Standing Committee
for Economic and Commercial Cooperation
of the Organization of Islamic Cooperation (COMCEC)

COMCEC

Reducing On-Farm Food Losses In the OIC Member Countries

COMCEC COORDINATION OFFICE
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AAC	Albanian Agriculture Competitiveness
ADM	Archer Daniels Midland
ADMI	Archer Daniels Midland Institute
ADPs	Agricultural Development Programs
AGRA	Alliance for a Green Revolution in Africa
AIMS	Agricultural Input Markets Strengthening
AMARTA	Agribusiness Market and Support Activity
AMFRD	Agency for Marine and Fisheries Research and Development
APHLIS	African Postharvest Losses Information System
APL	Adaptable Program Loan
ASC	Aquaculture Stewardship Council
AUSAID	Australian Aid
AVC	Agricultural Value Chains
AVRDC	Asian Vegetable Research and Development Center
BARI	Bangladesh Agricultural Research Institute
BBW	Banana Bacteria Wilt
BKPM	Badan Koordinasi Penanaman Model
BMGF	Bill and Melinda Gates Foundation
CARDER	Regional Agricultural Center for Rural Development
CBI	Centre for the Promotion of Imports
CCAB	Cold Chain Alliance Bangladesh
CDOP	Community Development Outreach Programme
CGIAR	Consultative Group for International Agricultural Research
CIDA	Canadian International Development Agency
CIP	International Potato Center
CLP	Critical Loss Points
CNFA	Cultivating New Frontiers in Agriculture
CPAP	Tajikistan's Country Program Action Plan
CRP	Cassava Revolution Programme
CRS	Catholic Relief Services
CSAM	Commodity Systems Assessment Methodology
DADTCO	Dutch Agricultural Development & Trading Company
DAP	Diammonium Phosphate
DRC	Democratic Republic of the Congo
EAVS	European Association for Veterinary Specialization
EC	European Commission
ECOWAS	Economic Community of West African States
EU	European Union
FAO	Food and Agriculture Organization
FAOSTAT	FAO Statistical Database
FAS	Foreign Agricultural Service
FAS	Food Security and Agribusiness Support (Egypt)
FAST	Farmer Advisory Services in Tajikistan
FFGI	Food and Feed Grain Institute
FMARD	Federal Ministry of Agriculture Nigeria
FSC	Food Supply Chain
GCCA	Global Cold Chain Alliance

GES	Growth Enhancement Support
GIS	Geographic Information System
GKI	Global Knowledge Initiative
GREEN	Growing Resources for Enhanced Agricultural Enterprises and Nutrition
GIZ	German International Development
HLPE	High Level Panel of Experts
IBD	Infectious Bursal Disease
ICT	Information and Communications Technology
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDEA	Investment in Developing Export Agriculture
IFC	International Finance Corporation
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
IGAD	Institute for Development Support
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
IMNV	Infectious Myonecrosis Virus
INPhO	Postharvest Information Network
INRA	French National Institute for Agricultural Research
IRRI	International Rice Research Institute
IUCN	International Union for the Conservation of Nature
KAFA'A	Knowledge and Action Fostering Advances in Agriculture
KAM	Koperasi Artha Mina
KG	Kilogram
KSU	Kansas State University
MMAF	Ministry of Maritime Affairs and Fisheries
MT	Metric Tonnes
NAADS	National Agricultural Advisory Services
NACA	Network for Aquaculture Centres
NARO	National Agricultural Research Organization
NDV	Newcastle Disease Virus
NGO	Nongovernmental Organization
NIHORT	National Horticultural Research Institute
NRCRI	National Root Crop Research Institute
OIC	Organization of Islamic Cooperation
OSCE	Organization for Security and Cooperation in Europe
OIE	World Organization for Animal Health
PADAP	Project for Development Support for Peri-urban Agriculture
PEF	Postharvest Education Foundation
PHHS	Postharvest Handling and Storage
PHTSC	Postharvest Technologies and Services Center
PIBD	Presidential Initiative in Banana Development
PRODIAG	Project for Development and Investment in Agriculture in Gabon
RDCMFPPB	Research and Development Center for Marine and Fisheries Processing Product and Biotechnology
RISING	Research in Sustainable Intensification for the Next Generation
RTEP	Roots and Tubers Expansion Programme
SAWBO	Scientific Animations Without Borders
SDGs	Sustainable Development Goals

SGR	Strategic Grain Reserves
SHB	Oils Corporation of Benin
SIK	Swedish Institute for Food and Biotechnology
SPF	Special Pathogen Free
SPS	Sanitary and Phytosanitary Standards
SSA	Sub-Saharan Africa
SSF	Small-Scale Fisheries
TIKA	Turkish Technical Assistance Team
TRIS	Tuber and Root Information System
TSI	Turkish Statistical Institute
TURKSTAT	Turkish Statistical Institute
TYLCV	Tomato Yellow Leaf Curl Virus
UAE	United Arab Emirates
UNBS	Uganda National Bureau of Standards
UNDP	United Nations Development Program
UNIDO	United Nations Industrial Development Organization
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WAAPP	West African Agriculture and Productivity Program
WFLO	World Food Logistics Organization
WFP	World Food Programme
WFPC	World Food Preservation Center
WOR	World Ocean Review
WRI	World Resources Institute
WUR	Wageningen University Research Centre for Development Innovation
WVEPAH	World Veterinary Education in Production Animal Health

EXECUTIVE SUMMARY

From October-December 2015, the Post-Harvest Education Foundation (PEF) and the World Food Logistics Organization (WFLO) assessed on-farm losses to provide recommendations to reduce such losses in the OIC Member Countries. Existing literature cites on-farm losses throughout Africa, Asia, and the Middle East as ranging from 23-39%. Globally, the highest on-farm losses have been described for fruits and vegetables, followed by cereals in South and Southeast Asia and roots and tubers in Sub-Saharan Africa. When converted into calories, global food loss and waste amounts to approximately 24 percent of all food produced.

Section 1 of this report provides a conceptual framework for the assessment of on-farm food losses, building on standard definitions by FAO, WRI and the SAVE FOOD Initiative to determine appropriate definitions and examples for each food group studied: cereals, roots and tubers, oilseeds and pulses, fruits and vegetables, meat and dairy products, and fish and seafood. For the purposes of this study, the boundaries of on-farm losses were defined from production to farm gate, which includes growing, harvesting and on-farm handling.

The literature review in Section 2 offers an overview of the levels, types and relative importance of on-farm food losses for the six food groups in the OIC Member Countries. The countries with the most available data on many different crops and foods include Bangladesh, Egypt, Indonesia, Nigeria, Pakistan, Turkey and Uganda. Cereals demonstrated high losses of 10-50%, with roots and tubers at 10-80%. Oilseeds and pulses revealed losses of 5-34%, with fruits and vegetables ranging from 3-43%. Meat and dairy losses ranged between 3-52%. In the literature, fish and seafood losses are divided into quantity and quality losses of 5-100% and 12-70%, respectively. Key informant surveys verified these findings.

Section 3 details eight case studies of on-farm losses using a modified Commodity Systems Assessment Methodology (CSAM).

- Maize in Uganda reported 10-45% with extreme defects or decay after two-four weeks of on-farm storage with overall economic losses calculated at US$70-126 million.
- Sweetpotato in Nigeria reported on-farm losses of 1-20%, with an economic value of between US$6-17.2 million.
- Cassava, also in Nigeria, reported 1-10% for a related value of US $18-90 million. The lost cassava could feed 10% of Nigeria's population for a full year.
- Groundnut in Benin showed losses estimated at 10-15% for a related value of $600,000-6.3 million, depending on the season.
- Observed tomato losses in Egypt ranged from 0-45%. Harvested four times each year, a conservative estimate of 15-20% equates 1.28-2.17 million tonnes for approximately US$255-340 million in annual lost earnings.
- Plantains in Uganda reported 0-30% loss, with an economic value in the range of US$54-63 million per year.

- Broiler meat in Turkey revealed an estimated 4% of on-farm losses corresponding to between US$80-88 million. The lost food could have provided enough protein nutrition for 625,000 persons for a full year at 50 grams per day.
- Fish and shrimp in Indonesia are estimated at losses of 5%, which have been evaluated at US$103.5. This amount of lost fish and shrimp could have supplied the protein needs for 75,500 persons for a full year at 50 grams per day.

Section 4 elaborates on the causes and consequences of on-farm food losses and evaluates their implications on production, use, food security, and the environment. Across the six food groups, common causes cited include pests, poor water management or drought, lack of proper storage facilities, poor harvesting practices, poor cultural practices (pruning, fertilizing, and pesticide spraying), lack of proper processing and packaging, poor information and planning, poor temperature management, and delays in transport or distribution. On farm food losses can have significant impacts on production leading to lost revenue, lower yields and waste of resources, consumption, food security, the environment, and food safety.

Section 5 presents on the current resources available to OIC Member Countries for reducing on-farm losses. Traditionally 95% of agricultural research and extension efforts have targeted production aimed at increasing yields and reducing on-farm food losses via improved seeds/planting materials, cultivation practices, fertilization, irrigation, pest management and sustainable production practices. Ongoing efforts to reduce food losses are united through many global and regional alliances, along with existing educational opportunities to build capacity via formal and informal approaches, use of modern internet communications including internet based telephone calls and outreach programs using mobile devices. It is suggested to form an OIC Member Countries Working Group on on-farm loss reduction to coordinate future efforts.

Policy recommendations are proposed in Section 6 with collaborative solutions to reduce on-farm food losses. Several serious pests contribute to significant on farm losses and require additional research and resources in the coming year. Furthermore, large scale training programs are needed for all stakeholders across all value chains on how to reduce food losses. Lastly, advocacy is needed inform policy makers and investors on the benefit of reducing on-farm losses by investing in infrastructure, providing access to inputs, credit and capacity building, regulating contracting practices, and strengthening producer groups.

The study has seven recommendations to reduce on-farm losses in the OIC countries:

- **Close Knowledge and Data Gap.** Implement studies in each OIC Member Country to collect data and identify specific causes of on-farm losses for key crops.
- **Upgrade Food Supply Chains.** Connect farmers to output markets to reduce on-farm food losses and provide higher income for farmers in the OIC Member countries.
- **Build Technical and Training Capacity.** Address gaps in the technical and training capacity of on-farm food loss researchers and extension specialists.

- **Develop Core Resource Group.** Strengthen in-country personnel who can contribute to capacity building initiatives and undertake food loss prevention initiatives.
- **Build Capacity of Stakeholders.** Address gaps in the technical and managerial capacity of extension workers, farmers, fishers, and food supply chain workers.
- **Develop Projects for Key Value Chains**. Provide funding for key actions, technology packages and projects on reducing losses in OIC Member Countries.
- **Provide Competitive Funds**. Implement a cycle where countries can apply for specific **research** and development projects to reduce on-farm.

Recommendations are intended to be practical, applicable, concrete, open to collaborative efforts and capable of being implemented on a small, medium or large scale to match currently available resources. Key to efforts to reduce on-farm losses is capacity building at all levels, and informing policy makers on the benefit of reducing on-farm losses.

INTRODUCTION

It is widely recognized that there are major losses of food along supply chains all over the world (Koester et al 2013). The Food and Agriculture Organization (FAO) estimates that roughly one-third of the annual global food production, which equalled 1.3 billion tonnes of food in 2009, is lost in the supply chain before reaching the final consumer. This means that huge amounts of resources such as seeds, labour, land, water, fertilizer and energy are used during agricultural production and then lost during the food supply chain. The new Sustainable Development Goals (SDGs) adopted by the United Nation member countries in September 2015 include Goal 12 (sustainable production and consumption) and Target 12.3 which calls for the world to cut per capita food wastage in half by 2030 (United Nations, 2015). Similarly, the African Union heads of state and government promised in June 2014 to end hunger and halve the current post-harvest food losses by 2025.

According to the general definitions provided by the FAO and the World Resources Institute (WRI), food losses refer to pre-consumer stage losses which are namely production, postharvest handling, storage, processing, and distribution. The food losses caused by consumers are called food waste, which occurs toward the end of the food chain during retail marketing, food service and home consumption.

The research commissioned by FAO in 2011 for INTERPACK and carried out by the Swedish Institute for Food and Biotechnology (SIK) noted that food losses in developing countries occur mainly during the early and middle phases of the crop production cycle and can be traced to technical limitations of agricultural producers during the harvesting and pre-harvesting period. Developing country food loss occurs mostly during the production, handling, storage and processing periods, whereas in developed countries foods are wasted at the consumer level. Most of the Organization for Islamic Cooperation (OIC) Member Countries are defined as developing countries, and so it is likely that high losses occur during on-farm (including harvest) and postharvest (handling, storage, processing, packaging, transportation, distribution, and marketing) stages.

The pattern and size of food losses and waste throughout the food supply chain remains poorly understood for the vast majority of the OIC Member Countries, which include a high diversity of counties. Most farmers in these countries live on the margins of food insecurity, and a reduction in food losses could have an immediate and significant impact on their livelihoods.

In this analytical study, the losses that occur at the initial stages on the farm were examined in the OIC Member Countries. Therefore, postharvest losses and food waste (consumption stages) are not included in this study. The overall objective of the study is to contribute to increasing the productivity of the agriculture sector and to sustaining the food security in the OIC Member Countries by reducing on-farm food losses. The definitions and causes of such losses vary according to the type of agricultural commodities.

The ensuing report is divided into six sections. Section 1 outlines the conceptual framework for assessing on-farm food losses, including definitions and examples for each food group, the methodology of the study, an overview of global food losses, the levels and types of losses for six food groups, and the relative importance of on-farm food losses.

Section 2 provides estimates of food losses and waste for OIC Member Countries, including information on the relative importance of on-farm losses, and the detailed findings regarding on-farm losses in the OIC Member Countries, based on literature reviews and key informant surveys.

Section 3 details eight case studies of on-farm losses for specific foods in the OIC Member Countries, beginning with the status and importance of the commodity group for the chosen member country. Status and importance is followed by production volumes of the commodity group as well as its contribution to the economy; an assessment of on-farm food losses in this commodity group; the calculation of economic burden to the country; and the causes of on-farm food losses for the selected agricultural commodity. Each case study provides a description of the measures and strategies implemented for on-farm food loss reduction in the country and the lessons learned.

Section 4 elaborates on the causes and consequences of on-farm food losses and evaluates the implications of on-farm losses on production, use, food security, and the environment.

Section 5 presents the available information on the resources that are presently mobilized to reduce on-farm losses in the OIC Member Countries, and provides recommendations for the additional resources that are needed in terms of technology, farmers' training, institutional support, communication, and knowledge to significantly impact food losses. The section includes a description of the programs, projects and studies that have been implemented to reduce food losses in OIC Member Countries and the common characteristics and results of these efforts.

Section 6 provides policy recommendations and proposes collaborative solutions for the OIC Member Countries for reducing on-farm food losses. Recommendations are intended to be practical, applicable to the identified problems, concrete, open to collaborative efforts, and capable of being implemented on a small, medium or large scale to match currently available resources and scope within the countries.

1. CONCEPTUAL FRAMEWORK FOR ON-FARM FOOD LOSSES

Food losses and waste occur in different stages in the supply chain with different categorizations by different organizations. As such, they have been defined in various fashions by a variety of agencies. The differing definitions and examples of losses at the stages of the food supply chain are described in Table 1.1 as are the varying definitions of food losses in current use and under development. Early definitions found in the literature are generally unclear, overlapping in some cases and using many different terms to describe the same food supply chain stages. Definitions are still changing with each new publication, and a recent High Level Panel of Experts on Food Security and Nutrition report on food losses and waste stated, "Different definitions, different metrics, different measurement protocols and the lack of standards for data collection adapted to different countries and products, makes it difficult – and sometimes impossible – to compare studies, systems and countries" (HLPE, 2014).

1.1 Definitions

According to Lipinski et al (2013) "food loss" refers to food that spills, spoils, suffers a reduction in quality such as bruising or wilting, or otherwise gets lost before it reaches the consumer. Food loss is the unintended result of an agricultural process or technical limitation in handling, storage, infrastructure, packaging, or marketing. "Food waste" refers to food that is of good quality and fit for human consumption but that does not get consumed because it is discarded—either before or after it spoils.

In many cases, especially in early literature, "postharvest losses" has included on-farm losses during harvesting, handling and storage losses and the losses due to consumption waste. Their main distinction was made between food loss and food waste, based on the stage of the food chain at which the loss or waste of food physically occurs. The HLPE report did not segregate on-farm losses from any of the other types of food losses. They state only that "food loss" happens at the earlier stages of food chains, and "food waste" happens at the later consumption stages, placing the boundary either at retail or the consumer level.

The definitions are still under discussion and further development. The WRI is leading the new "global food loss and waste protocol" in an attempt to develop universally accepted definitions and standards for future measurements, but their view is primarily focused on developed food systems. In 2013, FAO published a definition which specified that food loss can occur starting from the moment that:

- Crops are ripe in the field, plantation, or orchard;
- Animals are on the farm—in the field, sty, pen, shed, or coop—ready for slaughter;
- Milk has been drawn from the udder; and
- Aquaculture fish are mature in the pond.

However, many times an activity or practice undertaken during production can lead directly to food losses at the moment of harvest and further down the value chain, such as when crops or animals do not receive adequate nutrition, are not protected from known pests (i.e. insects or weeds), or suffer sun-burn or wind damage. FAO and the SAVE FOOD Initiative (2015, as yet unpublished) have recently updated their definitions of food losses to include intentional or unintentional pre-harvest losses. These updated definitions for food losses will be used in all FAO programmes going forward. In the new definition, pre-harvest losses are included in the production stage, and harvesting has been moved into the category of postharvest losses. The details will be found in the FAO (in press at the time of this report). Table 1.1 summarizes the variety of definitions available.

Table 1.1: Varying Definitions of Food Losses in Use and Under Development

Varying Definitions			
Sources	FAO (Gustavsson 2011; SIK 2013)	WRI (Lipinski et al 2013; Food loss and waste protocol, on-going as of 2015)	SAVE FOOD Initiative (2015)
On-Farm Losses	Any losses in the agricultural production stage until completion of harvesting	Losses during production or harvest in the form of foods left behind by poor harvesting equipment, discarded or not harvested or discarded because they fail to meet quality standards or are uneconomical to harvest.	Losses during production, including food that is fit to enter the food supply chain (FSC), but intentionally discarded or redirected to non-food use in the pre-harvest phase; and food that is harvest-mature and unintentionally getting spoilt in the pre-harvest phase.
Postharvest Losses	Food damage or degradation of food during the different stages such as handling, storage, processing, packaging, and distribution to the moment of final consumption	Losses during handling and storage in the form of food degraded by pests, fungus, and disease, and losses during processing and packaging in the form of spilled milk, damaged fish, and foods unsuitable for processing.	Losses during harvesting and handling Losses during storage Losses during processing, packaging and distribution

Food Waste	Consumer stage losses in food supply chain.	Losses during distribution and marketing in the form of edible food discarded because it is non-compliant with aesthetic quality standards or is not sold before "best before" and "use-by" dates. Losses during consumption in the form of food purchased by consumers, restaurants, and caterers but not eaten.	Losses during consumption

Source: Gustavsson 2011; SIK 2013, Lipinski et al 2013; Food loss and waste protocol, on-going as of 2015; SAVE FOOD Initiative, 2015.

Although the FAO definition of food wastage (loss and waste) is currently under discussion, it is expected to eventually include waste of inputs to production, such as water or energy (e.g., fuelwood in smallholder operations). As a key target of rural poverty elimination goals, greater attention is focusing on the loss in the monetary value of foods such as fish. This is not necessarily a result of loss of fish as food, but due to a downgrading in value irrespective of quality. Three types of losses are being considered in small-scale fisheries (FAO 2014):

i. Physical: fish not used after capture, harvest or landing. These fish are totally lost from the supply chain and not consumed or utilized.
ii. Quality: products that are spoiled or damaged but not to the extent that they are thrown away. The nutritional value may or may not be affected.
iii. Market Force: Loss due to market reaction affecting the selling price to such an extent that, irrespective of quality, fish sells for a lower price. These downgrades in market value are experienced by food producers for many other crops and food products.

For the purposes of this analytical study, a hybrid definition of on-farm losses has been utilized, with boundaries from production to farm gate including harvesting. Included in the assessments of on-farm losses are all of the stages and steps involved in:

- Growing foods that are damaged, decayed or immediately lost. This includes inadequate production, cultivation and pest protection practices that lead directly to physical or quality losses of plant foods or animals at the time of harvest.
- Harvesting foods, including losses that occur due to timing of harvesting and methods of gathering, cutting, selection or collection that cause physical damage or quality losses and related market losses.
- Handling foods on the farm or ranch after the harvest, including sorting, cleaning, trimming, packing, threshing and drying grains and legumes, curing roots, tubers and bulb crops, packing or bulking, temporary on-farm storage, and loading onto vehicles at the farm gate.

All of these activities and practices are under the direct control of the farmer and the farm workers that are producing and harvesting foods, and handling food crops, animals and animal products on the farm after the harvest.

Table 1.2: Definitions of On-Farm Losses for this Analytical Study

Food Groups	PEF/WFLO Definition of "On-Farm Losses"	Support in the Literature
Cereals	Production, harvesting, threshing, cleaning, drying, bagging or bulking, on-farm temporary storage, loading	Initial stage of the farm to the completion of harvesting. Includes losses due to mechanical damage and/or spillage during harvest operation (e.g. threshing or fruit picking) and waste due to crops sorted out post-harvest (SIK, 2013). Losses during production or harvest in the form of produce left behind by poor harvesting equipment, and fruits/vegetables not harvested or discarded because they fail to meet quality standards (Lipinski, et al., 2013).
Roots and Tubers	Production, harvesting, sorting, cleaning, curing, packing or bulking, on-farm temporary storage, loading	
Oilseeds and Pulses	Production, harvesting, threshing, cleaning, drying, bagging or bulking, on-farm temporary storage, loading	
Fruits and Vegetables	Production, harvesting, sorting, grading, trimming, packing or bulking, on-farm temporary storage, loading	
Meat and Dairy Products	Production, harvesting (selection of live animals, collection of milk or eggs), packaging (of milk or eggs), loading	Includes decreased milk production due to dairy cow sickness (mastitis) and animal death during breeding (Gustavsson et al., 2011).
Fish and Seafood	Production, harvesting or collecting, sorting, grading, packing, loading	Losses during production or harvest in the form of fish left behind by poor harvesting equipment, and fish not harvested or discarded because they fail to meet quality standards (Lipinski, et al., 2013). Includes losses of mature fish stocks on farms (Gustavsson et al., 2011).

Source: a collection of definitions from PEF and WFLO, Gustavsson et al., 2011, Lipinski, et al., 2013, SIK, 2013.

1.2 Methodology

The analytical study of on-farm losses in the OIC Member Countries was carried out using three data collection methods: literature reviews, key informant surveys and interviews, and case studies.

1.2.1 Literature Review and Syntheses

The analytical study draws upon research and programming that focuses on previous field studies to assess food losses in the different commodity groups in the focus countries. While preparing the study the consultants reviewed the written and visual literature, investigated the information, documents and experience of relevant countries and international institutions, and accessed the resources of relevant national institutions. The consultants reviewed the existing

on-farm food loss assessments in the OIC Member Countries, especially the recent studies sponsored by the FAO, international institutions and organizations as well as any available country-specific reports and analysis.

1.2.2 Key Informant Surveys and Interviews

The consultants conducted online and email-based surveys for collecting data on food losses and on-farm food losses for all agricultural commodities from key informants selected from the 57 OIC Member Countries. Through the PEF, stakeholders were engaged by utilizing e-Forums and e-network exchanges throughout the OIC Member Countries via online discussion groups. PEF currently hosts a forum on Postharvest Training with more than 3,800 global members, many of whom are postharvest experts and food loss reduction specialists located in institutions in developing countries. Others are well known experts that work on agricultural projects. Exchanges included dialogue on technologies that have been working effectively in their respective environments to reduce on-farm losses, as well as challenges and priorities for uptake of these technologies on a larger scale.

The regional experts selected as key informants encompassed a wide range of research and extension expertise and technical specialties, from engineering, food processing, postharvest handling and pest management to socioeconomics and gender studies. The postharvest experts invited to the online consultation meetings included representatives of the Arab, Asian and African Groups as designated by the OIC.

Key informant surveys were sent via email during September and October 2015 to 100 people in 50 OIC Member Countries. No experts with food loss expertise could be identified in Comoros, Mauritania, Somalia, Brunei, Maldives, Suriname or Guinea-Bissau.

The key informant surveys were intended to gather expert opinion on food losses and on-farm losses in their specific country. A unique scale was developed to force the key informants to think about their local situation for each food group (see Annex A). As a result, the rating scale did not match the FAO estimates, which are whole percentages of 20%, 35% or 45% losses, depending on the food group. The FAO estimates were listed in the introduction to the survey for reference, but effectively this scale represents perceived impact of losses on livelihoods. Losses below 10% are tolerated.

The rating scale provided to the key informants is provided below:

- 5 = very high (more than 50%)
- 4 = high (30 to 50%)
- 3 = moderate (10 to 30%)
- 2 = low (5 to 10%)
- 1 = very low (less than 5%)

Question 1 inquired about the perceived general level of food losses for each food group, as compared to FAO global estimates. Key informants were not expected to provide anything more than their perception of whether losses for each of the food groups were very low, low, moderate, high, or very high. Percentages were included to give them an idea of what might be considered low or very high. For analysis purposes, ratings were rounded to the nearest whole number or midpoint, where 1.5 = 5%, 2.5 = 10%, 3.5 = 30% and 4.5 = 50% losses.

Question 2 provided a list of 18 potential causes and sources of losses based on the literature reviews and consultant experience, and key informants were asked to check the most important causes or sources of food losses in their country for each type of food. The majority of the line items provided (11) were on-farm causes, but additional potential causes were listed to enable the calculation of the relative importance of on-farm causes of losses.

Question 3 asked key informants to rate their estimation of the level of on-farm food losses for various food groups in their country. On-farm losses were categorized into three broad groups as production, harvesting and on-farm handling, and the ratings of individual key informants were averaged for each country.

Question 4 requested whether the informant was aware of any activities or projects aimed at reducing food losses in the respective country. PEF and WFLO followed up via email and LinkedIn with any key informant who indicated that there were food loss reduction projects or activities active in their country, and interviewed them regarding specifics related to on-farm loss reduction.

1.2.3 Case Studies

The countries, crops and foods that were selected as the focus for eight case studies provide a more detailed look at the levels and causes of on-farm losses of key crops and animal-based foods in the OIC Member Countries. The case studies cover the period of time from production, including any pre-harvest factors that may lead directly to losses, to harvesting and handling on the farm until farm gate. Farm gate refers to transport from the farm and/or sale to a buyer who takes responsibility for the crop. Annex B provides a series of tables of the top most produced crops and livestock (in tonnes per annum) and the types of fisheries for each of the 57 OIC Member Countries, based on FAOSTAT data for 2013.

