research Laboratories (NARL)** supports the use of maize cribs at farm level and the construction of community and commercial stores, concrete drying yards, hermetic storage structures such as mud bins, super bags and 100 kg metal silo storage units. In addition, the post-harvest programme at NARL has distributed solar and biomass dryers that use charcoal or firewood.

Agricultural Business Initiative (aBi) Trust contributes to increasing the availability of farm inputs and improving the quality, supply and access to the market of selected maize and oil seeds value chains among others. The Trust has been involved in promoting trade-related sanitary and phytosanitary (SPS) and quality management systems (QMS), collective marketing, grain drying equipment, tarpaulins, moisture meters, and warehousing/storage facilities to improve product quality and competitiveness (aBi Trust, 2012). The aBi Trust supports the provision of financial and technical services to farmers' organizations and small and medium enterprises (SMEs).

Through the **Post-harvest handling and agro-processing (PHH-AP)** theme, since 1998 Sasakawa Global 2000-Uganda has been one of the major institutions supporting Uganda's maize value chain. Support is given to the use of improved shelling, drying and storage technologies (tarpaulins, concrete drying yards and cribs and cleaning and threshing equipment). Farmers' access to drying facilities has been approved through the One Stop Centre Associations (OSCAs) where farmers in the vicinity openly and freely access drying yards.

By using the value chain approach and Agricultural Innovation Platforms (AIPs), **the Sustainable Intensification of Maize-Legume cropping systems for food security in Eastern and Southern Africa (SIMLESA)** contributes to the improvement of the livelihoods of maize and legume producers by addressing preproduction, production and post-harvest challenges in the commodity value chains (Nanyeenya *et al.*, 2013). In Aromo and Lira subcounties of Lira district,

SIMLESA supports the use of 5-tonne maize cribs for individual smallholder farmers.

Four such cribs were constructed at model farmer sites. This is where farmer group members congregate for skill development, on-farm demonstrations and participatory project monitoring and evaluation activities. These cross-learning centres also serve as pivotal points for future collective grain storage and marketing. This project is funded by the International Maize and Wheat Improvement Center (CIMMYT) and the Australian Centre for International Agricultural Research (ACIAR).

The **Food and Agriculture Organization of the United Nations (FAO)** project OSRO/UGA/102/EC: 'Support to National Agricultural Research Organization: Improving food security and agricultural livelihood of the war affected communities in Acholi and Teso', targeted building capacity for hermetic storage, evaluation of modified atmosphere storage options and validation of grain super bag storage option on-farm in 2014 in order to reduce maize and beans post-harvest losses in Gulu and Pader. The project trained 100 Farmer Field Schools (FFS) groups in hermetic storage options and other post-harvest management options; selected 60 members of FFS groups to participate in on-farm validation of grain super bag storage; redesigned and evaluated metal silos for enhanced efficacy to address storage pests for increased weevil mortality and grain quality and developed manuals on technologies. The recommendation was made that more districts/farmers be reached with the technologies.

The World Food Programme (WFP) has provided post-harvest management training skills mostly for drying, cleaning and storage of maize in mini-silos. WFP has supported the acquisition and use of storage containers with different capacities: metal silos of 500 kg to 1 200 kg, plastic silos of 300 kg, Super bags of 100 kg, GrainSafe bags of 2 000 kg and Zero fly bags of up to 100 kg. In different parts of northern Uganda, WFP has also constructed large capacity stores under the Purchase for Progress Project in Lira at Amach and Barr subcounties and in Gulu district. Thanks to this action, farmers have been able to increase the storage life and quality of maize, thus leading to increasing farm incomes by at least 30 percent. The maize market's biggest player is WFP, which buys for its feeding programmes in the region's conflict zones.

Religious institutions supporting the improvement of maize post-harvest handling include **Catholic Relief Services (CRS), CARITAS-Uganda and KULIKA Charitable Trust** in the areas of group formation, Village Savings and Loan Associations (VSLAs) and collective marketing.

Other institutions that support programmes for improving post-harvest activities and maize quality are the International Fertilizer Development Centre (IFDC); World Vision International, which promotes the use of one-tonne silos; Welt Hunger; ASB, an organization based in The Netherlands Chemonics International Inc., a project funded by the United States and Volunteer Efforts for Development Concerns (VEDCO), which is a local NGO. Other NGOs such as KULIKA and SG 2000 promote 30 to 40 tonne collective community stores.

THE PROCESS OF POLICY-MAKING AND CURRENT POLICY FRAMEWORK OR NATIONAL STRATEGY

Agriculture trade liberalisation

The government public sector enterprises, also known as parastatals, were dismantled in the 1990s following Economic Structural Adjustment Programmes (ESAPs). This resulted in the implementation of privatisation and liberalisation policies. The agricultural commodity market was completely liberalised for all products including maize (FAO-MAFAP, 2012). Both domestic and international trade in all agricultural products has since remained in private hands. The government is no longer a sole importer, distributer and supplier of agricultural production inputs. The overall government policy framework in the agricultural sector, therefore, continues to emphasise private sector participation and investments. This emphasis is highlighted in a comprehensive strategy to deal with major constraints to private sector development, called the Medium-Term Competitive Strategy (MTCS) for the private sector (2000-2005). Currently, several firms are involved in maize bulking, storage, transport and processing in Uganda, which does not have, as yet, a formal trade structure for the marketing of maize.

Trade policies impacting maize trade include:

Customs tariff and non-tariff barriers – After ratification of the Customs Union, some tariffs were reduced while others were totally abolished as a step towards harmonising trade policies and taxes within the East African Community (EAC) Region. Uganda, Kenya and Tanzania have all adopted zero rate value added tax (VAT) on maize imports from within the EAC.

TABLE 9.2
Maize grading standards in the East African Community

Characteristics	Maximum limits			Method of test
	Grade 1	Grade 2	Grade 3	
Foreign matter, % m/m	0.5	1.0	1.5	ISO 605
Inorganic matter, % m/m	0.25	0.5	0.75	
Broken kernels, % m/m	2.0	4.0	6.0	
Pest damaged grains, m/m	1.0	3.0	5.0	
Rotten and diseased grains, percentage m/m	2.0	4.0	5.0	
Discoloured grains, % m/m	0.5	1.0	1.5	
Moisture, percent m/m	13.0	13.0	13.0	EAS285/ISO 711/712
Immature/Shrivelled grains, % m/m	1.0	2.0	3.0	ISO 605
Debris, % m/m	0.1	0.1	0.1	
Total Aflatoxins, ppb	10			ISO 16050
Aflatoxin B1, ppb	5			
Fumonisin, ppm	2			
Total defectives grains, % m/m	4.0	5.0	7.0	ISO 605

Export policies – Consistent with its commitment to a liberal trade policy, Uganda has emphasised that its maize export sector will remain as open as possible. Uganda has no maize export taxes, charges or levies. Importing countries largely regulate Uganda's maize grain exporters. Despite the fact that no policy per se discourages the exportation of maize, exporters must have certification for fumigation, phytosanitary and quality standards.

Exchange rate policy – Of relevance to maize production is the exchange rate policy addressed by the Bank of Uganda (BOU). BOU has continued to pursue a flexible exchange rate policy, whereby it intervenes in the foreign exchange market primarily to dampen short-term volatility of the exchange rate.

Price control – With the progressive liberalisation of Uganda's economy, a process that included trade among others, price regulation was abandoned as a trade policy tool. There is no export duty on maize (as well as other agricultural products); the government has not instituted any bans or other restrictions on trade in food commodities. As such, the market determines all prices (FAO-MAFAP, 2012), which results in wildly fluctuating prices for farmers.

Equipment and machinery imports – Import Duty Exemptions have been put in place, which apply to company motor vehicles, personal effects and plant and machinery. There are also provisions for duty drawback facilities. This allows exporters to claim taxes on inputs used to manufacture exportable products. With the exception of mining there is a uniform corporation tax rate of 30 percent, which allows the "carrying forward of losses". This means that profits are not taxable until the previous years' losses have been fully covered.

Quality standards for maize

According to the East African Grain Council (EAGC), maize standards have a 13-point grading system (EAC, 2011). If maize complies with these standards, and once hygiene of storage premises conforms to established warehouse standards, the trader qualifies to sell maize grain to international markets and the WFP, which is one of the leading maize grain buyers.

East African Standards are formulated in accordance with the procedures established by the East African Standards Committee. The Committee is composed of representatives of the National Standards Bodies in Partner States, together with the representatives from the private sectors and consumer organizations. Maize grain

quality standards have been developed to take into account the structure and specific requirements of the CODEX Alimentarius, United Nations Economic Commission for Europe (UNECE), United States, International Organization for Standardization (ISO) and other internationally significant standards. These place maize into three grades (Table 9.2).

RELEVANT INSTITUTIONS AND THEIR ROLE IN THE SMALL AND MEDIUM MAIZE INDUSTRY SECTOR

To align its strategic objectives with the national vision, the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) established the **National Agricultural Research Organization (NARO)** as a key player in providing high technologies to farmers to increase agricultural productivity and incomes.

In the same vein, the **National Agricultural Advisory Services (NAADS)** was restructured under the Prosperity for All (PFA) programme to provide support in the areas of input distribution and technical advice. The NAADS also supports farmers in organizing themselves into production groups, marketing groups or Savings and Credit Cooperative Organizations (SACCOs) (MAAIF, 2011).

Regarding food quality and safety issues, it is the role of the **Uganda National Bureau of Standards (UNBS)** to formulate and promote the use of standards; enforce standards for protecting public health and safety and the environment against dangerous, counterfeit and substandard products; ensure fairness in trade and precision in industry through reliable measurement systems; strengthen Uganda's economy by enhancing the competitiveness of local industries and promotion of quality exports through standardisation, quality assurance, testing and metrology.

Development agents have established **a number of commodity value chain actor platforms** at regional levels. These are known as Multi-Stakeholder Platforms (MSPs), and cover commodities including oilseeds, pineapples, dairy, pigs, cassava, rice, maize, coffee, poultry and Irish potatoes. The platforms are confined to regions rather than having national coverage. The existence of a number of these platforms is donor dependent; so there is a risk they will cease to exist when the projects end.

Chapter 10
The maize supply chain - situation analysis

DESCRIPTION OF THE SELECTED MAIZE SUPPLY CHAIN

Selected supply chains

The supply chains selected (maize grain and maize flour) are those found in Apac and Lira districts, in the Lango subregion, northern Uganda. Both districts were chosen because of the intensity of maize production, the presence or availability of agroprocessing and marketing services. Apac is one of the leading producers of maize in northern Uganda and Lira district is the main trade and processing hub. All locations supply to one and the same food supply chain.

The grain and maize flour supply chains are all rated highly important in terms of economy, employment provision and contribution to national food consumption (Table 10.3). In regard to the generation of foreign exchange, the grain supply chain generates more than the flour supply chain. Indeed, the export of maize flour is a recent development, mainly targeting South Sudan.

TABLE 10.1
Food supply chain in the maize subsector in Apac

FSC #	Geographical location	Final product	Volume of final product (tonne/year)	Number of people involved in production	Market of final product Location, buyers	Comments
1	Apac	Maize grain	45 730*	41 920 men 43 915 women°	Villages, Lira town and other parts of the country	49 % of the population provides the labour force and 47.5 % of the population is involved in maize production (UBOS, 2012).
2	Apac	Maize flour	>15 090**	<100 men <20 women°°	Villages, Lira town and other parts of the country	

* 2012 Statistical Abstract. Uganda Bureau of Statistics (UBOS, 2012).

** Assumes 40 percent of district production was sold, and 80 percent of the grain is milled (UBOS, 2010b).

° The population data used is that of National Population Housing and Census (UBOS, 2014b).°° Estimated values

TABLE 10.2
Food supply chain in the maize subsector in Lira

FSC #	Geographical location	Final product	Volume of final product (tonne/year)	Number of people involved in production	Market of final product Location, buyers	Comments
1	Lira	Maize grain	17 160*	32 995 men 35 800 women°	Villages, Lira town and other parts of the country	49 % of the population provides the labour force and 34.2 % of the population is involved in maize production (UBOS, 2012).
2	Lira	Maize flour	>9 060**	<500 men <50 women°°	Villages, Lira town and other parts of the country	

* 2012 Statistical Abstract. Uganda Bureau of Statistics (UBOS, 2012).

** Assumes 40 percent of district production was sold, and 80 percent of the grain is milled (UBOS, 2010b).

° The population data used is that of National Population Housing and Census (UBOS, 2014b).°° Estimated values

TABLE 10.3
Importance of the maize supply chains at national level

FSC #	Economic importance H/M/L	Employment provision H/M/L	Generation of foreign exchange H/M/L	Contribution to national food consumption H/M/L	Contribution to national nutrition/diet H/M/L	Environmental impact H/M/L
1	H	H	H	H	M	L
2	H	H	M	H	M	L

Description of the study area

The study was conducted from February 2015 to May 2015 in Ibuje and Akokoro subcounties in Apac, and in Amac and Barr subcounties in Lira.

Rainfall in the two districts is bimodal with one peak during April-May and the other in August-October. The average minimum and maximum temperatures are 22.5 °C and 25.5 °C, respectively. Farmers can grow two maize crops annually. The first planting season starts in March/April, while the second starts in August/September. The harvest seasons occur between July-August and December-January (Figure 10.1). Farmers commonly plant seed saved from the previous season. The most prevalent variety of maize grown by farmers in Lira and Apac districts is the open pollinated variety (OPV) Longe 5, which is an improved crop variety producing enhanced yields and reduced disease-related losses.

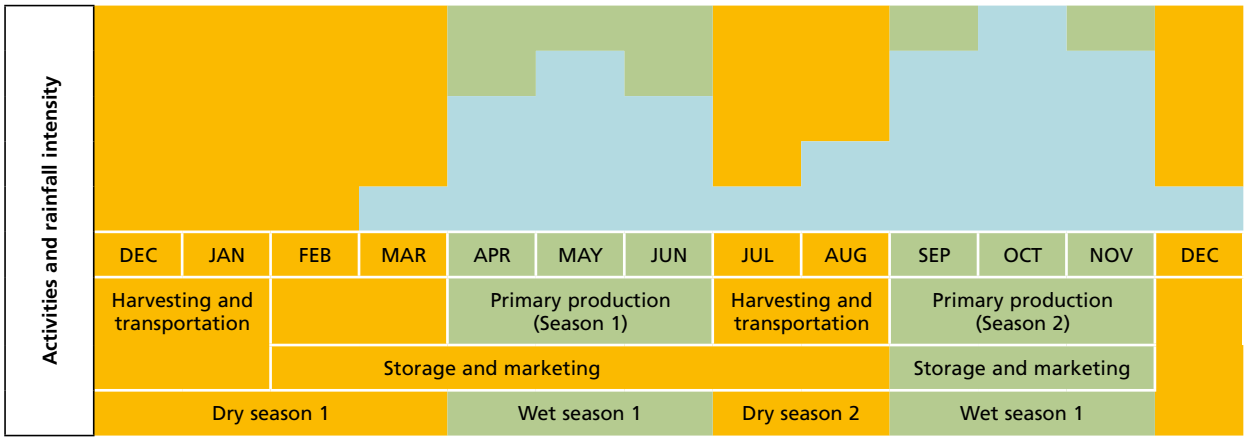
Description of the supply chains

In both districts, maize is transported from the primary producers to the consumers through several players: farmers, local produce dealers, millers, wholesalers, retailers and consumers. Maize is harvested, dried and shelled. Farmers participate in field management, harvesting, drying, storage and selling of maize grains.

Overall, an estimated 32 280 people are involved in the production of maize in the four subcounties of study, assuming that every member of the household (between 14 and 64 years) participates in maize production. Subsistence farmers are widespread. They cultivate maize on less than 1 ha and use traditional farming methods. The inputs used in production are seed, labour and hoes. The farmers use ox-ploughs and hoes to prepare the land.

Harvesting / field drying – In both districts, maize is harvested in piece meal by plucking and heaping cobs with sheaths in the field or removing sheaths and carrying them home right away. Farmers use knives and nails to remove the husks from the maize ears and either throw the cobs on uncovered ground, in basins or onto tarpaulins. Not all farmers plant at the same time, therefore, harvesting lasts about 4 months. Generally the crop is transported from the field to the homestead using bicycles and head portage. Some farmers leave the crop to dry in the field before harvesting and storage followed up by subsequent periodic re-drying on uncovered ground.

FIGURE 10.1
Seasonal crop calendar



Source: Survey data

Drying – Maize is dried at home, normally on uncovered ground. A few farmers use tarpaulins to dry maize.

Shelling – sticks are used to shell the maize. When sticks are used, shelling is done quickly but spillage and breakage is high.

Farm storage – Maize is mainly stored in the main dwellings and the remaining is stored in cribs and cane granaries. The storage period usually lasts up to three months. In a few cases, famers use storage pesticides such as Malathion dust 2 percent and phosphine fumigant to reduce weevil damage. Where phosphine is used, it is applied unprofessionally and thus exposes users to the dangers of pesticide poisoning.

Sales – Marketing includes looking for buyers and selling the produce. Farmers sell the bulk of their maize to primary bulkers, who in turn sell it to processors or processor agents. Farmers also sell the shelled grain to rural households. As a result of the lack of a central collection place and inadequate on-farm storage facilities, the marketing of maize grain is conducted individually (none, or very little collective marketing). The farmers do not usually have a large selection of buyers, who often set the prices. Farmers have no access to marketing information on prices and transportation costs. All their information comes from grain traders. The grain is sold at home or at the village markets. Farmers transport the maize grain to the nearest trading centre for marketing. The cost of transactions increase with the distance; in Apac the trading centre is 1 to 2 km away, but it is more than 100 km from Lira.

At the point of sale, local grain storeowners store the maize in polypropylene bags and sell it to medium-sized millers directly or to rural traders and agents, who will sell the stock of maize grain to medium and large-sized millers.

Milling – Can be categorised as medium-sized (commonly referred to as *posho millers*) and large millers. Medium-sized millers sell *maize flour* to urban and rural households, retailers or institutions including schools. The milling capacities range from 6 to 10 tonnes/day. The grain is occasionally stored for clients such as schools. Large millers procure the maize grain from local traders and agents and sell the flour to urban retailers and traders.

THE EXISTING MARKETING SYSTEM IN THE MAIZE SUPPLY CHAIN, FOR SMALL-SCALE PRODUCERS

Maize markets in Uganda are highly liberalised with minimal government interventions. Since the liberalisation of the marketing system, several private sector entrepreneurs have joined the various parts of the maize supply chain, including maize bulking, storage, transport, trading and processing. The supply chain has many participants with many traders and agents.

Maize is commonly sold in 122 kg sacks without premium price incentives for better quality grain. The pricing system is based on a kilogram unit and, when packed tightly, a so-called 100 kg sack can weigh up to 140 kg. Some of the maize is sold

TABLE 10.4
Price of maize by time of sale and main buyer type

Selling period	Price of Maize (UGX per kilogram)
	Mean
Immediately	500
Within one month	600
Within 3 months	700
Within 6 months	800
Mean	650
Main buyers, Lira (percent)	
Millers' Agents	13.3
Informal small scale buyers	80
Other	6.7

TABLE 10.5
Maize grain transaction costs (UGX per kilogram)

Hired labour	182
Services – ploughing	38
Purchased inputs	120
Finance	76
Farm cost of production (COP)	416
Farmgate price	500
Value-added by farmer	84
Local transport to rural primary bulker	59
Additional bulking at district town	88
Transport to Kampala grain trader	88
Cost into store (includes drying)	234
Cleaning, re-bagging, fumigation	146
Intermediate transaction costs	615

by volume in 2 to 20 kg tins. More than 80 percent of households lack proper storage facilities for maize grain. Therefore, to avoid damage caused by storage pests and other infestations, the grain is mostly sold within one month of harvesting to primary bulkers who often store it and sell at higher prices when the supply has reduced and the price is higher. During this period, market supply does not meet demand. The weight of the maize from the trader was, on average, 122 kg per bag.

As mentioned earlier, it is mandatory to meet the EAGC quality standards for large buyers such as WFP and to trade within the East African Community. These standards include parameters such as no live insects and there is minimum tolerance of broken grain among others.

Therefore, the price is highly influenced by the time in the season. Prices increase as the supply falls. During the harvesting season, prices are lower because of the temporary oversupply of maize and the price for maize is the lowest. Millers occasionally store grain for their clients in anticipation of better prices in the future.

When most of the grain is sold, produce buyers find it costly to collect the remaining small volumes scattered in the rural areas. Besides, the grain is often of poor quality because of weevil damage. These grains are sold to community members, or on a piecemeal basis at rural weekly markets.

The flour is sold by the kilogram and prices differ with the grade. The study reveals that Grade II is the most preferred product at the local and national market.

QUANTIFICATION OF STAKEHOLDERS' INVOLVEMENT AND BENEFITS

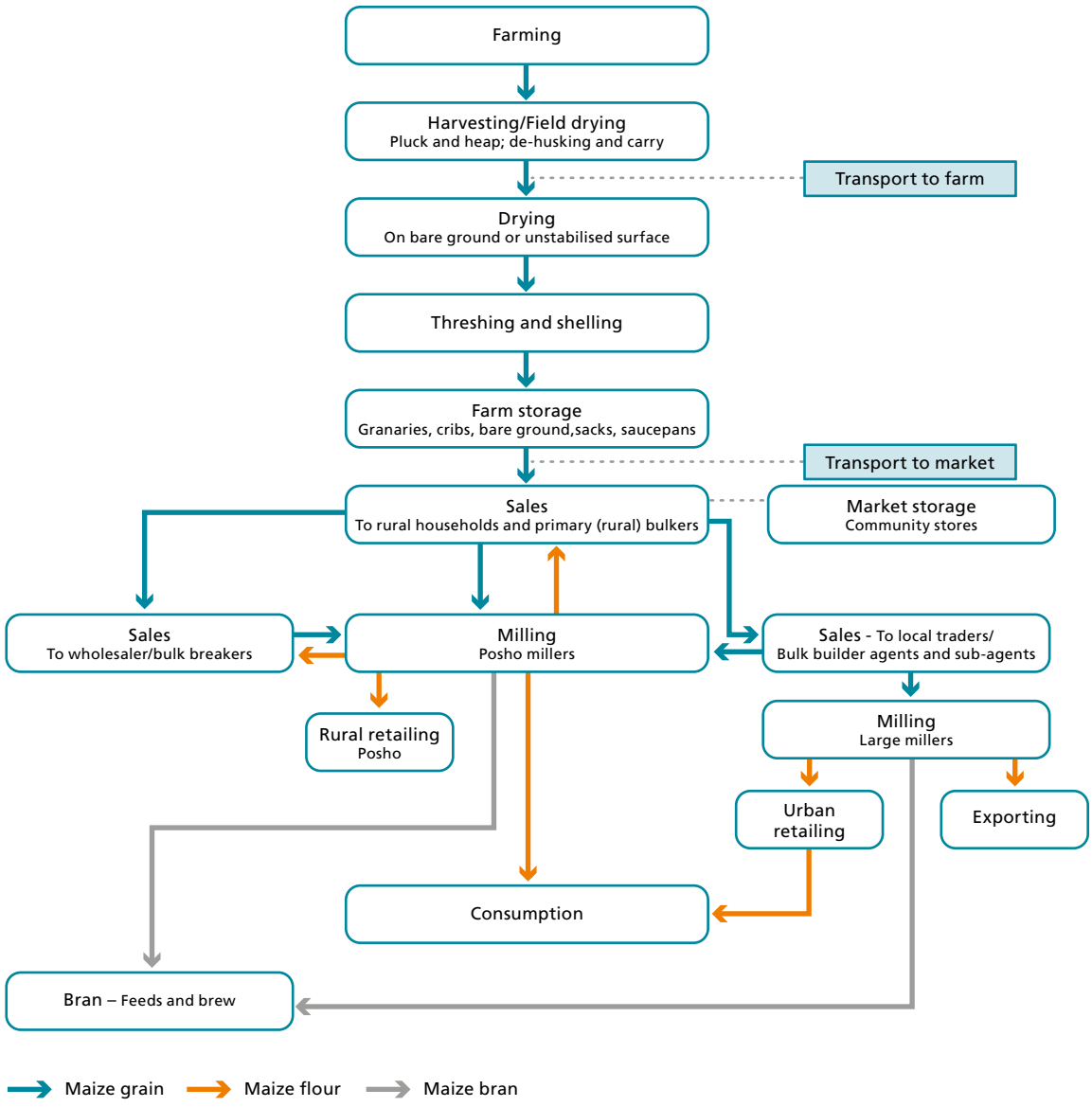
Maize production contributes significantly to food security and the livelihoods of small-scale farmers in Uganda. Maize is a major food item and provides famers with an important source of income. There are approximately 3.6 million producer households at the national level, of which about 1.5 to 1.8 are employed as commercial maize producers. In Lira and Apac districts, the annual income from maize production is respectively UGX 1 213 000 and 1 492 000. In the study area the main source of income is crop cultivation.

The rating of income-generation and home consumption presented in Table 10.8 is based on discussions with the stakeholders about the relative importance of maize to the supply chain actors.

Households in Lira district have a long history of maize production (15 years' experience, 7 years for Apac). Farm families are actively involved in all production activities and do not employ hired labour. Hired labour is, however, commonly used for weeding; the average proportion of farmers hired for this activity is 49 percent.

Most of the household heads are of middle economically active age (37.9 ± 2 and 44.5 ± 3 years in Apac and Lira districts, respectively). Findings concerning human capital – as expressed by level of education – indicate that 64 percent of households are headed by individuals whose highest attainment is primary or elementary education. Women headed households contain more decision-makers who have no form of formal

FIGURE 10.2
Flow diagram showing the maize supply chain



Source: Survey data

education, which is explained by women having limited access to education. Male headed households have more decision-makers with secondary and tertiary education.

Women in the study area have an essential role in maize production activities. However, they are excluded from, or have limited involvement in, other activities in the supply chain, relating to transportation, agroprocessing and sales, which are traditionally dominated by men. Women participate only in sales at local markets. Men's greater responsibilities involve negotiating with buyers and selling the products at the different trade levels along the chain. Therefore, a gender division of labour persists, with women being more prevalent in farm work. The underlying causes of these gender disparities are linked to traditional practices that are perpetuated by cultural and social norms that limit women's participation in diversified employment opportunities.

TABLE 10.6
Products in the maize supply chain

Activity in FSC	Product	Weight from 100 kg	Conversion factor
Shelling	Maize grain	70	0.7
Milling	Maize flour	66	0.66
Milling	Maize bran	30	0.3

TABLE 10.7
Income and job creation by stage in the supply chain

Value chain stage	Number of jobs	Income earned (UGX/kg)	Comments
Primary production	1 800 000	84	Considers 50 % of maize producer households to be commercial enterprises
Wholesale trading	3 800	170	These include rural bulkers, transporters and urban bulker (wholesaler's agents) and wholesalers themselves
Maize milling	6 900	153	Processor bulking agents, transporters and millers
Retail trading	4 500	120	Rural and urban shop owners, market stall operators and roadside maize grain vendors
Export trade	800	180	20 export trading companies and transporters: each one on average hires 4 people

Source: EPRC, 2013 and author's computation

TABLE 10.8
Importance of the maize supply chain for the actors

FSC actor	Income-generation	Home consumption
Farmers	H	H
Maize grain aggregators (store keepers)	H	L
Transporters	L	L
Input dealers	M	L
Millers	H	L

In addition, women have limited access to financial services such as for land, credit, extension services and agricultural technologies. They don't have the same access as men to transport equipment (e.g. bicycles, motorbikes, vehicles…). Bicycles and head portage are generally used to transport the crop from the field to the homestead. Women usually carry the crop on their heads whereas men commonly use bicycles. Transport to markets is mainly by bicycle.

Further to their substantial involvement in agricultural work, women undertake most of the reproductive and household work, including time spent caring for children and the sick, and processing food. Women play a key role in supporting their households in achieving food and nutrition security.

Cultural practices, beliefs, social norms and values regarding women's and men's involvement in the different links of the value chain, such as transport, processing, storage and marketing influence the way women and men participate in food supply chains. Gender differentials determine the access women and men have to productive resources and services and the share of benefits they can acquire, influencing the efficiency of the processes. Persistent gender discrimination should be addressed by giving women the same access to agricultural technology, equipment and productive resources. Evidence indicates that if rural women in developing countries had the same access to productive resources as men, they could increase yields on their farms by 20 to 30 percent and their contribution could reduce the total num-

TABLE 10.9
Preliminary screening of food losses in the selected maize supply chain

Food supply chain by geographical area and market product			
Step in the FSC	Expected Loss Points		Comments and remarks
	Quantitative (percentage) CLP or LLP	Qualitative CLP or LLP	
Harvesting and transportation	2.3	Mould contamination	Spillage, incomplete and unclaimed grain and cobs, soiling, damage by rodents and animals (monkeys, pigs, goats and cattle) and rain if the harvest is delayed.
Household storage, shelling and drying	15.7	Mould contamination, foreign materials, discolouration and aflatoxin content	Spillage, breakage from beating cobs. Grain packed in ordinary bags that are torn and spill the whole and broken grains. Pest damage resulting from poor drying on uncovered ground and heaping of the grain on floors and verandas of dwellings. Poor aeration; rat, termite and weevil damage; mixing of partially dried grain with chaff and dust; discolouration and mould contamination.
Transportation, rural bulking and storage	1.9	Mould contamination	Spillage and damage caused by the rain. Packaging and vehicles not waterproof.
Transportation, urban bulking and storage	2.1	Mould contamination	Spillage and damage caused by the rain. Packaging and vehicles not waterproof.
Grain milling	5	Mould contamination	Grain spillage at un-loading, machine feeding, flour spillage, cleaning and blowing. Contamination occurs when grain is mixed with dirty flour and dirty flour with the clean.
Flour wholesale trading	0.25	Discolouration	Discolouration from mould as a result of high moisture content and poor storage.
Flour, bran retail trading	0.2	Discolouration	

Source: information provided by the key informants (preliminary screening phase)

ber of hungry people by 12 to 17 percent (FAO, 2011). Access to and control over economic and financial resources is critical to enabling rural women's economic empowerment, improving food security and improving life in rural communities.

In Apac district, where maize is one of the major crops, subsistence agriculture is the main economic activity and employs 80 percent of the population. Women do approximately 75 percent of the work. Deliberate efforts are being made to ensure that women and youth receive and participate in extension services and training, especially in the NAADS Programme, which targets youth, women and the disabled to ensure equal opportunities for participating in all activities and taking up leadership positions.

FIGURE 10.3
Discoloured and broken grain from poor grain drying processes



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FOOD LOSSES IN THE SELECTED FOOD SUPPLY CHAIN

Consultations with experts during interviews at the preliminary stages of the case studies facilitated the pre-identification of three critical loss points: harvesting, storage and milling.

Chapter 11

The food losses – study findings and results

DESCRIPTION OF THE FOOD SUPPLY CHAIN: RISK FACTORS AND IMPACTS

Preharvest conditions and actions in the field can indirectly lead to losses at later stages in the chain, as production and agronomic practices influence quality at harvest, suitability for transport and shipping, storage stability and shelf-life after harvest (HLPE, 2014).

At the preproduction stage, various constraints have been identified as risk factors that influence maize losses (Table 11.1). These include:

- Limited use of improved inputs including certified seeds and improved technology because of high costs and poor delivery services.
- The susceptibility of the cultivated maize varieties to storage weevils also determines the loss levels incurred (Mwololo *et al.*, 2012).
- High vulnerability to climate with erratic rainfall patterns, resulting in drought stress or prolonged rains during some seasons.
- Limited knowledge of stakeholders about the losses and possible loss reduction measures.

CRITICAL LOSS POINTS: QUANTITATIVE AND QUALITATIVE FOOD LOSSES IN THE SELECTED MAIZE CHAINS

The field study involved interviews with farmers, millers, extension workers, and other pertinent stakeholders in the maize value chain. In addition, samples were collected along various stages of the food supply chain but focussing on the farmer and aggregator level. The product was analysed for quality at various storage durations and in different locations.

Respondents from maize producing households shared their perceptions of the key stages where losses are high.

- Harvesting – 81 percent of the respondents reported that most of the losses were attributed to spillage.
- Transportation from field to homestead – 72 percent of the respondents reported losses from spillage.
- Shelling – Breakages were recorded by 30 percent of households as being a major form of loss and 60 percent of the respondents reported losses from spillage.
- Storage – Pests/weevils (58 percent of respondents), presence of debris because of incomplete cleaning of grain, and aflatoxin contamination were the main form of losses during storage. Poor storage structures, poor cleaning, winnowing and drying processes are principal causes of losses.
- Milling – is a cause of quantitative loss of maize flour. The poor conditions of the mills (broken parts that lead to leakage and allow flour to escape from the system) are responsible for milling losses.

Three critical loss points were identified in this study as harvesting, storage and milling. The results of the quantitative losses are indicated in Table 11.4.

Table 11.5 shows the results of observations made along the food supply chain on how maize was scored in terms of market value. The maize is rejected when maize is mouldy and rotten, because of high moisture content or termite and weevil damage, and aflatoxin levels are over the acceptable values (10 ppb). Mouldy grain with weevils, however, can be fed to poultry and livestock such as pigs at the household level. In addition, when consulted during the focus group discussions in both districts, farmers reported that sometimes they use the damaged grain to prepare a local brew *Malwa* and *Kwete*. This can then be sold at UGX 1 800 per litre. This chain of production was not very well explained. The grain at this stage, however, will have already lost over 50 percent of its market value.

TABLE 11.1
Food loss risk factors

Factor	Unit	Relation to food losses: contributing to low losses	Value (observed in the case study)
Maize variety	Name	Not resistant to storage pests	Most farmers produce Longe series maize. Longe 5 is an open-pollinated variety (OPVs) that has been widely promoted as quality protein maize. The variety has a higher protein content; improved yields; disease-related losses are reduced (e.g. turcicum leaf blight).
Good Agricultural Practices (GAP)	Y/N	Yes, to some extent	Farmers observe timely planting and crop management practices. However, post-harvest handling practices are not adequate. Farmers delay harvesting, use poor threshing, drying and storage techniques/practices.
Rainfall during production	mm	Causes reduction in quality in the field as well as affecting drying	No rainfall was recorded during the study period.
Production supply/ demand ratio	Ratio	< 1	
Rainfall during post-harvest phase	Mm	Low	The period following harvesting of the crop was dry, and may not have had a significant effect on losses.
Post-harvest technology	L/M/H	High	Farmers lack improved post-harvest technologies, and employ poor practices. Technologies such as shellers exist but most farmers do not use them. Instead, sticks are used to thresh the grain.
POs / Coops	Y/N	Yes	Cooperatives are far away from the town of Lira, but most farmers in Apac do not belong to cooperatives.
Processing technology	L/M/H	High	There are some small-scale millers in the villages; most are in towns. The condition of the mills affects milling efficiency.
Good Manufacturing Practices (GMP)	Y/N	Yes	The condition of the maize mills, such as broken parts, contributes to milling losses.
Packaging materials and facilities	L/M/H	High	Polyethylene bags are used for packaging maize grain, which are prone to tearing resulting in losses during storage and transportation.
Cold chains	Y/N	No	Not applicable to maize
Transport duration	Hour	Low duration	Transportation to the nearest trading centre for grain marketing. The cost of the transaction increases with the distance. In Apac the trading centre is 1 to 2 km away but over 100 km from Lira.
Market information	L/M/H	High	Market information obtained from grain traders who purchase the grain from farmers.
Price incentive for quality	Y/N	Yes	None in both Lira and Apac. In the region, however, for large buyers such as WFP, maize meeting EAGC standards is the only type accepted for marketing.
Knowledge of FSC actors	L/M/H	High	Farmers lack adequate information on improved grain storage technologies. Wholesalers do not have much knowledge about management of storage pests. Millers do not manage storage of produce well and thus produce is exposed to damage by rats and insects. This is also as a result of lack of education about grain storage methods.
Consumer access to food product	L/M/H	High	Households have access to food as long as there is no crop failure. Also, there are diversified food crops such as cassava, beans and sweet potato.

Legend: Y/N = yes / no; L/M/H = low / medium / high.

TABLE 11.2
Detailed description of the maize supply chain (four subcounties) – Basics

Stage in food supply chain	Location	Months of the year	No. of actors*		Products	Quantity (tonne per acre)	Facilities/ Equipment	Duration/ Distance	Inputs and Services
			Men	Women					
Primary production	Akokoro, Amac, Barr, Ibuje	April-July (1st season)	13 359	13 861	Maize grain	1.2	Oxen drawn ploughs, hoes, spray pumps	4 months	Seed, fertilizers Labour (ploughing, planting, weeding and harvesting)
		Sept.-Dec. (2nd season)	13 359	13 861	Maize grain	1.2	Oxen drawn ploughs, hoes, spray pumps	4 months	
Harvesting and transporting to homestead	Akokoro, Amac, Barr, Ibuje	July-Aug. Dec.- Jan.	13 359	13 861	Maize grain	1.17	Bags, baskets, tarpaulins, bicycles	2 to 3 days	Labour, knives, machetes, nails
Drying and shelling	Akokoro, Amac, Barr, Ibuje	July-Aug. Dec.- Jan.	<13 359	<13 861	Maize grain	1.01	Bags, on the ground, sticks, sacks, tarpaulins	2 months for each season	Labour, hand-shellers, sticks, packing bags
Household storage*	Akokoro, Amac, Barr, Ibuje	Year round	<13 359	<13 861	Maize grain	1	Main house, cribs, granary	1 to 3 months	Labour, storage pesticides, bags
Transportation	Akokoro, Amac, Barr, Ibuje,	Year round	<13 359	<13 861	Maize grain	0.99	Bags, bicycles, motorcycles, vehicles	2 hours, 60 km radius on earth roads	Labour for off-loading, vehicles services and repairs
Market sales	Akokoro, Amac, Barr, Ibuje	Year round	<13 359	<13 861	Maize grain	0.97	Stores, packaging bags, weighing scales	12 months	Labour, market information
Milling	Lira	Year round	55	5	Maize flour Maize bran, broken maize	0.92	Mills, weighing scale, tarpaulins, bags, water	12 months	Labour, market information, utilities (power)
	Apac	Year round	20	5	Maize flour Maize bran, broken maize	0.92	Machinery and workshops, weighing scales, tarpaulins, bags, water	12 months	Labour, market information, utilities (power)
Transportation	Apac, Lira	August - April	8	60	Maize grain	0.91	Weighing scale, tarpaulins, bags, water lorries	Up to 350 km	Market information, vehicle services and repair
Wholesale	Lira and Apac	Year round	30	80	Maize grain and sifted maize flour	0.91	Weighing scale, tarpaulins, bags, warehouse, wholesale shops	12 months	Transport, sampling spears, labour, market information
Retail	All year round	Year round	105	125	Maize grain Maize flour	0.91	Mills, weighing scale, tarpaulins, bags, retail shops	12 months	Transport, labour, market information

Notes: *47.6 percent and 52.4 percent of the male and female population make up the labour force, respectively.

Primary production, bulking and transportation have discrete seasonality. Wholesaling and milling continue throughout the year since actors at these stages obtain grain from other regions outside Lira and Apac. Packing bags are used during the transport of grain and flour. Weak bags are already damaged and torn when sampling spears are used and grain is shelled with a stick, causing additional spillage. In addition, men hired to load and unload are paid according to the number of bags handled. They tend to work quickly and are not responsible for spilled grain that is commonly not reclaimed.

TABLE 11.3
Detailed description of the maize supply chain – Impacts

Stage in food supply chain	Cost of production USD/kg	Value of products USD/kg	Value-added/ margins USD/kg	Gender / social pattern
Primary production (land preparation, planting, weeding)	0.09			Men are in charge of land preparation, women participate in planting.
Harvest	0.003			By men and women.
Drying and shelling	0.02			Shelling by women using a stick to beat the grain, but men also participate when a machine is hired for shelling.
Storage	0.03	0.25	0.11	Both women and men are involved in storage activities and children participate when re-drying.
Transportation	0.03			Male dominated stage because of the limited involvement of women in the manual work of loading/unloading; women do not own bicycles and vehicles used to transport grain.
Market sales	0.03			Traditionally dominated by men when the crop has to be sold at the village store but women participate in sales at local markets.
Agroprocessing (milling grade 1)	0.09	0.63	0.48	Dominated by men since the processing plant is outside the community and women have mobility restrictions and do not own bicycles.
Winnowing	0.009		Na	Dominated by men since this is done at the milling and agroprocessors stage where women have limited involvement.
Storage			Na	Dominated by men who deal with buyers at this level.
Transportation			Na	Male dominated stage because of social exclusion of women from long distance driving of commercial vehicles.
Wholesale			Na	Dominated by men who deal with buyers at this level.
Storage space			Na	Dominated by men who deal with grain bulkers at this level.
Retail			Na	Men dominate for upper scale retail businesses such as shops. Women lack the capital and also social exclusion and illiteracy levels mean that women are unable to work in the shops. Market vending of grain at local markets is by women.

Source: Interviews of FSC's actors at the survey stage
Na: not available

TABLE 11.4
Level of losses at the selected critical loss points

District	Stage	Product	Percentage of loss (quantitative)	Cause
Apac	Harvesting	Cob	1.9	Spillage
	Storage	Grain	26.8*	Weevil damage, mould contamination, breakage (quantitative and qualitative loss). Losses were determined from loss assessment and interviews
	Milling	Flour	5	Leakage from machinery
Lira	Harvesting	Cob losses	4.7	Spillage
	Storage	Grain	7.2*	Pest damage, mould, breakage, rodents
	Milling	Flour	5	Poor status of machines

*Cumulative household-level storage, drying and threshing losses

TABLE 11.5
Quality scoring of maize grain

Product	Maize grain	
Quality Score	Description of the quality	Percentage reduction of market value
0	Mouldy, discoloured and rotten maize with aflatoxin levels over 10 ppb	100
1	Visibly mouldy, contains weevils and smells but is not rotten, can be fed to livestock	40
2	Grain is discoloured, with broken seeds, some foreign matter and over 50 % of the grain contains weevils, with live insects	30
3	Discoloured, at least 10 % weevil infested grain with some live insects and with 2 to 5 % foreign matter, pathological damage, mould	15-20
4	No live insects but at least 10 % of the grain contains weevils, breakage visible	5
5	Mechanical damage, breakage and a few live insects	5
6	No live insects but little foreign matter (less than 5 %)	0
7	As in 6	
8	As in 6	
9	As in 6	
10	No live insects and no breakage, no bad odour	0

TABLE 11.6
Results of farmers' sample quality analysis after three months of storage

Maize samples evaluated	District	* Percentage of insect damage grain	Moisture content	Percentage of mechanical damage	Percentage of discolouration	Percentage of debris	Percentage of samples positive with aflatoxin (at 10 ppb)
8	Lira	11.2	12.4	0.6	3.1	0.7	30
10	Apac	20	12.2	1.6	2.1	0.7	50
UGC standard (percentage)	≤	1.0	14	*5.5	*5.5	-	0
Mean		15.6	12.3	1.1	2.6	0.7	40

*The main storage pest attacking the samples is Sitophiluszeamais (the maize weevil). All the damaged samples are infested with this pest. The above table gives a value to the mean damaged grains.

TABLE 11.7
Variation in grain quality at community aggregation centres after four months of storage in Lira

	Town ship	* Percentage of insect damage	Percentage of mechanical damage	Percentage discolouration	Percentage of foreign matter	Percentage of moisture content
	Barr	10.3	0.9	4.3	0.3	10.3
	Ngetta	24.8	0.7	2.7	1.3	10.6
	Produce line	22.1	1.04	5	0.9	10.8
	Aler	28.3	1.02	3	10.8	10.1
Overall mean		21.4	0.9	3.7	3.3	10.5

THE CAUSES OF FOOD LOSSES AND IDENTIFIED (POTENTIAL) LOSS REDUCTION MEASURES

The results from the field studies showed a variation in losses among key actors and locations in the maize value chain. These losses were attributed to a number of factors ranging from delayed harvesting, farmers' inability to value the losses that occur, poor harvesting methods, poor drying, poor storage methods and structures, poor hygienic conditions and defective milling machines among others.

The losses that occur include spillage at all stages, reduced grain quality (discoloration and mould contamination during drying), breakage during threshing, and mould contamination and insect damage during storage.

Harvesting losses

At the harvesting stage, all the fields visited contained maize that had been left in the field, because of incomplete harvesting or spillage. Though not quantified, farmers threw maize on uncovered ground during harvesting, thus predisposing the grain to contamination. Another possible reason for harvest losses is farmers' ignorance of the factors that causes loss and the lack of appreciation of the magnitude of these losses. As a result, there is minimal supervision of harvesting practices and thus incomplete harvesting and high spillage. Careless handling of the produce from the field to homestead is a major contributor to maize losses. Women carry the maize on their heads and men use bicycles. In addition, storage pests such as the maize weevil *S. zeamais* cause damage to the whole grain in the field. Some farmers leave their maize to dry in the field believing that the grain will be of better quality. Delayed harvesting, however, results in pest introduction at the field level. Further, high humidity in the field increases discolouration, especially in the first season.

Drying of grain

Maize is dried on uncovered ground at the farm level. As a result of this practice, maize becomes contaminated with foreign matter and debris that lower the quality of the handled grain. Drying on the un-protected ground also means that the grain can become discoloured. As a result, grain does not meet the required market standard and is rejected. Farmers lack proper drying facilities for grain such as cribs and tarpaulins.

In Apac district, for instance, most farmers bring the grain from the field after it has been dried in the field. This exposes the grain to high losses resulting from mould contamination, since it usually rains during the first season at the time of field drying. As a result, maize from this season will usually be more shrivelled and discoloured and contaminated with mould because of improper field drying. The grains are also contaminated when they are spread on wet courtyards to dry. At times, farmers delay spreading their maize out to dry for days because of the rain. This results in mould, termite damage and thus poor quality grain. Some grain will be thrown away but, in most cases, it is mixed with clean grain and milled into flour.

During the second season (December-January harvest), farmers reported dry conditions, which enabled them to dry directly on the ground. The farmers try to maintain the quality required by the millers but good quality is not necessarily rewarded by higher prices.

Improving the drying of maize by using adequate facilities or equipment can result in significant reduction in losses at this stage.

Threshing of grain

Threshing is accomplished using knives and bare hands for small quantities, with greater quantities a stick is used to hit the maize. Hand shelling is laborious and is not feasible for large grain volumes. As such, farmers resort to beating the grain resulting in breakage and thus post-harvest losses. As the grain is threshed some is spilled and scattered and, in many cases, cannot be recovered. The broken grain is also more susceptible to mould and weevil contamination and thus will deteriorate faster during storage. Although there are a few shellers in Lira, most of the farmers interviewed had not accessed them. There is, therefore, a need for sensitisation and increased access to threshing technologies, for both men and women, to reduce drudgery and time spent during this process.

Storage losses

Losses observed for stored products include damage by storage insect pests (maize weevil *Sitophilus zeamais (Motsch.)* and the Angumois grain moth (*Sitotroga cerealella* (Oliv.). Other factors causing losses are mould contamination; insect frass, debris accumulation, rodent infestation, termite attack and discolouration related to inadequate storage conditions. Farmers believe that grain stored containing debris will increase its shelf-life and it will be damaged less by insect storage pests.

Discolouration results from humid conditions during storage caused by inadequate drying, poor

TABLE 11.8
Summary result matrix of maize losses (following)

Stage in food supply chain/ process	Type of loss Qn/Ql	Percentage lost in this process Quantity	Percentage of quality loss incurred in this process	Percentage loss in the FSC Quantity	Cause of loss/ Reason for low loss	Reduced market value	Impact/ Stakeholders affected (men/women)	Perception of stakeholders (men/ women)	Suggested solutions
Harvesting – Apac	Qn	1.9	-		Poor harvest scheduling and timing Left over during harvesting – may be attributed to: ▪ lack of equipment and good practices, careless handling of the produce; ▪ lack of or poor supervision; ▪ farmers simply being unconcerned about the quantity left in the field; ▪ lack of appreciation of the magnitude of the losses that occur. Field transporting – spilling; Inadequate means of transport (women carry on their head and men use bicycles).	Loss in value can be the result of reduced market volumes as a result of spillage. In this case it is directly equal to the amount of lost grain.	Reduced food and income for farmer families.	Ignored because it has never been quantified (one farmer said that maize should be left for the wild birds to feed on).	sensitisation and training of men and women in harvesting techniques; improve women's access to facilities, technologies and productive resources; supervision during harvesting; correct timing of harvesting.
Harvesting – Lira		4.7	-						
Storage – Apac	Qn			26.8	There is reduction in quality of grain because of the poor odour, presence of live insects and damaged grain. Weevils in grain lead to market rejection and devaluation of the grain. This occurs during on-farm storage in polyethylene bags and on-ground storage in the dwelling. Community aggregation stores also experience losses during storage and this can be over 30 %.	Occurs but was difficult to quantify. At storage longer than 3 months, damage and mould contamination can result in 50 % loss in market value.	Reduced quantity and quality. Reduced food and income for farmer families. Economic loss; rejection of the product.	Farmers are aware of the high level of losses during storage. Both men and women said losses occurred because of weevil damage.	Training in storage pest management; Research into more appropriate storage techniques.
	Ql			Up to 50	Humid conditions in the field and in storage. Poor temperature management. Lack of proper storage facilities. Insufficient drying and inadequate storage conditions. ▪ Discolouration; ▪ High moisture content leading to mould thus aflatoxin contamination.	At times the contamination is not detected, but at the level of regional trade grain rejection occurs when contamination is higher than the accepted level. If contamination with aflatoxin occurs, this can lead to rejection of grain by markets.	Reduced food and income for farmer families. Health risk to farmers and final consumers because of aflatoxin contamination. Economic loss.	Known but apart from re-drying of grain. Most times, quality loss in storage is not quantified. Danger of aflatoxin unknown to both men and women. Ignored because it has never been quantified.	Proper grain drying prior to storage and re-drying during on-farm storage. Improvement of storage conditions/facilities. Use of appropriate storage bags e.g. grain pro bags. Placement of bags on pallets. Use of fumigants and powders such as Actellic super during storage. Separation of old from new stock.

TABLE 11.8
(Continued)

Stage in food supply chain/ process	Type of loss Qn/Ql	Percentage lost in this process Quantity	Percentage of quality loss incurred in this process	Percentage loss in the FSC Quantity	Cause of loss/ Reason for low loss	Reduced market value	Impact/ Stakeholders affected (men/women)	Perception of stakeholders (men/ women)	Suggested solutions
Storage –Lira	Qn			7.2	There is reduction in quality of grain because of poor odour, live insect presence, and damaged grain. Weevil infested grain leads to market rejections and devaluation of grain. This is during on-farm storage in polyethylene bags and on-ground storage on the floor in the house.		Reduced food and income for farmer families; Economic loss; Rejection of the product.		Improvement of storage conditions/facilities. Use of appropriate storage bags, e.g. grain Pro bags. Placement of bags on pallets. Use of fumigants and powder insecticides in storage. Separation of old from new stock. Training in storage pest management. Research into more appropriate storage techniques.
	Ql			30	Aflatoxin infestation.	Rejection if detected but currently, at local market level, no testing.	Health risk to consumers.		
Milling	Qn	5			Poor mill conditions – leakage.	None	Reduced food volume for farmers and other consumers. Traders also incur losses because of the reduction in quantity. Financial loss.		Repair of mills. Regular maintenance of mills. Sensitisation and training of millers to result in better milling practices.

Note: Qn = Quantity; Ql = Quality.

Powder insecticides used include Malathion 2 percent dust. This pesticide has already been banned by international pesticide regulatory organizations for use in food products. Its use therefore is not recommended.

The use of fumigants (Aluminium phosphide in this case) is without proper safety and user guidelines. The consequences are two-fold: there is a risk of poisoning; and – over-dosage increases the danger of insecticide resistance, especially to phosphine. This is, however, the last resort for weevil management so that farmers can attain the grade required for export.

TABLE 11.9
Percentages of aflatoxin contaminated maize samples from traders' stores after 4-month storage

Site	Percentage of samples with aflatoxin levels above 10 ppb (n=10)
Barr	76.1
Lira central produce line	50
Aler	66.6
Overall mean	64.2
Acceptable level	0

FIGURE 11.1
Weevils coming out of a storage bag at a grain aggregation store



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storage conditions (temperature, humidity, etc.) and lack of storage capacity. For example, many farmers store grain on the uncovered floor, mix the maize grain with other products such as cassava chips and sunflower and fail to place maize bags on pallets. Where an attempt is made to use pallets, either they are insufficient, or are placed very close to the walls and roof.

In many cases, no space is left for air circulation within the pallets resulting in the grain moulding and a faster proliferation of insect pests. Most farmers store maize for a period of 2 months, while others extend the storage to 3 months. Adequate storage conditions are required to reduce losses at this stage. Improvement of storage structures will result in better grain quality. This will mean farmers will not need to rush sales for fear of maize contamination.

Rural traders

The rural traders mainly face challenges regarding the quality of the grain received from farmers, especially in relation to high moisture content, high levels of impurities, unfilled and broken grains. Rural traders, in particular the local grain store owners who buy grain at the village level, do not have appropriate storage for maize. Maize is stored in polypropylene bags, which are roughly stacked in the stores. Stores have poor ventilation and thus expose grain to low air circulation and result in the grain becoming contaminated with mould. Indeed, samples from these stores are heavily infested with weevils after 4 months' storage and have high levels of aflatoxin contamination. Millers obtain most of their grain for processing at this point. The grain may lose its good quality at this stage of the FSC if the store-owners do not learn and implement good practices. Therefore capacity-building and technologies are needed at this point in the supply chain as well as at the farmer level.