A wealth of information exists for the African Group, where the major cereals are maize, millet, rice and sorghum. Roots and tubers are also of primary importance, with high production of cassava, sweet potatoes, yams and other root crops, such as cocoyam, taro, and dasheen. Additional major crops include bananas, plantains, cowpeas, groundnuts and oil palm fruits.

To further examine the Cereals food group, a case study of maize in Uganda was selected, since maize is one of the top crops, with 900 million metric tonnes (MT) produced worldwide in 2013/2014 as per the United States Department of Agriculture (USDA) references on grains

(Foreign Agricultural Service/USDA, Office of Global Analysis Dec 2015). Among the OIC Member Countries, Indonesia, Nigeria, Egypt, Pakistan, Turkey are also major producers.

For the Roots and Tubers food group, two crops in Nigeria were selected. Cassava is a top global food crop in many of the OIC Member Countries, and sweet potatoes are similar to malanga, yam, taro, and potatoes which are also in high production.

The Oilseeds and Pulses group included a case study performed on groundnuts in Benin. Major producers among the OIC Member Countries also include Nigeria, Sudan, Indonesia, Burkina Faso, Cameroon, Niger, Mali, and Chad.

Fruits and Vegetables are an enormous group of food crops, so there are two case studies. The first case study concerns tomatoes in Egypt. Tomatoes are similar to capsicum, aubergine (eggplant) and hot peppers regarding the management of on-farm losses and major OIC producers include Turkey, Egypt, Iran, Nigeria, Uzbekistan, Morocco, Syria and Tunisia. The second case study is on bananas and plantains in Uganda, which are an important economic resource for rural farmers in Uganda. Farming communities in Uganda have consistently ranked the banana crop as their most important crop because the plant produces all year-round and has multiple uses including food, beverages, snacks, feed, industrial spirits, crafts and medicinal uses.

Within all three of the OIC country groups, African, Arab and Asian, eggs, cow milk and chicken meat are of primary importance. In the Arab group camel and buffalo milk are among the top food products, while in Asia it is indigenous chicken meat. For the African countries, cattle meat is among the top produced livestock based foods. For the case study on meat and dairy products, chicken (broiler meat) in Turkey was selected. Broiler meat is the most produced animal food in the world, and is a highly valuable agricultural product. Among the OIC Member Countries, Saudi Arabia, Indonesia, Malaysia, Jordan are major producers.

Aquaculture is the source of nearly 50% of global fisheries production, and is growing at a rapid pace in the Arab Group, especially in Egypt and Jordan, and in the Asian Group throughout Bangladesh, Indonesia, Malaysia and Turkey. It is defined as fish farming, including breeding (production of seeds or fry), controlled feeding, and controlled harvesting of fish or crustaceans. This normally requires capital and if often out of reach for small-scale or artisanal producers. For the case study on Fish and Seafood, aquaculture production of shrimp and tilapia in Indonesia was selected. Top global producers among OIC Member Countries also include Bangladesh and Egypt.

For each of the case studies on food crops, consultants conducted a modified Commodity Systems Assessment Methodology (CSAM) field survey, focusing on planning, production, harvesting, and on-farm handling, and interviewed producers, extension workers and intermediaries. Local consultants visited six farms for each case study. They collected a wide

assortment of data on physical and quality losses during the harvest and the on-farm handling period on each farm through questions to farmers and field workers, direct measurements of food losses, and observations of harvesting and handling practices. Photos documented incidents of food damage, defects or decay.

Quality sorting was performed by the consultant via a random selection of 20 produce samples on each farm. Percentages (number out of count of 20) were based on a quality sort with ratings from 5 to register extreme defects, decay or damage; 3 for moderate defects, decay or damage; and 1 for no defects, decay or damage.

For each case study, a summary of the causes of on-farm losses for the specific crop or food product, examples of how to reduce these losses, the lessons learned and general recommendations for reducing on-farm losses for the food group are provided.

1.3 Overview of Global Food Losses and Waste

The percentages of food losses and waste of the edible parts of food products in different commodity groups (cereals, roots and tubers, oilseeds and pulses, fruits and vegetables, meat, dairy products, fish and seafood) differ in the various regions world. At this time, a lack of solid data on OIC Member Countries does not enable a valid comparison between the OIC Member Countries and the data that exists for rest of the world.

Globally, food loss and waste average one-third of the total food produced based on weight. This amounted to 1.3 billion tonnes of lost food in 2009. When converted into calories, global food loss and waste are equal to approximately 24% of all food produced (Lipinski et al 2013). This is a loss of 1.5 quadrillion kilocalories per year.

Fruits and vegetables and roots and tuber crops all have the highest rates of quantitative losses, in part due to their high water content. Global quantitative food losses and waste per year are roughly 30% for cereals, 40-50% for root crops, fruits and vegetables, 20% for oil seeds, meat and dairy, and 30% for fish (Gustavsson et al 2011). This global FAO study was based on the available literature at the time, and calculated estimated weight losses based upon reported measurements, surveys and observations of experts (SIK 2013).

1.4 Types of Food Losses and Waste

There are three major types of food losses:

- **Quantitative losses:** loss of weight, loss of volume; discards due to physical damage or serious decays.
- **Qualitative losses:** damage, loss of freshness, poor visual appearance, changes in color, wilting, yellowing, dehydration or water loss, decay symptoms, or nutritional losses.
- **Economic losses:** loss of monetary value per kilogram (kg) or per unit.

Both quantitative and qualitative losses on the farm will result in monetary or economic losses. In the first case, farmers will have less volume or weight to sell, and in the second case, the price offered for their produce will be lower than that offered for higher quality food products.

There are five stages of the food chain where food losses and waste can occur:

- Production losses: on-farm cultivation practices, harvesting
- Postharvest handling: sorting, grading, trimming, packing, cooling, and storage losses
- Processing losses
- Distribution losses: transport, shipping to markets, marketing
- Consumer waste: home consumption discards or food service waste

The first two stages are included in on-farm losses, but reporting can be complicated by local variations regarding if and when, where and for what foods postharvest handling and storage takes place on the farm.

These can also be detailed as:

1. Production losses
2. Harvest losses
3. Handling losses on the farm
4. Postharvest losses
   4.1. Transportation (to storage) losses
   4.2. Storage losses
   4.3. Processing losses
   4.4. Packaging losses
   4.5. Distribution losses
   4.6. Marketing losses
5. Consumer waste

Lipinski et al (2013) provided estimates of percentages of food losses at the five stages of the food chain for three regions of the world where OIC member countries are located, based on the report of Gustavsson et al (2011). The estimated percentages of total food losses and waste are 17% in South and Southeast Asia; 19% in North Africa, West and Central Asia; and 23% in Sub-Saharan Africa. The global average is 32% mainly due to the enormous amount of food losses and waste occurring in North America where it is estimated to be higher than 42%.

Table 1.3: Estimates of Food Losses/Waste by Stage of the Food Chain

	Region		
Stage	**North Africa, West and Central Asia**	**South and Southeast Asia**	**Sub-Saharan Africa**
Production	23%	32%	39%
Handling/Storage	21%	37%	37%
Processing	4%	4%	7%
Distribution/Marketing	18%	15%	13%
Consumption	34%	13%	5%
Total Food Losses and Waste	**100%**	**100%**	**100%**
% of Total Food Available in the Region that is Lost or Wasted	**19%**	**17%**	**23%**

Source: Lipinski et al (2013).

The information presented above does not yet exist for the OIC Member Countries, but further in this report, Table 2.2 contains findings on the OIC Member Countries based the surveys and Table 2.3 demonstrates global losses and waste estimates by the FAO in comparison with COMCEC Analytical Study Findings. In addition, Tables 2.4 through 2.9 provide information on losses and on-farm losses in different food groups.

Despite many technical improvements in production, harvesting, and postharvest management since the 1970s when food losses were first measured by FAO, food losses are still significant today. Losses vary by crop, variety, year, climate, storage type, drying method, handling techniques, transportation methods, distribution system, and infestation magnitude. General causes of losses include financial, managerial and technical limitations in production practices, harvesting techniques, and postharvest handling technologies (Hussein 2005).

1.5 The Relative Importance of On-Farm Losses

As demonstrated by Table 1.3 above, Lipinski et al (2013) provided estimates of the production and harvesting and postharvest handling and storage losses for three regions of the world where OIC Member Countries are located, based on the estimates and assumptions used in the report of Gustavsson et al (2011). The percentages of production and harvesting losses range from 23% in North Africa, West and Central Asia; 32% in South and Southeast Asia; and 39% in Sub-Saharan Africa.

On-farm losses occur during production and at the time of harvesting. The immediate losses in food calories, nutrition and monetary value are borne directly by the farmers. Postharvest handling that takes place on the farm after the harvest can then either protect foods from losses or become an added cause of losses. Reducing food losses on the farm can therefore increase incomes and directly alleviate poverty. Lipinski et al (2013) provides the following examples:

- Reducing physical losses can increase the amount of food available to farmers for their own consumption or for sale to market.
- Reducing food losses can reduce the likelihood small-holders becoming net food buyers.
- Reducing quality losses can better maintain the nutritional value of food.
- Reducing food losses increases the return on investment of time spent on farming and could reduce the total time needed to work in the fields. This is especially important for smallholder farmers and women.

The percentages of postharvest handling and storage losses in these three regions are similar in relative importance to those of production and harvesting, but it is not possible to determine whether these losses took place on the farm or not. In the case of the FAO estimates, some of the original data used to calculate estimates includes on-farm handling practices and some of the data does not. For example, data on cereals losses may or may not include losses during on-farm drying and bulk storage, while data on fruit losses may or may not include losses due to damage during packing and loading.

Any damage, defects, wounds, bruises or diseases that the crops or foods suffer during their production, harvesting and on-farm postharvest handling pre-disposes them to pathogen attack and leads to more rapid deterioration. Any delays in marketing perishable foods after harvest will reduce shelf life, quality/appearance and nutritional quality, any of which can reduce market value per kg.

According to SIK (2013) estimates for on-farm losses (production and harvesting) for the food groups in the three regions of the world where OIC member countries are located range from 29 million tonnes per year in North Africa, West and Central Asia; 44 million tonnes per year in Sub-Saharan Africa; and 85 million tonnes per year in South and Southeast Asia (Table 1.4). It should be noted that the SIK (2013) estimates are based on the findings of a small assortment of field studies for specific foods in specific countries, which were used to make wider assumptions and then the associated calculations and estimations for each region.

Table 1.4 Estimates of On-Farm Food Losses during Production and Harvesting

	Region, Measured in Millions Tonnes		
Food Group	North Africa, West and Central Asia	South and Southeast Asia	Sub-Saharan Africa (SSA)
Cereals	4.1	**25.1**	4.6
Roots and Tubers	1.2	6.3	**26.4**
Oilseeds and Pulses	0.8	6.8	2.8
Fruits and Vegetables	**20.1**	**37.7**	**7.1**
Meat	0.8	1.4	2.0
Fish and Seafood	0.1	0.9	0.1
Milk and Eggs	2.2	6.2	1.3
Total	**29**	**85**	**44**

Source: SIK 2013.

The most noticeable on-farm losses highlighted in this summary table due to their massive volumes, are for cereals, roots and tubers, and fruits and vegetables. Cereals, which are the predominant food crops in South and Southeast Asia, are estimated at 25.1 million tonnes per year lost. Roots and tubers, which are the predominant food crops in SSA, are estimated at 26.4 million tonnes per year lost. Fruits and vegetables, which are important crops in all three regions, are estimated at a total of 64.9 million tonnes per year lost. The high levels of weight losses in fruits and vegetables is due mainly to their very high levels of water content and high perishability.

Specific estimates for the on-farm losses for each of the OIC Member Countries were not determined as part of the FAO global study of food losses and waste (SIK, 2013). However, it can be assumed that production and harvesting losses will be similar to those of the countries used for the basis of the estimations in each of the regions where the OIC Member Countries are located. Therefore, it is expected that on-farm losses of cereals, roots and tubers, and fruits and vegetables will account for the majority of the losses.

2. OVERVIEW OF ON-FARM LOSSES IN THE OIC

This chapter presents data on food losses and waste in the OIC Member Countries and the relative importance of on-farm losses. The data was collected based on a full literature review, key informant surveys in the OIC member countries and follow-ups via e-mail and Linked-In. These sources provided the data for describing the current status of information on estimates of on-farm losses in the OIC Member Countries.

2.1 Estimates for Food Losses and Waste for the OIC Member Countries

Respondents provided information on food losses and waste for 30 of the OIC member countries. This includes 21 informants from Africa, 17 informants from the Arab world and 26 informants from Asia with 9 or 10 countries in each group represented. The countries include most of the major food producing countries and those with higher populations (above 20 million). This table reflects only a few major differences between the analytical study and FAO global estimates when broken out into the FAO regions and the OIC Member Country Groups.

Assessed loss percentages reported for most of the commodity groups in the Arab and Asian Groups were similar to but generally lower than those reported by FAO in 2011, including estimates based on 2009 and earlier data. Estimations by key informants for the Arab group, with the exception of meats and dairy, were lower than FAO estimates. Estimations by key informants of the losses for roots and tubers, oilseeds and pulses and fruits and vegetables were lower for the Asian group. It is possible that food losses have been decreasing due to the renewed global focus on reducing food losses and waste since 2011.

Table 2.1: Average Ratings on a Scale of 1-5 for Food Groups by Key Informants

Analytical Study Findings			
Food Group	**Arab Group**	**Asian Group**	**African Group**
Cereals	3	3	3
Roots and Tubers	3	3	4
Oilseeds and Pulses	2	2	3
Fruits and Vegetables	4	4	4
Meat and Dairy	3	3	3
Fish and Seafood	2	3	3

Source: Key Informant Surveys.
Rating Scale: 1= 0-5%; 2= 5-10%; 3= 10-30%; 4=30-50%; 5= 50-100%

Table 2.2: Global Losses and Waste Estimates by FAO vs COMCEC Analytical Study Findings

	Global Losses/Waste Estimates FAO 2009 Data			COMCEC Analytical Study Findings (2015)		
Food Groups	**North Africa, West and Central Asia**	**South and Southeast Asia**	**SSA**	**Arab Group**	**Asian Group**	**African Group**
Cereals	30%	20%	20%	10-30%	10-30%	10-30%
Roots and Tubers	32%	41%	45%	10-30%	10-30%	30-50%
Oilseeds and Pulses	30%	28%	28%	5-10%	5-10%	10-30%
Fruits and Vegetables	52%	52%	55%	30-50%	30-50%	30-50%
Meat and Dairy	23%	20%	20%	10-30%	10-30%	10-30%
Fish and Seafood	30%	33%	32%	5-10%	10-30%	10-30%

Sources: Gustavsson et al., 2011 and Key Informant Surveys.

Direct measurements have not been made for all of the food groups in many of the OIC member countries, but the following examples from key informants and country-based research studies provide a reasonable estimation of food losses for key crops in 25 countries. The countries with the most available data on many different crops and foods include Bangladesh, Egypt, Indonesia, Nigeria, Pakistan, Turkey and Uganda, all of which have very high populations and high levels of food production. The information provided in this section of the report is based on field food loss assessments, and does not include the findings of controlled laboratory experimental studies or experiments that test field production practices or postharvest handling technologies.

The ranges of food losses as reported for the six commodity groups are very wide, varying from very low losses to extremely high losses, which reflects the reality as these types of local assessments and case studies provide a snap-shot of the current conditions, which can vary widely and change rapidly over time.

2.1.1. Cereals: Rice, Maize, Sorghum, Millet, Wheat

The World Bank published a report on Missing Foods (World Bank, 2011) which was largely based on the estimates provided by the African Postharvest Losses Information System (APHLIS). Physical grain losses in Africa prior to processing can range from 10-20%, including harvesting losses in the range of 4-8% (APHLIS data). In Burkina Faso, losses for rice was reported by AGRA (2013) as 6-24%. Harvesting rice too early results in a larger percentage of unfilled or immature grains, which lowers yield and causes higher grain breakage during milling. Harvesting too late leads to excessive losses and increased breakage in rice during threshing and milling. It was shown in Proceedings of the 20th Session of the International Rice Commission (2002) that grain losses range from 5.6 to 60% if harvesting is done one week to four weeks beyond the maturity date. In general, the correct time to harvest is one week before the maturity date.

Affognon et al (2014) reviewed more than 130 published documents on postharvest losses in Africa (including Benin and Mozambique), and reported their summary findings on maximum losses for maize at 25.5%, +/- 15.3 losses in 66 documents and rice at 25.6% +/- 27.4 losses in four documents. Comparisons of reported losses in cases where interventions were made to reduce losses via improved handling and storage showed approximately 50% lower losses.

AfricaRice reported in Cameroon that shattering losses double from 2.75% to 5.46% when grain moisture at harvest drops from 20% to 15% after a period of 3.5 days. Field stacking losses were 8.72% and 8.36% for harvesting at 20% and 15% grain moisture, respectively (Ndindeng et al 2015). In Mali, losses for cereals were reported by AGRA (2013) to be 20-30% for maize; 10-15% for rice; and 2-15% for sorghum, while in Mozambique, they were reported to be 18.4% for maize; 11.2% for rice; 12.6% for sorghum and 11.1% for millet. Harvest losses in Sierra Leone for rice were reported to be 5% (FAO 2009).

In Nigeria, losses for maize were reported by AGRA (2013) to be 20% and an in-country evaluation of Nigeria's commodity storage and management infrastructure by Ileleji et al. (2009) concluded that despite having up to 1.3 million tonnes of modern bulk storage capacity and more than 48 warehouse structures for its Strategic Grain Reserves program (SGR), unsatisfactory management of stored grain by staff at these facilities resulted in huge post-harvest losses (up to 50% in some cases). Losses incurred were primarily due to the lack of adequate knowledge and implementation of sound stored grain management practices, making this system hugely inefficient. Huge physical and quality losses, estimated at 15-30%, were also incurred along the value chain in on-farm and in private sector warehouse.

In Uganda, harvesting losses for maize was due to careless harvesting, which resulted in spillage. Mean losses were 4% of the farmers' potential harvest. At farmer storage level, mean losses were at 20% after 3 months of maize grain storage. The mean percentage loss causative factors included: 16.4% insect damage on grain, breakage accounted for 1.0% loss, discoloration was also found at 2.6% levels in and foreign matter at 1.9%. Results showed 40% of the samples evaluated were positive with Aflatoxin B1 (Muyinza et al 2015).

The estimated total post-harvest loss of on-farm paddy rice in Bangladesh is 14%, a figure that includes harvesting (1.06–6.5%), handling and transport (0.63–6.0%), threshing (1.65–2.0%), drying (1.56–5%) and storage (3.05–7.5%) for a total of 27% (Bala et al., 2010). A recent study in Iran (Asadi et al. 2010), estimated maize waste at the harvesting stage at 0.5-2%.

Losses of wheat in Tajikistan were reported to be 4.3% at production; 1.3% at postharvest and storage; 1.8% at processing and packaging; 2.2% at distribution; and 1.6% at marketing for a total of approximately 11% (Nabieva 2015).

FAO sponsored studies in Turkey reported that wheat losses during production and harvesting were 5.1% due to poor quality seeds (saved seeds from prior harvest), unsuitable varieties, lack

of rain at needed growing period, damage to plants during cultivation, pests and diseases, and mechanical errors in harvesting/machine operations. Additionally, 4% losses were estimated due to spillage during loading on farm (Tatlıdil et al, 2013).

Table 2.3: Literature Review on Cereals Losses

Countries	Maize	Rice	Sorghum	Millet	Wheat	Cereals
APHLIS Africa						10-20%
Burkina Faso		6–24%				
Benin	25.5%	25.6%				
Bangladesh		27%				
Cameroon		14%				
Iran	0.5-2%					
Mali	20-30%	10-15%	2-15%			
Mozambique	18.4%	11.2%	12.6%	11.1%		
Nigeria	20%					
Nigeria						50%
Sierra Leone		5%				
Tajikistan					11%	
Turkey					9.1	
Uganda	24%					
Range	0.5–30%	5-27%	2-15%	11.1%	9.1-11%	10-50%

Source: International Rice Commission, 2002; FAO, 2009; Bala et al., 2010; Asadi et al., 2010; World Bank, 2011; Tatlıdil et al., 2013; Affognon et al., 2014; Ndindeng et al., 2015; AGRA, 2013; Ileleji et al., 2009; Muyinza et al., 2015; Nabieva 2015; APHLIS.

When the same data set for cereals is summarized again for the on-farm losses in production and harvesting, there is a lot less information to report, and the reported range of on-farm losses are relatively low. Published reports of on-farm losses for cereals are available for only a single study on six OIC Member Countries: Bangladesh (rice), Cameroon (rice), Iran (maize), Tajikistan (wheat), Turkey (wheat) and Uganda (maize). Overall, the limited information on on-farm losses for cereals crops in the OIC Member Countries shows a range of losses that are much lower than FAO estimates.

Table 2.4: Literature Review on On-Farm Losses for Cereals

Countries	Maize	Rice	Sorghum	Millet	Wheat	Notes
APHLIS Africa						4–8% harvesting losses for cereals
Bangladesh		1-6.5%				Includes drying, on-farm and storage
Cameroon		14%				Includes shattering and field stacking for drying
Iran	0.5-2%					
Tajikistan					4.3%	
Turkey					9.1%	Includes spillage during on-farm loading
Uganda	4%					
Range	**0.5–4%**	**1-14%**			**4.3-9.1%**	

Source: International Rice Commission, 2002; FAO, 2009; Bala et al., 2010; Asadi et al., 2010; World Bank, 2011; Tatlıdil et al., 2013; Affognon et al., 2014; Ndindeng et al., 2015; AGRA, 2013; Ileleji et al., 2009; Muyinza et al., 2015; Nabieva 2015; APHLIS.

2.1.2. Roots and Tubers: Cassava, Potatoes, Sweet Potatoes, Yams

Harvest wounds during digging is the most common cause of damage and on-farm losses for roots and tubers. It is easy to damage root and tuber crops when digging, especially when using large hand tools or mechanical harvesters such as lifters. The produce can be cut or broken, leaving wounds that provide easy access for disease organisms. Harvesting losses for cassava tend to be higher during the dry season because it is more difficult to dig; roots break and remain in the soil. For these products, wounds and bruises are the triggers of primary deterioration (vascular streaking with blue-black or brownish occlusions and chemical deposits). In fact, for most root and tuber crops, decay organisms are wound pathogens and will infect the crop via the sites of an injury. Root and tuber processing losses are typical during small-scale root crop processing, including estimates for washing (0-5%), sorting (5-50%), slicing/dicing (5-10%), packaging (0-10%) and rejection (0-5%) (UNIDO 2004).

Affognon et al. (2014) reviewed more than 130 documents on postharvest losses in Africa, and reported summary findings the following root and tuber crops:

- Cassava: 23.5% +/- 20 average losses in 9 documents
- Yams: 41.6% +/- 10.3 average losses in 7 documents
- Sweetpotatoes: 43.6% +/- 27.4 average losses in 6 documents
- Potatoes: 21.6% +/- 7.5 average losses in 3 documents

In Benin, harvesting loses for cassava were 13.6% (Bokanga 1999). Comparisons of reported losses in cases where interventions were made to reduce losses via improved handling and storage) showed results of approximately 50% decreases.

In Mozambique and Mali, losses for cassava were reported by AGRA (2013) to be 27%. Yams in Nigeria were reported to suffer 12.4% physical losses, which was an economic loss of 10.5% (Okoh 1997) while losses for cassava were reported by AGRA (2013) as 28%, with yam losses at 37% due to damage during the harvest. For West Africa, it is estimated that 10-50% of yam tubers are lost during on-farm storage (Amusa et al 2003) and a further 10-40% are lost during transport due to damage and rots (Rees and Bancroft 2003). Losses for both sweet potatoes and cassava were reported by AGRA (2013) as 20 to 25% in Uganda.

Average harvest losses in Bangladesh for potato were reported to be 6% (Hossain 2009) while Zulfiqar et al (2005) reported on losses in potatoes (12%) in Pakistan. In Tajikistan, losses in potatoes were reported to be 4.9% (production stage); 5.2% (postharvest/storage); 0.2% (processing and packaging); 6.4% (distribution) and 4.3% (marketing) for a total of 22% (Nabieva 2015),

An FAO-sponsored food loss assessment in Guyana reported that postharvest losses of cassava were 23.0% for farmers who retailed at the public, roadside or mobile markets (Craig et al 2015). At harvest, total losses for cassava averaged 6.5% mainly due to physical damages, where pathological and entomological damages were 3.0% and 3.5% respectively (Mohammed et al 2015). A similar FAO study in Turkey reported losses for potatoes at 7% due to a number of unfavorable practices: poor cultivation practices, damage at harvesting caused by tuber cuts, leaving tubers in the field, untimely harvesting, harvesting on wet land, and harvesting under unfavorable temperatures (Tatlıdil et al, 2013).

Table 2.5: Literature Review on Roots and Tubers Losses

Countries	Cassava	Yams	Sweetpotatoes	Potatoes	Notes
SSA	23.5%	41.6%	43.6%	21.6%	Averages of many studies
Bangladesh				6%	
Benin	13.6%				
Guyana	6.5%				
Nigeria	28%	37%			AGRA case studies
West Africa		10-50%			
Pakistan				12%	
Tajikistan				22%	
Turkey				7%	
Uganda	20-25%	20-25%			
UNIDO Estimates					Sum of 10-80% in processing root crops
Range	**6.5-28%**	**10-41.6%**	**43.6%**	**6-22%**	**10-80%**

Source: Okoh 1997; Bokanga, 1999; Amusa et al., 2003; Rees and Bancroft, 2003; UNIDO 2004; Zulfiqar et al., 2005; Hossain 2009; AGRA, 2013; Tatlıdil et al., 2013; Affognon et al.,2014; Nabieva 2015,Craig et al., 2015; Mohammed et al., 2015.

For on-farm losses in production and harvesting there is a lot less information to report. Benin and Guyana (cassava), Nigeria (cassava and yams) and Tajikistan and Turkey (potatoes) have published reports of on-farm losses. Overall, the limited information for on-farm losses for tropical root/tuber crops in the OIC Member Countries shows a range of losses that are similar to the FAO estimates.

Table 2.6: Literature Review on On-farm Losses of Roots and Tubers Losses

Countries	Cassava	Yams	Sweetpotatoes	Potatoes	Notes
Benin	13.6%				
Guyana	6.5%				
Nigeria	28%	37%			Damage during harvest
Tajikistan				4.9%	
Turkey				7%	
Range	**6.5-28%**	**37%**		**4.9-7%**	

Source: Okoh 1997; Bokanga, 1999; Amusa et al., 2003; Rees and Bancroft, 2003; UNIDO 2004; Zulfiqar et al., 2005; Hossain 2009; AGRA, 2013; Tatlıdil et al., 2013; Affognon et al.,2014; Nabieva 2015,Craig et al., 2015; Mohammed et al., 2015.

2.1.3. Oilseeds and Pulses: Groundnuts, Dry Beans, Cowpeas

Pod losses during harvesting are substantial at 20-30%, although they are higher in the Virginia than the Spanish types. The harvesting losses are dependent on a number of factors including the method of harvest and soil moisture content. Excessive soil moisture at the time of harvest also damages crop quality, but on the other hand, soil moisture-deficit may increase the pod losses (Nautiyal 2002). Pod shattering, which refers to the spillage of seeds from drying pods that split, can be a problem, but losses are not usually serious unless harvest is delayed (Gomez 2004). Bruchid weevils are insects infest pulse crops while in storage and in the fields by laying eggs in cracks or cuts in the pod (Nautiyal 2002).

In Uganda, groundnuts should be harvested when approximately 75% of the pods have reached maturity. Harvesting at the right time gives the farmer the maximum yield and grade. If harvesting is too early, grading factors and market value will be lower. If harvesting is too late, over-mature pods can lose peg strength resulting in yield loss (Okello et al 2013). Losses for groundnuts were reported by AGRA (2013) as 9-18.5%.

Losses for groundnuts in Mali were reported by AGRA (2013) to be 20-30% during the harvesting stage. Typical on-farm losses for groundnuts include pest attacks. Among the major arthropods in soil and plant samples taken from groundnut farms in Mali, Burkina-Faso, Niger and Nigeria, termites of the genus Microtermes (Isoptera: Termitidae) were the most abundant and widely distributed species of economic importance. Most of the whitegrub (Coleoptera: Scarabaeidae) and millipede (Myriapoda: Odontopygidae) species identified belonged to the genera of Schyzonycha and Peridontopyge, respectively. Percentages of plants attacked by termites, white grubs and millipedes were 39, 11 and 9%, respectively. Yield loss due to termites was estimated at 10-30% (Umeh et al., 1999). The yield loss in groundnuts due to competition by weeds may range between 30-34%. The yield losses are higher when the crop is rain-fed and Spanish compared to an irrigated crop and Virginia runner (Nautiyal 2002).

In Uganda, losses for dry beans were reported by AGRA (2013) as 5-15%. FAO (2013) estimates that bean yields in Uganda are 30% below potential yields due to cultivation practices and nutrient deficiencies (Sebuwufu, 2013). This is especially important for Egypt, Sudan and Yemen as faba beans (dry broad beans), chickpeas and lentils are among the most important food crops in those countries, representing a major part of the daily diet and a source of protein. Within Egypt, faba beans (broad bean or fava bean) are the most important pulse representing 80% of the pulses produced (Hassanein et al, 2000).

Affognon et al (2014) reviewed more than 130 documents on postharvest losses in Africa, and reported their summary findings for cowpeas (23.5% +/- 22 average losses in 9 documents) and dry beans (14% +/- 1 average losses in 2 documents). Comparisons of reported losses in cases where interventions were made to reduce losses (via improved handling and storage, including metal silos and PICS bags) showed results of approximately 50% decreases.

Table 2.7: Literature Review on Oilseeds and Pulses Losses

Countries	Groundnuts	Dry Beans	Cowpeas	Notes
Uganda	9 -18.5%	30%		Low yield dry beans
Mali	20-30%			
Globally	10 -30%			Termites
Globally	30-34%			Weeds
Globally	20-30%			Dry soil, peg losses
Uganda		5 -15%		
SSA		14%	23.5%	Average from 9 studies for cowpeas
Range	**9 – 34%**	**5 – 30%**	**23.5%**	

Source: Umeh et al., 1999; Hassanein et al., 2000; Nautiyal, 2002; Gomez, 2004; AGRA, 2013; FAO, 2013; Sebuwufu, 2013; Affognon et al., 2014.

There is a lot less information to report on-farm losses (production and harvesting) in oilseeds and pulses than for the general losses of the same crop in general. Information was only found for groundnuts and dry beans. Published reports of documented on-farm losses are available for only two OIC Member Countries: Mali and Uganda. On-farm losses of oilseeds and pulses are generally higher than those estimated by FAO.

Table 2.8: Literature Review on On-Farm Losses for Oilseeds and Pulses

Countries	Groundnuts	Dry Beans	Cowpeas	Notes
Uganda		30%		Low yields
Mali	20-30%			
Globally	10-30%			Termites
Globally	30-34%			Weeds
Globally	20-30%			Dry soil, peg losses
Uganda		30%		
Range	**10–34%**	**30%**		

Source: Umeh et al., 1999; Hassanein et al., 2000; Nautiyal, 2002; Gomez, 2004; AGRA, 2013; FAO, 2013; Sebuwufu, 2013; Affognon et al., 2014.

2.1.4 Fruits and Vegetables

The fruits and vegetables involved in this study include many types such as bananas, mangoes, litchis, olives, citrus, tomatoes, peppers, leafy greens, onions. As such there is a broad range of existing information. Kader et al (2012) provided an estimate of losses for fruits and vegetable

crops ranging from 4-12% due to harvesting practices which included: over-maturity/immaturity, direct exposure to sunlight, inadequate filed containers, mechanical damage due to rough picking and handling in the field, and delays in marketing. Each fruit and vegetable faces its own causes for loss such as parasitic nematodes that reduce yields in bananas and plantain crops by 12.3% (ADMI 2015).

Affognon et al (2014) reviewed more than 130 documents on postharvest losses in Africa, and reported their summary findings as listed below:

- Mango: 55.9% +/- 25.4 average losses in 9 documents
- Tomato: 33.7% +/- 19.3 average losses in 8 documents
- Bananas: 35.7% losses in one document
- Okra: 23.4 +/- 4.5 losses in 3 documents
- Oranges: 18.8% +/- 15.6 losses in 2 documents

Comparisons of reported losses in cases where interventions were made to reduce losses via improved handling and cool storage showed results of approximately 50% decreases.

In Sub-Saharan Africa (Cameroon, Mali, Burkina Faso), Asian Vegetable Research and Development Center (AVRDC) studies on fresh leafy vegetable nutritional value losses reveal that these traditional vegetables, once harvested, immediately start to lose their nutritional and sensory quality. Being very perishable, they are often sold at loss during the season of availability. Persistence of the green color and freshness of leafy vegetables (amaranth, African nightshade, jute mallow and Roselle) is maintained up to seven days after harvesting via an improved evaporative cool storage system compared to one day with traditional storage system. In contrast, African eggplant and okra fruit kept their fresh characteristics, an indication of vitamin content, for about 25 days (Parkouda et al 2015).

In Benin, WFLO (2010) measured physical losses for tomatoes (23% on farm, 31.2% at the wholesale market, and 26.4% at the retail market), peppers (5.9% on farm, 6.2% at the wholesale market, and 11% at the retail market), amaranths (17.3% on farm, and 17.3% at the retail market), and oranges 10% on farm, 11.6% at the wholesale market, and 10.9% at the retail market). Kodjogbe et al (2008) reported on harvesting losses for leafy vegetables at 36% and for tomatoes at 13%. Vayssieris et al (2008) reported on harvesting losses for mangoes to be 17-70% due to fruit flies infestations.

Olayemi et al (2010) measured losses in Nigeria for tomato (20% on-farm losses; 28% in transit losses), bell pepper (12% on-farm losses; 15% in transit losses), and hot pepper (8% on-farm losses; 10% in transit losses). The Federal Ministry of Agriculture Nigeria (FMARD) (2013) reports that citrus is one of the crops affected most by postharvest losses, recording 40-50% losses. According to Jolaoso (2011) over 50% of citrus fruits are lost in transit between farm and market in Nigeria. The National Horticultural Research Institute (NIHORT, 2000) estimates that 30% of citrus is lost due to postharvest handling.

In Egypt, viruses can reduce tomato harvests by 60-70%. Sunburn damages fruits and vegetables and can reduce harvestable yield by 15-30%. Losses of oranges were due to defects, with 21% missing the calyx and more than 30% suffering from insect damage (Salama, et al 2015), while in Morocco, olives that escape fruit fly infestation are harvested by beating the branches. These beatings cause injury, making them vulnerable to mold attack during transport and storage. The losses caused by beating, fruit flies and mold may be as much as 30%, and also result in increased oil acidity that reduces nutritional quality (Bounfour 2015).

Kamrul Hassan et al (2010) surveyed losses in many different types of fruits and vegetables in Bangladesh, and reported losses ranging from 23.6-43.5%; for mangoes, harvesting losses alone were reported to be 3.5%. For litchi fruits, a survey reported losses of 8% at harvest, 4.6% during handling and 7.5% by the consumer for a total of about 20% (Molla et al 2010). AVRDC conducted loss assessments in Bangladesh during 2014-15 and reported that quantitative postharvest loss of tomato and eggplant was around 26% and 20% of the total harvested quantity respectively. The qualitative loss occurred in 7% and 6.5% of the harvested tomato along the postharvest chain for tomato and eggplant respectively, with the highest loss at the farmer's level. In Bangladesh, farmers incurred the highest postharvest loss, followed by wholesalers, while retailers and collectors experienced the least (Gautam et al 2015).

Recent loss assessments undertaken by WFLO and Winrock International for vegetables in Bangladesh reported 1% losses for hot chilies, 8-15% harvesting losses for cabbage, and 10-12% harvesting losses for cauliflower due to rough practices and leaving the produce in direct sun after harvest (Cold Chain Alliance Bangladesh, 2014). In neighboring Pakistan, Zulfiqar et al (2005) reported on losses in tomatoes at 22% and onions at 9%.

According to Craig et al (2015), postharvest losses of fresh table ripe mangoes in Guyana at harvesting were 15%. At display and sale, losses measured at 17%, making total losses for fresh mango 32%, with total economic loss estimated at US$902,000. Additionally, postharvest losses of tomatoes were 34% with losses at harvesting, packinghouse and marketing at 11%, 10.5% and 12.5% respectively. Estimated total economic loss was US$7.9 million.

In Iraq, lack of specific knowledge and technical expertise in harvesting, sorting and packing leads to on-farm losses of tomatoes and vegetable crops. Unsuitable harvesting times and conditions also contribute (Key informant, College of Agriculture, University of Baghdad).

Figure 2.1: Overripe Tomatoes in Dirty Crates and Poor Quality Packages for Vegetables

Photo Source: Key Informant in Iraq.

In Tajikistan, losses in onions were reported to be 5.3% at production stage; 7.1% at postharvest and storage; 0.3% at processing and packaging; 6.0% at distribution and 4.1% during marketing for a total of about 23% (Nabieva 2015). Low quality seeds and inputs reduce yields for vegetables, but farmers using compost and improved vegetable seed with extension support from Feed the Future have increased yields 15-20% during their first year of production (Gaparova 2015).

An FAO study reported on losses for tomatoes in Turkey (Tatlıdil et al, 2013). Losses during production and harvesting were 20% due to improper maturity, poor harvesting practices, sunburn or open canopy, rough handling, damage to plants and fruits, and losses during on-farm handling were 8% due to poor quality field containers, exposure to direct sun after harvesting, and delays in transport from the farm. On-farm losses for tomatoes are increased by heat and hot weather in Yemen (Key informant in Yemen, Dr.Isam Al-madhagi Assistant Professor at University of Sana'a). Please note, the key informant ran out to the wholesale marketplace between bombings in Sanaa to take some photos and video of produce handling for this report.

Figure 2.2: Overheated Tomato Fruits in Yemen Fail to Ripen, Many Will Never Turn Full Red

Photo Source: Key Informant in Yemen

A recent literature review published by PEF reported on fruit and vegetable losses in five OIC member countries in North Africa and the Middle East.

Table 2.9: North Africa and Middle East Fresh Produce Losses

Country	Crops	Data Collection Methods	Losses (%)	Citation
Egypt	Oranges Tomatoes	Sampling	14% 15%	El Shazly et al 2009
Egypt	Pomegranate Onion	Sampling	23% 19%	Tolba et.al 2009
Iran	Grapes	Survey	13%	Jowkar 2005
Jordan	Tomato Eggplant Pepper Squash	Sampling	18% 19.4% 23% 21.9%	El-Assi 2002
Oman	Fresh produce	Survey	3–19%	Opara 2003
Saudi Arabia	Tomato Cucumber Figs Grapes Dates	Survey	17% 21.3% 19.8% 15.9 %-22.8% 15%	Al-Kahtani and Kaleefah 2011

Source: PEF White Paper 15-02, 2015.

In contrast, Tables 2.11 and 2.12 provide a summary of the literature review findings.

Table 2.10: Summary Table for Literature Review on Fruit Losses

Country/Region	Bananas	Mangoes	Litchis	Citrus	Olives	Fruits
Globally						4-12% at harvest
Bangladesh		3.5% at harvest	20%			23-43%
Benin		17-70%		32%		
Guyana		32%				
Morocco					30%	
Nigeria				40-50%		
Nigeria				30-50%		
Egypt				14%		23% pomegranate
Iran						13% grapes
Oman						3–19%

Saudi Arabia						19.8% figs 16-22% grapes 15% dates
Egypt				21 -30%		
Turkey					9%	
SSA	35.6%	56%		18.8%		
Range	**35.6%**	**32-70%**	**20%**	**14–50%**	**30%**	**3–43%**

Source: NIHORT, 2000; Zulfiqar et al., 2005; Kodjogbe et al., 2008; Vayssieris et al., 2008; WFLO; 2010;; Olayemi et al., 2010; Hassan et al., 2010; Molla et al., 2010; Jolaoso, 2011; Kader et al., 2012; Tatlıdil et al., 2013; FMARD, 2013; Affognon et al., 2014; ADMI, 2015; Parkouda et al., 2015; Salama et al., 2015; Bounfour, 2015; AVRDC, 2014-15; Gautam et al., 2015; Craig et al., 2015; Nabieva, 2015; Gaparova, 2015.

Table 2.11: Summary Table for Literature Review on Vegetable Losses

Country/Region	Tomatoes	Peppers	Leafy Greens	Onions	Vegetables
Globally					4-12% at harvest
Bangladesh	26%	1%	8-15%		23-43%
Benin	13-80%	21%	35-36%		
Guyana	34%				
Nigeria	48%	18- 27%			
Pakistan	22%			9%	
Tajikistan				23%	
Turkey	28%				
Egypt	15-30%			19%	
Jordan	18%	23%			19.4% eggplant 21.9% squash
Oman					3- 19%
Saudi Arabia	17%				21.3% cucumber
SSA	33.7%				
Range	**15–80%**	**18-27%**	**35-36%**	**9-23%**	**3–43%**

Source: NIHORT, 2000; Zulfiqar et al., 2005; Kodjogbe et al., 2008; Vayssieris et al., 2008; WFLO; 2010; Olayemi et al., 2010; Hassan et al., 2010; Molla et al., 2010; Jolaoso, 2011; Kader et al., 2012; Tatlıdil et al., 2013; FMARD, 2013; Affognon et al., 2014; ADMI, 2015; Parkouda et al., 2015; Salama et al., 2015; Bounfour, 2015; AVRDC, 2014-15; Gautam et al., 2015; Craig et al., 2015; Nabieva, 2015; Gaparova, 2015

Information for on-farm losses in production and harvesting is rare for fruits and vegetables in the OIC Member Countries. For fruits it is available only for seven OIC Member Countries: Bangladesh (litchis), Benin (citrus and bananas), Guyana (mangoes), Morocco and Turkey (olives) and Egypt (citrus). Overall, the limited information for on-farm losses for fruit and vegetable crops in the OIC Member Countries shows a range of losses that are similar to FAO estimates.

Table 2.12: Summary Table for Literature Review on On-farm Fruit Losses

Country/Region	Bananas	Mangoes	Litchis	Citrus	Olives	Notes
Bangladesh		3.5%	8%			
Benin		17-70%		10%		Fruit fly damage
Guyana		15%				
Morocco					30%	
Egypt				21-30%		Damage to calyx
Turkey					9%	Harvest and on-farm stockpiling damage
SSA	12.3%					Includes Benin
Range	**12.3%**	**3.5-15%**	**8%**	**10-30%**	**30%**	

Source: NIHORT, 2000; Zulfiqar et al., 2005; Kodjogbe et al., 2008; Vayssieris et al., 2008; WFLO; 2010;; Olayemi et al., 2010; Hassan et al., 2010; Molla et al., 2010; Jolaoso, 2011; Kader et al., 2012; Tatlıdil et al., 2013; FMARD, 2013; Affognon et al., 2014; ADMI, 2015; Parkouda et al., 2015; Salama et al., 2015; Bounfour, 2015; AVRDC, 2014-15; Gautam et al., 2015; Craig et al., 2015; Nabieva, 2015; Gaparova, 2015.

Published reports of on-farm losses of vegetables are available for only eight OIC Member Countries: Bangladesh, Benin, Guyana, Nigeria, Pakistan, Turkey and Egypt. Most studies focused on tomatoes and peppers, but there was one study that included on-farm losses of cabbage and cauliflower in Bangladesh, two studies on leafy greens (amaranths) in Benin, and one study that included on-farm losses of onions in Tajikistan.

Table 2.13: Summary Table for Literature Review on On-Farm Vegetable Losses

Country/Region	Tomatoes	Peppers	Leafy Greens	Onions	Notes
Bangladesh		1%	8-15%		Cabbage and cauliflower
Benin	13-23%	5.9%	17.3-36%		
Guyana	11%				
Nigeria	20%	8-12%			
Pakistan	22%				
Tajikistan				5.3%	
Turkey	28%				
Egypt	15-30%				Sunburn
Range	**11-30%**	**1-12%**	**8-36%**	**5.3%**	

Source: NIHORT, 2000; Zulfiqar et al., 2005; Kodjogbe et al., 2008; Vayssieris et al., 2008; WFLO; 2010;; Olayemi et al., 2010; Hassan et al., 2010; Molla et al., 2010; Jolaoso, 2011; Kader et al., 2012; Tatlıdil et al., 2013; FMARD, 2013; Affognon et al., 2014; ADMI, 2015; Parkouda et al., 2015; Salama et al., 2015; Bounfour, 2015; AVRDC, 2014-15; Gautam et al., 2015; Craig et al., 2015; Nabieva, 2015; Gaparova, 2015.

2.1.5. Meat and Dairy Products

High animal mortality during production or transport are frequently caused by diseases such as pneumonia, digestive diseases and parasites. Mosses of dairy products are mostly due to spillage and market forces. The information presented below reveals specific losses from the literature review per country or region broken down by product type.

Cattle

- Mali: Calf mortality rate overall is 17% during the first year of life and total a 5% perinatal loss (Wymann et al. 2006).
- Pakistan: Calf mortality rate in Peshawar city is 18% in one year (Khan 2007).
- Turkey: FAO study reported losses for cattle meat production, including 10% due to diseases (brucellosis), poor environmental conditions, feeding practices and animal care; and 0.2% losses due to overloading of trucks on farm (Tatlıdil et al, 2013).
- Sub-Saharan Africa: SIK assumed an average 10% mortality rate for cattle bred in SSA.

Milk

The literature revealed some important generalities about milk. Agricultural production losses related to dairy cow illnesses (mostly mastitis infections) are the cause of approximately 3-4% decrease in milk yield worldwide (Gustavsson et al 2011). During the wet season, milk losses reportedly more than doubled because timely collection of milk from farms was hindered by the poor road conditions, which are made even worse by the rains. It is estimated that during the wet season, up to 42.8% of milk produced remains on the farm unsold due to failure of buyers to access remote farms, and spoilage losses at the farm are mainly attributed to unhygienic milk handling (Lore et al 2005).

The number of spoilage bacteria in raw milk depends on the level of hygiene during milking and the cleanliness of the vessels used for collecting, storing and transporting the milk. During the first 2–3 hours after milking, raw milk is protected from spoilage by inherent natural antibacterial substances that inhibit the growth of spoilage bacteria. However, if the milk is not cooled, these antibacterial substances break down causing bacteria to multiply rapidly. Cooling milk to less than 10°C may prevent spoilage for up to three days (ILRI Dairy Training Manual 2006). Souring of milk may not always be considered a loss, since it may be consumed by the farm family or fed to animals (Staal and Kaguongo 2003).

Specific country or regional information is as follows:

- Tajikistan: Milk losses were reported to be 7.2% at production; 0.4% at postharvest and storage; 0.7% at processing and packaging; 4.6% at distribution and 2.0% during marketing for a total of approximately 15% (Nabieva 2015).
- Turkey: Milk losses of 10% were reported due to poor barn conditions, mastitis, poor feeding and milking practices (Tatlıdil et al, 2013).
- Uganda: Spillage of milk on-farm is estimated at 10% to 52% (Kasirye 2003).
- East Africa: Postharvest losses of milk at the farm represented 1.3-6.4% of the value of available milk at the farm level (Lore et al., 2005). The value of milk lost was calculated for each season separately (with lower prices in the wet season when supplies were higher), based on quantities of milk lost at the farm and market chain as determined in the rapid appraisals done for FAO and ILRI. Current aflatoxin infection is due to infested feed that should be thrown away (Gizachew et al., 2016).

Poultry

The FAO has classified poultry production systems in four categories or sectors based on the level of integration of operations, the marketing system and the level of biosecurity. Sector 1 refers to the large-scale integrated commercial systems with high commercial orientation and high biosecurity. Sector 4, at the other extreme, refers to village-level production systems with households raising few birds for their own consumption or for local markets, and minimal levels of biosecurity. Sectors 2 and 3 fall in between these two extremes depending on the level of market linkage and the level of biosecurity.

FAO (2005) estimated the percentage of family scale poultry production, and found high levels in nine OIC member countries in Africa (Cameroon 70%; Cote d'Ivoire 73%; Gambia 90%; Mali 90%; Nigeria 93%; Senegal 70%; Sudan 75%; Togo 70%; Uganda 80%) and in Indonesia (64%) among the top 20. These small scale systems are generally of low productivity but also require very few inputs, and so can be profitable enterprises, as well as a source of improved nutrition for the family. Aflatoxin can be found in meat, but there is no available information.

Specific country or regional information is as follows:

- Bangladesh: Mortality rate in two sampled meat production broiler farms were 7% and 9% (Jabbar et al. 2007).

- Indonesia: Broiler mortality on average for chickens is 6% with the layer mortality at 8% (USAID 2013).
- Jordan: Average broiler mortality for chickens is 5% (AL-Sharafat & Al-Fawwaz 2013).
- Turkey: Transport losses for broilers increase as time in transit increases (from 4% at less than 120 min to 6% live weight loss in 10 hours) (Aral et al 2014).

Eggs

- Bangladesh: Mortality rate of layer hens in poultry farms was 9% for unvaccinated birds and 4.5% for birds vaccinated against Infectious Bursal Disease (IBD) (Huq 2002).
- Sub-Saharan Africa: SIK (2013) assumes an average 8% mortality rate of layer hens.
- Turkey: An FAO case study reported on 6% losses in eggs due to animal deaths due to diseases during production, and 1% losses on farm due to low quality packages/packing materials, rough handling (Tatlıdil et al, 2013).

Table 2.14: Summary Table for Literature Review on Meat and Dairy Losses

Country/Region	Cattle	Poultry	Milk	Eggs	Notes
Mali	17%				
Pakistan	18%				
SSA	10%			8%	Assumptions
Indonesia		6-8%			
Jordan		5%			
Turkey	10.2%	4-6%	10%	7%	
Bangladesh		7-9%			
Globally			3-4%		Mastitis
Tajikistan			15%		
Uganda			10-52%		
Uganda			42%		Unsold in wet season
Bangladesh				4.5-9%	
Globally		Up to 50%		Up to 50%	Avian flu
Range	**10-18%**	**4-50%**	**3-52%**	**4.5-50%**	

Source: Huq 2002; Staal and Kaguongo, 2003; Kasirye, 2003; Lore et al., 2005; FAO, 2005; Wymann et al., 2006; ILRI Dairy Training Manual 2006; Khan, 2007; Gustavsson et al., 2011; AL-Sharafat and Al-Fawwaz, 2013; Tatlıdil et al., 2013; Tatlıdil et al., 2013; USAID, 2013; SIK, 2013; Aral et al 2014; Nabieva, 2015.

The same data sets for meat and dairy products are summarized for on-farm losses in production and harvesting or collecting, and the highest levels of losses were found to be related to uncontrolled diseases (for poultry and eggs) or unsold milk. Data is available for eight OIC Member Countries for cattle, poultry, milk and/or eggs. Overall, the limited information for on-

farm losses for meats and dairy products in the OIC Member Countries shows a range of losses that are similar to FAO estimates.

Globally, poultry and egg production are growing rapidly, and high density production methods can increase disease incidence and quickly spread to the entire flock. Avian flu virus and Newcastle disease can cause 50% or higher mortality if left uncontrolled.

Table 2.15: Summary Table for Literature Review on On-farm Meat and Dairy Losses

Country/Region	Cattle	Poultry	Milk	Eggs	Notes
Mali	17%				Mortality
Pakistan	18%				Mortality
Indonesia		6-8%			Mortality
Jordan		5%			Mortality
Turkey	10.2%		10%	7%	FAO case studies
Bangladesh		7-9%		4.5-9%	Mortality
Tajikistan			7.2%		
Uganda			10-52%		Spillage
Uganda			42%		Unsold in wet season
Range	**10-18%**	**5-9%**	**7-52%**	**4.5-9.0%**	

Source: Huq 2002; Staal and Kaguongo, 2003; Kasirye, 2003; Lore et al., 2005; FAO, 2005; Wymann et al., 2006; ILRI Dairy Training Manual 2006; Khan, 2007; Gustavsson et al., 2011; AL-Sharafat and Al-Fawwaz, 2013; Tatlıdil et al., 2013; Tatlıdil et al., 2013; USAID, 2013; SIK, 2013; Aral et al 2014; Nabieva, 2015.

2.1.6. Fish and Seafood

Globally, estimates of postharvest fish losses range between 20-75%. The severity of the situation is described in FAO Fisheries and Aquaculture Technical Paper No. 550. The perishability of fish makes it more susceptible to losses in hot tropical developing countries.

Aquaculture is often cited as the cause of huge losses to pelagic fish stocks (pilchards and sardines etc.) because these are used to produce fish meal and fodder for prawns and salmon in farms. Losses and wastage from the farm-produced seafood are normally controlled and well managed, since capital intensive value chains are established. The food losses therefore are more "political" issues like the morality of usage of fishmeal and waste or usage of pelagic fish for production of "luxury food" exports instead of for local fish consumption.

According to FAO experts, small-scale fisheries (SSFs) do not usually throw fish away. Their physical losses are caused by animal and bird depredation, insect infestation, fish being washed back into the water or spilling on the ground, and some issues related to food safety. From most assessments conducted in the past decade by FAO, deliberate discarding of fish is found to be a

highly undesirable act by fishers, under the prevailing scarcity of aquatic resources. Studies indicate that physical losses in SSFs are low, ranging from less than 5% to 10%. Quality losses are much higher, and may account for more than 70% of total losses.

Case studies in Bangladesh reported 12-15% quality loss for the national fish (ilish) and a total aquaculture production of 1 billion tonnes per year (Nowsad Alam 2010). A case study undertaken in North Java, Indonesia assessed fish losses along the entire food chain. In Muara Angke, the major fish in fishing ports and processing centers was squid which was further processed into boiled salted squid without drying. The possibility of losses may occur at any step throughout the supply chain, starting from fish capture, fish landing to consumption (estimated to be 30% in some reviews). However, the actors in the food supply chain seemed to be aware of this possibility of losses and they have found strategies to overcome them. It was recorded that the losses were less than 5%.