At 4 months of storage, all the sampled grain lots were infested with weevils. Analysis of the level of aflatoxin contamination from traders' samples showed that over 70 percent were infested at over 30 ppb (the minimum standard is 10 ppb). This was analysed using the rapid afla kit tests and further analysis may be needed to quantify the exact content of the contamination.

Milling losses

Milling losses were mainly quantitative as a result of broken parts at maize mills, which are the result of failure or the reluctance of the proprietors to carry out regular service and maintenance. This reason may be because such losses do not directly affect the millers, but instead are borne by their clients. Qualitative losses are also possible, especially when different quality products pass through the same machines without being cleaned. Also, in order to facilitate the removal of the husk during milling, millers mix the grain with water on dirty concrete floors. This predisposes the grain to contamination and results in contaminated flour. Repair and maintenance of the equipment, as well as training and capacity-building are potential intervention measures that would reduce maize losses at this stage of the supply chain.

FIGURE 11.2
Flour and bran spillage from poorly maintained mills



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Storage at the mill

Millers occasionally store grain for their clients, or in anticipation of better prices in the future. Storage conditions at the mill, however, may not be good enough for long-term storage. In certain instances, the grains are packed in good bags, but the bags are placed on concrete floors and there is no regular grain inspection or re-drying. This practice may also result in quality deterioration.

Chapter 12

The food loss reduction strategy – conclusions and recommendations

IMPACT OF FOOD LOSSES IN THE SELECTED FOOD SUPPLY CHAIN

Food losses shown in this study are a result of poor practices and lack of appropriate technologies along the food supply chain.

In anticipation of the losses incurred during household storage, farmers are usually forced to rush the sale of their maize soon after harvest. This reduces the quantity of food available to the household that will cost more later in the season. In addition, just after harvest, the prices are very low, thus resulting in loss of stable incomes at the household level. Where farmers persist and store their grain in traditional granaries, losses can be as high as 50 percent because of weevil damage over 3 to 5 months of storage. In extreme cases, where mould contamination has set in, the grain cannot be sold, leading to financial losses, loss of livelihoods and contributing to food insecurity at the household and community level.

Losses affect food security in all its dimensions:

- Food availability – Reduction of the quantity and availability of maize and maize products.
- Food accessibility – Decreased access to food, for those involved in harvest and post-harvest operations and who face economic and income losses, and for consumers caused by the contribution of losses to tightening the food market and raising the price of food.
- Food utilisation – The negative impact on the safety, quality and nutrient composition of the produce all along the chain, including the consumer level, which negatively impacts consumers' nutrition and health.
- Food systems stability – Losses impede the stability of the supply chain.

REQUIRED INPUTS AND COST-BENEFIT ANALYSIS OF THE FOOD LOSS REDUCTION MEASURES (FOR 10-YEAR IMPLEMENTATION) IDENTIFIED AT THE CRITICAL LOSS POINTS

Food loss reduction measures

Addressing the losses at the critical loss points will need a multi-pronged approach to include both capacity-building and technological interventions that target different levels of operations and sections along the chain.

To address losses at the harvesting stage – It is important that farmers practice timely maize harvesting. This means that the maize should be allowed to dry for only 2 to 3 weeks after physiological maturity and then harvested and dried at home in improved cribs. Timely harvesting would result in reduced field-to-store pest infestation of grain, and fewer losses related to inefficient and improper grain harvesting.

Proposed solutions for decreasing harvesting losses include:

- sensitisation and training of men and women in harvesting methods and techniques and in harvest scheduling and timing;
- improved supervision; and
- improved access of women to facilities and equipment (e.g. wheelbarrows and bicycles) to ease field-to-home grain handling, which is a challenge for women.

According to WFP, it is estimated that USD 24 is needed to train one person in improved post-harvest management and storage pest-management losses in northern Uganda. There is a need to invest the appropriate funds and employ trainers and purchase the materials required to build farmers' capacity in northern Uganda to improve harvesting and other post-harvest stages.

TABLE 12.1
Budget calculation for maize food loss reduction using motorised shellers

	Motorised shellers (10 per subcounty)	Value	Unit
A	Product quantity	5 520	Tonne/year
B	Product value	250	USD/tonne
C	Loss rate	4	%
D	Anticipated loss reduction	80	%
E	Cost of intervention	20 310	USD
F	Depreciation	15	Years
G	Yearly costs of investment	1,350	USD/year
H	Yearly costs of operation	10	USD/year
I	Total yearly costs of solution	1 360	USD/year
J	Client costs per tonne product	0.25	USD/tonne
K	Food loss	220	Tonne/year
L	Economic loss	55 000	USD/year
M	Loss reduction	176	Tonne/year
N	Loss reduction savings	44 000	USD/year
O	Total Client costs	1 360	USD/year
P	Profitability of solution	42 640	USD/year

*Price of UGX 800/kg is assumed, which corresponds to USD 250 per tonne for the price attained if grain is sold after 6 months' storage

Preparatory stages to ensure safe grain storage – Producing good quality grain is crucial for farmers so as to ease access to the markets to sell their produce. Interventions are needed to ensure grain is of good quality prior to being stored. Thus, there is a need to ensure proper drying of the grain to remove the contamination linked to on-ground drying, termite damage, and the formation of mould, which results in contamination with aflatoxin. The adoption of an improved crib is recommended as one of the first technological packages to address losses at the stage of storage. This would also be labour-saving, as farmers will not be involved in the continuous re-drying of grain.

Second, to address the issue of grain breakage, and thus infestation with storage pests (Muyinza, 1998), it is recommended that the use of improved maize threshers be adopted, as one of the interventions to reduce losses during grain storage. There is the need to train farmers in the use of these technologies to facilitate their adoption.

The use of cribs and improved shellers will also need to be re-enforced by the use of sieves to clean the grain. These can easily be obtained at the community level. The three grain-preparation processes are linked to storage and will ensure that the right quality of grain is loaded into the storage structures.

To address losses during storage – Numerous technologies can be deployed depending on the availability of the equipment at the local level. These can be plastic silos (300 to 400 kg capacity), half-tonne silos, 1 to 3-tonne metal silos, grain safe bags and 30-tonne maize stores for community grain storage enterprises. In parallel, training should be provided to a few grain handlers at the community level that also covers fumigation. The beneficiaries of these training sessions can then provide this service at a fee to farmer group members, who will have structures such as 30-tonne stores. Training will include improved store sanitation and first-in-first-out (FIFO) practices for grain storage. Pallets should be used to reduce moisture migration from the ground, as well as moisture management practices.

To address losses at the milling critical loss point – There is need to ensure that millers are trained to carry out grain pretreatment prior to milling. This will ensure that the quality of the processed grain is not compromised. In addition, the use of improved mills will reduce spillage and the

probability of finding broken metal parts in the processed flour, which result in safety concerns for consumers. There is the need to link these interventions with repairs and regular servicing of machinery to ensure that no grain is lost during processing. It is thus strongly recommended that regular training be carried out to ensure millers recognise the need to service their machines and maintain the proper safety level of their product.

The costs and profitability of the solutions recommended for addressing the losses in a target subcounty have been calculated and presented in the Tables following. The calculations are based on 10 or 15 years of operation of the proposed improvements. However, the interventions suggested need thorough analysis as to their economic feasibility, environmental impact as well as social acceptability and how they will be managed, before they can become actual recommendations and be put into practice.

Budget calculation for maize loss reduction within a subcounty

Investing in motorised shellers – The use of motorised maize shellers to ensure that maize is shelled in the field will reduce weight and quality losses resulting from spillage, breakage, soiling and debris. Furthermore, the shelling cost of using a stick is UGX 3 000 per 120 kg bag. The cost for this operation is UGX 2 000 per 120 kg-bag using a motorised sheller.

This service is not common in northern Uganda but the machines are used in other areas where maize is a major crop. Shellers can be fabricated locally by private workshops in Lira town and at the Agricultural Engineering and Appropriate Technology Research Institute (AEATRI) at NARO. At the current cost of UGX 6 500 000/= USD 2 030 for a motorised sheller, a private investor would recover the investment within one year. This machine can last for at least 15 years. The machinery can be operated as a business, and would result in reduced losses at the farmer group level in addition to contributing to income-generation.

Investing in improved maize-drying cribs – The use of the cribs will reduce losses related to grain contamination during drying. A crib has two functions; it can be used both for drying and storage. However, protection of the produce, especially from thieves, has to be considered since cribs are constructed some distance from the dwelling, whereas small domestic silos can be accommodated inside houses. Adoption of cribs

TABLE 12.2
Budget calculation for maize food loss reduction using 5-tonne crib

	5-tonne crib (30 percent adoption)	Value	Unit
A	Product quantity (30 % of total production)	1 660	tonne/year
B	Product value	250	USD/tonne
C	Loss rate	3	%
D	Anticipated loss reduction	85	%
E	Cost of intervention	300 000	USD
F	Depreciation	15	Years
G	Yearly costs of investment	20 000	USD/year
H	Yearly costs of operation	0	USD/year
I	Total yearly costs of solution	20 000	USD/year
J	Client costs per tonne product	12	USD/tonne
K	Food loss	49.8	tonne/year
L	Economic loss	12 450	USD/year
M	Loss reduction	42.3	tonne/year
N	Loss reduction savings	10 580	USD/year
O	Total client costs	20 000	USD/year
P	Profitability of solution	- 9 420	USD/year

TABLE 12.3
Budget calculation for maize food loss reduction – using half-tonne domestic silos

	Half-tonne domestic silo (1 278 silos)	Value	Unit
A	Product quantity at subcounty level	4 600	tonne/year
B	Product value	250	USD/tonne
C	Loss rate	10*	%
D	Anticipated loss reduction	90	%
E	Cost of intervention	200 000	USD
F	Depreciation	10	Years
G	Yearly costs of investment	20 000	USD/year
H	Yearly costs of operation	0	USD/year
I	Total yearly costs of solution	20 000	USD/year
J	Client costs per tonne product	4.35	USD/tonne
K	Food loss	460	tonne/year
L	Economic loss	115 000	USD/year
M	Loss reduction	414	tonne/year
N	Loss reduction savings	103 500	USD/year
O	Total Client costs	20 000	USD/year
P	Profitability of solution	83 500	USD/year

*During on-farm storage, indicative levels of losses are about 10 percent.

TABLE 12.4
Budget calculation for maize food loss reduction using 3-tonne metal silos

	3-tonne silo (1 278 silos)	Value	Unit
A	Product quantity	4 600	tonne/year
B	Product value	250	USD/tonne
C	Loss rate	10	%
D	Anticipated loss reduction	85	%
E	Cost of intervention	580 910	USD
F	Depreciation	10	Years
G	Yearly costs of investment	58 090	USD/year
H	Yearly costs of operation	0	USD/year
I	Total yearly costs of solution	58 090	USD/year
J	Client costs per tonne product	12.6	USD/tonne
K	Food loss	460	Tonne/year
L	Economic loss	115 000	USD/year
M	Loss reduction	391	Tonne/year
N	Loss reduction savings	97 750	USD/year
O	Total client costs	58 090	USD/year
P	Profitability of solution	39 660	USD/year

TABLE 12.5
Budget calculation for maize food loss reduction using 300-kg plastic silos

	300-kg plastic silo (40 percent adoption)	Value	Unit
A	Product quantity (40 % of total production)	1 840	tonne/year
B	Product value	250	USD/tonne
C	Loss rate	10	%
D	Anticipated loss reduction	90	%
E	Cost of intervention	19 420	USD
F	Depreciation	10	Years
G	Yearly costs of investment	1 940	USD/year
H	Yearly costs of operation	0	USD/year
I	Total yearly costs of solution	1 940	USD/year
J	Client costs per tonne product	1.1	USD/tonne
K	Food loss	184	Tonne/year
L	Economic loss	46 000	USD/year
M	Loss reduction	166	Tonne/year
N	Loss reduction savings	41 400	USD/year
O	Total client costs	1 940	USD/year
P	Profitability of solution	39 460	USD/year

and silos will therefore be on a case-by-case basis. It may be that improvements to a traditional drying and storage structure will be adequate. In the beginning, it is projected that 30 percent of maize producer households will adopt the use of a crib, each costing UGX 2 500 000/= USD 781.3.

While technologies such as drying cribs are appropriate and well advised, the farmer can only profit from the intervention if they improve productivity (yield/ha) and obtain better prices for grain. Calculating the benefits of improved drying and storage for the farmer is not easy. Benefits could be measured in terms of reduced losses and higher selling prices. Improved drying and storage cribs could allow for maize harvested at 30 percent moisture content to be dried on the cob to recommended rates in about six weeks. The price of a new crib (USD 780) may seem very high to farmers and they may be reluctant to make the investment, even though it will benefit them in the long run. It is important to realize that a farmer is not building a crib or a store for just one season. He would be unlikely to get his investment back in one year. A well-constructed crib, regularly maintained, can last for many years (15 years). It is estimated that an additional income of USD 220 per annum would be earned as a result of adopting a crib, as the farmer will be able to sell his maize at USD 250 per tonne, instead of USD 187.5 per tonne. A household's investment in such an equipment would be recovered in around 4 years with the additional revenue earnings. It could also be suggested that two or three producers invest in a crib, and dry and sell their grain together. In this case, the costs related to the investment and maintenance of the crib would be shared between these households.

Investing in storage silos – Storage structures were also analysed: the metal silos as recommended by WFP and those being developed by NARO.

Using this storage technology, the quality of maize will be improved and can be stored for longer, enabling farmers to earn higher prices (UGX 700 to 800 per kg compared to a maximum of UGX 600 received when sales are made within one month of harvesting). Indeed, as stated previously in the report, farmers commonly sell maize grains within a month after harvesting because they lack storage facilities. Rural buyers who store the maize take advantage of the price margin.

Each silo of 500 kg costs UGX 500 000 (/= USD 160). According to the records of the Par-

ish Development Committees (PDCs), there are 1 278 maize producer households in a subcounty. Considering the current acreage of 1.8 acres per household and the mean yield of 1 200 kg per acre, and considering that farmers sell 80 percent of their produce, each household would then sell 3 455 kg of maize. A farmer can then earn approximately UGX 2 000 000 (/= USD 650) from maize production. In one season, a farmer would be able to buy a half-tonne silo. There is one workshop in Lira where these silos are made. The silos are currently supplied to agencies, including World Vision International, which recently acquired one-tonne silos. Other agencies including AKORION, ACTED, BRAC, CESVI and ACTED also support the purchase of metal silos and carry out capacity-building for farmers.

Profitability would be USD 83 500 if each household in a subcounty used a half-tonne silo.

Profitability is also calculated if using 3-tonne metal silos (estimated unit cost: UGX 1 454 550/= USD 450) and 300-kg plastic silos (estimated unit cost: UGX 120 000/= USD 37.5).

The profitability of solutions and supplies of storage facilities considered market prices. The prices used in the calculation take into account an acceptable mark-up (profit). The authors discussed construction of metallic silos with a fabricator in Lira town who supplied World Vision 1 and 3-tonne silos at a profit. Suppliers of polyfibre/plastic tanks are private firms who price their merchandise to the final consumer to include tax and profit.

Investing in a 30-tonne warehouse

The use of the 30-tonne warehouse (estimated unit cost: UGX 39 756 800/= USD 12 500) would benefit groups of farmers at the community level to store their grain, thus reducing the unit cost incurred by individual farmers. However, there will be need to ensure that the groups are well run and able to manage the grain activity.

Investing in hermetic bags

Use of hermetic bags is a choice that would be made by less privileged households that either cannot afford, or may be isolated and find the adoption of cribs, metallic silos and grain safes unsuitable for use in their circumstances. In this area, the average production of maize is about 2 160 kg per season. This means each adopting household would require 22 bags each at USD 2.12 totalling USD 46 per household. It is expected that each bag can last two years and would be used two seasons a year. At a loss rate of 10 percent at the storage stage and expected loss reduction of 85 percent, adopters will be able to extend the storage period by at least two months and would maintain premium quality and earn UGX 700-800 per kg instead of UGX 600 per kg of maize grain. In the final assessment, each household would obtain an additional profit of USD 54.5 per annum. This is equivalent to an additional 0.31 tonnes of maize put into maize production per household per annum.

Quick assessment of economic and social benefits of using crib and metallic silo solutions

Economic implications – By using these solutions, farmers will increase their revenues (they will be able to receive up to UGX 700 to 800 per kg of maize sold instead of the usual UGX 600 per kg). In general, there will be at least a 30 percent increase in maize-related income-generation. In addition, actors' confidence in the quality of the produce in the value chain will increase. Further, better grain quality will also improve the milling outturn.

Social implications

- It is foreseen that additional proceeds will be ploughed back into the workforce and local economy: field labour, manufacturers and suppliers of silos, training to apply solutions, etc.
- Labour and housing structures that serve/are employed to store the produce will be used for alternative use.
- Women will reduce their workload, and will have more time to participate in other productive activities, producers' organizations, as well as family activities. An additional positive aspect would be the reduction in the gender gap in accessing equipment, training, among others. The solutions will enhance food security by increasing the purchasing power of the household.
- The overall safety of food and nutritional value of food will be improved through reduction of the potential causes of aflatoxicosis.

There are no substantial environmental implications for the solution since the sealed system will not require additional use of land, water and energy and no waste products and wastewater will be discharged. In fact, if post-harvest management is improved, the practice of farmers expanding production by tilling more land will be reduced and land use will be environmentally more sustainable.

In Uganda, aggregate maize production is an

TABLE 12.6
Budget calculation for maize food loss reduction using a 30-tonne warehouse

	One 30-tonne warehouse	Value	Unit
A	Product quantity	4 600	Tonne/year
B	Product value	250	USD/tonne
C	Loss rate	10	%
D	Anticipated loss reduction	80	%
E	Cost of intervention	12 420	USD
F	Depreciation	15	Years
G	Yearly costs of investment	830	USD/year
H	Yearly costs of operation	100	USD/year
I	Total yearly costs of solution	930	USD/year
J	Client costs per tonne product	0.2	USD/tonne
K	Food loss	460	Tonne/year
L	Economic loss	115 000	USD/year
M	Loss reduction	368	Tonne/year
N	Loss reduction savings	92 000	USD/year
O	Total client costs	930	USD/year
P	Profitability of solution	91 070	USD/year

TABLE 12.7
Budget calculation for maize food loss reduction - using 100-kg hermetic bags (Household level)

	Hermetic bag (per household)	Value	Unit
A	Product quantity	3.6	Tonne/year
B	Product value	250	USD/tonne
C	Loss rate	10	%
D	Anticipated loss reduction	85	%
E	Cost of intervention	46	USD
F	Depreciation	2	Years
G	Yearly costs of investment	23	USD/year
H	Yearly costs of operation	0	USD/year
I	Total yearly costs of solution	23	USD/year
J	Client costs per tonne product	6.4	USD/tonne
K	Food loss	0.36	Tonne/year
L	Economic loss	90	USD/year
M	Loss reduction	0.31	Tonne/year
N	Loss reduction savings	77.5	USD/year
O	Total client costs	23	USD/year
P	Profitability of solution	54.5	USD/year

Profitability (USD/annum/household) = 54.5
Assumed to be used for two seasons a year, for 2 years
Profitability = value of 0.31 tonne of maize grain

estimated 2 748 000 tonnes and price per tonne is about USD 250; millers claim that most of the losses incurred at their level start at the farm (there are many foreign materials mostly soil, chaff, broken cobs, broken, dirty and mouldy or discoloured grain).

FOOD LOSS REDUCTION PLAN AND STRATEGY, INVESTMENT REQUIREMENTS

There is a need to develop a detailed intervention programme. The first strategic elements are provided in this section.

It is very important that technologies be adopted to address the factors causing losses that were identified at the critical loss points of harvesting, storage and milling. These technologies should be tailored to the needs of the actors in the value chain. Where groups of farmers are to use these technologies, capacity-building will be crucial to ensure farmers keep proper records, have a knowledge of financial management and maintain healthy group dynamics. Loss reduction interventions will thus not only involve delivery of the technologies but also ensuring that they are suitable and beneficial to the target groups.

These is therefore the need for the development of a clear roll out strategy to collect baseline information, monitor progress on loss reduction targets and ensure cost-sharing by the target groups, so that they will own the technologies and ensure they are optimally utilised in a sustainable manner. Gender concerns also need to be addressed effectively. It is important that technological changes result in the drudgery of women's work being reduced at the stages where they are directly responsible, such as during drying and threshing of the maize.

An integrated approach is necessary to guarantee the sustainable uptake and use of the technologies and to ensure communities own the interventions and are able and willing to continue their use after the life of the project. In addition, farmers can only transform from subsistence to commercial or market-driven farming if key challenges such as access to credit, market information and product quality assurance are adequately addressed. Farmers need to be engaged actively in attaining trade-related sanitary and phytosanitary and quality management systems.

The options discussed in this report indicate that their adoption could result in enhanced profitability of the maize farmers' enterprise at the smallholder level. The strategic intervention could be implemented in three components:

- sensitisation to create awareness about the losses, their causes and mitigation measures;
- capacity-building through training in the available technologies for loss reduction and the benefits of their adoption; and
- sourcing of support to increasing access to proper post-harvest handling, storage and processing technologies for the target farmers.

FOLLOW-UP ACTION PLAN AND CONCEPT NOTE FOR FUTURE INVESTMENT

Three critical loss points were identified in this study: harvesting, storage and milling, with the highest levels of cumulative losses during storage. Damage by insects, aflatoxin contamination, and the presence of debris are the main causes of losses. Proper storage is therefore needed to reduce these losses. Improvement of storage structures will result in better quality grain and increase food security and market access.

Given the current yield of 1 200 kg per acre, the mean acreage of 1.8 acres per household and considering that farmers sell 80 percent of their produce, each household would then sell 3 455 kg of maize. A farmer could earn approximately UGX 2 000 000 (/= USD 650) from maize production. If the maize is sold at UGX 800/kg, instead of UGX 600/kg, an additional income of at least UGX 700 000 (/= USD 220) per annum would be earned as a result of adopting the use of either a well-designed and built crib or silo. The money earned would be sufficient to recover the purchase price of a half-tonne metal silo; investment in a one or three-tonne silo could be recouped within around two years. This implies that a household's investment in a crib would be recovered in around 4 years.

Scenarios considered for the financing of the silos include credit, co-sharing, cash based procurement, potential suppliers and delivery system to farmers. There are several types of farmers with respect to their financial stability: Commercial farmers who produce at least 5 tonnes of maize grain can use the proceeds from their maize enterprise to finance the solutions. Farmers who save money through SACCOs can procure the interventions using their internal savings and credit arrangements. Another plausible channel could be the financing of loans as several banks offer financing for farm equipment and assets. Banks with branches in Lira town include the Bank of Africa, Housing Finance Bank and Centenary Bank.

TABLE 12.8
Summary table of losses, causes and solutions

Stage in the supply chain	Magnitude of losses in the FSC (per year) (subcounty level)			Intervention to reduce losses	Loss reduction (per year)		Total yearly costs of solution (USD/year)	Profitability (USD/year)
	Percentage	Weight (tonne)	USD		Percentage	USD		
Harvesting	3.3	182.1	38 630	Trainings	98	37 860	30 670	
Drying	3	165.6	41 400	Maize cribs at household level (30 percent adoption)	85	10 580	20 000	- 9 420
Threshing	4	220	55 000	Improved threshers at sub-county level	80	44 000	1,360	42 640
Household storage	10	460	115 000	500-kg metal silos	90	103 500	20 000	83 500
				3-tonne metal silos	85	97 750	58 090	39 660
				300-kg plastic silos (40 percent adoption)	90	41 400	1 940	39 460
				PICS bags (22 bags per household)	85	97 750	29 400	68 350
				30-tonne community store	80	92 000	930	91 070
Milling	5*			▪ Enforce standards and compliance to standards ▪ Regular inspection and repair of mills ▪ Promote collective bulking and marketing through cooperatives				

* Losses are 5 percent at milling. It is assumed that warehouse storage technology will reduce losses during milling since the quality of milled grain will improve.

Processes and approaches for technology application

Ensure that gender concerns are taken into account during dissemination of training and technology – This is in line with requirements in the ongoing strategic plan for agricultural policy. Gender concerns need to be taken into consideration when planning and in the roll out of piloting and promotion of the loss reduction technology.

Farmer awareness, promotion, sustaining interest and adoption – Information dissemination for the promotion of technology needs to ensure there is a system in place to continuously inform farmers of the existence of the loss reduction technologies for the three critical loss points identified. This could be achieved through radio programmes, and other media events where farmers can be shown the benefits of investing and using improved technologies in comparison to losses incurred when handling grain using traditional methods.

Efforts will also need to be made to promote multi stakeholder information platforms on maize and establish on-farm demonstrations/ trials, etc. – These efforts will enable an increase in the number of technologies reaching the beneficiaries, which can be achieved through both on-station and on-farm demonstrations given by researchers.

Demand for metallic silos – It is foreseen that every maize producer household will acquire at least one silo, which can be lifted and kept inside the main dwelling for safe-keeping. Given the numbers of households, it is expected that up to 1 280 silos will be adopted for use (one per maize producer household) in a subcounty.

Activities – Organization of training and awareness-raising activities to:

- Demonstrate the gravity of weight losses resulting from poor drying and storage of maize and income losses caused by rushed sales because of the lack of appropriate storage facilities. These issues were outlined in the focus group discussions conducted with farmers.
- Raise farmer awareness about the existence of metallic silos, cribs and motorised shellers, their benefits and returns on investment for households that adopt them: quality and optimum duration of the grain in the silos within the farming communities, price advantages and revenue generation, and the possibility of the incentive of earning premium prices for better quality grain. Media and other channels should be initiated to create awareness about the availability of these solutions, distribution channels and their advantages.

Beneficiaries – Stakeholders – women and men – should be involved in training. Drawing upon the experiences of WFP, AEATRI and NARL, which have trained technicians and artisans and/or promoted the use of cribs, silos and shellers. To ensure that women participate in training, there should be separate sessions and women trainers should be employed if needed. Women and men must be aware of the advantages of reducing the gender gaps by improvement in the conditions where women are involved along the chain. Value chain actors and support systems (especially millers and primary bulkers), local leaders and extension services are already engaged in this process.