This result can be used as a good example for fish loss reduction in any other food supply chain in Indonesia (Wibowo et al 2015). Fisheries (small artisanal) have problems with technical and logistical problems like infrastructure and missing cold chains or exploitation by traders. Lack of the use of ice at the time of harvest can lead to very high fish losses (70-100%) by the time of marketing a few hours or days later. In Mozambique, fish losses were assessed within the range of 39-58% (Wilson and Zithers, 2007). Forty percent of fish feeds and salted fish were contaminated with aflatoxin at mean levels of 105.2±1.3 and 44.1±0.4 ppb respectively.

Table 2.16: Summary Table for Literature Review on Fisheries Losses

Country/Region	Quantity Losses	Quality Losses	Notes
Bangladesh		12-15%	Ilish
Indonesia	5%		Squid
Indonesia	70-100%		Artisanal, lack of the use of ice
Mozambique	39-58%		Entire food supply chain
Globally	5-10%	70%	FAO FISH STAT
Range	**5-100%**	**12-70%**	

Source: Wilson and Zithers, 2007; Nowsad Alam, 2010; Wibowo et al., 2015.

When the same data set is summarized for published studies documenting on-farm fisheries losses, there is much less data to report. None of the data is directly related to on-farm losses in the OIC Member Countries.

Table 2.17: Summary Table for Literature Review on On-Farm Fisheries Losses

Region	Quantity Losses	Quality Losses	Notes
Globally	5-10%		FAO FISH STAT

Source: Wilson and Zithers, 2007; Nowsad Alam, 2010; Wibowo et al., 2015.

2.2 Estimates of On-Farm Losses by Key Informants

Key informants were asked to identify the stage of on-farm losses in production, harvesting, and on-farm handling, rate the level of on-farm losses, and provide information on the causes of losses for each food group. Potential on-farm related causes were listed in detail as the first 11 choices, but key informants were allowed to identify other possible causes of food losses. Key informants rated the levels of on-farm losses on a rating scale where:

- 5 = very high (more than 50%)
- 4 = high (30 to 50%)
- 3 = moderate (10 to 30%)
- 2 = low (5 to 10%)
- 1 = very low (less than 5%)

The rate of on-farm losses are summarized for each of the food groups as follows. On-farm losses for perishable crops were rated higher than on-farm losses of less perishable crops.

Table 2.18: Summary of Key Informant Rating of On-Farm Losses by Food Group

	Average Key Informant Ratings (Q1)			Overall Rating of On-Farm Losses (Q3)
Food Group	**Production**	**Harvesting**	**Handling**	
Cereals	Low	Low	Low	Moderate (10-30%)
Roots and Tubers	Moderate	Moderate	Low	High (30-50%)
Oilseeds and Pulses	Low	Low	Low	Moderate (10-30%)
Fruits and Vegetables	Moderate	Moderate	Moderate	High (30-50%)
Meats and Eggs	Low	Very Low	Very Low	Low (5-10%)
Milk and Dairy	Low	Low	Low	Moderate (10-30%)
Fish and Seafood	Low	Low	Low	Moderate (10-30%)

Source: Key Informant Surveys

There were no major differences between the average ratings of the key informants from each of the OIC Member Country Groups or within the three major stages of on-farm losses (production, harvesting and handling) when these stages were each rated individually. Milk and dairy products were an exception as the rated on-farm losses in UAE, Syria, Bangladesh and Indonesia were higher than for any of the other countries.

Cereals

Overall, for cereals, key informants rated the on-farm losses low for each stage, with a sum of a moderate level of on-farm losses of 10-30%.

Roots and Tubers

Key informants rated on-farm losses for root and tuber crops as low to moderate for each stage, with a sum of a high level of on-farm losses of 30-50%. Estimated losses during harvesting and handling were rated slightly higher than production losses.

Oilseeds and Pulses

Overall, for oilseed and pulses, key informants rated the on-farm losses as low for each stage, with a sum of a moderate level of on-farm losses of 10-30%.

Fruits and Vegetables

For fruits and vegetables, the overall rate by the key informants of the on-farm losses was higher than those for staple crops, and moderate for each stage, with a sum of 30-50% which is related to high levels of on-farm losses.

Meat and Eggs

Key informants for meat and eggs ratings for on-farm losses for the Africa Group were slightly higher than for those in the Arab and Asian Groups. Overall, key informants rated the on-farm losses as low to very low for each stage, with a sum of a low level of on-farm losses of 5-10%.

Milk and Dairy

On-farm losses for milk and dairy as rated by key informants in the United Arab Emirates (UAE), Syria, Bangladesh and Indonesia were higher than the other countries. Overall, key informants rated milk and dairy on-farm losses as low for each stage, with a moderate of on-farm losses of 10-30%. Key informant average ratings were slightly higher for harvesting and collection for the Arab group, and slightly higher for handling for the African Group.

Fish and Seafood

Key informants rated on-farm losses for fish and seafood as low for production, harvesting and handling, with a moderate sum of aquaculture production or fishing losses of 10-30%.

2.3. Summary of Available Information for On-Farm Losses for the OIC Member Countries

All the data provided in the literature reviews and key informant survey results for on-farm losses in the OIC Member Countries are reported in Tables 2.19-2.21 located below and organized by group. These tables include information reported in the case studies, which are discussed in Section 3. Fifty-seven countries and six food groups create a total of 342 combinations, each of which may refer to data on several individual key crops or food products. However, information for individual countries was found to be rare, literature reviews offered information on only a few crops and animal foods, and 64 key informants provided estimates based upon their personal perceptions for the food groups that fell within their area of expertise. For many of the countries there was a single key informant, which makes any generalizations less reliable.

Overall, the perceived and measured on-farm losses for perishable plant based foods (roots and tubers and fruits and vegetables) were higher than on-farm losses reported for staple crops (cereals, oilseeds and pulses). On-farm losses for meats, eggs, milk and dairy products and fish and seafood were generally low, but varied more widely from country to country, depending on whether the cooling, which occurs via ice or refrigeration is available after harvesting or collection to slow the rate of losses.

Table 2.19: Summary of Data Sources and Estimates of On-Farm Losses for the Arab Group

Country	Food Group	Literature Reviews	Key Informant (#) & Loss Estimates for Production, Harvest, & Handling Stages	Case Studies
Egypt	Cereals		(3) 5-10%/5-10%/5-10%	
	Roots & Tubers		(3) 10%/5-10%/5-10%	
	Oilseeds & Pulses		(3) 5-10%/5-10%/5-10%	
	Fruits & Vegetables	21-30% Citrus 15-30% Tomatoes	(3) 10-30%/10-30%/30%	15% Tomatoes
	Meat & Dairy		(2) 5%/5-10%/5-10%	
	Fish & Seafood		(2) 5-10%/5%/5%	
Iraq	Cereals		(1) 10-30%/10-30%/5-10%	
	Roots & Tubers		(1) 0-5%/10-30%/0-5%	
	Oilseeds & Pulses		(1) 10-30%/0-5%/5-10%	
	Fruits & Vegetables		(1) 10-30%/0-5%/10-30%	
	Meat & Dairy		(1) 5-10%/5-10%/10-30%	
	Fish & Seafood		(1) 0-5%/0-5%/10-30%	
Jordan	Cereals		(2) 10-30%/0-5%/0-5%	
	Roots & Tubers		(2) 10-30%/0-5%/0-5%	
	Oilseeds & Pulses		(2) 5-10%/5-10%/5-10%	
	Fruits & Vegetables		(1) 10-30%/0-5%/0-5%	
	Meat & Dairy		(2) 10%/10%/10%	
	Fish & Seafood	5% Poultry		
Lebanon	Cereals		(4) 5-10%/5-10%/5-10%	
	Roots & Tubers		(4) 10%/10%/10-30%	
	Oilseeds & Pulses		(2) 5-10%/5-10%/5-10%	

Country	Food Group	Literature Reviews	Key Informant (#) & Loss Estimates for Production, Harvest, & Handling Stages	Case Studies
	Fruits & Vegetables		(4) 10-30%/10-30%/30-50%	
	Meat & Dairy		(3) 5-10%/5-10%/5-10%	
	Fish & Seafood		(1) 5-10%/10-30%/10-30%	
Morocco	Oilseeds & Pulses	30% Olives		
Palestine	Fruits & Vegetables		(1) 10-30%/10-30%/10-30%	
	Meat & Dairy		(1) 0-5%/10-30%/10-30%	
Sudan	Cereals		(2) 10-30%/0-5%/0-5%	
	Roots & Tubers		(1) - / 5-10%/5-10%	
	Fruits & Vegetables		(2) 10%/5-10%/10-30%	
Syria	Cereals		(1)10-30%/30-50%/10-30%	
	Roots & Tubers		(1) 5-10%/5-10%/10-30%	
	Oilseeds & Pulses		(1) 5-10%/10-30%/10-30%	
	Fruits & Vegetables		(1) 10-30%/10-30%/30-50%	
	Meat & Dairy		(1) 5-10%/5-10%/10-30%	
	Fish & Seafood		(1) 5-10%/10-30%/10-30%	
UAE	Cereals		(1) 50% and higher	
	Roots & Tubers		(1) 50% and higher	
	Oilseeds & Pulses		(1) 30%	
	Fruits & Vegetables		(1) 50% and higher	
	Meat & Dairy		(1) 30%	
	Fish & Seafood		(1) 10%	
Yemen	Cereals		(3) 10-30%/10-30%/10-30%	
	Roots & Tubers		(3) 10-30%/10-30%/10-30%	
	Oilseeds & Pulses		(3) 5-10%/10-30%/10-30%	
	Fruits & Vegetables		(3) 10-30%/30-50%/30-50%	
	Meat & Dairy		(2) 5-10%/10-30%/10-30%	
	Fish & Seafood		(2) 5-10%/10%/10%	

Source: Key Informant Surveys.

Table 2.20: Summary of Data Sources and Estimates of On-Farm Losses the Asian Group

Country	Food Group	Literature Reviews	Key Informant (#) & Loss Estimates for Production, Harvest, & Handling Stages	Case Studies
Afghanistan	Fruits & Vegetables		(2)30%/30%/30-50%	
Albania	Cereals		(2) 10%/10-30%/30%	
	Roots & Tubers		(2) 10-30%/10%/10-30%	
	Oilseeds & Pulses		(2) 10%/10-30%/10-30%	
	Fruits & Vegetables		(2) 10%/10%/10-30%	
	Meat & Dairy		(2) 5-10%/5-10%/10%	
	Fish & Seafood		(2) 10%/10%/10%	
Bangladesh	Cereals	1-6.5% Rice	(4) 10%/5-10%/5-10%	
	Roots & Tubers		(4) 5-10%/10-30%/10-30%	
	Oilseeds & Pulses		(4) 5-10%/5-10%/5-10%	
	Fruits & Vegetables	8% Litchis	(4)10-30%/10-30%/10-30%	
	Meat & Dairy	7-9% Broilers 4.5-9% Layers	(2) 5-10%/5-10%/5-10%	
	Fish & Seafood		(1) 10-30%/10-30%/5-10%	
Indonesia	Cereals		(3) 0-5%/5-10%/10-30%	
	Roots & Tubers		(2) 5-10%/10-30%/10-30%	
	Oilseeds & Pulses		(1) 10-30%/30-50%	
	Fruits & Vegetables		(3)30-50%/30-50%/10-30%	
	Meat & Dairy	6-8% Poultry	(2)10-30%/10-30%/10-30%	
	Fish & Seafood	5-10% Fish	(1) 0-5%/10%/10-30% (1) 5% or less (aquaculture farm visits in 2015)	5% shrimp 5% tilapia
Iran	Cereals	0.5 – 2% Maize	(1)10-30%/30-50%/10-30%	
	Roots & Tubers		(1)10-30%/10-30%/10-30%	
	Oilseeds & Pulses		(1)30-50%/30-50%/30-50%	
	Fruits & Vegetables		(1) 0-5%	
	Meat & Dairy		(1) 0-5%	

Country	Food Group	Literature Reviews	Key Informant (#) & Loss Estimates for Production, Harvest, & Handling Stages	Case Studies
Malaysia	Roots & Tubers		(1) 0-5%/0-5%/0-5%	
	Oilseeds & Pulses		(1) 10-30%/10-30%/0-5%	
	Fruits & Vegetables		(1) 0-5%/0-5%/0-5%	
	Meat & Dairy		(1)10-30%/10-30%/10-30%	
	Fish & Seafood		(1) 0-5%/0-5%/0-5%	
	Fish and Seafood		(1) 0-5%/0-5%/0-5%	
Pakistan	Cereals		(4) 5-10%/10-30%/10-30%	
	Roots & Tubers		(3) 5-10%/10-30%/10-30%	
	Oilseeds & Pulses		(2) 5%/10%/10%	
	Fruits & Vegetables	22% Tomatoes	(3) 10-30%/5-10%/30-50%	
	Meat & Dairy	18% Cattle	(2) 5-10%/0-5%/10-30%	
	Fish & Seafood		(3) 5-10%/5-10%/10%	
Tajikistan	Cereals	4.3% Wheat	(2) 5-10%/10-30%/10-30%	
	Roots & Tubers		(2) 5-10%/5-10%/10-30%	
	Oilseeds & Pulses		(1) 5-10%/0-5%/5-10%	
	Fruits & Vegetables	5.3% Onions	(2) 0-5%/ 30-50%/30-50%	
	Meat & Dairy	7.2% Milk	(1) 0-5%/0-5%/5-10%	
	Fish & Seafood		(1) 0-5%/0-5%/10-30%	
Turkey	Cereals	9.1% Wheat	(1) 5-10%/10-30%/10-30%	
	Roots & Tubers	7% Potatoes	(2) 5-10%/5-10%/10-30%	
	Oilseeds & Pulses	9% Olives	(1) 5-10%/0-5%/5-10%	
	Fruits & Vegetables	28% Tomatoes	(2) 5-10%/30-50%/10-30%	
	Meat & Dairy	10.2% Cattle 10% Milk 7% Eggs	(1) 0-5%/10-30%/5-10%	4% Broiler Chickens
	Fish & Seafood		(1) 0-5%/10-30%/10-30%	
	Cereals		(1) 5-10%/10-30%/10-30%	

Country	Food Group	Literature Reviews	Key Informant (#) & Loss Estimates for Production, Harvest, & Handling Stages	Case Studies
Uzbekistan	Roots & Tubers		(2) 5-10%/10-30%/10-30%	
	Oilseeds & Pulses		(1) 5-10%/5-10%/5-10%	
	Fruits & Vegetables		(2) 5-10%/10-30%/30%	
	Meat & Dairy		(1) 5%/ 5-10%/5-10%	
	Fish & Seafood		(1) 5-10%/5-10%/5-10%	
Guyana	Cereals		(2) 10-30%/30-50%/5%	
	Roots & Tubers		(2) 5-10%/5-10%/10%	
	Oilseeds & Pulses	6.5% Cassava	(2) 10-30%/10-30%/10%	
	Fruits & Vegetables	15% Mangoes 11% Tomatoes	(2) 10%/5-10%/10-30%	
	Meat & Dairy		(1) 10-30%/5-10%	
	Fish & Seafood		(1) 10-30%/5-10%	

Source: Key Informant Surveys.

Table 2.21: Summary Data Sources and Estimates of On-Farm Losses for the African Group

Country	Food Group	Literature Reviews	Key Informant (#) & Loss Estimates for Production, Harvest, & Handling Stages	Case Studies
Benin	Cereals		(3)10%/5-10%/10%	
	Roots & Tubers	13.6% Cassava	(2) 10%/10%/30%	
	Oilseeds & Pulses		(1) 5-10%/5-10%/5-10%	
	Fruits & Vegetables	10% Citrus 17-70% Mangoes 12.3% Bananas 23% Tomatoes 13% Tomatoes 5.9% Peppers 17.3% Leafy Greens 36% Leafy Greens	(3) 30%/30%/30-50%	
	Meat & Dairy		(3) 5-10%/5-10%/5-10%	

Country	Food Group	Literature Reviews	Key Informant (#) & Loss Estimates for Production, Harvest, & Handling Stages	Case Studies
	Fish & Seafood		(1) --/10-30%/10-30%	
Burkina Faso	Cereals		(3) 5-10%/5-10%/5-10%	
	Roots & Tubers		(1)10-30%/10-30%/30-50%	
	Oilseeds & Pulses		(1) 10-30%/5-10%/0-5%	
	Fruits & Vegetables		(3) 30%/10-30%/30-50%	
	Meat & Dairy		(2) 10-30%/0-5%/0-5%	
	Fish & Seafood		(1) 0-5%/0-5%/5-10%	
Cameroon	Cereals	14% Rice	(1) 10-30%/5-10%/0-5%	
	Roots & Tubers		(1) 10-30%/10-30%/5-10%	
	Oilseeds & Pulses		(1) 10-30%/10-30%/0-5%	
	Fruits & Vegetables		(1) 5-10%/30-50%/5-10%	
	Meat & Dairy		(1) 5-10%/5-10%/0-5%	
	Fish & Seafood		(1) 10-30%/0-5%/0-5%	
Gabon	Cereals		(1) 0-5%/5-10%/5-10%	
	Roots & Tubers		(1) 5-10%/0-5%/10-30%	
	Oilseeds & Pulses		(1) 5-10%/0-5%/5-10%	
Gambia	Cereals		(1) 5-10%/10-30%/5-10%	
	Roots & Tubers		(1) 0-5%/30-50%/10-30%	
	Oilseeds & Pulses		(1) 5-10%/30-50%/5-10%	
	Fruits & Vegetables		(1)10-30%/30-50%/10-30%	
	Meat & Dairy		(1) 10-30%/ --/ 5-10%	
	Fish & Seafood		(1) --/--/ 50% or more	
Mali	Oilseeds & Pulses	20-30% Groundnuts		
	Meat & Dairy	17% Cattle		
	Cereals		(4) 10%/10-30%/10-30%	

Country	Food Group	Literature Reviews	Key Informant (#) & Loss Estimates for Production, Harvest, & Handling Stages	Case Studies
Nigeria	Roots & Tubers	28% Cassava 37% Yams	(4) 5-10%/5-10%/10%	2-5% Cassava 2-5% Sweetpotato
	Oilseeds & Pulses		(4) 5-10%/5-10%/5-10%	
	Fruits & Vegetables	8-10% Peppers 20% Tomatoes	(4)10-30%/10-30%/10-30%	
	Meat & Dairy		(3) 5-10%/10-30%/10-30%	
	Fish & Seafood		(4) 10%/10%/10%	
Senegal	Cereals		(2) 5-10%/10%/10-30%	
	Roots & Tubers		(2) 5-10%/10-30%/30-50%	
	Oilseeds & Pulses		(2) 10-30%/10%/10%	% Groundnuts
	Fruits & Vegetables		(3) 10%/10-30%/30-50%	
	Meat & Dairy		(2) 5-10%/5-10%/10-30%	
	Fish & Seafood		(4) 5-10%/5-10%/5-10%	
Sierra Leone	Cereals		(1) 5-10%/5-10%/0-5%	
	Roots & Tubers		(1) 0-5%/0-5%/0-5%	
	Oilseeds & Pulses		(1) 0-5%/0-5%/0-5%	
	Fruits & Vegetables		(1) 0-5%/0-5%/0-5%	
	Meat & Dairy		(1) 0-5%/5-10%/0-5%	
	Fish & Seafood		(1) 0-5%/0-5%/0-5%	
Uganda	Cereals	4% Maize	(2) 10%/10-30%/10%	10% Maize
	Roots & Tubers		(1) 5-10%/10-30%/10-30%	
	Oilseeds & Pulses	30% Dry Beans	(1) 5-10%/5-10%/5-10%	
	Fruits & Vegetables		(1) 5-10%/30-50%/10-30%	5% Bananas, Plantains
	Meat & Dairy	10-52% Milk	(1) 0-5%/10-30%/10-30%	
	Fish & Seafood		(1) 0-5%/10-30%/10-30%	

Source: Key Informant Surveys.

3. CASE STUDIES

As described in the methodology for the analytical study, the consultants made a series of field visits for collecting more detailed data for the case studies. Each case study focused on one country and one or two agricultural commodities. The consultants used interviews, observations and detailed face-to-face surveys with national researchers, extension officers as well as private sector representatives. The commodities analyzed in these case studies were chosen from the key agricultural products for each country that were in season during the field visits.

Value chain assessments were conducted by field teams using a modified Commodity Systems Assessment Methodology (CSAM), focusing mainly on the pre-production and production period, up until the harvest and farm gate. The case studies cover the period of time during production, including any pre-harvest factors that may lead directly to losses, harvesting, handling on the farm until farm gate, which includes transport away from the farm and/or the selling to a buyer who takes responsibility for the crop.

CSAM is a systematic process of using surveys, interviews, and observations to collect data on the key aspects of the value chain, including postharvest handling and marketing (La Gra 1990; Kitinoja and Kasmire 2002). A standardized data collection worksheet was used by each of the field teams to measure losses and quality of the crops on-farm.

For all site visits in each case study, quality sorting was performed by the consultant via a random selection of 20 samples. Percentages were based on a quality sort (# out of count of 20) with ratings from 5 for extreme defects, decay or damage; 3 for moderate defects, decay or damage; and 1 for none.

The results from these rapid assessments, focusing mainly on the production and harvesting components provide input for promoting technology awareness, adoption and utilization, as well as help to answer key research questions to inform the OIC Member Country policy and programming.

3.1. Case Study 1: Maize in Uganda

Maize *zea mays L.* is an important cereal crop, with 900 million tonnes produced worldwide. Among the OIC Member Countries, Uganda, Indonesia, Nigeria, Egypt, Pakistan, Turkey are all major producers.

Uganda provides over 40% of the calories from maize consumed in both rural and urban areas. The crop has increasingly become a staple food in many parts of the country due to changes in peoples eating habits. Small-scale farmers, who constitute the bulk (80%) of the rural poor, also account for the largest share of maize production. It is grown in every part of the country and a direct source of livelihood to over two million households, over 1000 traders/merchants and 600 millers. Increasingly, maize has become a major non-traditional export cash crop particularly benefitting smallholder farmers. Two crops per year can be produced due to the bimodal rainfall pattern in Uganda (World Bank 2011).

3.1.1. Status and Importance

Although there are many ethnic groups in Uganda representing various cultures, maize is the only crop that is grown across the country. It is consumed by all in various forms, such as roasting while fresh or processing into maize flour to make posho and porridge. Posho and porridge are consumed in all institutions, primary and secondary schools, universities, prisons and military barracks. Posho is a major meal in all lower income earners and middle class. It is also exported to the neighboring countries of Kenya, Tanzania, Democratic Republic of the Congo (DRC), Rwanda, Burundi and Southern Sudan.

The volume of maize production in Uganda was 2.8m tonnes per annum in 2012 and in 2013 (FAOSTAT). Maize is the 5th most important crop in Uganda in terms of production, after plantains, cassava, sweet potatoes and sugar cane.

3.1.2. Assessment of On-Farm Losses and Economic Burden

The seasons for maize production in southwest Uganda are July to September and January to March. On-farm assessments at six maize farms in southwestern Uganda provided the following data on losses related to on-farm practices.

Table 3.1: On-Farm Practices at Six Maize Farms in Uganda

Farm	Details on Farm	Quality Sort by Consultant for Extreme Defects or Decay	Quality Sort by Consultant For Moderate Defects or Decay	Notes on On-Farm Practices for Maize
1	50 acres SW Uganda Crops: maize, tomatoes, papaya, bananas, mangoes, sweet pepper, coffee	10%	15%	Dried in maize crib to 14% moisture, shelled with motorized sheller, stored on-farm for 1 month.
2	10 acres SW Uganda Crops: maize, beans, cassava, cabbages, tomatoes, coffee	30%	10%	Dried on cobs on the ground, shelled by beating with sticks, 40% was decayed in 3 weeks.
3	17 acres SW Uganda Crops: maize, beans, potatoes, coffee, cassava, cabbages, tomatoes	20%	15%	Dried in the garden to 20% moisture, motorized shelling, stored in sacks for 1 month.
4	40 acres SW Uganda Crops: maize, coffee, beans, potatoes, cassava, onions, Passion fruits	45%	15%	Dried on a tarpaulin on-farm to 25% moisture, shelled, stored for 1 month in woven sacks.
5	32 acres SW Uganda Crops: maize, beans, potatoes, coffee, cassava, onions, Jack fruits	10%	15%	Dried on a tarpaulin on-farm to 18% moisture, shelled, stored for 1 month in woven sacks.
6	11 acres SW Uganda Crops: maize, beans, cassava, watermelon, coffee	15%	5%	Dried on-farm on cobs to 18% moisture, shelled, stored for 2 weeks in woven sacks.
Range: 10-45% with extreme defects or decay after 2 weeks-one month of on-farm storage.				
Conservative Estimate of On-Farm Losses: 10-15%				

Source: Site Visits and Interviews Conducted During Assessment.

The consultant was not present during the harvest, but observed maize cobs left behind in the field (estimated at 5%). Muyinza et al (2015) recently measured harvest losses for maize in Uganda of 4%; followed by 20% losses after three months of storage on farm. The World Bank

(2011) reported maize losses in Sub-Saharan Africa during harvesting, field drying, shelling, and on-farm storage for three months at 17.9 % for hot humid zone small scale farms.

The maize assessed during the field visits suffered from extreme defects and decay on 10-45% of the crop. Taking a conservative estimate of on-farm losses of 10-15% during harvesting and drying, and a total production of 2.8 metric tonnes per year, maize losses on farm equal 280,000 to 420,000 tonnes per year. Maize has a food value of 3700 kilocalories per kg, which means that on-farm losses in food value is at a minimum of 1.04 trillion kilocalories. This amount could have fed 1.14 million persons for a full year at 2500 kcal/day or 3.4% of Uganda's population of 34 million. At a farm gate value of US$250-300 per tonne, the loss of economic value for Uganda's maize farmers is in the range of US$70 to $126 million.

Table 3.2: Summary of the Volume and Market Value of On-Farm Losses of Maize in Uganda

Total Volume Produced per Annum	Conservative Estimates of On-Farm Losses	Losses in Volume	Market Value per Tonne	Losses in Value
2.8 Million Tonnes ($700 to 840 million)	10%	280,000	$250	$70 million
	10%	280,000	$300	$84 million
	15%	420,000	$250	$105 million
	15%	420,000	$300	$126 million

Source: Based on Above Estimates.

3.1.3. Causes of On-Farm Losses

There are a range of factors causing on-farm food loss for maize. These include:

- Improper use of fertilizers and herbicides.
- Poor pest and disease management practices.
- Poor harvesting practices, such as leaving cobs behind in the field when harvested maize is collected.
- Poor drying practices allow maize to become decayed (whether stored in piles, sacks or cribs). Drying the crop directly on the ground can attract insect pests and also be a source of aflatoxin contamination.
- Poor shelling practices, such as beating the cobs with sticks or trampling the cobs.