TABLE 12.9
Summary table of losses, causes and solutions

Critical Loss Point	Type of loss	Cause of loss	Level of loss (percent)	Intervention to reduce losses	Yearly cost of solution (USD/year)	Profitability (USD/year)	Actors
Harvesting	▪ Insect damage ▪ Rotting ▪ Sprouting ▪ Vermin ▪ Mould ▪ Spillage ▪ Discolouration	▪ Delay in harvesting ▪ Poor harvest management ▪ Varietal susceptibility ▪ Competing demands of labour ▪ Lack of transport ▪ Thieves	3.3	▪ Awareness-raising and training for producers in harvesting and post-harvest handling practices ▪ Provision of simple technologies to aid transportation and drying of grain ▪ Improve harvest management ▪ Re-tooling extension workers for post-harvest management ▪ Facilitate group formation (farmer field schools) so farmers can assist each other during harvest periods ▪ Support the review of agricultural policies and strategies			FAO The Ministry of Agriculture Extension; Post-harvest Department; Crop Protection Department National Agricultural Research Organizations Implementation partner organizations/NGOs National farmers' associations
Drying (also contributing to losses during storage)	▪ Grain discolouration ▪ Foreign matters and debris ▪ Termite damage ▪ Mould contamination	▪ Poor drying process	3	▪ Training all actors ▪ Encourage adoption of maize cribs at household level	To be part of the training of farmers and other value chain actors		FAO, WFP Ministry of Agriculture Extension National Agricultural Research Organizations Implementing partner organizations/NGO Credit/microfinance institutions
Threshing (also contributing to losses during storage)	▪ Physical contamination with debris ▪ Grain breakage ▪ Spillage	▪ Poor threshing ▪ Lack of knowledge of post-harvest handling	4	▪ Demonstration of improved threshing technologies ▪ Provide credit/loans to allow acquisition of improved threshers	To be part of the training for farmers and other value chain actors		FAO, WFP Ministry of Agriculture Extension National Agricultural Research organizations Implementing partner organizations/NGO Credit/microfinance institutions

TABLE 12.9
(Continued)

Critical Loss Point	Type of loss	Cause of loss	Level of loss (percent)	Intervention to reduce losses	Yearly cost of solution (USD/year)	Profitability (USD/year)	Actors
Storage Household-level handling stages done after drying and threshing	▪ Weevil damage ▪ Aflatoxin contamination ▪ Termite damage ▪ Rat damage ▪ Mould infestation	▪ Poor storage structures and conditions ▪ Poor storage/packaging containers ▪ Poor treatment ▪ Poor drying process ▪ Lack of knowledge of PHH and storage practices ▪ Lack of pest management technologies	10	▪ Training of all actors (producers, millers and traders) in post-harvest handling ▪ Demonstration of improved storage structures ▪ Provide credit/loans to allow acquisition of improved structures ▪ Support government in the streamlining of policy for marketing and storage by the private and public sector ▪ Promote storage facilities, e.g. cribs, metallic and plastic silos and use of hermetic bags at household level ▪ Train and assist local artisans to construct storage facilities ▪ Promote commodity exchange (warehousing and receipting). ▪ Promote producer platforms such as the PPP ▪ Government to build market and road infrastructure ▪ Government to join forces with the RBA to provide further subsidies to cover the purchase of silos so farmers can afford them ▪ Government to introduce a silo by-law policy for every farming household. This will ensure food availability ▪ Involvement of the private sector to improve the distribution network and accessibility of silos. ▪ Strengthening and capacity-building of farmer organizations through which farmers can be trained and linked to markets ▪ Incentives: An incentive should be introduced for farmers who properly harvest, dry, and store their crops. For example a prime price for farmers who store grain in silos	To be part of the training of farmers and other value chain actors		FAO, WFP Ministry of Agriculture Extension National Agricultural Research organizations Implementing partner organizations/NGO Credit/microfinance institutions

TABLE 12.9
(Continued)

Critical Loss Point	Type of loss	Cause of loss	Level of loss (percent)	Intervention to reduce losses	Yearly cost of solution (USD/year)	Profitability (USD/year)	Actors
				▪ Exchange visits for farmers so they can learn from more experienced and successful farmers ▪ Media campaigns to compliment training. What is required is a campaign to change behaviour to encourage farmers to adopt the use of improved post-harvest handling practices. This campaign should be in local languages and drama skits should be created to facilitate farmers' understanding and adoption of the messages ▪ Engage the financial sector partners to bridge the credit gap for accessing post-harvest technologies			
				▪ Hermetic bags (22 bags per household)	29 400	68 350	
				▪ Provide 3-tonne metal silos (to 1 278 maize producer households in sub-county – 1 278 silos)	58 090	39 660	
				▪ Provide maize crib (to 30 percent of 1 278 maize producer households in subcounty – 384 cribs)	20 000	- 9 420	
				▪ Provide motorized maize shellers (10 per subcounty)	1 360	42 640	
				▪ 30-tonne store (one warehouse)	930	91 070	
Milling	▪ Contamination ▪ Spillage leading to loss in quantity	▪ Poor conditions of the mill e.g. broken parts of maize mills ▪ Failure/reluctance of the proprietors to carry out regular servicing and maintenance ▪ Milling good quality grain after poor quality ▪ Moistening grain on dirty concrete floor in preparation for de-husking	5	▪ Enforce standards for milling facilities ▪ Regular inspection and repair of mills ▪ Promote collective bulking and marketing through cooperatives ▪ Enforce adherence to uniform quality and standards.	Training costs and costs of enforcing regulation		Ministry of Trade and Commerce; Bureau of Standards; Consumer Organizations; Cooperative Alliance; Millers Associations; Grain Councils

PART 4

Sunflower value chain

Districts of Apac and Lira, Northern Uganda

INTRODUCTION

Agriculture is the most important sector for the Ugandan economy. The sector employs 66 percent of the working population aged 10 years and above (UBOS, 2012). It contributes up to nearly 20 percent of gross domestic product (GDP), accounts for 48 percent of exports and provides a large proportion of the raw materials for industry (MAAIF, 2010). Food processing alone accounts for about 40 percent of total manufacturing. The Development Strategy and Investment Plan (DSIP) were aligned and anchored in the National Development Plan (NDP) as one of the drivers of growth. The DSIP noted that the agricultural sector faces several output-level challenges. The main one being: low levels of productivity across most enterprises; high losses because of pests, vectors and diseases; failure to comply with increasingly demanding international quality and standards for traded food and agricultural products; and inadequate infrastructure for value-addition processes including marketing, storage and distribution. These challenges are further intensified by inadequate access or feeder roads that increase the costs of marketing; multiple policy frameworks that, in some cases, compound investors' uncertainty about the environment; the negative consequences of climate change exhibited by prolonged dry seasons, abrupt changes in intensity and shifts in the cessation and on-set of rains. In terms of human nutrition, it has been observed that Uganda's average calorie intake at about 2 066 is still less than the recommended daily calorie intake of 2 300 (EPRC, 2009).

Post-harvest loss reduction has taken centre stage in the fight against food and nutrition insecurity and the low incomes of smallholder farmers in Africa. Losses are manifested in the form of weight losses (pests, spillage or shrinkage from loss of moisture), quality loss (changes in grade characteristics of colour, shape, or flavour), nutritional loss, loss of seed viability, and economic loss (lost income because of lower prices and rushed sales, reduced quantities and/or poor

quality products being presented to the market (MAAIF – SG 2000, 2013).

To address these issues, a food loss assessment study was undertaken along the sunflower food supply chain in the framework of a joint project implemented by the United Nations Rome-based Agencies the Food and Agricultural Organization of the United Nations (FAO), the International Fund for Agricultural Development (IFAD), and the World Food Programme (WFP): *Mainstreaming food loss reduction initiatives for smallholders in food deficit areas,* which was funded by the Swiss Development and Cooperation Agency. The overall objective of the project was to improve food security and income-generation opportunities through reduction of food losses in supported food grains and pulses value chains.

The food loss assessment study aimed to identify the critical loss points in the selected supply chains, the key stages at which food losses occur, why they occur, the extent and impact of food losses and the economic, social and environmental implications of the food losses. Furthermore, these studies also evaluated the feasibility of potential interventions to reduce food losses and waste.

METHODOLOGY

The assessment of post-harvest losses used the 'food loss analysis' case study methodology developed by FAO under the Save Food Initiative (FAO, 2016). The methodology included a preliminary screening of food losses based on secondary data and expert consultations; a survey provided some indicative levels of food losses based on observations, direct measurements and responses from sampled supply chain actors; sampling assessment; and solution-finding synthesis to facilitate development of interventions to address the observed food losses. The supply chain stages observed were primary production, harvesting, threshing, transport to the household, drying and winnowing, storage, producer sales, bulking and milling. The involvement of men, women and children in various activities along the value chain was discussed.

The screening identified harvesting, storage and milling as critical food loss points in the sunflower FSC (see Chapter 15 - Table 15.1). A field study was conducted from February 2015 to May 2015 in Ibuje and Akokoro subcounties in Apac and Amach and Barr subcounties in Lira district. Information was collected on the magnitude and cause of loss at the different stages of the FSC. The study involved interviews with farmers, millers, extension, and other pertinent stakeholders in the sunflower value chain (see Annex 2 – List of persons consulted). Semi-structured interviews were also conducted involving 70 sunflower producing households. The majority of households were male headed (76% in Lira and 92% in Apac).

The harvest losses are actual figures derived from sampling data collected to assess losses in the two districts. Thirty-five fields were randomly sampled and three quadrants (4 x 4 m) were harvested from each field, threshed and weighed. The other losses were estimates made by farmers, traders, millers and other key informants.

Samples were collected, to assess the quality of the sunflower grain going through the food supply chain, at aggregation points at the village level and from farmers (n=20). The samples were analysed for the level of impurities and aflatoxin presence.

Chapter 13

The sunflower subsector – Introduction and background

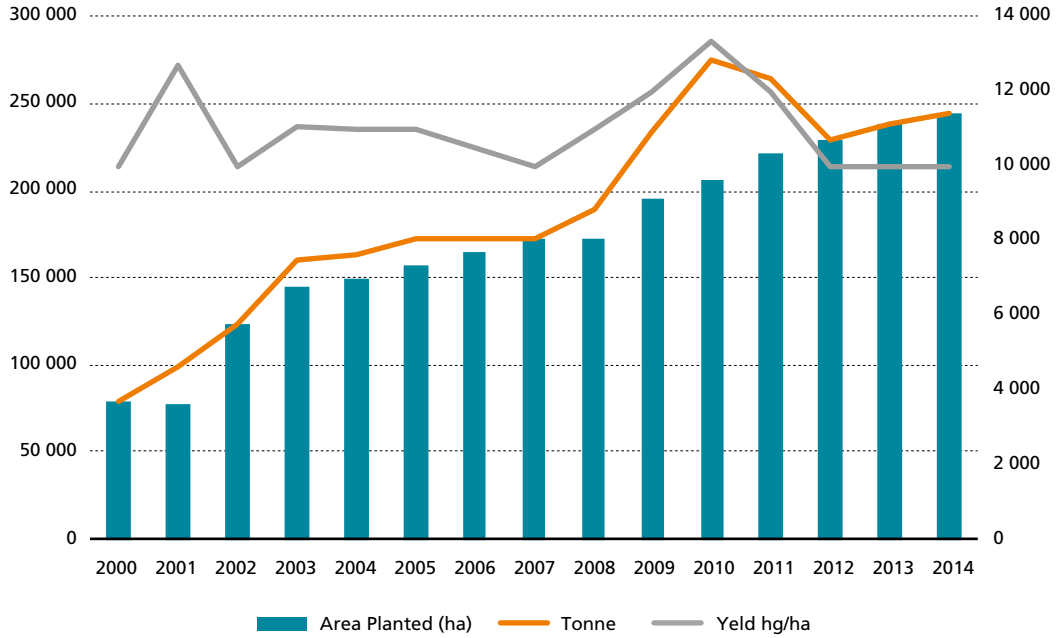
STATUS AND IMPORTANCE OF THE SUNFLOWER SUBSECTOR AND DEVELOPMENTS OVER THE LAST 15 YEARS

Sunflower was introduced to Uganda in the 1920s and by the 1960s it was widely grown throughout the country. It is one of the oilseed crops identified by the Government of Uganda and several donors as a prospective poverty-reduction crop (Ton *et al.*, 2010). Furthermore, the increasing domestic demand for vegetable oils makes sunflower essential oil crop for substituting the importation of vegetable oils. The demand for sunflower has been growing at a rate of 3 percent per annum.

Sunflower seed is the lead domestic raw material for vegetable oil. Annual production was registered as up to 245 000 tonnes in 2014 from 79 000 tonnes in 2000 (Figure 13.1). Uganda is ranked twentieth in sunflower production in the world with a share of 0.6 percent (http://www.factfish.com/statistic-country/uganda/sunflower+seed,+production+quantity).

Uganda's sunflower oil export increased steadily from 84 tonnes in 2004 to 3 959 tonnes in 2012. These exports correspond to earnings of USD 23 000 and USD 593 000 respectively. Despite the increase in production, the importation of sunflower has also been increasing at the same time from no imports in 2000 to 331 tonnes in 2012 (Figure 13.2).

FIGURE 13.1
Trend in sunflower production and yield in Uganda, 2000-2014



Source: FAOSTAT data

TABLE 13.1
National production information on sunflower

	Annual production (tonne/ year[1])	Cultivated area (ha)	Average yield (tonne/ha)
Raw material	245 000[2]	240 000[2]	1.02
Annual average growth over the last 10 years (%)	5.00 %[2]	5.00 %[2]	-1.35 %[2]
Average cost of production (USD/acre)	123.7[3]		
	On-farm consumption	Marketed	
Percentage of production (sunflower grain)	6.0[4]	94.0[4]	
Marketed product	Volume (tonne/year)	Value (USD/year)	
Sunflower grain	230 300[5]	94 752[6]	
Sunflower oil	83 000[7]	29 050 000	
Seed cake			
Export volume (sunflower oil)	3 959[8]	5 983 000[8]	
Export volume (sunflower cake)	8 742[8]	1 980 000[8]	
Number, gender, age of	Female	Male	Total
Producers			83 000[9]
Traders	NA	NA	NA
Small-scale processors	NA	NA	106[10]
Large-scale processor	NA	NA	4[10]
	Small	Medium	Large
Level of processing operations	L	L	L
Level of trading/ wholesale operations	M	M	M
Level of retail operations	M	M	M

[1] tonne/year = Metric Tonne / Year; [2] Data for 2014 (FAOSTAT, 2015); [3] VODP 2-2015 Fact Sheets; [4] Derived from Dalipagic and Elepu 2014; [5] Annual production* percentage of sunflower grain that is marketed; [6] 1 USD was UGX 2 778 in December 2014. The mean price of sunflower in season 2 of 2014 was USD 0.35 /kg; [7] Data for 2014 (FAOSTAT, 2015); [8] Data for 2013 (FAOSTAT, 2015); [9] VODP Progress Report for July 2016 (MAAIF, 2017); LMH= Low/ Medium/ High; NA=Data Not Available.

The sunflower supply chain ratings are provided in Table 13.2. Both sunflower grain and oil are rated as high in economic importance, while the provision of employment, contribution to national food consumption and national nutrition are rated as medium for both products. Sunflower seed cake is rated low in all the other variables.

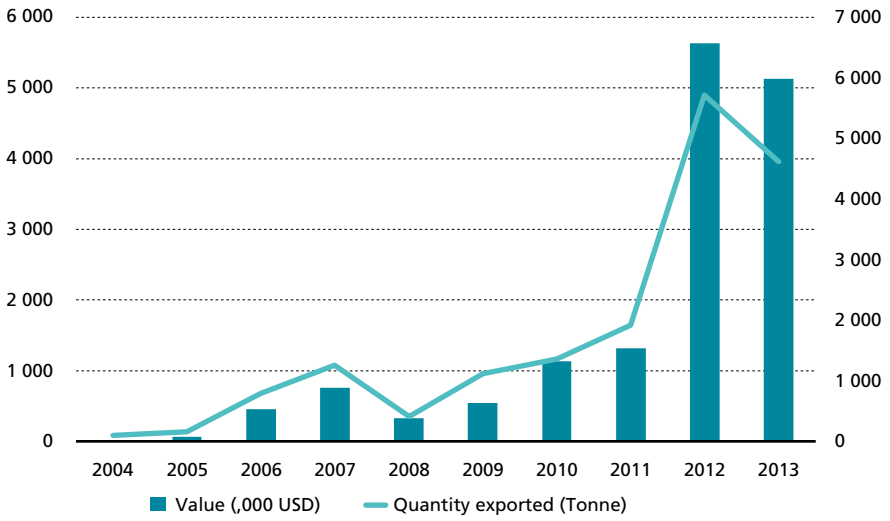
INVENTORY OF ACTIVITIES AND LESSONS LEARNED FROM PAST AND ONGOING INTERVENTIONS

Mukwano group of companies

The Mukwano group started activities in the early 1990s, and has remained a leader in the vegetable oil sector. In 2003, Mukwano worked in collaboration with the Investment for Developing Export Agriculture project (IDEA) of the United States Agency for International Development (USAID) and the Serere Agricultural and Animal Production Research Institute (SAARI) to introduce and release a high-yielding (800–900 kg/acre), high-oil content (40% oil content) sunflower hybrid (PAN 7351) from South Africa.

Mukwano relied on the National Agricultural Research Organisation (NARO) to conduct the adaptability and verification tests on the new variety. Currently, Mukwano works with 60 000 farmers nationwide. The company offers forward contracts to farmers and guarantees minimum prices, offers seed on credit, technical advice and

FIGURE 13.2
Trend in sunflower oil export (volume and value) 2004–2013



Source: FAOSTAT data

TABLE 13.2
Importance of the sunflower supply chains at the national level

FSC #	Economic Importance H/M/L	Employment provision H/M/L	Foreign exchange generation H/M/L	Contribution to national food consumption H/M/L	Contribution to national nutrition/ diet H/M/L	Environmental impact H/M/L
Sunflower grain	H	M	L	M	M	L
Sunflower oil	H	M	L	M	M	L
Sunflower Cake	M	L	L	L	L	L

Source: Authors' analysis based on literature.

marketing. The company also has a team of purchasing agents to coordinate extension services, and purchase and store the crop. Premium prices are offered based on the quality of the grain presented as a raw material for oil processing. Dirty, high moisture content seed and mouldy sunflower is discounted up to one-third of the price offered for good quality sunflower seed.

The International Fund for Agricultural Development (IFAD)

IFAD has been supporting Uganda's sunflower subsector through the **Vegetable Oil Development Project (VODP)**, which has been implemented by the Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF) since 1998. The major foci of the first programme (VODP 1) included adaptive varietal research and variety development by NARO, oil seed multiplication and distribution and farmer mobilisation through groups, provision of extension services, and promotion of small-scale sunflower oil pressing. Considerable progress has been achieved for aspects pertaining to agronomic and group organization. The evaluation of VODP 1 recommended interventions on value-addition and post-harvest handling, group marketing, and supporting development of food standards and codes of practice for vegetable oils through the Uganda National Bureau of Standards (UNBS) (IFAD, 2011).

The recommendations are being implemented through the VODP 2 (2011–2019), supported by the project: The Oil Subsector Support Platform (OSSUPs), which was established for market coordination, technological upgrading and the provision of financial services. This Platform has brought different stakeholders on board with the assumption that each stakeholder would play an important role in strengthening the sunflower value chain. However, it was realised that

interests/stakes differed and conflicts occurred between players. It was therefore deemed that collective action needs facilitation that is tailored to the real dynamics of conflicting interests, commercial time spans and regional diversity. As a result of its activities UOSPA learned that farmers tend to listen and adopt technologies from each other faster than from extension service providers.

The Oil Crops Research Programme

The Oil Crops Research Programme, at the National Semi-Arid Resources Research Institute (NaSARRI) of NARO, has developed and disseminated two sunflower varieties (Sesun 1H and Sesun 2H), both with a yield potential of 1 500 to 2 000 kg/ha. The two varieties have higher oil content compared with the open pollinated variety, sunfola (35% oil content and average yields of 400 kg/acre), which has been in production since 1991. Research attention is being focused on variety development and generation of management practices for improved production. Management practices include planting dates, density, weed management, fertilizer use, and intercropping with other crops (http://www.nasarri.go.ug/sunflower.php). Currently, the Oil Crops Research Programme is multiplying seed under the Vegetable Oil Development Project. The focus is also shifting to breeding for varieties with high oleic fatty acid content, which are highly demanded in Switzerland.

The Agricultural Business Initiative (aBi) Trust

The aBi Trust contributes to increasing the availability of farm inputs and improving the quality, supply and access to the market for several crops, including sunflower (aBi Trust, 2012). Improvements are achieved through training in good agricultural practices, post-harvest handling, collective marketing and the establishment of value-addition facilities. The Trust has been involved in promoting trade-related Sanitary and Phyto-Sanitary (SPS) and Quality Management Systems (QMS), collective marketing, grain drying equipment, tarpaulins, moisture meters, and warehousing and storage facilities to improve product quality and competitiveness. aBi Trust supports the provision of financial and technical services to farmer organizations and Small and Medium Enterprises (SMEs).

SNV, The Netherlands

A civil society organization, SNV Uganda and the Mukwano Group of companies signed a partnership agreement (Mwesige, 2010 and Beyssac *et al.*, 2012) to implement an inclusive business model. This model aims to expand capacity among rural farmers in order for them to be able to participate in the oil seed value chain. The model enables challenges to be addressed including inadequate access to good quality seed, lack of market information, poor input supply systems, weak producer groups, poor bulking and post-harvest handling facilities and technologies and limited access to affordable finance.

THE PROCESS OF POLICYMAKING AND CURRENT POLICY FRAMEWORK

The Agricultural Sector Strategic Plan (ASSP) 2015/2016- 2019/2020 is the current guiding policy for agricultural research and development in Uganda. The ASSP replaces the Agricultural Sector Development Strategy and Investment Plan (DSIP) 2010/2011–2014/2015 although the priorities do not vary. The priorities of the ASSP are to: increase production and productivity of agricultural commodities and enterprises; increase access to critical farm inputs; improve access to markets and value-addition and strengthen the quality of agricultural commodities; and strengthen the agricultural services institutions and the enabling environment.

RELEVANT INSTITUTIONS AND ROLES IN THE SMALL AND MEDIUM SUNFLOWER INDUSTRY SECTOR

The Uganda oil seed subsector platform

The Uganda Oil Seed Subsector Platform was established in 2007. The platform is funded by IFAD and SNV, and has been implemented by the Agency for Sustainable Rural Transformation (AFSRT) since 2012 (Speijer and Heemskerk, 2013). The national platform now has four local hubs where economic actors and service providers meet. The Platform plays an important role in coordination between actors including processors, service providers, farmer organizations, research, government representatives, the NGO sector and financial institutions. The Platform facilitates quarterly meetings among stakeholders where strategies are developed according to the needs of the stakeholders. A number of results have been attributed to the Platform including: greater efficiency throughout the value chain, through dialogue and concerted action; increased interaction between actors in the value chain for example increased collaboration between input suppliers to ensure better seed varieties are available for

farmers; and engagement of the financial sector where banks have created new financial products for small farmers (Speijer and Heemskerk, 2013).

Uganda Oilseed Producers and Processors Association

Currently, the oil seed producers and processors are organized under the umbrella of the Uganda Oilseed Producers (farmers) and Processors (millers) Association (UOSPA). This association provides a platform for private members to collectively voice their concerns and promote their issues of interest. In both districts, the UOSPA is promoting the production and processing of sunflowers. One way UOSPA staff carry out capacity-development in the oil value chain is through providing technical training in hygiene, quality assurance, post-harvest handling and marketing (market intelligence and business networking) among others. In order to have a wider coverage, UOSPA has adopted a strategy of building the capacity of model farmers as extension link farmers to act as catalysts for change.

The UOSPA has also supported farmer groups in their transit to cooperatives and linked these cooperatives to the private sector for financial and input support. In addition, UOSPA has recently established a laboratory in Lira to test soils and grain quality (including aflatoxin tests). The soil tests include characteristics tested for PH, Nitrogen, Phosphorus, Potassium, and Organic matter. A small levy is added to test samples; each sample costs UGX 50 000 (USD 17). Unfortunately, many oilseed producers and cooperatives are not making maximum use of this facility even when it is free. This implies that results on aflatoxin tests are still scarce. Furthermore, UOSPA has established product development and transfer centres in Kumi, Mbale and Lira to increase the incomes of beneficiary farmers, add-value and increase consumption by the producers.

The National Agricultural Research Organization (NARO)

The NARO mandate is to conduct research and come up with appropriate technologies, which are then disseminated by the extension and farmer advisory organ of the Government National Agricultural Advisory Services (NAADS). Technology is promoted in partnership with the recently established farm input provision wing of the agricultural sector: Operation Wealth Creation (OWC), which distributes agricultural inputs to farmers. The OWC is a new Initiative under the Presidents' Office, which was set up to support NAADS's traditional extension service.

The Agency for Sustainable Rural Transformation (AFSRT)

The Agency for Sustainable Rural Transformation (AFSRT) through Multi-stakeholder Platforms use a business development model together with SNV, UOSPA and aBi Trust to train farmers and processor working groups on aspects of oil seed collective marketing, appropriate post-harvest handling and the offered quality enhancement technologies such as moisture meters and tarpaulins.

UNBS quality assurance activities

The Uganda National Bureau of Standards (UNBS) has the role of formulating and promoting standards to protect the public from health and safety concerns. The code of practice for hygiene in handling, storage and milling of vegetable oilseed exists (UNBS, 2006). These guidelines also regulate the acceptable grades for quality sunflower oil and cake. The UNBS, in partnership with MAAIF through VODP 2, is working to develop, promote and enforce quality standards and a quality assurance system for vegetable oils. Activities under this support include the development of vegetable oil standards and training actors along the vegetable oil value chains about the standards.

Chapter 14

The situational analysis of the sunflower supply chain

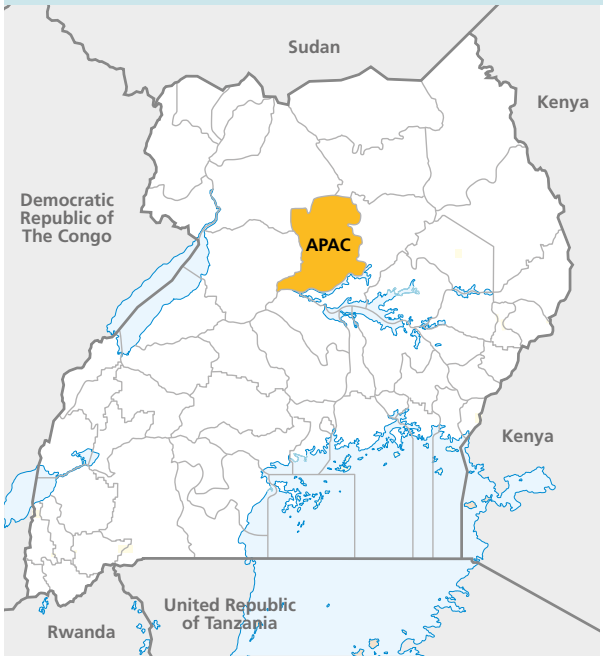
DESCRIPTION OF THE SELECTED STUDY AREAS

The case study on the sunflower supply chain (grain, oil and seed cake) was conducted in Apac and Lira districts (Figure 14.1). The districts are located in the Lango subregion in northern Uganda. Of the total oil seed produced in Uganda 49.9 percent comes from the northern region. Sunflower processing is mainly concentrated in the Lango subregion. Lira and Apac districts are the major producers of sunflower however Lira is the oil-processing hub.