Some farmers use Diammonium Phosphate (DAP) and urea fertilizers when they are not well informed about the effects on the soil, which leads to acidification. Other farmers use and on occasion misuse herbicides (Glyphosate and 2-4 D amine) which affects the quality of the produce. Mono cropping without use of fertilizers has negatively impacted maize productivity.

The majority of the farmers first cut the maize before it's completely dry. This is done to reduce damage to the crop during harvest, and to facilitate quick drying. It enables farmers to benefit from higher prices because at the peak of the harvest, prices normally fall. If it is dry enough, farmers begin to harvest at any time of the day beginning from morning. Once cut, the maize stalks stay in the field for about a week or two depending on the intensity of the heat.

Uganda faces additional challenges including maize streak virus, maize weevils, white leaf blight and maize rust, maize stalk borer, army worms that attack maize during production, and witch weed (striga) that causes stunting. Birds also cause tremendous losses especially in regions where birds are not considered a food source.

Table 3.3: Percent Losses when Maize is Harvested at Various Stages Beyond Full Maturity

% Moisture at Harvest (Full Maturity = 30% Moisture)				
	30%	**25%**	**20%**	**15%**
Missing Grain	1.4%	2.6%	4.7%	8.7%
Damaged Grain	5.5%	8.5%	12.9%	19.7%

Source: Odogola and Henriksson, 1991.

Maize is collected from the field after drying, with approximately 5% overlooked and left to rot on the ground and then shelled and stored or sold. There is no grading, and if sorted, the same price per kg is offered. There are no local or national regulatory standards.

One potential solution could be the use of picking bags to harvest maize that is partially dried while standing on the stalk, followed by the use of tarpaulin to protect the crop during handling and while completely drying the maize. One picking bag costs approximately US $4 and a tarpaulin of 5mx8m costs approximately US $12.

Figure 3.1: Decay Symptoms in Stored Maize and in Maize with Beans

Source: Site visits conducted during assessment.

3.1.4. Measures and Strategies Implemented for On-Farm Loss Reduction in Uganda

The objective of the postharvest handling and storage (PHHS) project was to disseminate improved drying, threshing, cleaning, and storage technologies in the major grain-producing areas of Uganda. The project was funded by the United States Agency for International Development (USAID) and Uganda and was initially planned to be housed at the national postharvest program (Kawanda); however, the project was merged with the IDEA project and implemented by the food and feed grain institute (FFGI) and Kansas State University (KSU).

On strategy for improved maize drying on the farm can be done using a maize crib, which is elevated on poles with cement footing and screened to prevent rodent damage during drying.

Figure 3.2: Maize Crib in Uganda

Photo source: Field visits

Other projects targeted low-value crops, including maize, rice, wheat, and beans in the major grain-producing districts of Uganda. One project, active in the districts of Kapchorwa, Iganga, Masindi, Lira, Kasese, and Kiboga, where large volumes of maize are produced annually, started the manufacture of a range of new postharvest equipment in Uganda, with permission and design from IRRI. By the end of project, it had helped to establish three local workshops in Uganda to manufacture threshers and dryers as well as cleaning and grading equipment. These factories have continued to operate since the end of funding in 2001 (World Bank 2011).

There are many private companies that deal with maize produce, export, and value addition. A new organization, Amatheon Agriculture (from the United States) will soon come on board with anticipated new incentives. The World Food Programme (WFP) is working in Uganda and Burkina Faso to develop improved handling, drying and storage for cereals and pulses. They have recently published a new training manual, which be located online and is listed in the references. The International Rice Research Institute (IRRI) also provides field manuals on harvesting and on-farm operations for rice, which can be located on-line.

3.1.5. Lessons Learned from the Case Study

The field visits revealed several practices that raise concerns and can lead to an increase in on-farm losses. Maize threshed by beating and dried on-farm without using a crib was slow to dry and likely to develop decay. The same conditions that lead to fungi attack and mold development may also create an environment that allows aflatoxin to develop on stored maize.

Specific recommendations to reduce on-farm losses for cereals include:

- Harvest maize at the optimum time, when the stalks have dried and moisture of the grain is about 30%.
- Ensure the harvesting tools, drying location and equipment is clean and disinfected, ready to receive the cobs. This includes carts, wheel barrows, bags and baskets.

- Harvest gently, using a picking bag to collect the maize cobs. Straps help to distribute the load, and the bottom of the bags can open for gentle release of the crops into field containers. Examples can be viewed by visiting the Pleasant Hill Grain website.
- Dry properly on-farm to 12-15% moisture before shelling or threshing, packaging, transport or storage.
- Keep the grain as clean as possible; dry on cement floor or on tarpaulin to reduce chance of soil contamination.
- Dry maize on smaller tarps. This facilitates the good practice of bringing the drying crop indoors at night and/or if it is threatening to rain.
- Avoid beating maize to shell the kernels from the cobs as it damages the grains and makes them more susceptible to diseases and rots. Losses due to spillage are common during shelling that is done by beating the cobs with sticks.

General recommendations for reducing on-farm losses for grains include:

- Harvest at proper moisture of 30% for maize; 20-25% for rice; 16-20% for dry beans.
- Drying facilities are considered particularly important in light of climate change that has sometimes caused wet spells just before harvest resulting in inadequately dried crops leading to mycotoxin formation and poor quality.
- Encourage the development of an on-farm, low-cost drying process that is able to bring down the moisture content of crops to 13% as fast as possible to reduce losses. Low moisture (8-13%, depending on the commodity) reduces significant loss of product due to deterioration in the quality of the product.

3.2. Case Study 2: Sweetpotato in Nigeria

Sweetpotato *Ipomoea balatas,* is a very important food crop in Nigeria, and it is similar to malanga, yam, taro, cocoyam, potato, and cassava which are produced in many of the OIC member countries. Sweetpotato is an excellent source of Vitamin A for the sub-Saharan Africa where lack of Vitamin A weakens the immune system, leaving an individual more susceptible to deadly diseases such as measles, malaria, and diarrhea.

3.2.1. Status and Importance

Nigeria is the second largest producer of sweetpotato in the world after China (FAOSTAT 2015) producing 3,450,000 tonnes in 2013 with a yield of 30,804 hg/ha (FAOSTAT, 2015). It is generally considered as a minor crop within Nigeria, in terms of total production and consumption due to the fact that it is usually grown and locally consumed by independent smallholders on small plots. However, sweetpotatoes are gaining importance in the Nigerian diet due to the relative ease of cultivation, early maturity (compared to other root and tuber staples) and enormous industrial and economic potentials (Fawole, 2007).

The Tuber and Root Information System (TRIS), developed by the International Institute of Tropical Agriculture (IITA), has taken a different approach for sweetpotato, as well as yams and cassava, by modeling the physical parameters which estimate an ordinal suitability ranking for each crop across Africa. Rankings are determined by a combination of factors including soil classes, annual rainfall, temperature regimes and length of growing period (Tewe et. al. 2001). The TRIS model indicates that most potential sweetpotato cultivation in Nigeria occurs in the "middle belt" (Tewe et. al. 2001), a broad range of the country occurring from approximately 7-11° North.

3.2.2. Assessment of On-Farm Losses and Economic Burden

On-farm assessments during field visits at six sweetpotato farms in Ogun State provided the following data. Losses at the moment of harvest were relatively low.

Table 3.4: On-Farm Assessments at Six Sweetpotato Farms in Ogun State

Farm	Farm Details	Sorted During Harvest	Quality Sort by Consultant (Extreme Defects or Decay)	Quality Sort by Consultant (Moderate Defects or Decay)	Sorted for Size (% Discarded by Trader at Farm Gate
1	0.5 ha Sweet-potatoes	1%	15%	35%	35% medium 65% small 0% discards
2	0.7 ha Sweet-potatoes	2%	15%	40%	5% large 20% medium 75% small 0% discards

Farm	Farm Details	Sorted During Harvest	Quality Sort by Consultant (Extreme Defects or Decay)	Quality Sort by Consultant (Moderate Defects or Decay)	Sorted for Size (% Discarded by Trader at Farm Gate
3	1.3 ha Sweet-potatoes	2%	15%	30%	10% large 25% medium 65% small 0% discards
4	0.75 ha Sweet-potatoes	1%	20%	30%	5% large 30% medium 65% small 0% discards
5	1.5 ha Sweet-potatoes	1%	5%	10%	20% medium 80% small 0% discards
6	1.95 ha Sweet-potatoes	1%	5%	10%	12% large 88% small
Range: 1-2% sorted out and discarded; 5-20% with extreme defects and decay.					
Conservative estimate of on-farm losses: 2-5%.					

Source: Site Visits and Interviews Conducted During Assessment

Sweetpotatoes are harvested a day before being sold in the market, beginning in the early morning. As a result, farmers harvest only what they expect to sell at the farm gate. The remaining tubers are left in situ until the previous harvest have been sold off. Harvest is manual, using hoes and cutlasses at maturity, and while typical farmers can employ hired labour, they usually rely on family members as most farms are small. Women involved in cultivation and harvesting with harvested tubers placed in woven baskets and later packaged mostly with sacks made from polypropylene materials. Two varieties of sweetpotatoes were common as pictured below.

Figure 3.3: Sweetpotato Varieties with White Flesh and Yellow or Purple-Skin

Photo Source: Site Visits

Damage to sweetpotatoes occurred from rodent bites, cuts or bruised roots, broken roots, circular rot, sunburn, and infected termite bites. Defects included misshapen roots, knotted roots, and very small roots.

The price offered for sweetpotatoes was based on volume. The weight was not measured but the roots were sorted into small and large categories and placed into a 50kg rice sack, filled to the top. Minimal sorting occurs to remove the rotten tubers, although many tubers with disease, rot, or injured roots were left to be sold within the lot. The roots packed in the sack heat up due to respiration. Farms received prices ranging from N1500-N2000 per bag, with no differentiation between large and small roots. The consultant estimated the bags to weigh about 80-100kg, which made the price equal to $10 per 100kg. (200 Naira = US$1).

Figure 3.4: Unwashed Harvested Roots, Packed into Used Rice Sacks

Photo Source: On-Farm Visits.

Figure 3.5: Buyers at Farm Gate Re-Grading Roots after Purchase from Farmers

Source: On-Farm Visits.

With a conservative estimate of on-farm physical losses of 2-5% and total annual production of 3.45 million tonnes in Nigeria, the losses experienced by sweetpotato growers is in the range of 69,000 to 172,000 tonnes per year. Damage and defects are reflected in the offered prices, so the farm gate value of sweetpotatoes tends to be low. At an average farm gate value of $87.50-$100

per tonne, and on-farm losses of 69,000-172,000 tonnes, the economic losses of sweetpotatoes farmers is in the range of US$6-17.2 million per year.

Table 3.5: Summary of the Volume and Market Value of On-Farm Losses of Sweetpotatoes in Nigeria

Total Volume Produced per Annum	Conservative Estimates of On-Farm Losses	Losses in Volume	Market Value per Tonne	Losses in Value
3.45 Million Tonnes ($302-345 million)	2%	69,000	$87.5	$ 6 million
	2%	69,000	$100	$ 6.9 million
	5%	172,000	$87.7	$ 15 million
	5%	172,000	$100	$ 17.2 million

Source: Based on Above Estimates.

Sweetpotatoes have a food value of 860 kilocalories per kg. The loss in food value of 69,000 tonnes of sweetpotatoes is approximately 59.34 billion kilocalories that could have fed 65,000 persons for a full year at 2,500 kcal/day.

3.2.3. Causes of On-Farm Losses

Sweetpotato is particularly productive in poor soils which makes it favorable for tropical soils where fertilizer is not available (Martin, 1988). The local climate supports the growth of sweetpotato, and different varieties adapt well to that particular locality. However, in the Southwestern part of the country where there is heavy rainfall, some varieties are prone to rot and insect infestation before they are harvested.

From observations, lack of best practices affects the quality of the produce. From the interviews conducted, farmers that do not carry out adequate weeding for their sweetpotato farm had issues of rot and insect infestation. In addition, this year, due to inadequate rainfall, most of the tubers were small, especially the purple skinned sweet potato variety.

Several pests and diseases affect the quality of the sweetpotato. The sweetpotato weevil is a major pest in Nigeria, causing losses up to 80%. Unfortunately, orange-fleshed clones have generally been found to be more susceptible. Others include sweet potato whitefly and the banded winged whitefly. Knot Nematode (Meloidogyne spp.) can attack sweet potato root and cause damage resulting in crop losses of potentially as much as 20-30%, but some clones (55 reported) have been found to demonstrate some resistance (Tewe et. al, 2001). Major storage diseases are caused by fungi and include Rhizopus soft rot, Java black rot, Charcoal rot, Black rot, Circular Spot and Fusarium root rot, most of which gain entry when the roots are wounded during the harvest.

Other factors affecting quality include:

- Rodent damage;
- Cuts and bruises from rough harvesting (see Figure. 3.7);
- Rots;
- No curing on farm before sale (increased scuffing damage, abrasions);
- Use of very large packages (100kg sacks); and
- Lack of shade during the day between harvest and sale at the farm gate.

3.2.4. Measures and Strategies Implemented for On-Farm Loss Reduction in Nigeria

Relevant institutes in Nigeria include the IITA, a member of the Consultative Group for International Agricultural Research (CGIAR) and National Root Crop Research Institute (NRCRI) located at Umudike, Umahia in Nigeria. NRCRI aims at the development of new sweet potato varieties with desirable attributes and the development or improvement of agronomic packages that will enhance sweet potato cultivars and largely contribute to the agricultural/food economy of the nation. The programme has the national mandate of genetic improvement of sweet potato productions, generation of improved production packages that will sustain high yields, formulation of disease and pest control strategies, and development of post-harvest technologies and extension of findings to end-users through established channels (NRCRI, 2015). Other relevant institutions include Agricultural Development Programs (ADPs) and the Roots and Tubers Expansion Programme (RTEP).

Yellow and orange fleshed sweet potatoes are promoted in West Africa and East Africa by several international donor agencies including the International Potato Center (CIP), Helen Keller International, the Bill and Melinda Gates Foundation (BMGF), and USAID, as they are a good source of Vitamin A. Burri et al. (2011) recently reported on "Evaluating sweet potato as an intervention food to prevent vitamin A deficiency." Sweet potato is generally a more important source of income for women than for men as the latter generate higher earnings from crops such as yam and rice which have resource requirements, notably labor, more amenable to men. The lower labor requirements of sweet potato, coupled with its short maturity time and the possibility of growing it at least twice a year, make the crop an attractive option for women farmers seeking income earning opportunities (David and Madu 2014).

3.2.5. Lessons Learned from the Case Study

This case study revealed a number of lessons that could be applied to improve the quality of sweetpotatoes in Nigeria, and more broadly in other countries.

Pay attention to harvest indices (days from planting) for optimum quality and yield.

- Provide improved pest control for insects and rodents if roots are left in the field after full maturity.
- Gently harvest and dig roots and tuber crops to prevent physical damage.
- Avoid rough handling after harvest; do not step on or sit on heaps of harvested crops.
- Provide shade for harvested crops during transport delays from field to market.
- Streamline the value chain to decrease delays in transport from the farm.

3.3. Case Study 3: Cassava in Nigeria

Cassava is a high volume root crop, important across Africa. As a top producer, cassava is Nigeria's most important staple food, especially for smallholder farmers (DADTCO, 2012).

3.3.1. Status and Importance

Nigeria is the largest producer of cassava in the world (FAO, 2005; Sanni et al, 2009). Current production was estimated in 2010 to be 37.5 million metric tonnes with total area harvested at 3.13 million hectares for an average yield of 12 tonnes per hectare (FAOSTAT, 2012). By 2015 production was about 45 million tonnes per annum, a figure expected to double by 2020. Although the world leader in cassava production, Nigeria is not an active participant in cassava trade in the international markets as most cassava is targeted at the domestic food market.

3.3.2. Assessment of On-Farm Losses and Economic Burden

Cassava has a shelf-life that is generally expected to be of the order of 24–48 hours after harvest. Two types of postharvest deterioration are recognized: primary physiological deterioration that involves internal discoloration and is the initial cause of loss of market acceptability; and secondary deterioration due to microbial spoilage. If harvested cassava roots cannot be marketed within two or three days of harvest then they may be processed into dried products of low quality, which have lower value (Westby et al., 2002). On-farm assessments at six cassava farms in Ogun State provided the following data.

Table 3.6: On-Farm Assessments at Six Cassava Farms in Ogun State

Farm	Farm Details	Sorted During Harvest	Quality Sort by Consultant (Extreme Defects or Decay)	Quality Sort by Consultant (Moderate Defects or Decay)	Sorted for Size (Discarded by Trader at Farm Gate
1	30 hectares (15 farmers with 2 ha each) Mainly cassava for ethanol	0%	5%	15%	1%
2	2.6 ha Cassava, pepper, yam, melon and Roselle	0%	5%	15%	1%
3	7.6 ha Cassava for gari and fufu	1.5%	10%	10%	0.5%
4	25.5 ha Cassava for high quality flour	0%	5%	15%	0%
5	2 ha Cassava for gari and fufu	1%	5%	10%	0.5%
6	2.5 ha Cassava for gari	1%	5%	10%	Not sold
Range: 1-1.5% and 5-10%					
Conservative Estimate of On-Farm Losses: 2-5%					

Source: Site Visits and Interviews.

The quality grade is based on starch content and determines the amount that will be paid for cassava roots that will be sold for processing. The price is N40-50/kg of starch. Percentage of starch present in the roots varies from 10-25% with a price range from N6,000-12,000 per tonne. This is highly subject to change and is not stable. For high quality flour production, the offered prices at the time of this assessment were:

- Highest: N15,000/tonne (30% starch content)
- Middle: N11,000/tonne (22% starch content)
- Lowest: N7,500/tonne (15% starch content)

Other quality factors that affect the price include roots size, diseases, and cleanliness including trimming Very small roots are generally left on the farm. The quality defects will be documented at the processing facilities upon arrival, and the prices paid to the grower likely will be reduced by 15 to 20%.

When cassava roots are harvested to be eaten on the farm or processed into gari or fufu, the quality is considered less important (since the small sized and broken roots are still eaten). The price offered for these roots at each quality grade at the time of the assessment are:

- Highest: None; did Not Occur.
- Middle: N500/90-100kg.
- Lowest: N300/90-100kg.

Price per kilogram will also differ by season and time of year. For example, a 900100kg basket is valued at N400 during times when there is excess harvesting, but valued at N800 during times of scarcity. At the time of this report, 200 Naira is equivalent to US$1. Therefore, the equivalent in US$ is a range of $20-40 per tonne.

With a conservative estimate of on-farm losses on the order of 2-5% physical losses in Nigeria and a total production of 45 million tonnes, these losses equal 900,000 to 2,250,000 tonnes of cassava roots per year. At a market value of $20-40 per tonne, economic losses to farmers range from $18 to $90 million per year.

Table 3.7: Summary of the Volume and Market Value of On-Farm Losses of Cassava in Nigeria

Total Volume Produced per Annum	Conservative Estimates of On-Farm Losses	Losses in Volume	Market Value per Tonne	Losses in Value
45 million Tonnes ($900 million to 1.8 billion)	2%	900,000	$20	$18 million
	2%	900,000	$40	$36 million
	5%	2,250,000	$20	$45 million
	5%	2,250,000	$40	$90 million

Source: Based on Above Estimates.

Cassava has a food value of 1,600 kilocalories per kg. The on-farm losses in food value at a minimum equals approximately 14.4 trillion kilocalories. This could feed 15.78 million persons for a full year at 2,500 kcal/day (10% of Nigeria's population).

The lowest market value of these losses is US$15, for small roots or local gari production, to $38 per tonne, which are the lowest quality roots for starch or flour production. This amounts to $13.5m-85.5 million per year. The losses of highest quality roots or roots typically sold during times of scarcity would be worth twice as much to the growers. There are also financial losses when handling older fresh roots, as there is price discounting in anticipation of physical losses. Discounts can be as high as 90% for cassava that is more than three days old on wholesale markets.

3.3.3. Causes of On-Farm Food Losses

Generally, farmers will delay harvest until they can expect a higher price, preferring, in the absence of storage, to leave crops in situ or unharvested after maturity. Roots left in the field after full maturity are subject to pest attack, including insects, rodents, and fungi. Additionally, farm workers are not trained in harvesting and handling, and often cause damage to the crops.

Recent studies documented cassava growers' knowledge levels in Ogun State, Nigeria. The majority of the respondents (85-90%) demonstrated high awareness of land preparation, spacing improved varieties, fertilizers, herbicides and insecticides. However, low awareness was recorded for 91% of the respondents for harvesting activities. The implication that excess time could be expended in uprooting the cassava tubers, while there is the possibility that they might be unable to harvest properly (Oladoja et al 2009). The following practices impacted the quality of harvested cassava.

- Leaving the crop in the ground for too long can reduce quality and increase rotting.
- Leaving the roots in the ground after full maturity can increase damage and pest attacks from insects, rodents, and fungi.
- Rough digging and handling during harvesting leads to broken roots.
- Rough handling after harvesting causes physical damage.
- Leaving the harvest roots exposed to the sun.

Figure 3.6: Decayed Roots and Broken Roots

Source: Site Visits.

Figure 3.7: Harvested Cassava Waiting for Transport; Full Stem of Cassava Roots

Source: Site Visits.

Figure 3.8: Hired Worker Resting on Harvested Cassava; Carrying Roots to Transport Vehicle

Source: Site Visits.

3.3.4. Measures and Strategies Implemented for On-Farm Loss Reduction in Nigeria

As mentioned during the sweetpotato case study, relevant institutes in Nigeria that work on reducing losses in root and tuber crops include the IITA, a member of CGIAR, and NRCRI located at Umudike.

Direct government involvement in cassava production brought the commodity into the limelight in 2003 through the launching of the Presidential Initiative on Cassava (Sanogo and Adetunji 2008). The goal of this initiative was to promote cassava as a viable export and also develop the production system to sustain the national demand. Intervention focused on the development of production, processing, and marketing of processed products. Also, cassava is now a key element of the Government's Agricultural Transformation Action Plan under the Growth Enhancement Support (GES) Scheme in Nigeria. This programme seeks to lift 20 million resource-poor farmers out of subsistence farming. Fertilizers and seed were made available, accessible and affordable to farmers at a subsidized rate. Ogun State was one of the 14 States that benefitted from the first phase of GES roll out in the Southern belt of Nigeria.

There are several institutions that are involved in projects related to cassava with the goals of improved varieties (stem cuttings) and linking farmers with major processors and traders, but the most critical input suppliers for cassava cultivation are the farmers, international research institutions (such as IITA), ADPs, RTEP, and the Ministry of Agriculture with programs like Ogun State Cassava Revolution Programme (CRP). The Ogun State CRP aims at promoting the development of the cassava sub-sector within the State. It also aims at harnessing the enormous potentials in cassava for youth and women empowerment, enhancing food security, promotion of industrialization and poverty alleviation. They multiply cassava cutting, which results in improved varieties for farmers.

Generally, application of fertilizers, pesticides and herbicides is encouraged, but there is no documentation that application affects the quality of roots. However, thinning of cassava stems before maturity may result in low yield and small sized roots.

3.3.5. Lessons Learned from the Case Study

Several lessons can be learned from the relatively low levels of on-farm losses assessed for cassava in Nigeria.

- Offering price incentives for quality leads to producers paying attention to harvest indices (days from planting) for optimum quality and yield.
- On-farm losses can be reduced if improved pest control for insects and rodents is practiced for roots that are left in the field after full maturity.
- Gentle harvesting and digging of roots and tuber crops can prevent physical damage.
- Avoiding rough handling after harvest such as stepping on or sitting on the heaps of crops can reduce physical damage.
- Providing shade for harvested crops during delays in transport from the field to the market can reduce produce temperatures and reduce on-farm losses.
- Streamlining the value chain, such as creating direct links from the farm to the final buyer, decreases delays in transport from the farm.

3.4. Case Study 4: Groundnuts in Benin

Peanut is an annual legume. It is both a food and industrial crop. Groundnut is mainly exported for its oil content (of about 50%). West Africa cultivates around 57% of African production is nearly 5 million tons. Major OIC member country producers also include Senegal, Nigeria, Sudan, Indonesia, Burkina Faso, and Cameroon.

3.4.1. Status and Importance

Benin had a total of 150,000 tonnes of groundnut production in 2013 (FAOSTAT3), with a low yield of less than 600 kg/ha. Groundnut in Benin is rarely exported and mainly produced for local consumption, with a large part used for oil production and the rest used to make a highly valued product called kuli-kuli which are deep-fried groundnut sticks. Locally groundnuts are also consumed boiled, grilled and as peanut butter.

Peanuts are grown throughout the intertropical area. The optimum temperature for the growth of the plant is between 24 and 35ºC. Pod development is better when the temperature in the ground is less than 30ºC. Long days (greater than 14 hours) combined with the above 30ºC night temperatures can result in abundant production. Early sowing during long days leads to higher yields. Generally peanut plants are tolerant to drought, and they can be produced in regions of between 400 and 1200 mm rainfall. To facilitate the penetration of the root system light soils that are sandy fine-textured, loose and permeable are better suited for peanut. Clay soils are difficult to cultivate by hand like usual in Benin and suitable for peanuts when mechanization and irrigation is available. PH neutral soils are more suitable for peanuts.

The seeds used in Benin are usually those that are recycled from previous harvests. These seeds are not certified but are of good quality as 100% of interviewed producers stated. There is really no commercial seed production and seed distribution for peanut in Benin. The Regional Agricultural Center for Rural Development (CARDER) which is a support structure of the Ministry of Agriculture, Livestock and Fisheries, provides no seed to producers. Seeds are purchased at market or supplied by friends or relatives of peanut producers.

3.4.2. Assessment of On-Farm Losses & Economic Burden

There have been several reports of aflatoxin contamination in groundnuts in Benin (Egal et al. 2005). Otherwise not much is known known about the causes of on-farm losses since groundnut is an under-researched and under-developed crop with low yields and low quality, mainly due to high levels of aflatoxin in Benin. Required fertilizer application dates and doses are not respected, because input distribution is lacking.