Apac district is comprised of fourteen subcounties; Cegere, Apac, Ibuje, Alito, Aboke, Ayer, Bala, Akalo, Abong-Omola, Nambieso, Chawente, Akokoro, Aduku and Inomo. Lira has ten subcounties; Adekokwok, Aromo, Lira, Railway, Adeyel, Barr, Ogur, Amach, Central and Ojwina.

Rainfall in Apac and Lira is bimodal with one peak during April-May and the other in August-October. The average annual rainfall in the district varies between 1 200-1 600 mm. The average minimum and maximum temperatures are 22.50 °C and 25.50 °C, respectively. The absolute maximum temperature may barely rise above 36 °C, and absolute minimum barely falls below 20 °C. These conditions are favourable for sunflower production.

FIGURE 14.1
Map showing the location of Apac and Lira districts



Map of Uganda showing Apac district



Map of Uganda showing Lira district

Source: UN Map Map No. 3862.1 Rev. 1 (September 2002). Department of Public Information Cartographic Section

THE SUNFLOWER SUPPLY CHAIN IN APAC AND LIRA DISTRICTS

Description of the sunflower supply chain

The field study was conducted in Akokoro and Ibuje subcounties in Apac and Barr and Amach subcounties of Lira from February to May 2015. The study focused on the production and post-harvest handling of sunflower grain up to the bulking points in the selected subcounties and the processing of sunflower grain into oil and seed cake in Lira.

According to experts from the UOSPA, sunflower planting starts at the onset of rains in the first season and may continue until November as long as the rains persist. The common practice is that farmers start to plant sunflower after the harvest of other crops such as beans and soya beans; although 60 percent of farmers do not grow sunflower in the first season. The predominant varieties grown in Lira and Apac are PAN 7351 and Sunfola; market forces drive the greater use of PAN 7351. There is a readily available market for the variety, mainly with Mukawano, and the possibility of a slightly higher price (UGX 200 or USD 0.068 per kg) in comparison to other varieties.

The seasonal calendar for sunflower activities, as described by experts, is provided in Table 14.2. Harvesting occurs from July to December but a few farmers may be found harvesting in January. After harvesting and threshing, the sunflower seed is transported from the fields to homes, dried and winnowed. Most farmers do not store sunflower for more than one month before selling.

Farmers sell sunflower seed to large miller agents at collection points, local traders at farm-gate or a store, through own cooperatives and a few directly to millers. The seed is then processed at the millers, taken to a refinery to be sold as oil through traders (wholesalers and retailers) to consumers and also exported. The large mills operate throughout the year but the smaller mills from 6 to 7 months a year. The by-product, sunflower cake, is sold through traders or directly to feed mills in Uganda and to regional markets. The sunflower FSC is depicted in Figure 14.3.

Detailed description of the selected sunflower supply chain

Pre-production and production

The average size of sampled fields was 1.59 acres (0.64 ha) per household (1.67 acres or 0.67 ha in Amac, 2.1 acres or 0.84 ha in Barr, and 1 acre or 0.40 ha in Ibuje). Land is prepared is using ox-ploughs or men using hoes. The average cost of land preparation is UGX 60 000 per (USD 18.14) acre. Only a few households employ hired labour (28.9 % in Lira and 9.3% in Apac). Most farmers (67%) grew PAN7351. Household labour and women are usually engaged for planting. The seed rate is 2 kg of seed per acre. The price of seed ranges from UGX 5 000 per kg to UGX 25 000 (USD 1.5 to 7.6) per kg. Weeding is done at least twice by hand. The average cost for planting and weeding was UGX 30 000 (USD 9.1) per acre and UGX 40 000 (USD 12.1) per acre respectively.

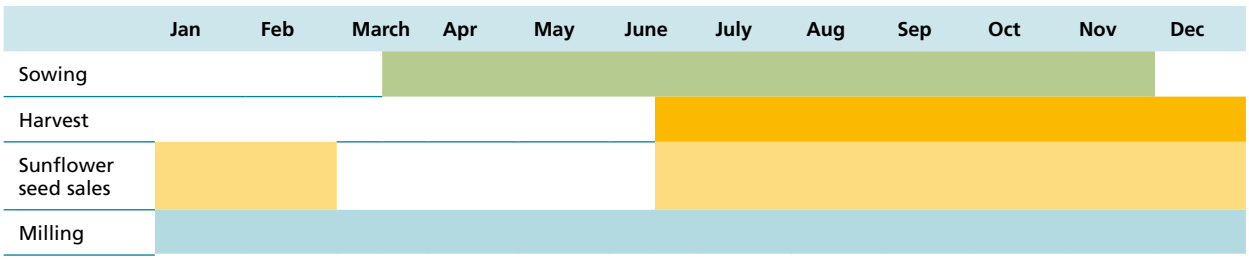
At the preproduction stage, various constraints were identified as risk factors for sunflower losses. These include:

- high price of certified seed (40.9%);
- unreliable input suppliers (21.5%);
- climate change effects resulting in prolonged rains during some seasons (16.1%);
- lack of quality sunflower seed (11.8%);
- weed infestation (46.2%);
- failure to prepare land on time (9 %); and
- damage by pests (36.3%).

Harvesting practices

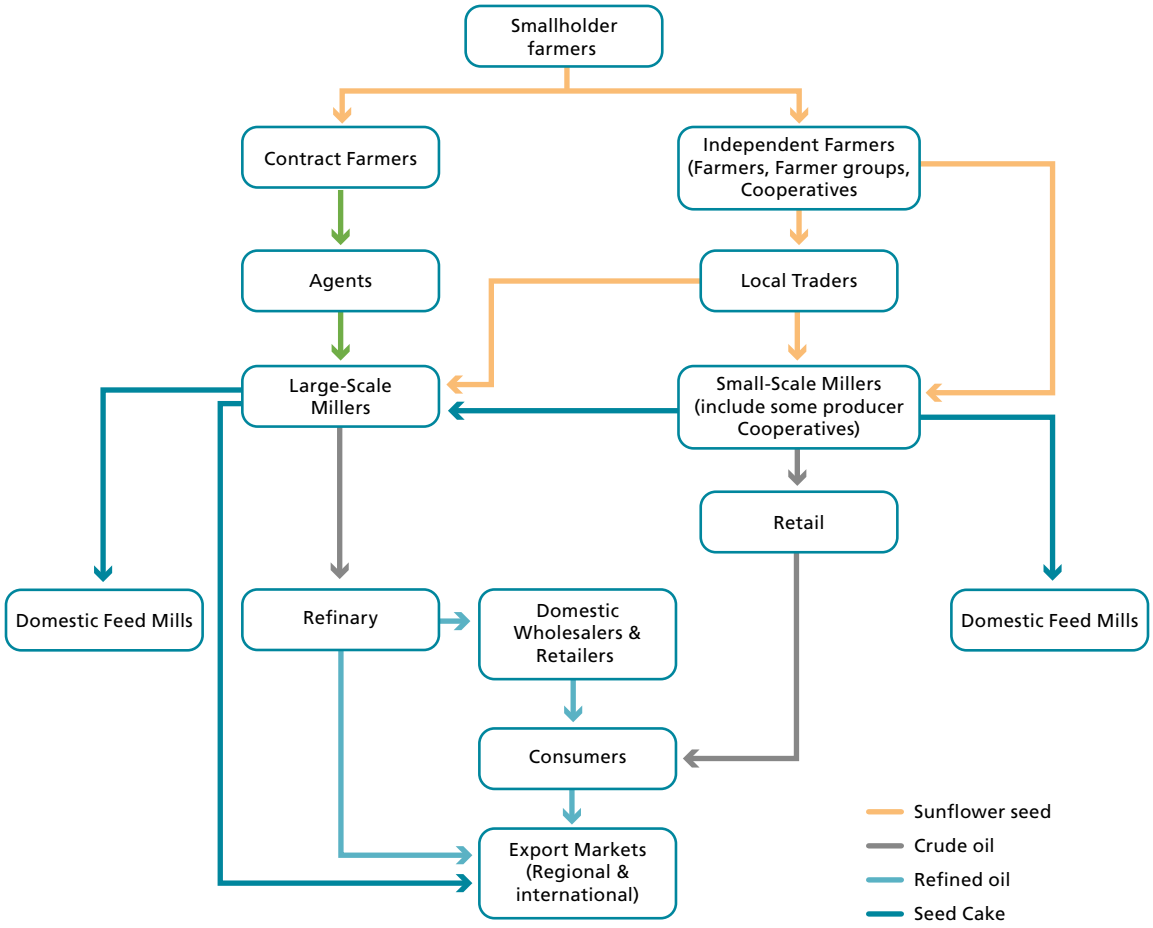
Sunflower is harvested by cutting the heads off using knives, or by breaking the heads off the stalks using the hands. The harvested heads are either thrown on uncovered ground, on tarpaulins, into large saucepans or basins. The heads collected in sauce-pans are then transported and

TABLE 14.2
The sunflower agricultural calendar



Source: Survey data

FIGURE 14.3
Flow diagram of the sunflower food supply chain



Source: Authors' illustration based on literature and key informant interviews

FIGURE 14.4
Sunflower heads, collecting harvested sunflower and seeds on uncovered ground



PHOTO 1, 2, 3 ©MICHAEL OTIM/WILLIAM NANYEENYA/HARRIET MUYINZA

FIGURE 14.5
Hand scrubbing to remove the seeds, collecting the seeds on a tarpaulin and seeds on tarpaulin covered ground



PHOTO 1, 2, 3 ©MICHAEL OTIM/WILLIAM NANYEENYA/HARRIET MUYINZA

poured on a tarpaulin; 30.7 percent of households used hired labour.

The average yield measured for the sampled farmers plots was 583 kg/ha (845.9 kg/ha in Akokoro, 775.4 kg/ha in Amach, 507 kg/ha in Barr and 491.9kg/ha in Ibuje).

According to key informants sometimes there plant maturity is not uniform in the same plot, which causes portions of the sunflower to become ready for harvest before others. Farmers harvest when most of the field is ready, leaving some sunflower left un-harvested in the field.

Threshing – the sunflower heads are threshed in the field on tarpaulins by beating the heads with sticks until all the seeds have been extracted (76.8% respondents) or by hand scrubbing (21 %). Threshing occurs soon after harvesting before the grain is transported to the household. Both men and women thresh sunflower. Some winnowing takes place to remove the dust and chaff before the grain is packed into bags and taken home for drying and winnowing.

Transportation – Being a commercial crop, both men and women carry the sunflower grain from the field to the home. Transportation is commonly by bicycles (75 % of male respondents and 50% of female respondents) and head portage (50% women and only 12.5% men).

Drying – Sunflower is dried at home, on tarpaulins (46.2%), unimproved (29.5%), stabilised (24.1%) and cemented (2.1%) surfaces. Where stabilised floors are used, these are in the courtyard and the floor is usually stabilised using mud or cow dung to form a firm surface for drying. Because of the fear that sunflower will loose weight as it dries farmers tend to dry for 1 to 2 days instead of the recommended 4 days. According to experts, farmers dry their sunflower to contain from 14 to 15 percent moisture content instead of the advised 12 percent.

Household storage – Sunflower is stored in the house (87.2%) for less than a month. Farmers who bulk and sell through cooperatives may store up to 1 to 3 months after harvesting. The main reasons for this practice of limiting the on-farm storage period are twofold. There is the concern about the rapid loss of moisture that occurs in sunflower during storage, which results in loss of weight and therefore loss of income. The second reason is the lack of proper storage facilities.

Sales – Farmers sell to local traders and agents (60.2%), at farmgate (10.8%), directly to millers (4.3%), commercial stores (4.3%) and other channels (20.4%). Most farmers sell the grain within 1 to 2 weeks after harvesting. A few households may retain three basins of sunflower (20 kg) to mill oil for home consumption. The mills do not charge for this as they retain the cake.

Local Trader/ Agent Bulking/ Cooperative Bulking

Agents, traders and cooperatives operate stores (rooms in houses, shops or stores). Once the seeds have been received, operations may include weighing, checking moisture content, dismantling the bags, re-drying and cleaning (winnowing). The sunflower is held for periods ranging from one week to three months. Most traders kept the grain for no more than one month but one farming cooperative said that on occasion they stretched the period to three months. All cooperatives (three chairpersons were interviewed) had moisture meters. All except one dismantled the bags, re-dried and cleaned the sunflower. Others, including the traders, said they checked by biting or by using

a moisture meter to ensure that the moisture content was satisfactory. They also checked the level of impurities using a sampling spear. After these controls the grain is stored.

The leaders of the cooperatives said they were strict about the grain received from farmers. Any grain that was too wet was not received. However they also purchased grain from non-members. The level of competition for sunflower is such that some traders will take on improperly dried and cleaned sunflower grain. The study showed that cooperative farmers can store grain longer and be in a better position to obtain higher prices than if they sell at the farmgate.

Milling/Crushing – There are 86 mills in Lira with a capacity of 62 percent (VODP 2). Of the 86 mills, three are categorised as large processors, processing at least 50-tonnes/day. The rest are small-scale processors handling 1 to 8 tonnes per day. According to experts from VODP 2, the situation with small-scale millers is very fluid with new entrants into the business while others are exiting. It is not unusual to find only 50 percent of the documented 86 mills are operational at any time.

Millers occasionally stock grain for their use but try to avoid longer storage periods because of the loss of moisture content and thus volume of the crop. Most milling machines require 7 percent moisture content for an optimal oil yield, yet farmers usually sell sunflower at 15 percent moisture content. The small-scale millers purchase most of their grain from traders and only a very small portion from farmers. As there is high competition for grain, millers usually have little choice about the quality of their purchase. The farmers and traders are unwilling to share the cost of cleaning the grain they sell to the millers. Consequently, the small-scale millers incur the greatest cost for poor post-harvest handling practices upstream and poor quality grain (i.e. grain with little oil content). The handling processes at the mills include off-loading, drying, cleaning and storage before crushing begins.

The large-scale millers are more particular about the quality of the grain. The agents are aware that poor quality grain will be penalised or not accepted. Some millers, such as Mukwano, impose a penalty of UGX 200 per kg for poor quality. At the time of the study Mukwano offered UGX 1 000 per kg for super grade, UGX 900 for medium grade and UGX 700 for low-grade sunflower seed. Anything below low grade is turned away. The same miller does not accept grain containing more than 2 percent impurities.

There are two farmer cooperatives in Lira and Apac that have started milling. These are Nyeko Rac Cooperative in Ogur and Saint Luke Cooperative in Apac.

The products in the FSC, and the conversion factors, are presented in Table 14.2. The conversion factors from grain to sunflower oil and seed cake differ with small-scale and large-scale milling because of the differences in the efficiency of their milling equipment.

The basics of the sunflower food supply chain are summarised in Table 14.3. The following assumptions were made to estimate the scenario.

- The population in Barr, Amach, Akokoro and Ibuje is 43 942; 34 822; 42 111 and 40 147 respectively (Source: UBOS, 2014).
- The number of households in Barr, Amach, Akokoro and Ibuje is 9 189; 7 039; 8 342 and 7 761 respectively (Source: UBOS 2014).
- Sunflower is grown by 65 percent of households (Source: Experts VODP 2).
- Deriving from the above-mentioned, there are 21 015 households in the four subcounties that produce sunflower.
- Since 60 percent of the households do not grow sunflower in the first season, it is assumed that all households produce sunflower once a year (Source of 60%: Experts UOSPA).
- The average field size is 0.64 ha and the average yields 583 kg/ha (Source: survey).
- Therefore 7 841 tonnes are produced annually in the four subcounties.
- Assume that 96 percent of sunflower grain is milled by large-scale millers while the small-scale millers handle 3.8 percent.
- Only 50 percent of the 86 mills in Lira and Apac are operational at any one time and three are large-scale millers.

THE MARKETING SYSTEM

Farmers produce sunflower independently or under contract with a large processor mainly Mukwano. Farmers under contract sell the entirety of their product to Mukwano (ITC, 2016), selling through agents or site coordinators who work on commission. The seeds are sold prior to the start of the planting period, the farmers are monitored and the seeds are collected when the farmers harvest and deliver to Mukwano. Other farmers sell to local traders at farmgate or a store.

TABLE 14.2
Products and conversion factors in the food supply chain

FSC STAGE	Output Product	Weight from 100 kg/units	Unit of Measure	Conversion Factor/kg of Sunflower
Farmer				
Harvesting	Unthreshed sunflower on heads	100	kg	-
Threshing	Sunflower seeds	100	kg	1.00
Transport to Household	Sunflower seeds	100	kg	1.00
Household Drying & Winnowing	Sunflower seeds	96	kg	1.04
Household Storage	Sunflower seeds	96	kg	1.00
Producer Sales	Sunflower seeds	96	kg	1.00
Traders & Cooperatives				
Redrying & Winnowing	Sunflower seeds	96	kg	1.00
Storage	Sunflower seeds	96	kg	1.00
Small-Scale Miller				
Redrying	Sunflower seeds	96	kg	1.00
Cleaning	Sunflower seeds	96	kg	1.00
Milling				
Oil	Sunflower oil	24	Litre	4.00
Cake	Sunflower cake	45	kg	0.53
Large-Scale Miller				
Redrying	Sunflower seeds	96	kg	1.00
Cleaning	Sunflower seeds	96	kg	1.00
Milling				
Oil	Sunflower oil	33.7	Litre	2.85
Cake	Sunflower cake	43.3	kg	0.78

Source: Survey data

The local traders collect sunflower grain at the farmgate or store, once they have bulked a quantity to sell to local millers. The traders may handle up to 10 tonnes of sunflower per season. Some farmers have formed producer organizations or cooperatives through which they bulk and sell to millers. A cooperative may handle up to 120 tonnes of sunflower per season. A few cooperatives (two in Lira and Apac) mill in addition to bulking and selling sunflower grain. The cooperative services to members include provision of seed on credit at planting, technical advice for production and post-harvest handling, procuring tarpaulins for members, monitoring farming practices to ensure good quality sunflower seed, bulking, value addition (cleaning) and marketing.

A few farmers sell directly to millers. Sunflower grain is sold in bags weighing 60 to 65 kg when properly filled or in 2 to 20 kg tins. Table 14.4 illustrates the price of a kilogram of sunflower at different selling points and periods. The average farmgate price at the time of the study was UGX 750/= (USD 0.23) per kilogram. The price of sunflower grain is highly influenced by how long it has been since the previous harvest. Prices are lowest during the harvest period when there is a plentiful supply of grain.

The millers produce oil and its by-product seed cake. The oil is sold in one, three, five and twenty

TABLE 14.3
Detailed description of the sunflower supply chain – Basics (Akokoro, Amach, Barr and Ibuje)

Stage in food supply chain	Location	Months of the year	Products	Quantity (kg) per FSC actor	Quantities (tonnes)	Duration/ distance	Services/equipment
Primary production	Akokoro, Amac, Barr, Ibuje	April-July (First season) Sept-December (Second season)	Sunflower grain			4 months	Ox-ploughs, hoes, labour
Harvesting	Akokoro, Amac, Barr, Ibuje	July-August Dec.-Jan.	Sunflower grain	373	7 841	2 – 3 days	Knives, bags, large saucepans, basins, tarpaulins, labour extension services
Threshing	Akokoro, Amac, Barr, Ibuje	July-August Dec.-Jan.	Sunflower grain	364	7 648	2 months for each season	Bags, sticks, sacks and tarpaulins
Drying and winnowing	Akokoro, Amac, Barr, Ibuje	July-August Dec.-Jan.	Sunflower grain	355	7 465	1-2 days	Tarpaulins, basins, winnowing baskets
Storage on-farm	Akokoro, Amac, Barr, Ibuje	Dec.-Feb .and July-Sept.	Sunflower grain	348	7 315	1-2 months	Bags, tarpaulins, labour
Transportation	Akokoro, Amac, Barr, Ibuje,	July-March	Sunflower grain	348	7 315	100 km (up to 4 hours)	Bags, bicycles, motorcycles, vehicles (trucks ferrying to Lira), Labour for off-loading, gunny bags, sampling spears and transport cost
Farmer sales	Akokoro, Amac, Barr, Ibuje	July-March (April to May no sunflower on market	Sunflower grain	348	7 315	4 months	Weighing scales, sampling spears, bags, market information
Trader bulking	Akokoro, Amac, Barr, Ibuje,	July to March	Sunflower grain		7 184	8 months	Mills, weighing scales, tarpaulins, Gunny bags
Small Scale Milling	Lira, Apac	July to March	Sunflower oil	1 551	62	8 months	Mills, weighing scales, tarpaulins, bags and Jerry cans
Small Scale Milling	Lira, Apac	July to March	Sunflower cake	11 630	465		
Large scale Milling	Lira, Apac	Year round	Sunflower oil	732 920	2 199	8 months	Mills, weighing scales, tarpaulins, bags and Jerry cans
Large scale Milling	Lira, Apac	Year round	Sunflower cake	2 695 600	8 087		
Wholesale	Lira, Kampala	Year round	Sunflower cake		2 199	All year	Transportation services, packaging, labour
Retail	Different parts of the country	Year round	Sunflower oil		2 199	All year	Jerry cans, plastic bottles and polyethylene bags

Note: There 3 large-scale millers in Lira. There are 40 operational small-scale millers in Lira and Apac

Source: Survey data

TABLE 14.4
Sunflower selling points, time and price in the study districts

Price at Selling point (UGX/kg)		Price at Selling point (USD/kg)
Key Selling Point	***Mean***	***Mean***
Farm Gate	750	0.23
Commercial Store	550	0.17
Take To Millers	1 150	0.35
Agents	700	0.21
Other	800	0.24
Average	790	0.24
Price offered by Selling period (UGX/kg)		***Price offered by Selling period (UGX/kg)***
Immediately	700	0.21
Within One Month	750	0.23
Within 3 Months	950	0.29
Other	300	0.09
Total	675	0.20

Source: Survey data; USD 1 = UGX 3 306

litre containers to retailers in Lira and traders from other cities such as Kampala. Mukwano takes the crude oil to the refinery in Kampala. The refined oil is sold to wholesalers and is exported. The seed cake is sold to feed mills in Uganda or is exported to regional markets.

DESCRIPTION OF THE SUNFLOWER SUPPLY CHAIN SOCIAL STRUCTURES

During the study, farmers (n=70) were asked to comment on the participation of men and women in the activities in the sunflower food supply chain. The summary of the findings is presented in Table 14.5. Unlike food crops, where women provide the labour for most activities from planting to storage, farmers said men work alongside women throughout the same stages of the sunflower supply chain. As is the cultural norm in Lira and Apac men plough and women are more involved in planting. Both men and women are involved in harvesting, threshing and transportation of sunflower from the field to the households. Children are hardly ever involved in these farm operations and where they participate girls are involved. Men also take over the sale of large quantities of produce while women are engaged in the retail of small quantities of oil at the markets and local shops. Men make most of the decisions about where to sell and in what quantities.

DESCRIPTION OF THE SUNFLOWER SUPPLY CHAIN ECONOMICS

The farmers, traders and small-scale millers were asked about the costs of their sunflower operations. Farmer expenditures discussed included cost of seed, labour for operations from ploughing to storage and tools used. The cost of tools was discounted according to useful years (number of seasons they can be used). For traders, agents and cooperatives involved in bulking sunflower expenditures were based on volumes handled in a season. The cost of grain purchase, labour (loading and off-loading, re-drying and cleaning), storage space and storage tools was obtained.

For small-scale millers, the emphasis was placed on the volume of grain handled in a season, labour required to dry and clean it and labour required for milling operations. It was difficult to obtain other information. The findings are presented in Table 14.6 and show that at the current output levels, the sampled farmers must earn at least USD 0.416 for a kilogram of sunflower grain to break even. But the average farmgate price of sunflower at the time of the study was USD 0.23. A position of gain can only come about if farmers increase their productivity and attain better prices for their grain. For example a yield of 1 235 kg/ha or 500 kg/acre lowers the cost of production for one kilogram of grain (ready to market) to USD 0.19. A loss making position is a disincentive for investment in improved technologies, included those for post-harvest.

TABLE 14.5
Food supply chain – Social structures

Stage in food supply chain	Involvement of women		Involvement of men		Who is mainly involved: women, men, children	Organization level of FSC actors[2]	Gender / social pattern
	Girls	Adult women	Boys	Adult men			
	Qualifier[1]	Qualifier	Qualifier	Qualifier			
Primary production Land preparation, planting, weeding		2		2	Men, women	Household	Men are in charge of land preparation, women participate in planting.
Harvest	2	2		2	Men, women	Individual household	By men and women. Both men and women may head load or use bicycles but more men use bicycles and more women than men head load. This shows that more men own bicycles than women.
Threshing					Men, women	Individual household	Sunflower heads are threshed with sticks soon after harvesting. Both men and women participate. It is usually done in the field. Children not usually involved but when it occurred girls were involved.
Drying and winnowing		2		2	Men and women	Individual household	Men and women carry out drying equally n. Mostly women winnow. Children rarely involved.
Storage		1		1	Men and women	Individual household, collective where farmer is member to a cooperative that has a store	Activities related to storage by both men and women. Producer Organizations (POs) without storage also store individually and in bulk on agreed sale date. Cooperatives with stores bulk sunflower for two weeks to a month. There are more women members in cooperatives than men.
Farmer sales	0.003 (transport-ation)	2		2		Individual household, collective where farmer is member to a cooperative or PO	Male dominated stage because of the limited involvement of women in the manual work of loading/offloading.
Agent/trader bulking				2	Men	Individual/ cooperative	Male dominated stage because of social exclusion of women from long distance transactions. Women involved where bulking is done at a cooperative
Transportation				3	Men	Individual	
Small-scale milling				2	Men		Men predominately own milling businesses. However small-scale millers hire women to clean and winnow sunflowers. The wage for drying and cleaning a bag of sunflower is UGX 2 000. Some millers pay UGX 300 for the same work.
Large-scale milling				4	Men		Dominated by men who deal with grain bulkers at this level.
Wholesale for oil and retail				4	Men (women in retail)		Men dominate for upper-scale retail businesses such as shops. Women lack the capital and also are subject to social exclusion and illiteracy levels that make it impossible for women to work in shops. Market vending of oil can be done by both genders but men dominate because of the high cost of the oil.

Source: Survey data; [1] Qualification of the equipment, conditions, access to services and training, 4: excellent, 3: good, 2: moderately good, 1: bad.
[2] Individual/household level/ cooperative

TABLE 14.6
Sunflower food supply chain economics

Stage in food supply chain	Main product	Unit of measure (UOM)	Cost of activity at stage (UGX/ kg)	Cost of activity at x stage (USD/ kg)	Conversion Factor	Adjusted cost (USD/Unit of final product)	Cumulative cost (USD/ UOM)	Remarks
Farmer								
Primary production	Un-threshed sunflower stalks converted to grain	kg	1 047	0.32		0.32	0.32	Cost of fertilizer not included
Harvesting	Sunflower grain	kg	246	0.07	-	-	0.32	Cost of labour
Threshing	Sunflower grain	kg	190	0.06	1.00	0.06	0.37	Cost of labour
Transport to household	Sunflower grain	kg	76.3	0.02	1.00	0.02	0.4	Cost of labour, tools
Drying and winnowing	Sunflower grain	kg	32.7	0.01	1.04	0.01	0.41	Cost of labour, tools
Household storage	Sunflower grain	kg	17.5	0.005	1.00	0.005	0.41	Cost of labour and bags
Producer/Farmer Sales	Sunflower grain	kg	10.8	0.003	1.00	0.003	0.42	Cost of off-loading labour and transport
Trader and cooperative sales								
Trader and cooperative Sales	Sunflower grain	kg	841	0.25	1.00	0.25	0.67	Cost of grain, workspace, loading and off-loading, cleaning and drying
Small-scale miller	Sunflower oil	Litre	1 193	0.36	4.00	1.44	2.11	Purchase of grain, labour (cleaning, loading and off-loading) space, tools, bags
Large-scale miller	Sunflower oil	Litre	1 216	0.37	2.85	1.05	1.72	Purchase of grain, labour (cleaning, loading and off-loading) space, tools, bags

Note: scale of operations is different for small and large-scale miller.

Source: Survey data; USD 1 = UGX 3 306

SUNFLOWER SUPPLY CHAIN RISK FACTORS

The food loss risk factors identified in the preceding sections are summarised in Table 14.7. The effect of these major risk factors starts at the preproduction stage through to harvesting and post-harvest handling.

TABLE 14.7:
Sunflower risk factors in the food supply chain

Factor	Unit	Relation to food losses: contributing to low losses	Value (observed in the case study)
Sunflower variety	Name	Pan7351 and Sunfola	High price of sunflower seed Pan7351, lack of quality seed.
Good Agricultural Practices (GAP)	Y/N	Yes, to some extent	In general, farmers observe timely planting and crop management practices. Post-harvest handling practices are not adequate. Farmers delay harvesting, use poor threshing, drying and storage techniques and practices.
Rainfall during production	mm		Rainfall was said to be moderate during the second season. The study occurred following this harvest season. Farmers report climate change effects resulting in prolonged rains during some seasons. Prolonged rains can cause spoilage of sunflower.
Production supply/demand ratio	Ratio	<1	Sunflower supply is below what the processors need. Processors in Lira are just operating at about 62% of their crushing capacity.
Rainfall during post-harvest phase	mm	No	Farmers report climate change effects resulting in prolonged rains during some seasons. Prolonged rains can cause spoilage of sunflower.
Post-harvest technology	L/M/H	High	There are no farmers with improved threshing and winnowing equipment. Sunflower is threshed by beating and drying is largely on tarpaulins, stabilised surfaces or on the ground. Farmers lack proper storage facilities.
POs/ Coops	Y/N	Yes	Cooperatives and POs exist and are being developed with the support of UOSPA, VODP 2, NGOs, and projects.
Processing technology	L/M/H	High	Most small-scale millers do not have efficient equipment and therefore incur losses during the milling process.
Good Manufacturing Practices (GMP)	Y/N	Yes	The level of hygiene in some mills is not good but this can be improved by training. Most drying is done on tarpaulins.
Packaging materials and facilities	L/M/H	High	Polyethylene bags are used pack sunflower grain and seed cake. Oil is packaged in jerry cans.
Cold chains	Y/N	NA	Not applicable for sunflower
Transport duration	Hour	Low duration	Transportation is informal for most farmers. Farmers who grow sunflower and supply Mukwano agents, transport the grain to the village aggregation stores, and from there the grain is transported using Mukwano vehicles. The cost of transaction increases with distance. In Apac the trading centre is 1 to 2 km away but is over 100 km from Lira.
Market information	L/M/H	High	Farmers do not usually obtain official market information from buyers; instead they rely on the village traders and agents for this information. Cooperatives have marketing committees that research prices and try to negotiate favourable deals with millers.
Price incentive for quality	Y/N	Yes	There are price incentives for quality, large millers discount low grade sunflower. This also makes agents and some bulkers sensitive. However the effect is minimal because of the intense competition for sunflower. Farmers still sell low quality seeds.

Source: Survey data

Chapter 15

Sunflower food losses - study findings and results

THE LEVEL AND CAUSE OF LOSS IN THE FSCS

Farmer level

The losses are calculated on the basis of estimations made by farmers, millers, extension and other pertinent stakeholders in the sunflower supply value chain, and their assessment of which cause is responsible for the losses. Loss estimates are also calculated based on spot sampling and analysis of sunflower at harvest.

Harvesting – Observations were made of the sunflower heads with grain left on them left lying around in the field after harvest and the quantity of grain left scattered on the ground in the quadrants was also observed, picked and weighed. In one of the fields up to 87 kg was lost in one hectare but the average loss was 2.46 percent of the total output. The causes of the loss were identified as:

- Spillage;
- Harvested heads left in the field without removing the grain. Partly because of non-uniform crop maturity;
- It was observed that dust stuck to the heads that are dropped on the ground upon harvesting.

Threshing – The exact loss at drying was not measured during the study. Farmers and key informants estimated losses at this stage to be 2.4 percent of the final output. The loss is a result of:

- Grain scattering and being spilled on the ground because of the impact of the sticks on the sunflower heads in the process of threshing. Grain is lost as a result of the rudimentary technology used for threshing.
- Some of the grain may break, leaving a portion of the grain on the head, while the other falls out. This is because of the technology used to separate the grain from the sunflower head.
- Some of the grain does not dislodge and remains on the head.

Drying – The exact loss at drying was not measured during the study. However key informants estimated that losses at this stage can be up to 3 percent of output. The losses are attributed to:

- Spillage because of the lack of proper drying facilities such as cribs and tarpaulins.
- Domestic animals eating the sunflower as the crop is left out to dry. This is a result of drying at ground level where animals can easily reach the grain.

The drying stage is an important stage in terms of risk of contamination and subsequent food loss. Sunflower grain comes in contact with the uncovered ground where tarpaulins are not used. Debris is added as farmers gather up the sunflower after drying. The accumulation of debris in the grain does not affect the farmer but causes economic loss to the traders and millers. Improper drying increases the risk of mould when the grain is not properly stored.

Household storage – The losses at this stage have been estimated at 2 percent of output. The key informants attributed the losses to:

- Spillage, caused by the grain scattering and becoming stuck in crevasses when not stored in bags and secure containers.
- Rodents eating the grain when the sunflower is not stored in secure containers.
- Lack of knowledge about appropriate storage techniques and practice.
- Lack of proper storage equipment (hermetic bags and plastic silos).
- Ignorance of food safety and how it may be compromised by farmers' actions.
- Lack of concern about losses that have been caused by farmers but are incurred by others in the food supply chain.

Local Trader/Agent Bulking/Cooperative Bulking

The exact loss at the trader/agent/cooperative bulking points was not measured during the study. Traders estimated losses at this stage to be 10 percent of the total volume of grain handled. The factors resulting in losses at this level are:

- Debris: Sunflower is purchased with a lot of debris (including dust and at times stones). The average amount of debris was estimated at 5 percent.
- Spillage (1 %) as bags are moved, opened for drying and cleaning.
- Excessive moisture in sunflower (3.20 percent): The moisture evaporates off as the grain is dried. The excessive moisture in sunflower occurs because of farmers' improper drying practices. Some traders do not have moisture meters and others do not care.
- Mould (0.50%) resulting from storing improperly dried sunflower and poor storage conditions. Most stores were constructed for use as shops.
- Rodents (0.30%) because of poor storage facilities.

The total loss reported at this level was adjusted to 1.80 percent, excluding loss because of debris and excessive moisture.

Small-Scale Milling/Crushing

The reported losses at this stage have been estimated at 14.90 percent of purchased grain. The key informants attributed the losses to:

- Debris (6.9%): The cleaning process (winnowers or air blowers) remove the dust and debris. This loss comes about because of the poor cleaning practices at the farmer level.
- Excessive moisture in sunflower (1.5% loss): The weight of grain to mill is reduced as the sunflower is re-dried. The intense competition for sunflower means that some millers buy grain even at 15 percent moisture content and higher.
- Mould (0.50%) resulting from storing improperly dried sunflower and poor storage conditions.
- Rodents (0.30%) because of poor storage facilities.
- Losses during the milling process (2%) are the result of the excessive heat in the oil expeller, which causes some of the oil to vaporise.
- Processing and handling of the cake (3%): The oil expellers (used by small-scale millers) do not extract the oil efficiently. As a result some oil is not extracted from the cake. Millers try to recover this cost by selling the cake to large-scale millers at an average price of UGX 950 (USD 0.28) per kg, who then extrude the oil from the cake. Cake is also sold to feed mills. By doing so the mills lose revenue that would have been earned if they had sold oil.

The reported loss was adjusted to exclude factors that do not result in reduction of quantity or quality of food (e.g. excessive moisture and debris). The adjusted loss came to 6.50 percent of the purchased grain.

It was also mentioned that improper storage of sunflower cake (exposure to moisture) causes it to mould and become soggy. In this state it must be discarded. Some millers have experienced 100 percent loss of cake because of moisture that came through leaking roofs.

Large-scale millers

The factors resulting in losses at this level are:

- Debris (10%): The cleaning process of winnowing or using blowers removes dust and debris. Millers mentioned blowing off 20 to 30 tonnes of dust from 2 500 tonnes of sunflower.
- Excessive moisture in sunflower (3%): This is because farmers do not dry grain well. Millers end up with less than the purchased weight of grain after re-drying.

While the above causes result in financial loss for the millers, they are not food losses.

Presumed food losses in the selected food supply chains

The presumed food losses presented in the Table 15.1 are estimates derived from discussions with key informants and published information.

QUALITY SCORING OF SUNFLOWER

Most actors, except millers, did not talk about the quality aspects of sunflower because they are unaware. Actors are similarly uninformed about the consequences of their handling practices on the quality of sunflower that they place in the FSC. The handling practices mentioned here include placing harvested sunflower heads on the ground, drying on the ground, not drying properly (to 10 to 12% moisture content), not having standard grain stores. Farmers, traders and millers are aware

TABLE 15.1
Preliminary screening of food losses in the selected sunflower supply chain

FSC # ___ , <geographical area>, <market product>			
Step in the FSC	**Expected Loss Points**		**Comments Remarks**
	Quantitative CLP or LLP	**Qualitative CLP or LLP**	
Harvesting	5 %	<1 %	Harvesting sunflower before it has matured producing poor seed quality or late harvest. Poor practices of throwing sunflower heads on uncovered ground result in spillage and contamination.
Threshing	2 %	<1 %	Often sunflower is threshed on a tarpaulin. However, the use of rudimentary tools result in some losses from spillage and breakage. Some seeds remain on the head possibly because of incomplete threshing or variety of sunflower
Transportation	<1 %	0	Loss from spillage. Most farmers try to sew the bags properly to reduce spillage
Drying on-farm	2 %	2 %	Some farmers dry on a tarpaulin (50 %), while others dry on uncovered ground. This results in contamination. Improper drying (up to 15 % MC instead of the recommended 10 to 12 %) results in the grain becoming mouldy. Others leave sunflower to dry in the field before harvesting resulting in spillage and bird damage.
Winnowing	<0.5 %	0	Inevitably as a result of winnowing, some sunflower seed is thrown away with the chaff or debris.
Storage on-farm	<0.5 %	<0.5 %	Storage is not a critical point for farmers because they do not store for long. In a few cases, however, the sunflower may be prone to damage by rats, spillage and contamination when the seeds have been poorly stored on uncovered ground in the house or mixed with other commodities
Storage at primary bulkers stores	3 %	<0.01 %	Primary bulkers may store for at least one month. There may be some spillage from torn bags, compact packing or lack of pallets in the store, and discolouration and mould contamination because of improper placement
Milling	6 %	<1 %	Milling is preceded by winnowing, where about 5 % of the chaff or debris is expected, and in re-drying. There may also be damage caused by rodents or spillage.

UOSPA, 2014 estimates a cleaning loss of 5 percent of sunflower bought from farmers. This figure has been used to estimate the loss at the mill.

TABLE 15.2
Level of impurities and aflatoxin contamination at 30 ppb in sunflower samples

District	Percentage	
	Level of impurities (debris)	**Level of aflatoxin contamination (at 30 ppb)**
Apac	7.8	75
Lira	9.9	32
Average	8.9	53.5

that improperly dried grain may mould. Mouldy sunflower is thrown away. This loss is avoided by either selling or using sunflower as quickly as possible or re-drying if it has to be stored.

The result of the analysis of the level of impurities and aflatoxin presence in samples from farmers and bulking points at village level is presented in Table 15.2.

The high proportion of impurities found confirms the millers' report about the amount of debris in the sunflower grain received. The samples were found to contain a level of aflatoxin beyond the acceptable level of 10 ppb for grains. Key informants at Mukawano reported an incidence where 300 000 tonnes of sunflower cake, which had been exported to Bangkok, was rejected because of high aflatoxin presence. This indicates an important need to address points at which aflatoxin contamination occurs in the food supply chain (in the field, during drying and storage).

TABLE 15.3
Critical loss points and causes of loss

Stage in food supply chain	Type of loss	Percentage of loss	Cause of loss
Actor: Farmer			
Harvesting	Quantitative	2.50 %	Crop left un harvested in the field, spillage
Threshing	Quantitative	2.40 %	Spillage
Drying	Quantitative	3.00 %	Spillage, eaten by domestic animals
Storage	Quantitative	2.00 %	Spillage, rodents
Actor: Trader and Cooperatives			
Drying, cleaning, storage	Quantitative	1.80 %	Spillage, mould, rodents
Actor: Small-scale miller			
Drying, cleaning, storage	Quantitative, Qualitative	1.50 %	Spillage, mould, rodents
Milling	Quantitative	5.00 %	Evaporation, un-extracted oil

THE CRITICAL LOSS POINTS

The critical loss points identified in this study are harvesting, threshing, drying, bulking, storage points, small-scale (storage and milling) (Table 15.3).

THE IMPACT OF THE LOSSES

Findings from the field studies were extrapolated to obtain the overall scenario of the sunflower FSC Losses for Apac and Lira districts. The following assumptions were made to estimate the district scenario.

- There were 71 813 households in Apac district and 89 165 households Lira district in 2014 (*Source:* UBOS, 2016).
- About 65 percent of the households in Apac and Lira districts produce sunflower (*Source:* Key informants VODP 2).
- The average area under sunflower cultivation per household in Apac and Lira districts in 2015 was 0.64 ha (*Source:* Field Sample).
- The estimated area under sunflower cultivation for Apac District in 2015 is 29 407 hectares. (*Source:* 71 813 x 65% x 0.64 ha).
- The estimated area under sunflower cultivation for Lira district in 2015 was 36 513 hectares (Source: 89 165 x 65% x 0.64 ha)
- Average sunflower yield in Apac and Lira districts was 583 kg/ha in 2015 (*Source:* Field Sample).
- Since 60 percent of households do not grow sunflower in the first season, it is assumed that most households produce sunflower once a year (*Source on 60%*: Experts UOSPA).
- The above imply that the average sunflower output per household in Apac and Lira districts in 2015 was 376 kg per year (*Source:* Field Sample).
- Based on the above, the sunflower output in Apac district in 2015 was 17 551 tonnes.
- Based on the above, sunflower output in Lira district in 2015 was 21 792 tonnes.
- The average farmgate price for sunflower in Apac and Lira districts at the time of the study was UGX 750/kg (USD 0.23/kg) (*Source:* Field Study).
- The average currency exchange rate was USD 1 to UGX 3 306.8 for June 2015 (*Source:* Bank of Uganda).

The impact (loss) is arrived at by calculating the annual sunflower output for Apac and Lira districts in 2015 (17 551 + 21 792 tonnes) multiplied by the potential percentage of product lost at the critical loss points in the food supply chain. The findings show that as a result of critical losses (from farmer to miller), a total of 7 152 tonnes of sunflower is lost in a year. That food loss translates into a financial loss of USD 1 622 510 (Table 15.5).

The detailed Summary result matrix for sunflower losses is provided in Table 15.4. The percentage of the product that goes through each stage in the food supply chain is considered to be 100 percent because of the sunflower produced by farmers is sold. The losses are calculated against the product that goes through the FSC.

TABLE 15.4
Summary matrix of sunflower food supply losses

Stage in food supply chain	Cause of loss/ reason for low loss	Type of loss Qn/Ql	Percentage lost in this process (Qn)	Percentage of the product that incurred quality loss in this process	CLP /LLP	Destination of food loss	Impact/ FSC actors affected (men/women)	Impact in kg/ ha	Impact in USD	Loss perception (men/women) of FSC actors	Suggested solutions
Actor: Farmer											
Harvest	Unharvested crop and spillage	Qn	2.50		CLP	Gardens	Income loss	14.30	3.30	Unware of the loss	Sensitisation on the magnitude of loss to encourage diligence and carefulness, proper seed bed preperation, timing of harvest
Threshing	Spillage	Qn	2.40		CLP	Gardens	Income loss	14.00	3.20	Unavoidable	Use of tarpaulins. Research into building low cost threshers that could be owned by cooperatives & service providers and hired by farmers
Drying	Spillage and eaten by domestic animals	Qn	3.00		CLP	Drying areas	Income loss	17.50	4.00	Lack of tarpaulins, have children chase off the animals	Use of tarpaulins and cribs
Storage	Spillage and Rodents	Qn	2.00		CLP		Income loss	11.70	2.70		Sensitisation not placing sunflower on the bare ground at any stage, use of pallets, hermatic bags & plastic silos
Actor: Trader and Cooperatives											
Redrying	Spillage, Mould and Rodents	Qn/Ql	1.30	0.50	CLP	Damped	Income loss	7.60	1.70		Proper storage practices, defining standards of good quality grain, penalising for any grain whose quality fall below minmum standards
Actor: Small-scale miller											
Storage	Spillage, Mould and Rodents	Qn/Ql	1.20	0.30	CLP	Dampened chaff is used as manure in gardens	Income loss	7.00	1.60	Attempt to mitigate by re-drying the grain before storage	Proper storage facilities, defining standards of good quality grain; penalise if grain quality falls below minimum standards
Milling	Evaporation and Unextracted Oil		5.00		CLP		Income loss	29.20	6.60	The nature of milling technology, some loss redeemed by selling cake	

TABLE 15.5
The impact of loss

Stage in food supply chain	Type of loss	Percentage loss	Percentage of product that goes through this stage	Percentage loss in the FSC	Seasonal weight loss (Tonne)	Annual weight loss (Tonne)	USD loss	Cause of Loss
Actor: Farmer								
Harvesting	Quantitative	2.14	100	2.14	842	842	191 020	Un-harvested crop
	Quantitative	0.32	100	0.32	126	126	28 585	Spillage
Subtotal		2.50			968	968	219 600	
Threshing	Quantitative	2.40	100	2.40	945	945	214 380	Spillage
Subtotal		2.40			945	945	214 380	
Drying	Quantitative	1.00	100	1.00	394	394	89 380	Spillage
	Quantitative	2.00	100	2.00	787	787	178 540	Eaten by domestic animals
Subtotal		3.00			1 181	1 181	267 920	
Storage	Quantitative	1.50	100	1.50	591	591	134 075	Spillage
	Quantitative	0.50	100	0.50	197	197	44 690	Rodents
Subtotal		2.00			788	788	178 770	
Actor: Trader and Cooperatives								
Drying. Cleaning. Storage	Quantitative	1.00	100	1.00	394	394	89 380	Spillage
	Quantitative and Qualitative	0.50	100	0.50	197	197	44 690	Mould
		0.30	100	0.30	119	119	27 000	Rodent
Subtotal		1.80			710	710	161 070	
Actor: Small Scale Miller								
Drying. Cleaning. Storage	Quantitative	1.00	100	1.00	394	394	89 380	Spillage
	Quantitative and Qualitative	0.30	100	0.30	119	119	27 000	Mould
	Quantitative	0.20	100	0.20	79	79	17 920	Rodent
Subtotal		1.50			592	592	134 300	
Milling		2.00	100	2.00	787	787	178 540	Evaporation
		3.00	100	3.00	1 181	1 181	267 920	Un-extracted oil
Subtotal		5.00			1 968	1 968	446 460	
Total Loss					7 152	7 152	1 622 510	

Chapter 16

The food loss reduction strategy

SUMMARY OF OBSERVATIONS

The critical loss points identified in this study are harvesting (2.46%), threshing (2.40%), drying (3%), farmer storage (2%); bulking storage points (1.80%), small-scale miller storage and milling (6.5%). Further analysis observed that the real causes of the food losses were as follows:

- Inappropriate growing practices – This is drawn from the observation that farmers' yields are very low, which is a result of poor growing practices. Farmers cannot profit from sunflower production unless their productivity improves. Farmers cannot invest in better technologies if they are operating at a loss.
- Inappropriate post-harvest techniques and practices.
- Inappropriate storage facilities and practices at bulking points (traders and cooperatives).
- Inappropriate storage practices and inefficient milling equipment at the small-scale milling level.

Further verification of the above after observation of FSC actor practices, and discussion with key informants, points to the following underlying causes of the losses:

- Inadequate insight as to the correct agronomic practices (seed bed preparation to post-harvest handling).
- A lack of motivation to exercise diligence and carefulness during activities from production to producer sales.
- No incentives to apply proper handling practices and therefore sell clean, well dried sunflower.
- Farmer, trader ignorance and lack of appreciation of the magnitude of the losses incurred during post-harvest handling.
- A lack of awareness of the harvesting practices, post-harvest handling and storage technologies available for individual and collective use.
- A lack of concern about the quality of work and its effect on the quality of sunflower going through the supply chain.
- Ignorance of the magnitude of the loss and the impact of post-harvest losses on household, business and national revenue earnings.

IMPLEMENTATION OF FOOD LOSS INTERVENTIONS

The interventions directed to the reduction of food losses as suggested in Table 16.1 should not be implemented as standalone. Rather, they should be formulated as part of the existing national strategies for food security, agriculture, natural resources and/or economic development. This will eliminate duplication of effort and investment of financial and non-financial resources towards crosscutting aspects of national interventions. For the purpose of quick and easy visibility, the interventions are discussed in the subsections below from farmer level up to the national level. Each of the interventions is placed at the level/point at which the cost will be met, even when the eventual effect is at a different level.

Implementation of food loss interventions at farmer level

Intervention

Interventions for reduction of food losses to be implemented at the farmer level include:

- Adoption of proper seed bed preparation and other agronomic practices for sunflower.
- Adopting appropriate harvest timing and improving handling of heads and grain.
- Consistent use of tarpaulins at harvesting, threshing, drying and winnowing.
- Adopting proper drying to at least 12 percent moisture content.
- Use of raised cribs at drying.
- Adopting modern threshing techniques scaled-down to smaller-holder farmer level.
- Cleaning dried grain according to set standards.

TABLE 16.1
Sunflower loss reduction strategies

Stage in food supply chain	Percentage loss in the FSC	Annual weight loss (Tonne)	USD loss	Cause of loss	Intervention to reduce loss	Loss reduction target	
						Percentage	*USD*
Actor: Farmer							
Harvesting	2.14	842	191 020	Un-harvested crop	Sensitisation about proper seed bed preparation and other agronomic practices and timing of harvest	80	152 815
	0.32	126	28 585	Spillage		80	22 870
Subtotal		968	219 600				
Threshing	2.40	945	214 380	Spillage	Use of tarpaulins, research into building low cost threshers that could be owned by cooperatives and service providers and hired by farmers	80	171 510
Subtotal		945	214 380				
Drying	1.00	394	89 380	Spillage	Use of tarpaulins and cribs	80	71 510
	2.00	787	178 540	Eaten by domestic animals		80	142 830
Subtotal		1 181	267 920				
Storage	1.50	591	134 075	Spillage	Sensitisation about placing sunflower on protected ground at all stage, use of pallets, hermetic bags and plastic silos	80	107 260
	0.50	197	44 690	Rodents		80	35 755
Subtotal		788	178 770				
Actor: Trader and Cooperatives							
Re-drying	1.00	394	89 380	Spillage	Proper storage practices, defining standards of good quality grain, penalising for any grain quality that falls below the minimum standards	80	71 510
	0.50	197	44 690	Mould		80	35 755
	0.30	119	27 000	Rodent		80	21 600
Subtotal		710	161 070				
Actor: Small-scale miller							

TABLE 16.1
(Continued)

Stage in food supply chain	Percentage loss in the FSC	Annual weight loss (Tonne)	USD loss	Cause of loss	Intervention to reduce loss	Loss reduction target	
Storage	1.00	394	89 380	Spillage	Proper storage practices, defining standards of good quality grain, penalising for any grain quality that falls below the minimum standards	80	71 510
	0.30	119	27 000	Mould		80	21 600
	0.20	79	17 920	Rodent		80	14 340
Subtotal		592	134 300				
Milling	2.00	787	178 540	Evaporation	Improving equipment	80	142 830
	3.00	1 181	267 920	Un-extracted oil		80	214 340
Subtotal		1 968	446 460				
Total Loss		7 152	1 622 510				1 298 015

Source: Survey data

- Use of intact storage such as hermetic bags and plastic silos.

Strategy

Farmers will not be motivated to make any changes or invest in post-harvest technologies as long as they are operating at a loss. Supporting farmers to improve productivity is an important starting point. Farmers are unaware and not bothered about the quality or safety of the sunflower they send to the FSC. The consequences of improper handling (drying, impurities/debris, contamination and mould) are not borne by them but by others in the FSC. Some are likely to view the consistent use of tarpaulins, use of hermetic bags and silos, proper drying as an unnecessary inconvenience and an avoidable cost. This is because of the mind set and failure to make a profit at low output.

While farmers are expected to use the proposed technologies and practices, sensitisation and capacity-building over a prolonged period of time is advised. A sustained approach is recommended to bring about a shift in the mind-set and continued uptake of new technologies and methods. A mix of sensitisation approaches can be used, but the core avenue for delivery of the above should be producer organizations or cooperatives. Currently VODP 2 is supporting the organization of farmers into groups and working with UOSPA, AFSRT and other agencies towards achieving this. Sensitisation about the recommended interventions can be intensified through these avenues.