Table 3.8: On-Farm Assessments at Six Groundnut Farms in Benin

Farm	Details on Farm	Quality Sort by Consultant (Extreme Defects or Decay)	Quality Sort by Consultant (Moderate Defects or Decay)	Notes on On-Farm Practices for Groundnuts
1	1 ha Bogandji Benin Groundnut, cowpea, tomato	10%	20%	Harvested at morning, dried pods on the ground between 2 to 3 days, transported with motorbike or bicycle at home, storage during 3 months.
2	1 ha Bogandji Benin Groundnut, cowpea, tomato	15%	15%	Harvested at morning, dried pods on the ground between 2 to 3 days, transported with motorbike or bicycle at home, storage during 3 months.
3	6000 m2 Bogandji Benin Groundnut, cowpea	10%	18%	Harvested at morning, dried pods on the ground between 2 to 3 days, transported with motorbike or bicycle at home, storage during 3 months in polyethylene bags.
4	1 ha Bogandji Benin Groundnut, cowpea, tomato	12%	20%	Harvested at morning, dried pods on the ground between 2 to 3 days, transported with motorbike or bicycle at home, storage during 3 months in polyethylene bags.
5	4000m2 Bogandji Benin Groundnut, cowpea, tomato	10%	20%	Harvested at morning, dried pods on the ground between 2 to 3 days, transported with motorbike or bicycle at home, storage during 3 months in polyethylene bags.
6	1 ha Bogandji Benin Groundnut, cowpea, tomato	10%	20%	Harvested, dried pods on the ground between 2 to 3 days, transported with motorbike or bicycle at home, storage during 3 months.
Range: 10-15% with extreme defects or decay.				
Conservative Estimate of On-Farm Losses: 10 to 20%				

Source: Site Visits.

Groundnut seeds are fragile. They are stored in pods to reduce attacks from pests. The pods are shelled by hand, preferably 10-15 days before planting, and then sorted to remove non-viable seeds that are moldy, small or have been attacked by insects. The seed disinfection treatment is dusted with a mixture of fungicides and insecticides at a dose of 2%. But none of the producers used seed treatment, preferring to focus on the cowpea crop. Peanuts are grown mainly for soil fertilization, and a bit for the production of local products called kuli-kuli (fried groundnut

sticks) or oil. The quality of the seed can be verified by a germination test. Sown seeds have a germination rate of 80-90%.

Peanuts should be grown on plot where they were not grown the previous year. The land is cleared and crop residues are burned in heaps. Then a light tillage or ridging is practiced. Peanuts also require a substantial amount of water. Therefore, producers plant after periods of heavy rain with a spacing of 30-50 cm. The amount needed to plant one hectare depends on the variety, quality seed and seed density, but usually 120-150kg in shell peanuts are used. It is recommended that only one seed is sown per hole to a depth of 3-5 cm of soil.

All farmers hoed two times during peanut production. The first time occurred between 10-15 days after sowing to control weeds. The second time occurred at the time of flowering, and took place before the output of gynophores. All producers use fertilizer at planting and only one survey respondent used urea at the time of flowering. The application rates of fertilizer are often not met. According to the peanut producers, pests encountered on the crop during production are termites, pod-sucking bugs, and centipedes, as well as rots caused by Aspergillus spp. (on seeds and seedlings), leaf spot, rust, root-knot nematodes and finally rodents. But according to the producers, no phytosanitary treatment is applied during planting in peanuts in Benin. Pesticides are not applied on peanuts in Azovè area and Benin in general.

Groundnuts are harvested by hand, by pulling up the plant. The plants are then dried via rapid, steady drying of the pods to avoid aflatoxin contamination. Harvested plants should be staked in the field for a few days to allow them to dry in the sun and air. Best practice would be to dry plants outside the field to reduce risk of toxin contamination before stripping the pods, with continued drying until the moisture content is reduced to 6-8%. This can normally be achieved by drying the pods in the sun for 6-7 days, taking care to cover them if it rains. If pods are exposed to the sun too long, both kernel quality and seed germination will be affected. This is the key step for avoiding aflatoxin contamination in groundnut.

The cost of production of groundnuts is calculated using the unit costs of the various operations of the six interviewed producers. The calculation is also done by quanti, which is the unit of measurement in Benin. In Azovè, the quanti is around 400 m2. The operations performed by producers in general are: purchase of seed, weeding, plowing, sowing, hoeing, NPK contribution, harvesting and transport of the products from the field toward the house. It should also be noted that the production cost also varies according to the period of abundance and peanut shortage on the market, since producers procure seeds on the market. The calculation (Table 3.9) is made for the period of abundance that is from March to May or June, because it is during this period that the six producers grow peanuts.

Table 3.9: Production Cost for Peanuts in Azove on One Quanti (400 m2) in FCFA

Activity (1 Quanti/400 m²)	Cost(FCFA)
Purchase of Seeds	600
Weeding	600
Soil preparation	500
Planting	400
Weeding	600
Fertilization (NPK)	835
Lifting/Harvest	350
Shelling	400
Transport	350
Total Cost of Production	**4,635**

Source: Site Visit Observations.

Non-dormant varieties of groundnuts are lifted when 2% of the plants show germination, while dormant varieties are lifted when a brown spot appears inside the pods. In general, maturity is recognized by the drying out of the shell of the grains and the detachment of the peduncle from the seed. After lifting, seeds are dried for two to three days to reduce the moisture content before shelling. These operations are performed by women and children.

Transport from the field to the home or market is done with motorcycles, motorcycle taxi, bicycles, or walking. The product is transported either in raffia baskets or polyethylene bags which protect the product well. Rarely are delays observed in the delivery of the product at home or in the market. Delays are observed if product needs to be transported on market day or if there is a shortage of taxi-motorbikes. The distances between fields and house producers or fields to the nearest market varies from three to eight kilometers.

Pods are stripped approximately two to six weeks after harvesting, when the pod water content stabilizes at around 10%. This operation consists of separating the pods from the vegetative parts of the plants (vines). In traditional farming systems, manual stripping is the rule, but this step has also been mechanized.

The sieving operation is generally done on the farm or at the collecting point. The classic sieve consists of a hexagonal or cylindrical cage made from bars. It allows part of the trash including sand, straw and broken pods to be eliminated. However, it cannot eliminate pods of other varieties, empty pods (pops), partially filled or immature pods. This is the most basic cleaning operation. In traditional culture, manual shelling is practiced and results in high quality beans and usually performed by women or children.

Figure 3.9: Sieving and Shelling Practices

Source: Site Visits.

After shelling, products are dried by gradually lowering the humidity to 8-10%. The pods are usually stored in polyethylene bags inside the house or attic. Attics and storage areas are treated only with rat poison to fight against rodents. It is during storage that the most significant losses are recorded at the farmer or producer level. According to the producers and sampling for measurements, losses can reach 25-30%.

Figure 3.10: Granary Used to Store Peanuts and Cereals

Source: Site Visits.

Groundnuts in Benin are generally produced for its oil, or roasted or made into kuli-kuli (fried groundnut sticks). The price of oil varies from 800 to 1000 FCFA per liter. The cakes are sold at FCFA 25 or 50 depending on size.

Figure 3.11: Processing Peanut into Oil and Groundnut Sticks

Source: Site Visits

The price for peanuts set by the producers who generally prefer to store peanuts and then sell in times of shortage. The peanut oil vendors, peanut stick processors or those that sell roasted peanuts are all potential customers. These clients prefer to buy large seed peanuts. A 100kg bag of unshelled peanuts is sold for around 12 000 FCFA (20$) in times of abundance, while in times of shortage it costs around 20,000 FCFA (40$). A bowl of shelled peanuts (30kg) costs around 25,000 FCFA (50$) in times of plenty and in times of shortage it costs around 42,000 FCFA (84$).

Table 3.10: Summary of the Volume and Market Value of On-Farm Losses of Groundnuts in Benin

Total Volume Produced per Annum	Conservative Estimates of On-Farm Losses	Losses in Volume	Market Value per Tonne	Losses in Value
150,000 Tonnes	2% In-Shell Peanuts	3,000	$200 In-Season $400 Off-Season	$ 600,000 $ 1.2 million
	5% Shelled Peanuts	7,500	$500 In-Season $840 Off-Season	$ 3.75 million $ 6.3 million

Source: Based on Above Estimates.

3.4.3. Causes of On-Farm Losses

The major diseases of economic importance affecting the groundnut crop in the field in West Africa and Benin are early and late leaf spots (Cercospora arachidicola [Mycosphaerella arachidis]), Phaeoisariopsis personata (M. berkeleyi), rust (Puccinia arachidis), collar rot (Aspergillus spp.), root rot (Macrophomina phaseolina) and stem rot (Sclerotium [Corticium] rolfsii). Among the major insect pests damaging groundnut are termites of the genus Microtermes (Isoptera: Termitidae); whitegrub (Coleoptera: Scarabaeidae) and millipede (Myriapoda: Odontopygidae) (FAO, 2003).

It is important to harvest groundnut at the right time, meaning when the crop is mature. This can be difficult because flowering is indeterminate in the groundnut. Therefore, there is a variable proportion of mature and immature pods at the end of the crop cycle. Groundnuts are mature when 70-80% of the inside of the pods shells have dark markings and the kernels are

plump, with color characteristic of that variety. If harvested prematurely, the kernels shrink upon drying, resulting in decreased shelling percentage, poor seed quality and lower oil content. If harvested late, non-dormant varieties will sprout in the field, resulting in yield losses (N'tare et al. 2008).

Of the global land area cultivating groundnut, nearly half (46%) is in Africa, where it is grown mostly by smallholders with little access to agricultural resources and technologies. According to recent studies, as a result of these limitations Africa only accounts for 28% of global production of groundnut (Spieldoch 2015). Major causes of on-farm losses include:

- Poor quality seeds and planting materials.
- Poor cultivation practices, inputs, pest management and a lack of mechanization.
- Poor moisture content management during and after harvesting, which increases the risk of aflatoxin contamination (immediate drying to less than 8% reduces this risk).

3.4.4. Measures and Strategies Implemented for On-Farm Loss Reduction in Benin

Peanuts are a very important crop in Benin especially as a source for oils and for the production of groundnut sticks (kuli-kuli) which are a very common snack for people, some groups like schoolchildren, university students, motorcycle taxi-drivers and apprentices consume then nearly daily. Groundnut sticks are high energy foods that can be eaten without preparation. But the industry is still disorganized. Oil production from the Oils Corporation of Benin (SHB) and FLUDOR Company is not sufficient to meet the needs of domestic consumption. At the level of small transformers, production is precarious with rudimentary techniques. Quality of groundnuts and especially contamination with aflatoxin is a problem.

The integrated approach for groundnuts (ICRISAT, 2013) provides information on best practices (Osiru & Waliyar, 2013). There are also a lot of problems during the storage of peanuts due to lack of infrastructure and adequate storage technology to control post-harvest pests of groundnut. Postharvest losses are enormous and can attain up to 25-30% of the production. There is need that the state and producer organization puts more effort in supporting this value chain which has not received any government support since the last 40 years in Benin, so that its potential role in the development of the national economy can be fully exploited. Producers have rarely access to credit for groundnut in Benin, even if these are made available to them the would find it difficult to repay such credits since the interest rates are generally very high

3.4.5. Lessons Learned from the Case Study

Drying grains, oilseeds and pulses involves exposing the seeds to ambient air with low relative humidity in order to evaporate the moisture from the grain or pulse. This process is crucial to the success of the drying operation and reducing losses from this operation will depend mainly on how efficiently this process is carried out. A common practice in some countries of the region is to spread the crops in the open air for drying for number of days until the product is dried to acceptable levels. This process lacks any control over the time required; the relative humidity of the ambient air; the sanitary status of the drying grounds; and hence more contamination and

higher losses due to molds, insects and rodents are to be expected. If the air is not dry enough the crop will never reach the desired moisture level or it will take a longer time than the recommended maximum of 12 hours. This will give an opportunity for mold to attack and higher levels of mycotoxins will be expected in the dried product. (Kader et al., 2012.)

Recommendations for reducing on-farm losses for pulses and oilseeds include:

- Use of good quality seeds and inputs.
- Harvesting at proper moisture, which for groundnuts is below 15%.
- Drying to low moisture (8 %) reduces significant losses of product due to deterioration in quality.
- Drying facilities are considered particularly important in light of climate changes such unanticipated rain just before harvest, which result in inadequately dried crops leading to mycotoxin formation and poor quality.
- Encouraging the development of an on-farm, low-cost drying process that is able to bring down the moisture content of crops to 8% as fast as possible to reduce loss.
- In-shell buying and marketing which reduces moisture influx and fungal development, but increases the bulkiness of the commodity.
- Use of hermetic storage Perdue University bags (PICS bags) which reduce aflatoxin contamination in groundnut.
- Use of hand or manual shellers for reducing damage to kernels during shelling.

3.5. Case Study 5: Tomato in Egypt

Tomato is an important vegetable crop in many of the OIC Member Countries. Major OIC producers include Turkey, Egypt, Iran, Nigeria, Uzbekistan, Morocco, Syria and Tunisia. Tomatoes are very similar to capsicum, aubergine, cucumbers and hot peppers regarding management of on-farm and postharvest losses.

3.5.1. Status and Importance

Egypt has the longest production season for tomatoes in the world, with a potential of 11 months per year depending on the climate and location (Tinawi 20101):

- North or Lower Egypt (Nubaria): June, July, and August.
- Middle Egypt (Beni Sweif, Minya): October, November, December
- Upper Egypt (Souhag, Kena, Esna): December, January, February, March, April, May

In 2013 more than 8.5 million tonnes of tomatoes were produced. From 2005-2010, 99% of the tomato production was for fresh consumption and 1% was a dual purpose and processed variety. Field tomatoes produce 3 kg per m^3 water and plastic house tomatoes produce 17 kg per m^3 water. Water is free on the Delta so farmers only need to buy a pump.

Table 3.11: Compilation Information on Production of Tomatoes in Egypt (Behaira Governorate in the Nile Delta Area)

Year	Production in Millions of Tonnes	Area of Production in Hectares	Area Harvested in Hectares	Productivity Tonne/Feddan	Producer Price $US/Tonne
2002	6.8	200,000			
2006	8.6				
2010	7.5	200,000			
2011	8.1		212,446	16.0	260.71
2012	8.6		216,395		235.31
2013	8.5		212,946		

Source: Source: Beltagy, (2008), Indian Horticulture Database 2011, TINAWY 2010, FAOSTAT, (2011) in Abou-Shleel and El-Shirbeny, (2014)), FAOSTAT 2013.

3.5.2. Assessment of On-Farm Losses and Economic Burden

The consultant and field team visited six farms in the Nile Delta region, and their on-farm assessments in the Behaira Governorate provided the following in Table 3.11.

Table 3.12: On-Farm Assessments at Six Tomato Farms in Egypt

Farm	Farm Details	Sorted During Harvest	Quality Sort by Consultant (% with Extreme Defects or Decay)	Quality Sort by Consultant (% with Moderate Defects or Decay)	Sorted for Size (% Discarded by Trader at Farm Gate
1	4 ha	0%	35%	45%	
2	12 ha	15%	15%	5%	
3	12 ha	15%	30%	30%	
4	15 ha	15%	20%	10%	
5	4 ha	15%	25%	0%	Lost 100% of 2 out of 4 harvests
6	8 ha	30%	20%	45%	
Range: 0-30% at harvest; 15-35% at quality sort					
Conservative Estimate of On-Farm Losses: 15-20%					

Source: Site Visits.

The weather was hot during the harvesting (32-39 °C), and the relative humidity was low (40%). Defects and damages were mainly due to yellowing by sunburn and mechanical damage by workers. Tomatoes are sold by the full crate, always assumed to hold 20 kg, but not weighed by

the farmer or the buyer. One crate sells for 30 Egyptian pounds (1.5 EP per kg), which is equal to US$0.20 per kg.

For four of the farms, there are four collection periods for every season (one per week therefore one month of harvesting). First harvest losses are 0-5%, second harvest losses are from 5-10%, third are 5-15%, and fourth range from 20-30%. There is an average of 15% on-farm losses in the form of discards at the time of harvesting. On a fifth farm, the leaves were not enough to cover and protect fruits from heat, so there was 30% losses due to sunburn, and the farmer was able to harvest only twice out of four times in August. The farmers face several options including:

- Trader buys the whole season of 4 harvests and harvests himself; most common.
- Trader buys individual harvest; farmer has to take care of the rest.
- Farmer takes care of harvest and sales.

In the first two options, the farmer leaves the sorting and grading to the trader. In the third option, the farmer does the sorting and trains the workers to remove unmarketable fruits. The local wholesale market is about 10 km from the farms, which is about 30 minutes by road. Taking a conservative estimate of on-farm losses of 15-20%, and an annual production volume of 8.5 million tonnes, Egyptian growers lose 1.28-2.17 million tonnes of tomatoes per year. At a market value of US $200 per tonne, total economic losses for tomato farmers is approximately US$255-$340 million in lost earning per year.

Table 3.13: Summary of Volumes and Market Value of On-farm Losses of Tomatoes in Egypt

Total Volume Produced per Annum	Conservative Estimates of On-Farm Losses	Losses in Volume (Tonnes)	Market Value per Tonne	Losses in Value per Tonne
8.5 Million Tonnes ($1.7 billion)	15%	1,275,000	$200	$255 million
	20%	2,170,000	$200	$340 million

Source: Site Visits

Tomatoes have a food value of 180 kilocalories per kg, plus many vitamins and minerals. The loss in food value is approximately 230.4 billion kilocalories. This amount could feed 250,000 persons for a full year at 2500 kcal/day.

3.5.3. Causes of On-Farm Losses

There were several major causes of on-farm losses observed and reported. According to the farmers interviewed, these causes include:

- High temperatures affect flowering and fruit because it damages the reproductive organs, and the pollen grains die so flowers drop.
- High temperatures increase insect activity and therefore virus and diseases, causing farmers to apply pesticides every day.
- Flowers and fruits are sunburned and die.
- Low temperatures inhibit growth of transplant; strong winter winds affect production.

- Winter increases fungal diseases as low temperature is combined with increased relative humidity, and therefore increases the incidence of diseases.

In fact under Egyptian climatic conditions tomato plants are vulnerable to infection with the early blight disease caused by *Alternaria solani*, which causes a great reduction in the quantity and quality of fruit yield. The *Alternaria* fungus can cause the disease on all parts of the plant (leaf blight, stem collar rot, and fruit lesions) and can result in severe damage during all stages of plant development. According to Geographic Information System (GIS) assessments of climate change impacts on tomato crop in Egypt (Abou-Shleel and El-Shirbeny, 2014) the increase of air temperature has a negative effect on fruit setting and leads to a decrease in tomato yield. They predict that due to climate change, in the year 2050 the sowing date and time will change; July will no longer be suitable for tomato fruit setting. And as of the year 2100, tomato fruit setting will not be suitable for three months which are June, July and August.

According to Lewis (2012), whitefly transmitted gemini viruses, specifically Tomato Yellow Leaf Curl Virus (TYLCV), have been identified as the most devastating plant viruses infecting tomato in Egypt. The Tomato yellow leaf curl virus causes about 65% yield losses in tomato annually in Egypt. Additional observations revealed that no thinning of flowers or of fruits is practiced. Pruning practices of suckers are only done under greenhouse growing conditions. *Tuta aboluta* (tomato leafminer or tomato borer) damage was observed in many fruits at the time of harvest. Blossom end rot was also observed. Tomatoes are covered by their own leaves or by weeds to protect them from the sun during production.

Harvesting is done from 5am till 11am and from 3:30pm till 6:30pm. During harvest, it was observed that:

- No tools are used. Tomatoes are plucked by hand, and specifically between two fingers.
- There is limited sorting at harvest; however the trader supervises workers to ensure they leave the non-marketable fruits on the plants; decision for harvest is made when 40% of the fruits are red.
- No shade is provided during harvest.

Some producers leave the fruits on the plant until 50% are red because after the first harvest, there is a danger that the plants will be damaged by labor, and most of the foliage will be destroyed leaving them exposed to heat and drought. Usually, culled produce is left in the field, although composting is not practiced; decaying fruits are left at the sorting site.

Figure 3.12: Insect and Mechanical Damage on Tomatoes Packed for Market

Photo Source: On-Farm Visits.

Causes of on-farm losses for tomatoes include:

- Lack of pruning and thinning;
- Poor blossom end rot control;
- Lack of protection from sunburn;
- Improper maturity at harvest (too early – will not ripen; too late - will be easily damaged during transport from the farm to the market);
- Rough harvesting practices damage the plants;
- Lack of stems from rough harvesting reduce market value;
- Leaving non-marketable fruits on the plants or in the field on the ground can spread disease inoculum or insects pests;
- Use of rough palm rib crates causes severe physical damage to tomatoes; and
- Leaving fruits exposed to the sun after harvest.

Figure 3.13: Palm Rib Crates Used on Egyptian Farms and Damaged, Sunburned Fruits

Photo Source: On-Farm Visits.

3.5.4. Measures and Strategies Implemented for On-Farm Loss Reduction in Egypt

According to the individuals interviewed, including the facilitators, there are no donor-funded projects to assist the tomato sector. There are several extension projects targeting pest management and production improvements for fruits and vegetables. Pesticides are sprayed every day from planting for 55 consecutive days, and then every three days until harvest. Farmers also spray fungicides on the plants right after harvest to protect the weakened plants and help them for the next harvest. There are no means of pesticide residue measurement and control, which could lead to food safety problems.

This year the new Food Security and Agribusiness Support (FAS) program is being initiated in Egypt. This is a five-year, $23-million, USAID-funded program implemented in Egypt, and it will include on farm and postharvest training activities.

3.5.5. Lessons Learned from the Case Study

Tomatoes produced in Egypt are exposed to too much direct sun, and the harvesting practices cause a lot of damage to the plants and fruits. Recommendations to reduce on-farm losses for tomatoes and general recommendations for fruits and vegetable crops include:

- Pest management: Improve control of white flies (virus vector) and tomato leaf miner.
- End Rot. Calcium should be applied to the soil at intervals, irrigation should be managed properly.
- Protection from sunburn: Provide filtered shade, such as shade cloth, to reduce sunburn damage and lower field temperature, which could increase fruit set.
- Improved harvesting: Harvest at proper maturity, and wait for color break to ensure fruit is fully mature; flavor is improved if red color is allowed to develop on the vine.
- Gentle harvesting: This is important to reduce damage for all fruit and vegetable crops.
- Improved containers: Use liners for palm rib crates, smooth the inside of the crates with sand-paper, and use reusable plastic vented crates when possible.
- Temperature management: Provide shade for the crops after harvesting and before transport, especially when temperatures are above 25 C.

Figure 3.14: Post-Harvest Crates Remain Uncovered; Shaded Areas are Recommended

Photos Source: On-Farm Visits

3.6. Case Study 6: Bananas and Plantains in Uganda

Plantains are the primary food crop in Uganda, and bananas are considered a major crop in Uganda. Bananas are produced in many OIC countries, where they are an important fruit crop for domestic use and exports. Bananas and plantains are very similar with respect to on-farm handling.

3.6.1. Status and Importance

Uganda produces 575,000 tonnes of bananas and 9 million tonnes of plantains annually. Plantains and cooking bananas, are Uganda's top produced food crop (FAOSTAT). Banana crops are an important economic resource for rural farmers in Uganda, and in particular rank high among enterprises that support livelihoods of smallholder poor rural farming communities. About 75% of Ugandan farmers grow the crops on 1.5 million hectares of land, an estimated 38% of the arable land under cultivation. Domestic per capita consumption of bananas in Uganda is estimated between 220-460 kg, the highest in the world (National Agricultural Research Organization, Uganda).

Farming communities in Uganda have consistently ranked the banana crop as their most important crop because the plant produces all year-round. Banana has a multiplicity of uses including food, beverages, snacks, feed, industrial spirits, crafts and medicinal uses.

3.6.2. Assessment of On-Farm Losses and Economic Burden

On-farm assessments at six banana and plantain farms in Western Uganda provided the following data. Mbarara district is in western Uganda, requiring approximately 12 hours by road (350 km) to reach Kampala wholesale markets:

Table 3.14: On Farm Assessments at Six Banana/Plantain Farms in Western Uganda

Farm	Farm Details	Quality Sort by Consultant (% with Extreme Defects or Decay)	Quality Sort by Consultant (% with Moderate Defects or Decay)	Sold by the Bunch Large = 20kg or more Medium = 18 kg Small = 15 kg or less Market Value
1 Plantains	10 acres Bananas, coffee, beans, cassava, cabbage, maize	10%	15%	20% large = $2.80, 40% medium= $ 2.40, 40% small =$ 1.40
2 Plantains	4.5 acres Bananas, beans, tomatoes, cabbages, coffee	0%	20%	40% large = $3.40, 40% medium= $ 2.30, 20% small =$ 1.40

Farm	Farm Details	Quality Sort by Consultant (% with Extreme Defects or Decay)	Quality Sort by Consultant (% with Moderate Defects or Decay)	Sold by the Bunch Large = 20kg or more Medium = 18 kg Small = 15 kg or less Market Value
3 Plantains	20 acres Bananas, beans, watermelon, cabbages, coffee	20%	10%	20% large = $2.80, 50% medium= $ 2.30, 30% small =$ 1.40
4 Plantains	55 acres Bananas, beans, maize, coffee, cabbages, cassava	5%	15%	20% large = $3.40, 50% medium= $ 2.30, 30% small =$ 1.40
5 Bananas (dessert)	18 acres Bananas, beans, coffee, sweet potatoes, tomatoes, maize	5%	15%	Ripened on farm, handled in woven baskets. 25% large = $0.60, 55% medium= $ 0.40, 20% small =$ 0.30
6 Plantains	30 acres Bananas, coffee, tomatoes, beans, cassava, cabbage	5%	30%	20% large = $3.00, 50% medium= $ 2.30, 30% small =$ 1.40
Range:		**0-20%**	**10-30%**	**$ 0.30-$3.40**
Conservative Estimate of On-Farm Losses:		**5%**	**15%**	**$1.40**

Source: Site Visits

Bananas are harvested all year around. None of the produce was pre-sorted at the time of harvest. Generally, no discards are made unless the fruits are ripe as traders will not buy ripe fruits. Market value is determined via the size of the bunch and its estimated weight. No containers are used for the harvested fruits, and plantains are handled as bunches. Dessert bananas are occasionally harvested, ripened and then the farmers will cut the fingers and stuff them into a large woven sacks. Either way, there is a high level of physical damage done to the fruits during harvesting from dropping bunches and handling as bunches are carried from the field and then loaded or stacked.

Figure 3.15: Damage Observed on Plantains during the Harvest

Source: On-Farm Visits

Banana Weevil is the most damaging insect pest of bananas in Uganda, and East Africa as a whole. Damage is most in neglected plots. The weevil lives, feeds and breeds in pseudostems for periods up to two years. It lays eggs against the sides of the stems. After hatching the larva burrow into pseudostems thereby weakening them and making them liable to wind damage.

With 9 million tonnes of plantains produced annually in Uganda, and taking a conservative estimate of on-farm losses of only 5%, total annual food losses are on the order of 450,000 tonnes. Plantains have a food value of 1220 kilocalories per kg. The on-farm losses in food value equal approximately 549 billion kilocalories that could have fed 602,000 persons for a full year at 2500 kcal/day. Even with a low market value of US$120 to $140 per tonne, economic losses for plantain farmers in Uganda are in the range of US$54 to $63 million per year.

Table 3.15: Summary of the Volume and Market Value of On-Farm Losses of Plantains in Uganda

Total Volume Produced per Annum	Conservative Estimates of On-Farm Losses	Losses in Volume	Market Value per Tonne	Losses in Value
9 million tonnes ($1.08 to 1.26 billion)	5%	450,000	$120	$54 million
	5%	450,000	$140	$63 million

Source: On-Farm Visits

3.6.3. Causes of On-Farm Losses

While losses in plantains and bananas in Uganda were found to be relatively low due to the direct market linkages with buyers, there are several obvious causes of on-farm losses, including rough handling and long delays between harvesting and loading onto transport vehicles.