Research will be important to adapt existing threshing techniques for smallholder farmer requirements and conditions. Threshers could be owned by cooperatives or interested service providers (as an investment) and hired out to farmers. This practice is used for maize in some areas and can be adopted for sunflower.

Cost implication

While the farmer uses interventions such as tarpaulins, cribs, cleaning and drying well, and uses hermetic bags and silos, causing this change in behaviour requires sensitisation for which the cost is not borne by the farmer, but by another level such as the local government (district) establishment or projects. The cost implications and profitability of the interventions for which the cost is borne by the farmers are presented in Table 16.2. The assumptions used to compute the values in the table are presented in Table 16.3.

While technologies such as drying cribs, hermetic bags and silos are appropriate and well advised, the farmer can only profit from the intervention if they improve productivity (yield/ha), obtain better prices for grain or lower prices for the interventions.

Implementation of food loss interventions at bulking points (trader, cooperatives)

Intervention

Most challenges at bulking points (debris, improperly dried grain) are the result of poor handling practices at the farmer level. Correcting practices at the farmer level will largely alleviate trader losses. Many traders already use tarpaulins when drying produce. All chairpersons of cooperatives interviewed said they owned moisture meters; but standards need to be developed and enforced for grain stores. Sensitisation and capacity-building is required for the proper handling of grain as well as the impacts of handling for food safety. Interventions to reduce sunflower grain losses at trader level include:

- Continuing to use moisture meters to measure grain moisture content at purchase.
- Continuing to use tarpaulins when drying.
- Using bulking places that meet set grain store standards.
- Managing grain and sunflower product stores according to set standards.
- Paying premium prices for good quality sunflower grain. Motivate farmers by paying premium prices for well filled, clean and properly dried sunflower grain.
- Use deterrent measures such as turning away any grain that does not meet the minimum standard requirements

Strategy

Traders are not concerned about the quality or safety of food and are likely to view the above interventions as an unnecessary inconvenience. Second, farmer cooperatives will require financial assistance or credit to build stores that meet required standards. This level of actors cannot set or enforce standards for grain handling, store type and management. Deterrent measures pose a risk of social problems in the community and are best implemented at the policy level, by the district establishing by-laws on grain standards. All that actors involved in bulking can do is follow the set standards and laws, build or rent proper stores and manage them well. While the cost of modifying storage facilities is borne by the trader, the cost of sensitisation is borne by the local government (district) establishment. Therefore, the cost and

TABLE 16.2
Cost and benefit analysis of interventions at farmer level

	Cost centre	Unit of measure	Tarpaulin	Hire-sunflower thresher	Drying cribs (1 000 kg)	Hermetic bag (400 kg)	Plastic silo	Calculation
			Value	Value	Value	Value	Value	
a	Production of sunflower per household	kg/season	376	376	376	376	376	
b	Value of sunflower (farm-gate price)	US$/kg	0.23	0.23	0.23	0.23	0.23	
c	Loss rate	%	3.70	2.40	2.00	2.00	2.00	
d	Anticipated loss reduction	%	80	100	80	80	80	
e	Cost of intervention	USD	0.40		1.21	16.6	46.6	Tarpaulin and crib are per square metre
f	Depreciation period	Seasons	4.00		5.00	2.00	20	Farmers produce sunflower once a year
g	Cost of investment per year	USD/year	0.10		0.24	8.30	2.30	e/f
h	Cost of operation per year	USD/year	0		0	0	0	
i	Total costs per year	USD/year	0.10		0.24	8.30	2.30	g+h
ia	Capacity of item	kg	25		25	400	500	Tarpaulin and crib: grain spread per square meter
ib	Number of loads per year	Loads	1.00		1.00	1.00	1.00	(1 load/season)
ic	Yearly throughput of item	kg/year	25		25	400	500	ia x ib
j	Costs per kg of product incurred	USD/kg	0.004	0.005	0.01	0.021	0.005	i / ic
k	Food loss	kg/year	14	9.00	8.00	8.00	8.00	cxa
l	Economic loss	USD/year	3.20	2.10	1.70	1.70	1.70	kxb
m	Loss reduction	kg/year	11	9.00	6.00	6.00	6.00	kxd
n	Loss reduction savings	USD/year	2.50	2.10	1.40	1.40	1.40	mxb
o	Total cost Incurred	USD/year	1.50	1.80	3.60	7.80	1.80	axj
p	Profitability of solution/household	USD/year	1.00	0.30	-2.30	-6.5	-0.39	n-o

profitability of sensitisation aspects are addressed at the district level.

Cost Implication

The cost implications and profitability of the interventions above are presented in Table 16.4. The following assumptions were made to compute the values in this table.

- Average amount of sunflower grain handled at a bulking point per season is 49 tonnes.
- The average price selling price by bulkers was USD/tonne 347.9, which translates to USD 0.35/kg.
- The loss at trader/cooperative bulking points as a result of storage factors (excluding spillage) is 0.80 percent.

TABLE 16.3
Assumption indicators

Assumptions		Farmer assumptions	Trader assumptions	Miller assumptions	
Number of households in Apac district		71 813	71 813	71 813	
Number of households in Lira district		89 165	89 165	89 165	
Number of households in Lira and Apac district		160 978	160 978	160 978	Households
Number of households producing sunflower		65 %	65 %	65 %	
Number of households producing sunflower		65 %	65 %	65 %	
Number of households producing sunflower		65 %	65 %	65 %	
Average sunflower area per household					
In hectares		0.643	0.643	0.643	Hectares
In acres		1.59	1.59	1.59	Acre
Average yield (Per household)		583	583	583	Kilogram
Output per household/season		376	376	376	Kilogram
Number of growing seasons per year		1	2	2	Seasons
Estimated area under sunflower cultivation per season		67 329	67 329	67 329	Hectares
Total output in Apac in kg/ha		17 551 097	17 551 097	17 551 097	Kilogram
Total output in Lira		21 791 926	21 791 926	21 791 926	Kilogram
Total in both districts		39 343 023	39 343 023	39 343 023	Kilogram
Selling point					
Average farmgate price		750	750	750	UGX
Average trader and cooperative price		750	750	750	UGX
Average miller price		1 150	1 150	1 150	
Average exchange rate	USD 1	3 306	3 306	3 306	UGX
Utilisation of sunflowers					
Percent of sunflowers consumed in the household		0	0	0	
Percent of sunflowers traded		100	100	100	
Tarpaulin					
Cost of Tarpaulin		12.10	12.10	12.10	USD
Size of tarpaulin in m2		30.00	30.00	30.00	Square metres
Cost per m2		0.40	0.40	0.40	USD
Grain spread per m2		25.00	25.00	25.00	kg
Depreciation period in harvests		4.00	4.00	4.00	Harvests
Thresher hire					
Cost of threshing per bag		0.30	0.91	0.91	USD
kg per bag		65.00	65.00	65.00	Square metres
Cost per kg		0.00	0.01	0.01	USD

TABLE 16.3
(Continued)

Assumptions	Farmer assumptions	Trader assumptions	Miller assumptions	
Drying crib				
Cost of crib	30.25	30.25	30.25	USD
Size of crib in m2	25.00	25.00	25.00	Square metres
Cost per m2	1.21	1.21	1.21	USD
Grain spread per m2	25.00	25.00	25.00	kg
Depreciation period in harvests	5.00	5.00	5.00	Years
Hermetic bag				
Cost of per bag	16.64	4.16	4.16	USD
Capacity of bag in kg	400.00	400.00	400.00	kg
Depreciation period in harvests	2.00	2.00	2.00	Harvests
Plastic silo				
Cost of per silo	46.58	46.58	46.58	USD
Capacity of silo in kg	500.00	500.00	500.00	kg
Depreciation period in years	20.00	20.00	20.00	Years
Depreciation period in harvests	20.00	40.00	40.00	Harvests
Metal silo medium				
Cost per silo	72.90	72.90	72.90	USD
Capacity of silo in kg	500.00	500.00	500.00	kg
Depreciation period in years	20.00	20.00	20.00	Years
Depreciation pPeriod in harvests	20.00	40.00	40.00	Harvests
Metal silo large				
Cost per silo	110.10	110.10	110.10	USD
Capacity of silo in kg	1 000.00	1 000.00	1 000.00	kg

Implementation of Food Loss Interventions at Small-Scale millers

Intervention and strategy

The causes of loss at the small-scale miller level are the result of storage practices and inefficient mills. The factors constraining small-scale millers from acquiring more efficient systems may be numerous. There is a need to research the causes of the unstable position of many small-scale millers. However the intervention and strategies for storage are similar to those discussed for the trader and cooperative bulking points.

Cost implication

The cost implications and profitability of the interventions are presented in Table 16.5. The following assumptions were made to compute the values in the Table.

- Average amount of sunflower grain milled per season is 135 tonnes. Given that there are two seasons per year, then the annual volume is 270 tonnes.
- Average price of sunflower grain at miller level per tonne is USD 347.9
- The loss from storage factors (excluding spillage) is 0.50 percent.

TABLE 16.4
Cost and benefit analysis of interventions at trader and cooperative bulking level

			Standard grain store	
	Cost centre	***Unit of measure***	***value***	***Calculation***
a	Volume of sunflowers handled per transaction	tonne/season	49	
b	Value of sunflowers (selling price)	USD/tonne	348	
c	Loss rate	%	0.80	The loss indicated is that which can be resolved by using the proposed intervention
d	Anticipated loss reduction	%	80	
e	Cost of intervention	USD	151	Cost per square meter
f	Depreciation period	Seasons	20	
g	Cost of investment per season	USD/season	7.60	e/f
h	Cost of operation per season	USD/season	0	
i	Total costs per season	USD/season	7.60	g+h
ia	Capacity of item	tonne	0.70	Capacity of square meter
ib	Number of loads per season	Loads	70	Turnover
ic	Seasonal throughput of item	tonne/season	49	ia x ib
j	Costs per tonne of product incurred	USD/tonne	0.16	i / ic
k	Food loss	tonne/season	0.39	c x a
l	Economic loss	USD/season	136	k x b
m	Loss reduction	tonne/season	0.31	k x d
n	Loss reduction savings	USD/season	109	m x b
o	Total cost Incurred	USD/season	7.60	a x j
p	Profitability of solution	USD/season	101	n-o

Implementation of food loss interventions at district level

Interventions

In general terms, interventions to reduce food losses for implementation at the district level are primarily:

- Sensitisation to create awareness about losses, causes and mitigation measures.
- Development of an inventory of local and other good harvesting and post-harvest practices and technologies.
- Training in available technologies for food loss reduction.
- Development of easily verifiable standards for sunflower grain and products and enforcement of compliance to the standards.
- Advocating for price differentiation for different grades (in terms of quality as a result of post-harvest handling).
- Improving availability of extension services and facilitating their service delivery.
- Strengthening of producer organizations or cooperatives in terms of structure, governance, transparency, business handling, collective infrastructure and equipment and marketing.
- Sensitisation about grain store management practices and standards.
- Facilitating linkage to financial services and supporting access to proper post-harvest handling, storage and milling technologies

Strategy

Well-established multi-stakeholder platforms exist for vegetable oils (OSSUP, UOSPA) and are important avenues for the design, sourcing support, setting annual targets and monitoring of the proposed interventions. A collection of

TABLE 16.5
Cost and benefit analysis of interventions at small-scale millers

			Standard grain store	
	Cost centre	***Unit of measure***	***value***	***Calculation***
a	Amount of sunflower grain milled per season	tonne/season	135	
b	Value of sunflowers (selling price)	USD/tonne	348	
c	Loss rate	%	0.80	The loss indicated is that which can be resolved by using the proposed intervention
d	Anticipated loss reduction	%	80	
e	Cost of Intervention	USD	151	Cost per square meter
f	Depreciation period	Seasons	20	
g	Cost of investment per season	USD/season	7.60	e/f
h	Cost of operation per season	USD/season	0	
i	Total costs per season	USD/season	7.60	g+h
ia	Capacity of Item	tonne	0.7	Capacity of square meter
ib	Number of loads per season	Loads	193	Turnover
ic	Seasonal throughput of Item	tonne/season	135	ia x ib
j	Costs per tonne of product Incurred	USD/tonne	0.06	i / ic
k	Food loss	tonne/season	1.10	cxa
l	Economic loss	USD/season	376	kxb
m	Loss reduction	tonne/season	0.86	kxd
n	Loss reduction savings	USD/season	301	mxb
o	Total cost Incurred	USD/season	7.60	axj
p	Profitability of solution	USD/season	293	n-o

well-defined food loss reduction goals should be set annually based on assessment of the progress made in each of the selected aspects.

The suggested format for sensitisation and capacity-building includes a 30-minute weekly programme on existing media platforms, especially radio and free-to-view television channels. The programme should run for 3 to 5 years. The content of the programme should be created around a well-connected story pattern that aims to transform attitudes. Extension workers and service providers who are coordinated within the district production office hierarchy should facilitate monthly community meetings.

Cost implication

The cost implications and profitability of the interventions above would have to be developed by the district. It was reported by traders that the District Local Government charges UGX 500/= (USD 0.15) per bag handled by the produce line or wholesale dealers. An annual grain loss of 3 957 tonnes/year in Lira and 3 187 tonnes/year in Apac at the critical loss points throughout the FSC could cost the Local Government revenue earnings of USD 2 485 300. Therefore the local government could offer 10 percent of revenue earnings from the grain trade in the districts towards support of extension to sunflower FSC actors. The cost implications and profitability of the interventions above are presented in Table 16.6 and Table 16.7.

Implementation of food loss interventions at the national level

Intervention

Interventions for the reduction of food losses to be implemented at the national level include:

TABLE 16.6
Cost and benefit analysis of interventions at Apac district local government level

			Sensitisation	
	Cost centre	***Unit of measure***	***value***	***Calculation***
a	Volume of Sunflowers Traded In District	tonne/season	17 551	
b	Value of Sunflowers (Selling Price)	USD/tonne	348	
c	Loss rate	%	18.2	
d	Anticipated loss reduction	%	80	
e	Cost of Intervention	USD/tonne	0.23	
f	Depreciation Period/Number of Season	Seasons		Farmers produce sunflower once a year
g	Cost of investment per MT	USD/tonne	0.23	e
h	Cost of operation per tonne	USD/tonne	0	
i	Total Costs per tonne	USD/tonne	0.23	g+h
ia	Capacity of Item	tonne		
ib	Number of loads per year	Loads		Turnover
ic	Yearly throughput of Item	tonne/year		ia x ib
j	Costs per Mt of product Incurred	USD/tonne	0.23	i
k	Food loss	tonne/year	3 187	cxa
l	Economic loss	USD/year	1 108 700	kxb
m	Loss reduction	tonne/year	2 550	kxd
n	Loss reduction savings	USD/year	886 960	mxb
o	Total cost incurred	USD/year	4 084	axj
p	Profitability of solution	USD/year	882 880	n-o

- Formulation of national standards for harvesting, post-harvest handling and storage of sunflower.
- Formulation of national food loss reduction policy.
- Adoption of national food reduction policy into national strategic direction.

Strategy

It is necessary to bring together the salient findings on food losses of sunflower along with other crops and agricultural products. This will enable the comparison and identification of crosscutting causes that could be addressed as a whole. However, keeping within the boundaries of this study, an overall concept of mitigating food losses should be prepared by a select committee at the national level. The concept should contain the strategic elements for reducing sunflower food losses. Each of the strategic elements should be accompanied by detailed activity sequences. The strategic elements should then be adopted as part of sector-wide national policy. The national policy may be accompanied by enabling laws and standards for implementation. The food loss interventions in the national strategy should be divided down to the district level for adopting them in ways that address the unique challenges found at the community level. The district level food loss strategy should be integrated into the overall longer-term and mid-term district strategy and considered in the annual district work plans and budgets.

QUICK ASSESSMENT OF ECONOMIC AND SOCIAL BENEFITS OF THE PROPOSED SOLUTIONS

Economic implications

Farmers must be supported to improve productivity to obtain the maximum benefit from the proposed solutions. Better practices at the farmer level will improve the quality of grain received at

TABLE 16.7
Cost and benefit analysis of interventions at Lira district local government level

			Sensitisation	
	Cost centre	***Unit of measure***	***value***	***Calculation***
a	Volume of Sunflowers Traded In District	tonne/season	21 792	
b	Value of Sunflowers (Selling Price)	USD/tonne	348	
c	Loss rate	%	18.2	
d	Anticipated loss reduction	%	80	
e	Cost of Intervention	USD/tonne	0.23	
f	Depreciation Period/Number of Seasons	Seasons		Farmers produce sunflower once a year
g	Cost of investment per MT	USD/tonne	0.23	e
h	Cost of operation per MT	USD/tonne	0	
i	Total Costs per MT	USD/tonne	0.23	g+h
ia	Capacity of Item	tonne		
ib	Number of loads per year	Loads		Turnover
ic	Yearly throughput of Item	tonne/year		ia x ib
j	Costs per Mt of product Incurred	USD/tonne	0.23	i
k	Food loss	tonne/year	3 957	cxa
l	Economic loss	USD/year	1 376 600	kxb
m	Loss reduction	tonne/year	3 166	kxd
n	Loss reduction savings	USD/year	1 101 280	mxb
o	Total Cost Incurred	USD/year	5 071	axj
p	Profitability of solution	USD/year	1 096 210	n-o

bulking points and millers and lower the cost of operations for cleaning and drying. Better quality grain can earn bulkers, including farmer cooperatives, a better price per kilogram of sunflower grain. Cooperatives have more women members than men implying that these benefits will also accrue to women.

Social Implications

The social implications of the solution will be to improve household livelihoods and welfare as a result of earning a higher income. In addition, more employment possibilities will be created through re-investing additional farm incomes to hire labour to improve field and post-harvest management. Labour and housing structures, used to store the produce at homesteads, will be used for alternative uses. Women who are the main caretakers of household storage will have a reduced workload. The solutions will enhance food security by elevating the purchasing power of households. Overall, the safety of sunflower seed cake will be improved because of the reduction in the potential causes of aflatoxicosis, which is that the grain contains high moisture content. There are foreseeable substantial environmental implications for the solutions, since improved drying and storage do not require the additional use of land and water; and energy produce from fuelwood. Furthermore, no hazardous waste products and wastewater will be discharged.

FOLLOW-UP ACTION PLAN/CONCEPT NOTE FOR FUTURE INVESTMENT

The critical loss points identified in this study are harvesting (2.46%), threshing (2.40%), drying (3%), farmer storage (2%); bulking storage points (1.80%), small-scale miller storage and milling (6.5%). High levels of aflatoxin contamination (75% Apac and 32% Lira) were found in samples from aggregation points at village level and from farmers.

Further analysis observed that the real causes of the food losses were: inappropriate growing practices; post-harvest techniques and practices; and storage practices and inefficient milling at the small-scale level.

In order to reduce the identified losses interventions are proposed at actor (farmer, bulking points, small-scale milling), district and national level. In general, the following will be required:

- Training in available technologies for loss reduction.
- Development of easily verifiable standards for sunflower grain and products and enforcing compliance with the standards.
- Advocating price differentiation for different grades (in terms of quality as a result of post-harvest handling).
- Improving the availability of extension services and facilitating their service delivery.
- Supporting to the strengthening of producer organizations or cooperatives (governance, transparency, business handling).
- Sensitisation about grain store management practices and standards.
- Facilitating linkage to financial services and supporting access to proper post-harvest handling, storage and milling technologies.

To address these losses, there is a need to improve farmer productivity and support them in attaining better prices for their grain. One way of attaining better prices is by bulking through farmer groups/producer organizations/cooperatives. Sunflower bulking by farmers at the community level to wait for better prices and attain better economies of scale that would enhance farmer incomes. A bulking arrangement may have a range of additional functions, such as providing inputs, saving, credit and extension.

However, these functions do not form the essence of bulking, although they may interact with the successful provision of the six necessary functions. The structure of governance for any form of bulking arrangement will have to find ways to balance these functions in a cost-efficient way. To manage the bulking arrangement in a successful and sustainable way, the system needs to have 'feedback mechanisms' that control for the cost-effectiveness of the arrangement and balance trust in transactions with logistic efficiency in availability of agricultural extension services.

Individual farmer post-harvest handling practices must also improve. Simple practices such as the use of a tarpaulin at threshing and drying must be encouraged. In addition, simple technologies such as threshers, cribs for drying and hermetic bags and plastic silos for storage are proposed. Simple sunflower threshing technologies exist internationally. Researchers and technicians at the Agricultural Engineering and Appropriate Technology Research Institute can investigate and adapt these threshers to ensure their efficacy. Threshers are not recommended for individual farmer ownership, but for hire. However a farmer cooperative could be supported to own a thresher and offer the service to farmers at a small fee. The National Agriculture Research Laboratories and AFSRT have designed cribs for maize that can also be adapted to suit sunflower drying. The WFP is promoting the use of hermetic bags and plastic silos for grain storage.

There is also the need to further investigate the influence of better trade policies and how these could impact the profitability of the different segments in the chain. More support could be given to farmer groups in negotiating better prices for better quality grain.

Thus reduction of sunflower food losses will require a combination of efforts to come up with the most appropriate strategy, which will then be adopted for different end users depending on their specific needs.

Gender considerations also need to be also addressed. This study learned that sunflower seems to be equally handled by both men and women. This is an opportunity the project can exploit to enhance household incomes.

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Annex 1
List of Experts Consulted

BEANS STUDY 2015-16

	Expert name	Title/Position	Institution
1.	John Michael Akena	Agricultural Officer	Oyam Town Council
2.	Cosmas Atim		
3.	Tony Ago		
4.	Joseph Kojo		
5.	Lydia Ejang		
6	Boniface Olwata		
7	Mildred Acen		
8	Abong	Trader	
9	Shaban Olal	Trader	

BEANS STUDY 2016-17

Name	Organization/designation	Location
Beatrice Birungi Byarugaba	MAAIF/agriculture Director Extension	Entebbe
Benson Ogwang	Extension officer	Oyam
Bambona Alex	Assistant commissioner food and nutrition security	Entebbe
Ario Micheal	Lira District Agricultural Officer	Lira
Okullu Samuel	Field extension officer	Oyam district
Andrew Ocen	AFSRT	Lira
John Micheal Akona	Extension officer	Oyam town council
Martin Tumuhereze	Resource Person	Entebbe
Prof. Brighton Mvumi	FAO-Zimbabwe	Zimbabwe
Richard Masagazi	Uganda Seed Traders Association (USTA)	Kampala
Moses Ogwal	Private sector foundation Uganda (PSFU)	Kampala
David Ogwang	Extension officer	Lira
Mufumbiro Hakeem	UNBS/Standards officer	Kampala
Dr Harriet Muyinza	NARO/National Focal Point and SRO	Wakiso
Patrick Odyomo	DAO Oyam district	Oyam

Name	Organization/designation	Location
Ms Bridget Mirembe	WFP/Communications officer	Kampala
Victor Ogwang	Extension officer	Dokolo
Sam Opule	DAO Apac district	Apac
Ms Rose Namugga	FAO/Project Technical Assistant	Wakiso
Winnie Amuge	Extension officer	Oyam
Dr Nanyenya William	Agricultural Economist-NARO	Tororo
Josephine Okot	Managing Director, Victoria Seeds Limited	Kampala

MAIZE STUDY

1.	Eunice Ojok	Cluster chairperson	Ober south cluster, Lira district
2.	Desiterio Omara	Small-scale maize mill operator	Amun A., Apac district
3.	Alfred Ochieng	Commercial rural store operator	Amun B., Apac district
4.	Bonefance Agambe	Independent agent	Ibuje, Apac disrict
5.	Victor Ogwang	Retired extension office and prominent farmer	Lira district
6.	Cedric Mutyaba	Research officer	NARL, NARO, Kawanda
7.	Michael Ario	District commercial officer	Lira district
8.	DorcusAlum	Agricultural Officer	DAP, Lira DLG
9.	Alex Ogwang	Programme manager	AFSRT
10.	Patrick Ogwang	Director	AFSRT
11.	Andrew Ocen	Agri-business management specialist	AFSRT
12.	Samuel Okullu	Manager	Bosceno Maize Millers
13.	Ogwal Kasimiro	Zonal agricultural development officer	NAADS, Lira
14.	Catherine Kemigisha	Field operations officer	SNV, Northeast
15.	Yuventino Obongo	Research Scientist	Ngetta ZARDI
16.	Ceasar Odongo	Project supervisor	AFSRT
17.	Lucy Adokorach	Field extension officer	AFSRT/WASH/FAO
18.	Lillian Bazare	East African Grain Council	
19.	Ramsey Magambo	Monitoring, Evaluation Sharing and Learning (MESL) SG 2000	
20.	Harriet Muyinza	National Focal Point	Mainstreaming food loss reduction initiative project by IFAD/FAO/WFP

SUNFLOWER STUDY

	Expert name	Title/Position	Institution
1	Eunice Ojok	Cluster Chairperson	Ober south cluster – Lira district
2	Alfred Ochieng	Commercial rural store operator	Amun B – Apac district
3	Boniface Agambe	Independent Agent	Ibuje - Apac district
4	Robert Adwek	Field Operations Manager –	Mukwano Industries – Lira District
5	Apollo Gidudu	General Manager –	Mt Meru– Lira district
6	Agnes Eyotalu	Extension Officer -	Agro-warehousing, Ltd Mount Meru – Lira
7	Victor Ogwang	Retired Extension Officer and Prominent Farmer	Lira district
8	Eng. Cedric Mutyaba	Research Officer	NARL- NARO – Kawanda
9	Nasir Muhamed	Oil mill operator scale.	MIAN Agro Small – Lira district
10	Michael Docus	District Commercial Officer	Lira district
11	Ario Alum	Agricultural Officer	DAP – Lira DLG
12	Fred Kasango	Hub Coordinator	VODP – Lira
13	Stella Akello	Administrative Assistant	UOSPA
14	Alex Ogwang	Program Manager	AFSRT
15	Patrick Ogwang	Director	AFSRT
16	Andrew Ochen	Agri-business management specialists	AFSRT
17	Ogwal Kasimiro	Zonal Agricultural Development Officer	NAADS – Lira
18	Catherine Kemigisha	Field Operations Officer	SNV – North –East
19	Yuventino Obongo	Research Scientist	Ngetta ZARDI
20	Ceasar Odongo	Project Supervisor	AFSRT
21	Lucy Adokorach	Field Extension Officer	AFSRT/WASH/FAO
23	Ramsey Magambo		Monitoring, Evaluation Sharing and Learning (MESL) SG 2000
24	Harriet Muyinza	NFP Food Loss Assessment Project	NARL/NARO – FAO
25	Mr. Walter Anyanga	Sunflower Breeder	NaSARRI
26	Jagdeep Singh	General Manager	Guru Nanak Oil Mills, Ltd
27	Hussain Sadam	Manager	Sunny Agro Mills
28	Harject Singh	Manager	DHOBA Enterprises
29	Dr. Bananuka John	Oil Seeds Coordinator	VODP 2/ MAAIF
30	Alele George	Chair Person	Barr Orphans Cooperative Society, Ltd
31	Opio Dennis	Chair Person	Nyeko Rac Cooperative
32	Ray Agong	Chief Executive Officer	Uganda Oil Seed Producers and Processors' Association
33	Kulbir Singh		IK Onkar Investment, Ltd