Rough handling damages produce during harvesting, carrying and loading. Bananas and plantains are harvested, and heaped in stacks according to size and then loaded on truck. There are no standards that are followed as grading is done on farm according to relative size of bunches: the bigger the bunch, the higher the offered price. Any size is taken to market provided

the trader and the farmer can agree on the price. Those not taken are already ripe; they are left on farm for consumption.

There are long delays between the time of harvesting and the sale at farm gate. After harvesting, the produce is not cooled at all. In this study, the temperatures in those stacks of bunches are quite high as they are placed near the loading site, with little regard for shade. The bananas are kept outdoors until the trader arrives for pickup. This can take two days. If the produce is in the open, farmers put old banana leaves over the heap to prevent direct sunshine from burning the produce.

Figure 3.16: Rough Handling during Harvest Causes Splits; Ripened Bananas Left On-Farm

Source: On-Farm Visits

3.6.4. Measures and Strategies Implemented for On-Farm Loss Reduction in Uganda

The Presidential Initiative in Banana Development (PIBD) has the goal is to add value to bananas, making flour and other products from the crop to increase shelf life. Research institutions like the National Agricultural Research Organization (NARO) research and release varieties to the public domain. They also research diseases and bring control and preventive measures. NAADS, the National Agricultural Advisory Services, dispenses researched varieties and all the technologies to the public.

Clean planting materials are available from certified tissue culture centers, but some farmers cannot afford these so they get materials from established plantations. This is not a recommended practice as it could spread Banana Bacteria Wilt (BBW). BBW almost destroyed bananas in Uganda in the early 21st century, but government attention prevented this from happening. Although it is still in some areas, most farmers are aware of how to handle it. Generally, BBW is very destructive with incidence of 70-80%, and in many plantations causing yield losses of 90%. Parasitic nematodes reduce yields in bananas and plantain crops by 12.3%. BMGF has made a $1 million investment in nematode control and their partners will be field testing the technologies in East Africa during 2016.

3.6.5. Lessons Learned from the Case Study

Several lessons can be learned from the on-farm observations of banana and plantain harvest and handling in Uganda. Rough handling and dropping of bunches during harvesting and

handling caused physical damage. Fruits left in heaps exposed to the sun became very hot and suffered from rapid quality deterioration. Specific recommendations to reduce on-farm losses of plantains and bananas, and general recommendations for improved on-farm handling of fruits and vegetable crops are provided as follows:

- Reduce rough handling: Requires training so that farmers are aware of the consequences of their practices especially during and after harvest.
- Proper harvesting (timing and handling practices): Training on how farmers should harvest at the right maturity for different markets, handling during harvest, the proper time of harvesting, and use of improved containers.
- Improved harvesting practices: Having two people harvest together would reduce damage due to dropping as one cuts the bunch, and the other carries it.
- Temperature management: Pre-cooling or provision of shade for the produce could help to reduce on-farm losses, slow the rate of ripening and decay.

3.7. Case Study 7: Broiler Meat in Turkey

Poultry (chicken) is the most produced animal food in the world. Saudi Arabia, Indonesia, Malaysia, Jordan among the OIC member countries are also major producers. Turkey is among the topmost poultry producing and exporting countries, with production of 1.76 million tonnes (2014) increasing to 2 million tonnes (2015).

3.7.1. Status and Importance

The top producers of broiler meat are the United States, Brazil, China, the European Union, India, Russia, Mexico, Argentina, and Turkey (2m tonnes), and Thailand and Indonesia (1.6m tonnes). Among the OIC Member Countries, Turkey is major exporter with 340,000 tonnes, importing 900,000 tonnes to Saudi Arabia and 690,000 tonnes to Iraq.

About 48% of the egg exports and 56% of broiler meat exports are to Iraq. Chicken legs are considered a by-product and are also exported. However, the poultryarabworld.org website recently reported that higher taxes in Iraq are troubling Turkish poultry exporters (Feb 27, 2015). In contrast, Russia's ITAR-TASS news agency reported on Turkey's plans to increase food supplies to Russia to $3.0 billion in 2015 from $1.2 billion in 2013 if customs duties are lowered. *Food Turkey Magazine* (2014) describes the industry as a modern food sector, noting one very large chicken producer with modern production facilities that earns $US28.8 million in annual sales, uses a new dry pluck system, and is halal certified.

Currently, there are currently 80 hatcheries, 322 breeding enterprise, 9,444 commercial broiler enterprises, and 994 commercial laying hen enterprises in Turkey, for a total of 10,840 (Yenilmez and Uruk 2014). The production level of the poultry meat in 1990 was 216,759 tonnes, increasing to 1,758,363 tonnes in 2013 (The Ministry of Food, Agriculture and Livestock, 2014). About 70-75% of production in Turkey come from integrated establishments and 15-20% of production made in semi-integrated establishments (Gulen and Nevzat 2010).

Poultry meat is generally synonymous with broiler meat (Bagust 1994). Broiler chickens account for 75% of world production of poultry meat, while the remaining 25% is distributed almost equally between turkeys and other species including ducks, geese, pigeons, and squab.

Table 3.16: Poultry Animals and Production in Turkey from 2006-2014

Number of Poultry Animals by Types, in Thousands					
Year	**Laying Hens**	**Broilers**	**Turkeys**	**Geese**	**Ducks**
2006	58,698	286,121	3,227	830	525
2007	64,286	205,082	2,675	1,023	482
2008	63,365	180,916	3,230	1,063	470
2009	66,500	163,469	2,755	945	413
2010	70,934	163,985	2,942	716	397
2011	78,957	158,917	2,563	680	382
2012	84,677	169,034	2,761	676	357
2013	88,721	177,433	2,925	755	368
2014	93,751	199,976	2,990	912	400
Poultry Meat and Shell Egg Production, in Various					
Year	**Chicken (Tonnes)**	**Turkey (Tonnes)**	**Total (Tonnes)**	**Hen Eggs (Thousands)**	
2006	917,659	17,062	934,721	11,733,572	
2007	1,068,454	31,467	1,099,921	12,724,959	
2008	1,087,682	35,451	1,123,133	13,190,696	
2009	1,293,315	30,242	1,323,557	13,832,726	
2010	1,444,059	31,965	1,476,024	11,840,396	
2011	1,613,309	36,331	1,649,640	12,954,686	
2012	1,723,919	41,931	1,765,850	14,910,774	
2013	1,758,363	39,627	1,797,990	16,496,751	
2014	1,894,669	48,662	1,943,331	17,145,389	

Source: Turkish Statistical Institute (TURKSTAT)

Indigenous poultry production in Turkey has been increasing (FAOSTAT) and by 2013 had nearly doubled since 2004. Consumer demand for fresh, local produce is on the rise in general. Feed to meat conversion ratios for modern breeds (2.65 kg feed per kg of chicken meat) are

more efficient than those for indigenous breeds (5 kg feed/kg meat). Much of the improvement is due to the shorter time until full size is reached (5 to 7 weeks for modern breeds to reach 2.5 kg in size, versus 12 to 17 weeks for indigenous breeds) (Taha 2003). Egg production also has been expanding rapidly, from less than 12 billion in 2010 to more than 16 billion in 2013 (FAOSTAT) and to over 17 billion in 2014 (TURKSTAT).

In Turkey, poultry meat production is about twice the production of red meat from cattle, sheep, and goats (Durmus et al 2012). However, the consumption of frozen poultry meat is quite low due to a lack of knowledge about these products. The results of the Durmus et al study in 2012 revealed an existing prejudice against frozen products and recommended that the consumers be better informed.

The poultry industry has used the latest technology and has a strategical importance for supplying animal protein in Turkey. Organic poultry was initiated without official legislation in 1985. In recent years, organic poultry production industry has become a popular alternative to the conventional production of egg and meat as consumer awareness increases. According to the data of 2013 published by the Ministry of Food, Agriculture and Livestock, there are 24 enterprises performing organic poultry farming in Turkey. The data 2013 published by the Ministry of Food, Agriculture and Livestock and Turkish Statistical Institute (TSI) reports that organic broiler and broiler meat productions have a 0.1% share while the organic laying hen's production and egg production have 0.3% and 0.6% share in the enterprises, respectively. That amount is expected to increase because of the increasing consciousness of consumers regarding health and lifestyle (Yenilmez and Uruk 2014).

3.7.2. Assessment of On-Farm Losses and Economic Burden

Estimated mortality rates for on-farm chickens range from 4-8% (Gustavsson 2011; SIK 2013). Most mortality occurs in the first or last week of life in baby chicks. Mortality after about day 45 is most likely due to heart attacks, ascites and leg problems since these diseases generally increase dramatically late in the life of the flock. Clearly death losses late in the flock can have serious negative consequences on both feed conversion and pounds of sellable meat. These problems can be reduced with proper feeding and lighting programs (Tabler et al 2004).

Immunization programs can help reduce losses from diseases, and proper management of space, water, feed and light can help keep the birds healthy and reduce their susceptibility to illness. Most Turkish poultry farms are "intensive" meaning they house the maximum number of birds and are well managed, so for the purposes of this case study we can assume the mortality losses will be on the lower end of the range (4%).

Newcastle disease is an infection of domestic poultry and other bird species with virulent Newcastle Disease Virus (NDV). It is a worldwide problem that presents primarily as an acute respiratory disease, but depression, nervous manifestations, or diarrhea may be the

predominant clinical form. Severity depends on the virulence of the infecting virus and host susceptibility. Occurrence of the disease is reportable and may result in trade restrictions.

Virulent NDV strains are endemic in poultry in most of Asia, Africa, and some countries of North and South America. With an affinity for red blood cells, the virus spreads rapidly throughout the body. It is highly contagious, spreading through droppings and nasal discharge via the air, direct contact, or contact with contaminated items such as bottoms of shoes, food, or infected dishes and cages. The virus can also penetrate eggshells that come in contact with infected tissue or food, infecting the embryo, and surviving outside a host for several weeks in a warm, humid environment and indefinitely in frozen material (Olsen and Orosz 2000).

Mass vaccination methods are less labor intensive but if not applied properly may lead to <85% of the flock being immunized, which is needed for herd immunity. Alternatively, individual administration of live vaccines is via the nares or conjunctival sac. Healthy chicks are vaccinated as early as day 1–4 of life. However, delaying vaccination until the second or third week avoids maternal antibody interference with an active immune response.

With 1,758,363 million tonnes of poultry produced per year in Turkey (2013) and on-farm losses of 4%, food losses are approximately 70,300 tonnes per year. The economic consequences of 70,300 tonnes of poultry losses at a farm gate price of US$1,000 to US$1,100 per tonne, ranges from US$70 million to US$77 million in lost revenue per year for Turkish poultry farmers.

Table 3.17: Volume and Market Value of On-Farm Losses of Broiler Meat in Turkey

Total Volume Produced per Annum	Conservative Estimates of On-Farm Losses	Losses in Volume	Market Value per Tonne	Losses in Value
2 Million Tonnes ($2-2.2 billion)	4%	80,000	$1,000	$80 million
	4%	80,000	$1,100	$88 million

Source: On-Farm Visits.

Approximately 60% of the live weight is edible food, equaling 42,000 tonnes of food lost per year. Poultry meat has a food value of 2,400 kilocalories per kg, of which 27% is high quality protein (162 g per kg). The on-farm losses in food value equals approximately 101 billion kilocalories and 11.4 billion grams of protein. The lost food could have provided enough protein nutrition for 625,000 persons for a full year at 50 g/day.

3.7.3. Causes of On-Farm Food Losses

Improper poultry house management is a cause of major loss and includes overcrowding, lack of ready access to water, poor quality feeds, and poor temperature management. These practices contribute to increased general mortality rates, which are considered to be low in Turkey at 4%. Viruses such as avian flu and Newcastle disease are another cause of losses. These are highly

contagious and easily spread in crowded poultry production houses. Fear of avian flu can also contribute to lowered market access.

3.7.4. Measures and Strategies Implemented for On-Farm Loss Reduction in Turkey

According to the 2013 Food Losses and Waste in Turkey Country Report published by FAO as part of the Food Losses and Waste in Europe and Central Asia component of the Agrarian Structures Initiative, "Agricultural policies in Turkey have undergone a significant reform process to solve long-lasting problems in the agricultural sector. The major problems of Turkish agriculture are the small size of farms, fragmented and scattered farms, low efficiency, insufficiencies in production and marketing infrastructures, low levels of professional agricultural activity, low investment capacity, low level of education, ineffective institutional structures and farmers' organizations."

This report was based upon data from the FAOSTAT Food and Balance Sheet related to Turkey, data from TURKSTAT and data from various reports prepared by the public and private sector as well as related NGOs. Focus group meetings with producers and stakeholders were also held to identify food losses and waste and Critical Loss Points (CLPs) in the supply chains of meat and meat products. It was found that most of these factors have been improved for broiler production operations, which are larger in scale, more modern, well organized and directly linked to the market via contracts with buyers.

Many studies related to breeding, raising, and feeding techniques in poultry production have been conducted by universities and other research institutes. As the research results were put in practice in the 1970s through 1990s, the production level per animal raised and production costs decreased (Durmus et al 2012).

The Poultry Research Institute conducted a study to determine the poultry meat consumption and consumer trends in Turkey. Using a questionnaire composed of 26 questions, a study was conducted with 2,241 families representing the consumer profile of Turkey, supplied by Turkish Statistical Institute. Of the participants, 98.26% were determined to consume poultry meat. Annual consumption was reported at 16.67 kg, and although it differed between regions, it is still considered low overall. Halal slaughter was considered important by 68.08% of respondents, and they mentioned that it should be signified on the package. Avian influenza disease affected consumption negatively with a rate of 41.01%. 67.11% of the participants believing that the poultry meat production is not inspected adequately (Durmus et al 2012).

The Ministry of Food, Agriculture and Livestock has made extensive strategic plans to improve the bovine and ovine industries, including capacity building for extension workers in cold chain development, animal health and welfare, as well as improved food safety (Turkish Ministry Strategic Plan 2013-2017). A similar plan for poultry could help to address some of the remaining issues in the poultry industry, and make consumers feel more secure regarding the safety of their locally produced foods.

3.7.5. Lessons Learned from the Case Study

Small-scale farms and enterprises without adequate marketing linkages are often the source of high animal food losses. Turkey has overcome many of these issues as it has transitioned into modern intensive systems for producing poultry meat or eggs following a trend whereby commercial groups intensify into large-scale, vertically integrated production. According to Bagust (1994), successful large scale operations need access to and control of the following:

- Feed: controls on the quality of the formulation of rations, feed components, milling, distribution systems, and feed storage on site will be important stages in the production system.
- Housing: appropriately designed buildings for control of the production environment, as well as good husbandry and management practices will be required to attain adequate productivity.
- Breeds: in addition to decisions on the use of local or imported breeds, a balance will need to be struck in choices of the respective characteristics for production, attractiveness to the consumer and costs.
- Health: a key factor in controlling production so as to sustain, increase or decrease production as the markets may dictate; access to Specified Pathogen free poultry stock will be needed.
- Markets: a critical feature of the demand-based system, some developing Asian countries are currently providing a lesson in the simultaneous development of internal and external markets. Where earning hard currency has been a priority, some operations (e.g. China, Thailand) have leap-frogged to meet the market needs of consumer countries (e.g. Hong Kong, Japan) rather than their local markets.

Disease control and management is another area where work is needed. Mass vaccination methods for Newcastle disease are less labor intensive but if not applied properly may lead to <85% of the flock being immunized, which is needed for herd immunity. Alternatively, individual administration of live vaccines is via the nares or conjunctival sac. Healthy chicks are vaccinated as early as day 1–4 of life. However, delaying vaccination until the second or third week avoids maternal antibody interference with an active immune response (Olsen and Orosz 2000).

3.8. Case Study 8: Fish and Shrimp Aquaculture in Indonesia

Fish farming (aquaculture) is a rapidly growing industry worldwide as capture fishery reaches capacity or over-use, and will soon provide the majority of fish/sea foods consumed. Top global producers also include Bangladesh, Egypt, and Nigeria is the top producer in Sub-Saharan Africa.

3.8.1. Status and Importance

Indonesia is among the top aquaculture producers in the world. Others include China with 62% of total production; India (8%); Vietnam (4.5%); Indonesia (3.9%); Bangladesh (2%); Thailand (2%); Norway (1.7%) and Egypt (1.5%). Indonesia is the world's second largest seafood producer with a total capture fisheries and aquaculture production of over 9.9 million tonnes in

2013. Almost 40% of this comes from aquaculture. In 2010 there were 1,447,418 households, firms and companies involved in the industry (BKPM 2011). Pond culture, marine culture and embankment aquaculture are all on the rise in Indonesia as well as in Asia and the world as a whole. World food fish aquaculture production more than doubled from 32.4 million tonnes in 2000 to 66.6 million tonnes in 2012 (FAO 2014), with Asia accounting for about 88 % of world aquaculture production by volume.

Aquaculture requires fewer feedstuffs to farm fish and seafood than beef and pigs. For example, it takes 15 times as much feed to produce 1 kilogram of beef as to produce 1 kilogram of carp. Aquaculture is thus a resource-efficient method per se of producing protein-rich food from animals (WOR 2012). Driven mainly by massive population growth, urbanization and increasing wealth in Asia, aquaculture has grown by about 8 percent per annum over the past 20 years, which is a faster growth rate than any other food sector. Aquaculture production in Indonesia totaled approximately 3.8 million tonnes in 2013 (FAO Fish Stat 2013).

The Indonesian shrimp sub-sector is relatively mature and professionally organized. While there are still companies that need to find their way to the high-end international markets, most large and medium-sized companies have well established links with the EU, the US and Japanese markets. The only two important species for exports are Pacific White and Black Tiger shrimp where production is concentrated on the island of Sumatra (including Lampung). Sumatra accounts for 42% of the total shrimp production, of which 64% of the total production volume is Pacific White shrimp. According to market value, shrimp is by far the most important export product reaching $1b in 2009. The most important market for Indonesian shrimp is the US with exports consisting mainly of Pacific White shrimp.

Table 3.18: Production of Black Tiger and Pacific White Shrimp per Island in 2010 (in tonnes)

Pacific White Shrimp	Share	Black Tiger Shrimp	Share	Total
86,428	62%	53,027	38%	13,9455
12,445	42%	17,860	58%	30,305
59,946	69%	26,684	31%	86,630
9,018	37%	15,168	63%	24,186
2,530	100%			2,530
32,627	100%			32,627
201,994	**64%**	**112,739**	**32%**	**314,733**

Source: MMAF (2011)

The production volume of pangasius and tilapia has increased significantly, with production of both species tripling between 2007 and 2010. The most important production regions for both species are in Sumatra, Java and Kalimantan. Most pangasius (nearly 100%) and tilapia (about 80%) are produced for domestic consumption.

Table 3.19: Production of Pangasius and Tilapia in 2010

Island	Pangasius	Tilapia
Sumatra	97,000	204,100
Java	19,900	158,800
Kalimantan	23,500	24,800
Sulawesi		16,200
Other Provinces	7,500	50,300
Total	**147,900**	**464,200**

Source: MMAF (2011)

More recent reports show tilapia production in Indonesia has reached nearly 670,000 tonnes, and in Egypt it has reached nearly 790,000 tonnes according to the World Aquaculture Society, 2013 (Fitzsimmons, et al., 2014). In Indonesia, tilapia is produced via cage culture, polyculture and rice culture methods. The main exporter is Regal Springs, the world's largest tilapia producer, which operates a large-scale integrated farm for the international market.

Indonesia has a multitude of marine and inland waterways suitable for aquaculture. Abuses such as antibiotics in fish feed and the over-fertilization of marine waters, however, have brought the industry into disrepute (WOR, 2012).

3.8.2. Assessment of On-Farm Losses and Economic Burden

Key informants in Indonesia visited several aquaculture farming operations in Eastern Java during the analytical study to verify the literature review findings and determine whether on-farm fish and shrimp losses were similar to those being reported by FISHSTAT. Their observations and interviews indicated that on-far losses are very low, generally believed by producers to be 5% or less. The aquaculture production practices in current use by moderate to large sized operations are highly standardized and losses have been reduced via the implementation of feeding and pest management practices. However, the lack of quality, certified fry leads to low productivity and high feeding costs for shrimp and fish (CBI 2012).

Black Tiger brood stock are collected from the wild while Pacific White brood stock are mostly imported from the Continental US, Hawaii, Taiwan or China. In these countries, hatcheries specialize in producing Special Pathogen Free (SPF) brood stocks that are less disease-prone.

The quality of Pacific White shrimp seed varies widely. The main problem is that SPF brood stocks are very expensive and many hatcheries therefore forego the higher quality from the US and Hawaii to import cheaper variants, especially from China (CBI, 2012). Black Tiger shrimp seeds are mostly produced by small-scale backyard hatcheries concentrated in specific regions like Aceh in northern Sumatra. There have been many complaints about the quality of Black

Tiger shrimp seeds as hatcheries lack the motivation and capital to improve the quality of seed production (CBI 2012). Input suppliers provide fish fry and fingerlings. Most of the centres for fingerling production are located in Java, in Sukabumi and Subang, and these centres often rely on government or donor support (CBI 2012).

Shrimp production reached over 400,000 tonnes in 2008 but declined to 338,000 tonnes in 2009 due to bad weather and disease, especially those caused by Infectious Myonecrosis Virus (IMNV). Production in Indonesia has since recovered.

The decision to harvest the fish from a pond or cage is made based on the following reasons:

- The fish has attained the right size at which it gives maximum profit in the market.
- Prevailing market opportunities, such as Ramadan or a local religious festival day, increase demand and potential profit, but the opportunity may be lost with delay.

Prices for shrimp largely depend upon size, so management of the production and feeding is critical for maximizing potential profits. As written in Antara News in 2013, the prices from the farms are Rp 75,000 per kg for smaller shrimp, with 70 shrimps per kg and Rp 86,000 per kg for medium size with 50 shrimps per kg and Rp 49,000 for the largest ones with 40 shrimps per kg. In 2012, prices averaged of Rp 48,000 per kg.

Shrimp farms are usually located in remote areas and most processors do not regard it as economically viable to collect directly from the small farmers. Therefore middlemen, also called collectors, traders, or Tokeh, are involved. The harvested shrimps are either brought to the agreed collection point by the farmers or are collected by the middlemen directly from the farmers. In any case, cooling boxes with ice are only used occasionally during transport. Delays can cause higher on-farm losses. The middlemen typically come to the farm and visually check and sort the shrimps according to quality and take them to sell them to processors or in a local market (CBI 2012).

According to the EU (2010), hygiene and food safety is still unsatisfactory at the middlemen level. The Good Handling Practices which are promoted by the Ministry of Maritime Affairs and Fisheries (MMAF) are generally not implemented; ice is not sufficiently used; and the weight of the shrimp is purposely increased by storing the product in water without ice. There is not a good link between MMAF and most middlemen, resulting in a lack of systematic information flow to the middlemen and insufficient knowledge of Good Handling Practices.

The middlemen have a dominant position within the value chain of pangasius and tilapia, and many work to distribute the fish products from the farmers to processors and local markets. In the provinces, most are small entrepreneurs serving local markets, who have a limited knowledge of market demands. Very basic means of transport (bicycles and motorbikes), storage, and marketing of the products are used. The lack of ice and cold storage options particularly affects the fish quality and lowers the bargaining power of fish farmers as the

middlemen have to sell the fish at reduced prices at the end of the day of harvesting in order to avoid a total loss of income.

With 3.8 million tonnes of aquaculture produce per year in Indonesia, and on-farm losses of 5%, results in aquaculture food losses of 190,000 tonnes per year. Approximately 400,000 tonnes of the total annual production is shrimp, and 5% losses is equal to 20,000 tonnes. Shrimp contains 1,200 kilocalories per kg, 22% of which is high quality protein (66 g per kg). The loss in food value for on-farm shrimp losses is approximately 24 billion kilocalories and 1.32 billion grams of protein. This amount of lost food could have supplied the protein needs for 72,300 persons for a full year at 50 g/day.

Approximately 670,000 tonnes of the total annual production is tilapia, and 5% losses is equal to 33,500 tonnes. Tilapia contains 823 kilocalories per kg, 20% of which is high quality protein (41 g per kg). The loss in food value for on-farm tilapia losses is approximately 27.6 billion kilocalories and 1.38 billion grams of protein. This amount of lost food could have supplied the protein needs for 75,500 persons for a full year at 50 g/day.

Farm gate prices are highly variable, depending on the size and quality of the harvested product, but the economic consequences of 20,000 tonnes of shrimp/prawn losses at a conservative farm gate price of US$4 per kg, and 33,500 tonnes of fish losses at a farm gate price of $US1 per kg, totals US$103 million per year in lost income for Indonesian aquaculture farmers.

Table 3.20: Volume and Market Value of On-Farm Losses of Fish and Shrimp in Indonesia

Total Volume Produced per Annum	Conservative Estimates of On-Farm Losses	Losses in Volume	Market Value per Tonne	Losses in Value
400,000 tonnes of shrimp ($16 billion)	5%	20,000	$4,000	$80
670,000 tonnes of tilapia ($670 million)	5%	33,500	$1,000	$33.5

Source: On-Farm Visits.

3.8.3. Causes of On-Farm Losses

Most of the on-farm losses for aquaculture are related to the use of poor quality starting materials, such as fry or seeds, and poor production practices including poor sanitation, pest management or feed quality. Starting with good quality seed or fish fry is one of the keys to success in aquaculture production. This, in addition to the use of high quality feeds and protection from predators, is very important.

Many aquatic insects in their larval and/or adult stages, prey upon fish hatchlings and fry and compete with them for food. The common insect predators are beetles, including the diving beetle (Cybister), water scavenger beetle (Sternolophus) and whirling beetle (Gyrinus) which

are the more dangerous forms. Back swimmers (Anisops) appear in swarms in manured ponds during rainy season and cause heavy damage. Other predatory members of this group are water scorpion (Laccotrephes), giant water bug (Belostoma) and water stick insect (Ranatra). Proper preparation of nursery ponds for stocking with spawn aims at total eradication of such predatory insects. The basic method is to apply a thin oily film (56 kg vegetable oil + 18 kg liquid soap) over the pond surface which chokes the respiratory tubes of aquatic insects. The spawn and fish food organisms remain unaffected (Kumar 1992). Proper insect management practices in Indonesia reduce this potential cause of on-farm losses.

Proper aquaculture production practices include, among other factors, water quality management, stocking patterns and density control. Though it is preferable to have ponds of a large size for better oxygenation of the water and quicker cooling via natural winds and night time temperature drops, there is a physical limitation. According to Kumar (1992), "large ponds are difficult to fill and even more difficult to harvest. There must be an optimum size and shape of the pond to balance size with practicability of management, i.e. large enough to allow proper growth of fish, but at the same time small enough to be manageable." The recommended optimum size is 0.4 ha – 1.0 ha (Sinha and Ramachandran, 1985). Use of proper pond size management practices in Indonesia reduce this potential cause of on-farm losses.