Annex 2
Currencies relevant to this report

Uganda Shilling (UGX)
United States dollar (USD)

Source of the information for exchange rates:
Bank of Uganda https://www.bou.or.ug/bou/collateral/exchange_rates.html

Currency exchange rate (2016-17)
The currency exchange rate used for this study is: USD 1 = UGX 3 200

Annex 3
Survey tools – Beans study 2016-17

A. HOUSEHOLD FORMAL SURVEY QUESTIONNAIRE

No.	Questions and Filters: Circle where codes are provided	
100	**Enumerator identification**	
101	Date of interview	
102	Name of enumerator	
	Location Data	
105	District	Oyam
106	Subcounty	
107	Parish	
108	Village	

No.	Questions and Filters	Coding Category	Code
200	**Household Socio-economic Characteristics**		
201	Name: Household head		
203a	Gender of Household	Female headed; 2. Male headed; 3. Female managed; 4. Child headed	
303b	Marital status	1. Single/Never married; 2. Married 3. Widowed 4. Divorced 5. Separated	
204	Age of household head	Age (full years) _____	
205	Education level of the household head (years completed) 1) None; 2) Primary; 3) Secondary; 4) Tertiary College; 5) University		
206	Main house: 1 = Brick - iron roofing; 2 = Brick - Grass thatch; 3 = Wood/tarpaulin/straw - Iron roofing; 4 = Wood and wattle and grass thatched; 5 = Grass thatched; / 6 = Wattle and Iron roofing; 7 = Other (specify)		
207a	Beans farming experience in current household Full years _____		
208a	Membership to producer groups/ associations (1 = Yes; 2 = No) MAIN FUNCTION(S) OF GROUP: 1) Input procurement, 2) Share skills/knowledge, 3) Pooling Labour, 4) Savings and Credit, 5) Collective Storage, 6) Collective marketing; 7) Other (specify)		
210	Household Members (number)	Total	Number: Male -------- Female: --------
210a	Household own and marketing transport resources 1) Bicycle; 2) Motorcycle; 3) Own truck; 4) None; 5) Other (specify)		
210b	Bean Marketing 1) Bicycle; 2) Motorcycle; 3) Own truck; 4) Boda-boda; 5)Other (specify)		

300	**Farm resources**			
302	**Land utilisation**			
302a	Land use	Crop	Acreage	
		Bean		
		All other crops		
		Fallow		
		Homestead		
	Total			
302a1	Bean cropping system	1 = Mixed; 2 = Mono-cropped		
302a2	Bean season	1 = First rains; 2 = Second rains; 3 = Both seasons		
302a3	Bean annual yield	Dried beans: Kilograms in both seasons Fresh beans: Dry seed equivalent kilograms		
302b	Bean variety	1) K132; 2) Local Black; 3) Local mixed; 4) _____ ; 5) _____ ; 6) _____ ; 7) _____ ; 8) Local		
303a	Do you use hired labour in bean farming activities (1 = Yes; 2 = No) Major activities involved 1) Harvesting; 2) transport; 3) Drying; 4) Threshing and winnowing; 5) How much on average do you spend on all these activities? UGX _____			
304a	Bean home consumption 2015a (Bags/kg)	Consumed before storage _____	Stored at and consumed piece meal _____	Given to relatives/friends_____
	Total consumed per season			
304b	Beans sold or marketed per season (Bags/Kg)			

Gender, Climate Change and Main Postharvest Activities for Beans

305	Bean harvesting method	1) Pluck/raise on sticks in-field; 2) Pluck/pack/carry 3) Other (Specify)

Household member and hired labour involved in harvesting (MULTIPLE RESPONSES):

1) Men; 2) Women; 3) Boys; 4) Girls; 5) All children; 6) Hired men; 7)Hired women

Why is it that the above household members are the ones involved in harvesting?

1) Cultural norms; 2) More energetic; 3) Are young; 4) Other (Specify)

Are there any norms and beliefs that influence men, women, girls and boys involvement in harvesting?

1) Yes; 2) No

What are these norms/beliefs?

Harvest months last season: 1=June-July; 2=Sept-Jan

Quantifying the loss points during harvesting last season

Anticipated quantity of beans to be produced (kg)	Total quantity actually harvested (kg)	Causes of loss	Amount lost per cause (kg)	Coping mechanism
		Code: 1 = Scattering; 2 = discolouration; 3 = moulds; 4 = not ready for harvest; 5 = sprouting; 6 = insects, 7 = rodents; 8 =diseases; 9 = incomplete harvest; 10 = drudgery; 11 =others	1 = 2 = 3 = 4 = 5 =	1= plan ahead for availability of enough labour, tools & containers; 2=harvest at the right time and moisture content; 3=harvest mature beans on a sunny day and place on a mat, tarpaulin or in sacks; 4=avoid delays in drying after harvesting; 5=know where the drying and shelling will be done and how the grain will be stored. 6=mend all holes in sacks and make sure stores are in good repair; 7=Other (Specify)

304b	Produce movement to homestead (Transport)	1) Head portage; 2) Own bicycle; 3) Boda-boda; 4) Own truck; 5) Buyer's truck; 6) Other

Household members and hired labour involved in carrying beans home (MULTIPLE RESPONSES):

1) Men; 2) Women; 3) Boys; 4) Girls; 5) All children; 6) Hired men; 7) Hired women

Why is it that the above household members are the ones involved in carrying beans home?

1) Cultural norms; 2) More energetic; 3) Are young; 4)Other (Specify)

Which technologies are used by each gender group to carry beans home? (INDICATE WHETHER HEAD PORTAGE, BICYCLE, BODABODA, TRUCK OR BUYER'S TRUCK FOR EACH)

1) Men ……

2) Women……..

3) Boys……..

4) Girls……..

5) Hired men……..

6) Hired women……..

Are there any norms and beliefs that influence men, women, girls and boys use of technologies in carrying beans home?

1) Yes; 2) No

What are these norms/beliefs?				
Quantifying the loss points during transportation last season				
Total quantity harvested beans loaded for transportation (kg)	Total quantity actually delivered (kg)	Causes of loss	Amount lost per cause (kg)	Coping mechanism
		1 = Spillage; 2 = leakage; 3 = damage; 4 = wettings; 5 =moulds; 6 = careless loading of produce; 7 =other	1= 2= 3=	1 = clean & strong containers; 2 = careful loading of produce in bags; 3 = other

Household member and hired labour involved in drying beans (MULTIPLE RESPONSES)
1) Men; 2) Women; 3) Boys; 4) Girls; 5) All children; 6) Hired men; 7) Hired women
Why is it that the above household members are the ones involved in drying beans?
1) Cultural norms; 2) More energetic; 3) Are young; 4)Other (Specify)
Are there any norms and beliefs that may influence men, women, girls and boys involvement in drying beans?
1) Yes; 2)No
What are these norms/beliefs?
How do you know your beans are dry enough for storage or sale? 1=Shaking pods; 2=sound made inside a tin; 3=feel by hand into a heap of produce; 4=salt-test method; 5=other

Quantifying the loss points during drying last season				
Total quantity actually harvested loaded for drying (Kg)	Total weight of dried beans (Kg)	Causes of loss	Amount lost per cause (kg)	Coping mechanism (and cost)
		1 = Spillage; 2 = discolouration; 3 = smell or off-odour; 4 = loss of flavour; taste; 5 = heat damage; domestic animals; 6 = poor seed germination; 7 = sprouting; 7 = other	1 = 2 = 3 = 4=	1=tarpaulins; 2=mats; 3=raised racks; 4=concrete stabilised yards; 5=other

304d	Threshing method	1) Beating/stick; 2) Hand stripping; 3 = Other

Household member and hired labour involved threshing beans (MULTIPLE RESPONSES)
1) Men; 2) Women; 3) Boys; 4) Girls; 5) All children; 6) Hired men; 7) Hired women
Why is it that the above household members are the ones involved in threshing beans?
1) Cultural norms/activities; 2) More energetic; 3) Are young; 4)Other (Specify)
Are there any norms and beliefs that may influence men, women, girls and boys involvement in threshing beans?
1) Yes; 2)No
What are these norms/beliefs?

Quantifying the loss points during threshing & winnowing last season				
Total quantity of dried beans for threshing / winnowing (kg)	Total weight of threshed / winnowed beans (Kg)	Causes of loss	Amount lost per cause (kg)	Coping mechanism (and cost)
		1 = breakages; 2 = low recovery / spillage; 3 = drudgery; 4 = incomplete threshing; 5 = contaminations and dust pollution	1 = 2 = 3 = 4 = 5 =	1 = avoid delays in threshing after harvesting; 2 = clean the grain properly after threshing; 3 = NARL bean thresher; 4 = tarpaulins; 5 = mobile motorised threshers; 6 = other

304e: Where storage: 1=main house; 2=mud –wattle granary; 3=kitchen; 4=cane granary; 5=veranda; 6)gunny bags; 7=Other

304e2: Storage methods: 1) Bags; 2) Heap on floor; 3) Hang in fireplace; 4) Other

Household member and hired labour involved in storage (MULTIPLE RESPONSES)

1) Men; 2) Women; 3) Boys; 4) Girls; 5) All children; 6) Hired men; 7) Hired women

Why is it that the above household members are the ones involved in storing beans?

1) Cultural norms/activities; 2) More energetic; 3) Are young; 4) Other (Specify)

Are there any norms and beliefs that may influence men, women, girls and boys involvement in storing beans?

1) Yes 2) No

What are these norms/beliefs?

Treatment in storage: 1) None; 2) Mix herbs (Name); 3) Storage chemicals (name)

Who in your household treats the stored beans?

1) Man; 2) Woman; 3) Boys; 4) Girls; 5) Hired men; 6) Hired women

How long do you store your beans after harvest (in weeks /months)?

Quantifying the loss points during storage last season

Total quantity of dried beans stored (kg)	Total weight of beans after storage (kg)	Causes of loss	Amount lost per cause (kg)	Coping mechanism (and cost)
		1 = rotting /moulds; 2 = discolouration; 3 = chemical abuse, 4 = sprouting; 5 = damage by Bruchids& rodents; 6 = re-wetting; 7 = thieves; 8 = poor germination; 9 = spillage; 10 = smell or off-odour; 11 = other	1= 2= 3= 4= 5= 6= 7=	1 = metal silos; 2 = plastic silos; 3 = cocoons; 4 = Polypropylene or polyethylene bags; 5 = collective storage bag warehousing; 6 = water proof tarpaulins; 7 = stacking bags on pallets; 8 = other

304d: Marketing method: 1) Quantity in 2-kg tins; 2) Quantity in 20Kg tins; 3) Quantity in 100 Kg sacks; 4) Sell green beans in field (estimate grain quantity); 5) Other

Household member and hired labour involved in selling beans (MULTIPLE RESPONSES)

1) Men; 2) Women; 3) Boys; 4) Girls; 5) All children; 6) Hired men; 7) Hired women

Why is it that the above household members are the ones involved in selling beans?

1) Cultural norms/activities; 2) More energetic; 3) Are young; 4) Other (Specify)

In your household, who keeps the proceeds or income from the sale of beans?

1) Man; 2) Woman; 3) Boys; 4) Girls; 5) Hired men; 6) Hired women

Why is it that the above household member(s) are the ones who keep the proceeds or income from bean sales?

Are there any norms and beliefs that may influence men, women, girls and boys involvement in selling beans?

1) Yes; 2) No

What are these norms/beliefs?	

305	Key Selling Point: 1) Farm gate; 2) Commercial store; 3) Take to community markets; 4) Agents; 5) Other (Specify)
	Main buyers 1 = Fellow farmers, 2 = Informal small scale buyers; 3 = Schools/institutions; 4 = Restaurants; 5 = Never sells; 6 = Other
306	Price offered by key buyer /main buyers/selling point:----------UGX/kg
307a	Selling period after harvest: 1)Immediately 2) Within month; 3)Within 3 months; 4) Within 6 months; 5) Other
	Price range usually offered during harvesting period: ----------UGX/kg
307b	Price range usually offered after 3-months storage period: ----------UGX/kg
	Premium price for quality: 1 = Variety uniformity; 2 = Absence of weevils; 3 = Clean no foreign materials/broken/rotten; 4 =large volume; 5 = sustainable supply; 6= Other
	Quantifying the loss points during beans marketing /selling last season

Anticipated quantity of beans to be marketed (kg)	Total weight of beans sold (kg)	Causes of loss	Amount lost per cause (kg)	Coping mechanism (and cost)
		1 = rotting /moulds; 2 = discolouration; 3 = chemical abuse, 4 = sprouting; 5 = damage by Bruchids& rodents; 6 = re-wetting; 7 = thieves; 8 = poor germination; 9 = spillage; 10 = smell or off-odour; 11 = other	1= 2= 3= 4= 5= 6= 7=	1 = metal silos; 2 = plastic silos; 3 = cocoons; 4 = polypropylene or polyethylene bags; 5 = contract suppler arrangement; 6 = other

317	Identification of critical loss points		
	Beans supply chain stage	Ranking importance of the supply chain stage	Key causes of loss
	Harvesting		
	Transportation		
	Drying		
	Threshing /winnowing		
	Storage		
	Marketing /Sale		

Damage codes: 1) Mould; 2) Caking; 3) Broken/shrivelled; 4) Pests/Weevils; 5) Fermented/rancid; 6) Discoloration; 7)Dust/rodent droppings; 8) Much dirt/chaff; 9) Spillage

400	Bean Value Chain Constraints, Soil management, Climate change & climate variability - (Tick one)
401	Main constraint to bean pre-production (Mention two or three) 1) Lack of quality seed; 2) High price of certified seed; 3) No reliable input supplies; 4) Failure to open land on time; 5) Shifts in seasons Prolonged rains; 5) Shifts in seasons prolonged drought; 6) Other (specify)
402	Main bean production constraints (Mention two or three) 1) Weed infestation; 2) Declining soil fertility; 3) Damage by wind; 4) Damage by pests; 5) Damage by diseases; 5) Other (specify)
403	Main bean postharvest constraints & marketing (MULTIPLE RESPONSES) 1= Spoilage due to prolonged rains; 2 = Spoilage due to lack of drying facilities; 3 = Spoilage due to lack of storage facilities; 4= Low income due to rushed sales just after harvest; 5 = Rampant thefts; 6 = Low bean grain prices; 7 = long distances between markets; 8 = lack of market information; 9 =high competition under the liberalised economy; 10=use services of middle men; 11=manipulating their weighing scales or cups; 12=lack of info on standards and where available non observance; 13 = Other (specify)……..
404	Do the above postharvest and marketing constraints affect men and women equally? 1) Yes; 2)No If yes, which constraints affect both men and women? If no, which constraints affect a particular gender group most? Constraints affecting women most Constraints that mostly affect men
	In your own opinion, what should be done to tackle hunger and poverty in this area? (COULD BE INFRASTRUCTURE; AWARENESS CAMPAIGN/TRAINING PROGRAMMES; IMPROVED TECHNOLOGIES FROM HARVESTING TO STORAGE, ETC.)
	Based on your experience as a producer/bean farmer, please suggest ways to reduce bean losses across the supply chain
	What kind of support/assistance would you want to boost your bean supply chain activities?

B. FOCUS GROUP DISCUSSION – GUIDE FOR BEAN FOOD SUPPLY CHAIN STAKEHOLDERS (PRODUCERS, TRADERS, LOCAL EXTENSION WORKERS, LOCAL LEADERS, ETC.) – BEANS STUDY 2016-17

(Conduct separate FGD for men and women -producers)

Date of Interview:
Name of Facilitator:
Name of note taker:
Subcounty:
Parish:
Village:
Participants (List the participants and their role):

1. How important are beans in your community? What changes have been brought about by growing beans?
2. What varieties of beans do you grow? What are the characteristics of the varieties grown (both desirable and undesirable?
3. What are the main postharvest activities undertaken for beans (or in the entire supply chain)? Who mainly undertakes these activities in your community? *(Probe activities such as Harvesting, Drying, Storage, Marketing and the major gender groups that undertake them – men, women, boys, girls, hired men, hired women and use a table or activity profile).*
4. Why is it that the above household members are the ones who perform the supply chain activities? *(Probe reasons why men, women, boys, girls or hired labour performs each activity - Harvesting, Drying, Storage, Marketing – refer to the table above and indicate reasons).*
5. Are there any norms and beliefs that influence men, women, girls and boys involvement in harvesting, drying, storage, and marketing? What are these norms/beliefs? *(Probe norms/beliefs for each supply chain activity - Weeding, Harvesting, Drying, Storage, Marketing based on gender group that performs the activity).*
6. In your community, who mainly keeps the proceeds or income from the sale or marketing of beans and why? *(Probe whether men, women, boys, girls, hired men; hired women and why).*
7. What are the main constraints faced by actors in the bean supply chain in your community? *(Probe for constraints in Harvesting (labour, weather/rains), transport (lack of bicycle, drudgery, poor roads), drying (lack of tarpaulins), threshing/cleaning (weather, dust), storage (lack sacks, pests, improved stores) and marketing (prices, information) including environmental constraints if any – use a table).*
8. Do bean postharvest losses/constraints differ according to geographical area in northern Uganda? If yes, then what are the main differences experienced by farmers in different provinces and what do you think causes them? For knowledge experts or extension workers.
9. Do bean postharvest constraints differ based on the variety? If yes, please explain how and why. Are there any preferred varieties? Which ones and why?
10. Do the above constraints affect female and male chain actors equally? Which constraints affect women or men most and why? *(Probe for constraints per supply chain activity - harvesting, transport, drying, threshing/cleaning, storage and marketing – use a table).*
11. On average, what proportion of total harvest is marketed against what is consumed by the household?
12. Are there any bean varieties preferred by the market/consumers? If Yes, how do farmers respond to this?

13. What are the most common bean marketing channels?
14. Which one of these channels do you prefer?
15. Do you incur bean losses at any point across the bean supply chain activities? What are the most critical loss points and what are the causes of the loss? Are the loss points the same for male and female actors in the supply chain? *(Probe loss points per supply chain activity – harvesting, transport, drying, threshing/cleaning, storage and marketing and causes for each – use a table).*
16. How are you addressing the constraints and bean losses you face throughout the entire supply chain?
17. Please suggest practical approaches for reducing postharvest losses across the supply chain. What do you think can be done to help female or male bean chain actors? Who needs to do what and when?
18. Do you store beans? How and for how long?
19. Do the actors apply anything to protect against storage pests? What are the most common methods?
20. Are there any food safety issues with regards to postharvest handling of beans? Explain.
21. What is the likely impact of climate change on the bean supply chain and what measures can be taken to minimise the effect, increase adaptation and increase resilience?

C. KEY INFORMANT INTERVIEW SCHEDULE – BEANS STUDY 2016-17

(FAO, IFAD, WFP implementing partners, MAAIF, national research institutions, district production/ extension staff, NAADS, chairpersons of farmer groups, marketing associations, etc.)

Name : _____Phone and email: _____

Organization:_____

Position of respondent in organization: _____

Year when Organization started operations: _____

Activities /services of the organization in the area:

Geographical coverage of the organization:_____

1. Who are the bean supply chain actors in this community?
2. What are the main constraints faced by bean supply chain actors in this area?
3. ***Probe for constraints by FSC stage (Harvesting, transport, drying, threshing/cleaning, storage and marketing)***
4. What are the main causes of these constraints?
5. Do bean postharvest constraints differ according to the variety? If yes, please explain in what ways. Are there any preferred varieties? Which ones and why?
6. Do bean postharvest constraints differ according to the gender of the actor in the value chain or the wealth status? If yes, please explain how.
7. Do bean postharvest problems differ according to geographical area in Uganda? If yes, then what are the main differences experienced by farmers in different provinces and what do you think causes them?
8. How are actors in the bean supply chain addressing these constraints?
9. ***Probe for practices by FSC stage (harvesting, transport, drying, threshing/cleaning, storage and marketing).***
10. What are the main strengths, weaknesses, opportunities and threats of the practices used by the bean supply chain actors in addressing these constraints? ***(Tabulate the SWOT)***
11. What is the likely impact of climate change on the bean supply chain and what measures can be taken to minimise the effect, increase adaptation and increase resilience?
12. Are there any food safety issues with regards to production and postharvest handling (including consumption) of beans? Explain.
13. How best do you think these constraints can be solved? By who? What are the resource implications and sustainability of the interventions? Do they affect men, women and children equally?
14. Which investments would give the best returns to which actors in the bean supply chain?
15. Suggest any ways in which value-addition can be improved for actors in the bean supply chain in this area.

Annex 4

Field Case Study implementation plan (beans study 2016-17)

FOOD SUPPLY CHAIN: BEANS

Date	Location	Activities	Team members
October, 2016	Kampala, Oyam district and Lira Town	Preliminary screening of food losses (screening): ▪ Documents and reports review ▪ Expert consultations	Engr. Mutyaba Joseph Cedric* Dr Okoboi Geoffrey** Dr Asaba Richard***
Nov.-Dec. 2016 January 2017	Oyam district and Lira Town	Survey food loss assessment (survey): ▪ Key informant interviews ▪ Household interviews; Focus group discussions	Engr. Mutyaba Joseph Cedric* Dr Okoboi Geoffrey** Dr Asaba Richard***
Nov. - Dec. 2016 January 2017	Oyam district and Lira Town	Load tracking and sampling assessment *(sampling):* Load tracking harvest, transport, threshing and winnowing and storage	Engr. Mutyaba Joseph Cedric* Dr Okoboi Geoffrey** Dr Asaba Richard*** 3 Field workers
Dec. 2016-April.2017	Oyam district and Lira Town	Solution finding (Synthesis): Report consolidation, Validation workshop	3 Field workers

*National Consultant - Subsector Specialist (SS)
**National Consultant – Agricultural Socio-economist (AE)
***National Consultant – Sociologist/Gender Specialist (GS)

Annex 5
Sample presentation of harvesting load tracking and sampling results – Beans study 2016-17 / Harvesting

A	**Product**	**Bean**			
B	**Event**	**Harvesting**			
C	**Duration of the event**	**November 2016**			
D	**Location**	**On-farm**			
	Before the event	**Experimental Unit**	**Weight/Area of unit**	**Nr of units**	**Total weight from area under crop**
E	Load	Quadrant	0.002 ha	n=24	5.14 kg
F	1st-stage sample				
G	2nd-stage sample				
		Value (score/%)	*Observations / Causes*		
H	Sample size 2nd-stage				
I	Average quality score (0 – 10)				
J	Percentage unfit (< 2)				
K	Percentage low quality (2-6)				
	After the event	**Experimental Unit**	**Weight/Area of unit**	**No. of units (quadrant)**	**Total weight kg**
L	Load	Quadrant	0.002 ha	n=24	4.95
M	1st-stage sample				
N	2nd-stage sample				
		Value (score / %)	*Observations / Causes*		
O	Sample size 2nd-stage				
P	Average quality score (0 – 10)				
Q	Percentage unfit (< 2)				
R	Percentage low quality (2-6)				
	Quantity loss	*Value (%)*	*Observations / Causes*		
S	Percentage lost (E-L)/E	3.6±0.7 %	Leaving beans un-harvested or uncollected because of heavy weed infestation, shattering and spillage of grains from pods, and harvesting done by children or hired labour.		
	Quality loss	*Value (%)*	*Observations / Causes*		
T	Percent age lost (Q-J)				
U	Percent age quality reduction (R-K)				

Annex 6

Sample presentation of on-farm storage load tracking and sampling results – Beans study 2016-17 / Storage

A	**Product**	**Bean**			
B	**Event**	**Storage**			
C	**Duration of the event**	**November 2016**			
D	**Location**	**On-farm**			
	Before the event	**Experimental Unit**	**Weight/Area of unit kg**	**Nol. of units**	**Total weight from area under crop kg**
E	Load	kg	10	n=15	150
F	1st-stage sample	kg	2	n=15	30
G	2nd-stage sample	kg	0.1	n=15	1.5
		Value (score/%)	*Observations / Causes*		
H	Sample size 2nd-stage	100 gram			
I	Average quality score (0 – 10)	Fit for trade 98 %			
J	Percentage unfit (< 2)	2±0.4 %	No insect Infestation; few shrivelled mouldy or discoloured beans, moisture content 14 %		
K	Percentage low quality (2-6)				
	After the event	**Experimental Unit**	**Weight of unit kg**	**No. of units**	**Total weight kg**
L	Load	kg	8	n=15	120
M	1st-stage sample	kg	2	n=15	30k
N	2nd-stage sample	kg	0.1	n=15	1.5
		Value (score / %)	*Observations / Causes*		
O	Sample size 2nd-stage	100 gram			
P	Average quality score (0 – 10)	Fit for trade 87.5 %			
Q	%age unfit (< 2)				
R	Percentage low quality (2-6)	12.5±1.6 %	Insect infestation: a number live insects, bored grains, shrivelled beans observed, moisture content 12.5%		
	Quantity loss	*Value (%)*	*Observations / Causes*		
S	Percentage lost (E-L)/E				
	Quality loss	*Value (%)*	*Observations / Causes*		
T	Percentage lost (Q-J)				
U	Percentage quality reduction (-RJ)	8.5±1.5%			

Annex 7

Interbank average exchange rates for 30 June 2015 (Sunflower study)

		Ugx Equivalent	
Currency	**Cross rates**	**Buying rates**	**Selling rates**
US Dollar/US Dollar	1.00000	3296.77	3306.77
Pound Sterling/US Dollar	1.57440	5190.43	5206.18
US Dollar/Swiss Franc	0.92910	3548.35	3559.11
US Dollar/Japanese Yen	122.66000	26.88	26.96
SDR/US Dollar	1.40323	4626.13	4640.16
Australian Dollar/US Dollar	0.76520	2522.69	2530.34
US Dollar/Canadian Dollar	1.23810	2662.77	2670.84
US Dollar/Danish Krone	6.69100	492.72	494.21
US Dollar/Swedish Krone	8.26310	398.97	400.19
US Dollar/Norwegian Krone	7.90320	417.14	418.41
US Dollar/New Zealand Dollar	0.68150	2246.75	2253.56
US Dollar/Kenya Shilling	98.65000	33.42	33.5
US Dollar/Tanzania Shilling	1973.00000	1.671	1.676
US Dollar/COMESA Dollar	1.00000	3296.77	3306.77
Euro/US Dollar	1.11510	3676.23	3687.38
Gold/US Dollar	1177.400000		

Source: https://www.bou.or.ug/bou/collateral/exchange_rates.html