Stocking practices and the quality of fish fry or seeds is another important factor in aquaculture production (DeSilva et al. 2015). Success of stocking programs may be affected by many variables, including but not limited to (Wahl et al. 1995; Li 1999; Brown and Day 2002):

- Stocking density and ecological carrying capacity of the receiving environment;
- Age and size of fish at stocking;
- Condition and health of fish;
- Genetic factors;
- Presence, amount of suitable habitat, food, competitors and predators at release sites;
- Timing of stocking relative to above factors; and
- Release methods.

Proper stocking management practices being used in Indonesia have reduced this potential cause of on-farm losses. According to key informants' direct observations during the analytical study, the major causes of on-farm aquaculture losses include the following, most of which are being properly managed in Indonesia:

- Poor quality stock (fry, seeds, fingerings) which reduces productivity;
- Diseases during production which reduces productivity and can lead to mortality;
- Poor quality feed that reduces productivity and is a source of aflatoxin contamination;
- Pests and predators including insects and birds that can eat the fish/shrimp;
- Poor harvest timing (hot weather, poor market access) which leads to rapid deterioration during and immediately after harvesting; and
- Lack of ice, cold storage, or aerated water tanks for use during delays between harvesting and selling which leads to rapid deterioration.

3.8.4. Measures and Strategies Implemented for On-Farm Loss Reduction in Indonesia

The Indonesian government described and explained its ambition and strategy with regard to the seafood sector in its industrialization policy. The government states that marine and fisheries industrialization is a process to enhance production systems to increase value adding capacity, productivity and the scale of production of fisheries products through modernization. This is supported by an integrated policy between macroeconomic development, infrastructure development, business and investment climate, knowledge, technology and human resources for community welfare.

Indonesia's main fishery authority is the MMAF. It is responsible for marine and fishery sector planning, management and administration in Indonesia. The Ministry comprises six line offices consisting of an Agency for Marine Affairs and Fisheries and five Directorate Generals covering Aquaculture, Capture Fisheries, Coastal and Small Islands, Marine and Fisheries Resource Controls and Processing and Marketing. These five directorates cover all aspects of the seafood industry from resource management, to development support, to information dissemination, to the implementation of regulations to the support of international marketing activities. MMAF has a large research agency which conducts research in all areas of the seafood industry (the Marine and Fisheries Research Agency). MMAF has a Marine and Fisheries Human Resource Development Agency that provides training for the fisheries, aquaculture and processing sector. Both agencies are under the direct authority of MMAF.

The government is currently developing policies to boost exports of tilapia. Due to the favorable climate in Indonesia, tilapia can be produced all year round and thus compete with tilapia from China that is only produced during the hot season. Food safety certification for exports with be required, depending upon the buyer country. For pangasius, CBI (2012) recommends that Indonesian producers would be better focusing on the domestic market rather than facing competition with Vietnamese pangasius.

The Aquaculture and Fisheries group of Wageningen University is planning to launch a programme to increase productivity in Indonesian shrimp farms for the Dutch Partners for Water Programme. At the time of this report, the baseline study in Demak district was complete, and future plans involved a kick-off for further research in three districts of Java in the first week of March 2016.

Rabobank Foundation works with Black Tiger producers in Aceh while Oxfam, the International Union for the Conservation of Nature (IUCN) and the Mangrove alliance work with Black Tiger producers in Kalimantan, Makassar and East Java. Both donors work especially with Black Tiger producers and try to enhance their productivity, competitiveness and try to prepare them for Aquaculture Stewardship Council (ASC) certification.

As many exporters are large companies with good financial resources and established links with the EU, USA and Japanese buyers, many of the exporters are interested in and being forced to look at developing plans for traceability and production of sustainable certified products. However, to make the right decisions about which certification(s) to pursue, exporters may need additional technical assistance. There is a Network for Aquaculture Centres in Asia-Pacific (NACA) which offers online information on many topics related to production and Better Management Practices (BMPs). A library of downloadable documents and reports is available to the public on the NACA website.

3.8.5. Lessons Learned from the Case Study

On-farm losses in Indonesia's aquaculture operations were relatively low and well managed. The actors in the food supply chain, especially the producers, seemed aware of the possibility of losses and the strategies to overcome them. The on-farm losses observed by key informants for this analytical study were less than 5%. This result can be used as a good example for fish loss reduction in any other food supply chain in Indonesia (Wibowo et al 2015) and a few lessons can be learned. Other countries address the major causes of on-farm losses by following the practices listed below, most of which are being used successfully in Indonesia.

- Use improved quality stocking inputs (fry, seeds, fingerings). This will address the reduced productivity currently being experienced. Support for development of nurseries will be needed at the national level, and perhaps some encouragement to help them import the higher quality shrimp stock rather than cheap seeds.
- Manage diseases during production. Many types of diseases reduce productivity and can lead to mortality. Paying attention to stocking density and disease management will lead to increased production from the same base of operations.
- Avoid the use of poor quality feed. Poor quality foods reduce productivity. It is recommended that aquaculture producers provide adequate nutrition to their ponds and other water bodies, and regularly measure the rate of fish or shrimp growth to monitor results. Test and control fungal contamination and mycotoxin levels.
- Manage and control pests and predators. Many insects and birds can eat the fish/shrimp, so successful aquaculture includes pest control practices. Water surface can be protected from insects with simple non-toxic soap and oil solutions.
- Avoid poor harvest timing. Paying attention to the timing of the harvest can avoid periods of excessive heat which leads to rapid deterioration during and immediately after harvesting and can ensure market access.
- Use ice or cold storage during delays between harvesting and selling. If delays are anticipated between harvesting fish or shrimp and having the lot picked up by the buyer, use of cooling (ice slurries or very cold water) can reduce the rapid deterioration of the produce.

3.9 Summary of the Case Study Findings

For each of the six case studies that focused on food crops, on-farm losses can be organized into three categories:

- Production: lost yield due to pests, poor water management, lower quality due to poor quality seeds, fertilization practices.
- Harvesting: physical damage; poor quality from improper maturity or moisture content.
- Handling: physical damage on-farm after harvesting, spillage, exposure to sun, heat, pests, use of poor quality containers.

Table 3.21: Major Causes of On-Farm Crop Losses and the Means for Reducing Losses

Case Study	Causes of On-Farm Losses	On-Farm Losses	Means for Reduction of On-Farm Losses
Maize in Uganda	Production: weeds, insect pests, poor soil fertility; Harvesting: harvesting too early or too late; Handling: leaving cobs in the field, poor drying practices.	10-15%	- Integrated pest management - Improved fertilization - Use improved drying practices (cement pads, tarpaulins or cribs) - Dry to 13% before bagging - Consider picking bags to collect cobs
Sweetpotatoes in Nigeria	Production: insect pests, fungi, rodents; Harvesting: damage during digging, harvesting too early or late; Handling: rough handling, leaving produce in the sun after harvest.	2-5%	- Improved pest management - Avoid harvesting damage - Protect produce from direct sun after harvest - Curing before bagging or loading
Cassava in Nigeria	Production: weeds, insect pests, fungi, rodents; Harvesting: damage during digging, harvesting too early or too late; Handling: rough handling, leaving produce in the sun after harvest.	2-5%	- Improved pest management - Avoid harvesting damage - Protect produce from direct sun after harvest - Curing before bagging or loading
Groundnuts in Benin	Production: poor quality seeds, weeds, insect pests, fungi; Harvesting: improper moisture content and/or maturity, rough practices; Handling: spillage during handling, exposure to direct sun.	10-15%	- Certified seeds - Improved pest management - Check maturity before harvest - Avoid harvesting damage - Dry to 6 to 8% moisture - Protect produce from rain and pests after harvest and

Case Study	Causes of On-Farm Losses	On-Farm Losses	Means for Reduction of On-Farm Losses
			during drying to prevent aflatoxin contamination
Tomatoes in Egypt	Production: weeds, insect pests, sunburn; Harvesting: rough harvesting, damage to plants and fruits; Handling: use of crates with sharp edges, physical damage, exposure to sun and heat after harvest.	15-20%	- Protect crop from weed competition - Improved canopy management to prevent sun damage - Use of plastic crates or adding liners in date palm rib crates - Protect produce from direct sun after harvest (use shade)
Plantains in Uganda	Harvesting: harvesting too early or too late, rough harvesting, dropping bunches; Handling: leaving bunches exposed to direct sun, rough handling during carrying, stacking and loading.	5%	- Check maturity before harvest - Avoid dropping, rough handling - Consider using two harvesters rather than one to reduce physical damage - Protect produce from direct sun after harvest (use shade)

Source: On-Farm Visits; Based on Own Experience and Evaluation.

4. CAUSES AND CONSEQUENCES OF ON-FARM FOOD LOSSES

4.1 Main Causes of On-Farm Losses

The complex issue of "lost yield" versus "food loss" is a difficult mix to unravel. Harmful insects, pathogens, nematodes, weeds, rodents, and other animals have an impact on crop yield through a chain of events that links the injuries they inflict on crop stands, to losses in crop quantity and quality via injuries cause, resulting in volumetric and economic losses (IITA 2010). These pest problems are responsible for significant losses that are estimated to range from 26-40% of the attainable, uninjured yield in major food and cash crops (Oerke 2006). Even greater levels of crop losses have been known to occur, depending on the nature of the crop, the nature of the pests, weather events, and any climatic conditions favoring pest outbreaks and damage.

Some examples of integrated pest management being promoted by CGIAR (IITA 2010) include:

- Cultural practices such as mulching, pruning, early harvesting and planting, grafting, roguing (removing affected plants), host-free period, and hand weeding;
- Pest control treatments such as soil solarization, hot water treatment, pheromone traps, sticky traps, bagging fruits, hand picking insects, and irradiation;
- Classical biocontrol, augmentative release, and exchange or redistribution of natural enemies between regions;
- Bio-pesticides such as Trichoderma, Pseudomonas, Bacillus subtilis, nuclear polyhedrous virus, Bt, Neem, entomopathogenic fungi, and nematodes; and
- Conventional and marker assisted breeding and genetically modified crops.

Some of these practices are simple and low-cost and can be implemented by farmers. The incorporation of living mulches is an example of an innovative cropping system for integrated soil and pest management in cereal-based farming systems, minimizing pest infestation, sustaining permanent soil cover, and increasing soil fertility (Chabi-Olaye et al. 2005).

Yields gaps are complex and difficult to pinpoint, but an idea of the potential range of production in comparison to the global averages can be observed from the FAOSTAT (2013) production yield database. Countries that can utilize irrigation consistently tend to have higher average yields than those countries that are rain dependent. Red indicates yields that are above the world average.

Table 4.1: The Range of Yields for Key Crops Produced in the OIC Member Countries

Crop Yields	Nigeria	Uganda	Egypt	Turkey	Indonesia	OIC Average*	World Average
Maize	2.0	2.4	7.8	8.9	4.8	5.2	5.5
Sweetpotatoes	3.1	4.7	32.2	-	14.7	11.2	12.6
Cassava	13.9	12.0	-	-	22.4	16.1	13.6
Groundnuts	1.3	0.7	3.2	3.5	2.6	2.3	1.8
Tomatoes	5.7	5.8	40	38.0	17.5	13,4	34.7
Plantains	6.2	5.4	-	-	-	5.8	6.9

Source: FAOSTAT.
**Average of the Listed Countries.*

Key informants were asked to provide information on the causes of losses for each food group. Potential on-farm related causes were listed in detail (the first 11 choices in a list of 18), so key informants could identify or add other possible causes of food losses for the food groups for which they held expertise.

4.1.1 Cereals

When key informants in each of the Arab, Asian and African Group countries were asked about important on-farm causes of losses for cereals they indicated that eight or more causes were important, with a wide range of poor practices and issues cited. For the Arab Group, pests on the farm was indicated by 14 of the 17 key informants. For the Asian Group, 19 of 22 key informants highlighted pests on the farm and 18 of 22 cited poor quality containers and sacks. For the African Group, 10 of the 11 on-farm line items were cited by more than 50% of the key informants.

The majority of key informants indicated that there were several other causes of losses for cereals, including lack of storage, processing, infrastructure and marketing options. For less perishable crops like cereals, these are commonly found causes of losses. Very few of the key informants mentioned delays in transport or temperature management as problems. A key informant from UAE reported "decoration waste" as a cause of cereals losses.

A key informant in Syria reported that there are additional food losses resulting from the ongoing fighting in Syria, which raises the rate of food losses to a high rates more than 50% due to:

- Fires in cereal crops;
- Road damage and highway outages;
- Inability to access wide areas planted with various crops; and
- Lack of electricity, seeds, fertilizer and pesticides.

Summary, with the highest ratings and percentages in each table highlighted.

Table 4.2: Tally of Numbers and % of Key Informant Responses for Cereals

Possible Causes of Food Losses for Cereals	Arab Group N = 17 (%)	Asian Group N =22 (%)	African Group N =17 (%)
Pre-Harvest Causes			
Poor information and planning	11 (63.70)	15 (68.18)	11 (63.7)
Lack of inputs (fertilizer, etc.)	8 (47.06)	13 (59.09)	10 (58.82)
Poor quality seeds, planting material	9 (52.94)	16 (72.73)	10 (58.82)
Pests on the farm (weeds, insects, rodents)	14 (82.53)	19 (86.36)	14 (82.53)
Poor cultural practices (pruning, fertilizing, pesticide spraying)	8 (47.06)	14 (63.64)	13 (76.47)
Poor water management or drought	10 (58.82)	16 (72.73)	13 (76.47)
Plant or animal diseases on the farm (fungi, viruses, bacterial rots)	11 (63.7)	16 (72.73)	10 (58.82)
Harvesting Causes			
Poor harvesting practices (incomplete harvesting)	10 (58.82)	13 (59.09)	9 (52.94)
Wrong time for harvest (immature, over-mature, improper moisture content)	6 (35.29)	9 (40.9)	6 (35.29)
Mechanical damage during postharvest threshing and handling (rough handling)	11 (63.7%)	4 (18.18)	10 (58.82)
Poor quality field containers or shipping packages	10 (58.82)	18 (81.82)	9 (52.94)
Other Causes			
Poor temperature management (too cold, too hot, no cold chain)	10 (58.82)	4 (18.18)	6 (35.29)
Lack of proper storage facilities	11 (63.70)	18 (81.82)	15 (88.24)
Lack of proper food processing and packaging	12 (70.59)	16 (72.73)	8 (47.06)
Delays in transport/distribution	7 (41.18)	9 (40.9)	5 (29.41)
Poor roads and related infrastructure	12 (70.59)	15 (68.18)	8 (47.06)
Lack of marketing options	10 (58.82)	11 (50)	6 (35.29)
Consumption (waste)	8 (47.06)	10 (40.9)	8 (47.06)

Source: Key Informant Surveys.

4.1.2. Roots and Tubers

Key informants in the Arab, Asian and African Groups indicated that 10 out of the 11 potential on-farm causes of losses were important. The Arab group cited poor information, poor water management, poor harvesting practices, wrong timing for harvesting, and poor quality field containers as the major causes of on-farm losses. The Asian Group key informants reported pests on the farm and mechanical damage in addition to the causes identified by the Arab Group. For perishable crops, these are common problems in all countries. More than 50% of the key informants for the African groups selected all the on-farm causes with the exception of the wrong time for harvest.

In addition to these on-farm causes of losses, more than 50% of all the key informants identified poor temperature management, lack of proper storage facilities, lack of proper food processing and packaging, delays in transportation, and lack of marketing options as important causes of losses for roots and tuber crops in their countries. A key informant from the UAE reported "decoration waste" as a cause of cereals losses; a key informant from Palestine reported on poor quality production of roots and tubers as a hindrance to marketing; and a key informant from Burkina Faso cited a "lack of competent extension service assistance."

Table 4.3: Tally of Numbers and % of Key Informant Responses for Roots and Tubers

Possible Causes of Food Losses for Roots and Tuber Crops	Arab Group N = 18 (%)	Asian Group N = 21 (%)	African Group N = 16 (%)
Pre-Harvest Causes			
Poor information and planning	14 (77.78)	13 (61.9)	14 (87.5)
Lack of inputs (fertilizer, etc.)	9 (50)	12 (57.14)	10 (62.5)
Poor quality seeds, planting material	12 (66.67)	11 (52.38)	10 (62.5)
Pests on the farm (weeds, insects, rodents)	13 (72.22)	18 (85.71)	15 (93.75)
Poor cultural practices (pruning, fertilizing, Pesticide spraying)	13 (72.22)	14 (66.67)	12 (75)
Poor water management or drought	14 (77.78)	10 (47.62)	9 (56.25)
Plant or animal diseases on the farm (fungi, viruses, bacterial rots)	12 (66.67)	14 (66.67)	11 (68.75)
Harvesting Causes			
Poor harvesting practices (damaged by cuts, bruises, etc.)	14 (77.78)	14 (66.67)	12 (75)
Wrong time for harvest (immature, over-mature)	14 (77.78)	14 (66.67)	5 (31.25)

Possible Causes of Food Losses for Roots and Tuber Crops	Arab Group N = 18 (%)	Asian Group N = 21 (%)	African Group N = 16 (%)
Mechanical damage during postharvest handling (rough handling, throwing, dropping)	13 (72.22)	13 (61.9)	11 (68.75)
Poor quality field containers or shipping packages	14 (77.78)	14 (66.67)	10 (62.5)
Other Causes			
Poor temperature management (too cold, too hot, no cold chain)	13 (72.22)	11 (52.38)	13 (81.25)
Lack of proper storage facilities	14 (77.78)	13 (61.9)	14 (87.5)
Lack of proper food processing and packaging	14 (77.78)	12 (57.14)	11 68.75
Delays in transport/distribution	11 (61.11)	11 (52.38)	10 (62.5)
Poor roads and related infrastructure	12 (66.67)	10 (47.62)	10 (62.5)
Lack of marketing options	14 (77.78)	11 (52.38)	10 (62.5)
Consumption (waste)	9 (50)	6 (28.71)	10 (62.5)

Source: Key Informant Surveys.

4.1.3. Oilseeds and Pulses

Key informants in the Arab, Asian and African Groups indicated that many of the potential on-farm causes of losses were important for their countries. The majority of the key informants in the Arab Group identified poor planning, poor quality seeds, pests on the farm, poor cultural practices, poor water management and plant diseases as the most important causes of food losses for oilseeds and pulses. Key informants for Asian Group countries identified many of these same causes, and key informants for countries in the African Group identified these causes plus mechanical damage and spillage on the farm.

Regarding other causes of losses, the majority of key informants in the Arab Group reported all the possible causes including poor temperature management, lack of proper storage facilities, processing, packaging, infrastructure, and marketing options. A key informant from UAE reported "decoration waste" as a cause of oilseeds and pulses losses. For the Asian Group, only lack of processing and packaging was viewed as an important cause of losses, and for the African Group, key informants identified lack of storage and lack of processing and packaging. One key informant in Turkey reported on rancidity problems and oxidation as an important cause of oilseeds losses.

For less perishable crops like oilseeds and pulses, these are commonly found causes of losses. Very few of the key informants mentioned delays in transport or temperature management as problems.

Table 4.4: Tally of Numbers and % of Key Informant Responses for Oilseeds and Pulses

Possible Causes of Food Losses for Oilseeds and Pulses	Arab Group N = 14 (%)	Asian Group N = 17 (%)	African Group N = 17 (%)
Pre-Harvest Causes			
Poor information and planning	8 (57.14)	10 (58.82)	9 (52.94)
Lack of inputs (fertilizer, etc.)	6 (42.86)	9 (52.94)	7 (41.18)
Poor quality seeds, planting material	7 (50)	7 (41.18)	9 (52.94)
Pests on the farm (weeds, insects, rodents)	9 (64.29)	13 (76.47)	10 (58.82)
Poor cultural practices (pruning, fertilizing, pesticide spraying)	8 (57.14)	13 (76.47)	8 (47.06%)
Poor water management or drought	9 (64.29)	6 (35.29)	9 (52.94)
Plant or animal diseases on the farm (fungi, viruses, bacterial rots)	9 (64.29)	11 (61.71)	10 (58.82)
Harvesting Causes			
Poor harvesting practices	6 (42.86)	8 (47.06%)	7 (41.18)
Wrong time for harvest (immature, over-mature)	6 (42.86)	6 (35.29)	6 (35.29)
Mechanical damage during postharvest handling (rough handling, spillage)	5 (35.71)	5 (29.41)	9 (52.94)
Poor quality field containers or shipping packages	7 (50)	5 (29.41)	6 (35.29)
Other Causes			
Poor temperature management (too cold, too hot, no cold chain)	7 (50)	5 (29.41)	5 (29.41)
Lack of proper storage facilities	10 (71.43)	8 (47.06)	9 (52.94)
Lack of proper food processing and packaging	11 (78.57)	10 (58.82)	10 (58.82)
Delays in transport/distribution	5 (35.71)	5 (29.41)	3 (17.65)
Poor roads and related infrastructure	9 (64.29)	6 (35.29)	6 (35.29)
Lack of marketing options	9 (64.29)	8 (47.06)	5 (29.41)
Consumption (waste)	9 (64.29)	4 (23.53)	4 (23.53)

Source: Key Informant Surveys.

4.1.3. Fruits and Vegetables

An overwhelming majority of key informants in the Arab, Asian and African Groups indicated that all 11 of the possible on-farm causes of losses were important for fruit and vegetables crops. Nearly every key informant included poor harvesting practices and mechanical damage on the farm as important for the fruit and vegetable crops in their country.

With regard to other causes of losses, poor temperature management, lack of proper storage, processing, packaging, delays in transport, poor infrastructure, and lack of marketing options were identified by a vast majority of all the key informants. In addition, one key informant from the UAE reported "decoration waste" as a cause of fruits and vegetables losses; a key informant from Turkey identified "unmarketable produce;" and a key informant from Gabon added "a lack of awareness of farmers" as an important cause of losses.

Table 4.5: Tally of Numbers and % of Key Informant Responses for Fruits and Vegetables

Possible Causes of Food Losses for Fruits and Vegetables	Arab Group N = 19 (%)	Asian Group N = 24 (%)	African Group N = 18 (%)
Pre-Harvest Causes			
Poor information and planning	16 (84.21)	23 (95.83)	15 (83.33)
Lack of inputs (fertilizer, etc.)	10 (52.63)	13 (54.17)	11 (61.11)
Poor quality seeds, planting material	13 (68.42)	13 (54.17)	10 (55.55)
Pests on the farm (weeds, insects, rodents)	17 (89.47)	22 (91.67)	16 (88.89)
Poor cultural practices (pruning, fertilizing, Pesticide spraying)	14 (73.68)	19 (79.17)	16 (88.89)
Poor water management or drought	15 (78.95)	15 62.5	11 (61.11)
Plant or animal diseases on the farm (fungi, viruses, bacterial rots)	13 (68.42)	18 (75)	14 (77.78)
Harvesting Causes			
Poor harvesting practices (damaged by cuts, bruises, etc.)	17 (89.47)	20 (83.33)	17 (94.44)
Wrong time for harvest (immature, over-mature)	16 (84.21)	17 (70.83)	15 (83.33)
Mechanical damage during postharvest handling (rough handling, throwing, dropping)	17 (89.47)	19 (79.17)	14 (77.78)
Poor quality field containers or shipping packages	18 (94.74)	18 (75)	14 (77.78)
Other Causes			

Possible Causes of Food Losses for Fruits and Vegetables	Arab Group N = 19 (%)	Asian Group N = 24 (%)	African Group N = 18 (%)
Poor temperature management (too cold, too hot, no cold chain)	17 (89.47)	21 (87.5)	13 (72.22)
Lack of proper storage facilities	18 (94.74)	21 (87.5)	16 (88.89)
Lack of proper food processing and packaging	16 (84.21)	18 (75)	16 (88.89)
Delays in transport/distribution	17 (89.47)	18 (75)	14 (77.78)
Poor roads and related infrastructure	14 (73.68)	19 (79.17)	13 (72.22)
Lack of marketing options	16 (84.21)	19 (79.17)	13 (72.22)
Consumption (waste)	11(57.89)	12 (50)	14 (77.78)

Source: Key Informant Surveys.

4.1.4. Meat and Eggs

There were fewer key informants with expertise in meats and eggs than for the crop-related food groups. The majority of key informants in the Arab, Asian and African Groups indicated that poor information, planning, and animal diseases on-farm were the most important causes of on-farm losses for meat and eggs. Key informants for the Arab and Asia Groups also identified poor quality shipping packages or containers for eggs as important causes of on-farm losses.

Regarding other possible causes of losses, key informants in all three OIC Member Country Groups included poor temperature management, lack of proper storage, processing, and packaging. These are all commonly found causes of losses for perishable foods.

In addition to the choices provided in the survey, a key informant from Yemen added "unhygienic conditions;" a key informant from Palestine reported "poor quality products;" and from the UAE there was "decorative waste" as important causes of losses of meats and eggs.

Table 4.6: Tally of Numbers and % of Key Informant Responses for Meats and Eggs

Possible Causes of Food Losses for Meat and Eggs	Arab Group N = 13 (%)	Asian Group N = 16 (%)	African Group N = 13 (%)
Pre-Harvest Causes			
Poor information and planning	11 (84.62)	9 (56.25)	8 (61.54)
Lack of inputs (feed, etc.)	5 (38.46)	5 (31.15)	5 (38.46)
Poor quality starting materials	1 (7.69)	0	2 (15.38)
Pests on the farm (insects, rodents)	3 (23.08)	3 (18.75)	4 (30.77)

Possible Causes of Food Losses for Meat and Eggs	Arab Group N = 13 (%)	Asian Group N = 16 (%)	African Group N = 13 (%)
Poor cultural practices (pruning, fertilizing, Pesticide spraying)	2 (15.38)	1 (6.25)	2 (15.38)
Poor water management or drought	2 (15.38)	5 (31.25)	1 (7.69)
Plant or animal diseases on the farm (fungi, viruses, bacterial rots)	9 (69.23)	7 (43.75)	9 (69.23)
Harvesting Causes			
Poor harvesting practices (damaged by cuts, bruises, etc.)	3 (23.08)	2 (12.5)	2 (15.38)
Wrong time for harvest (immature, over-mature)	0	0	1 (7.69)
Mechanical damage during postharvest handling (rough handling, throwing, dropping)	6 (46.15)	3 (18.75)	2 (15.38)
Poor quality field containers or shipping packages	8 (61.54)	11 (68.75)	4 (30.77)
Other Causes			
Poor temperature management (too cold, too hot, no cold chain)	9 (69.23)	13 (81.25)	9 (69.23)
Lack of proper storage facilities	12 (92.31)	13 (81.25)	10 (76.92)
Lack of proper food processing and packaging	10 (76.92)	12 (75)	10 (76.92)
Delays in transport/distribution	9 (69.23)	10 (62.5)	7 (53.85)
Poor roads and related infrastructure	12 (92.31)	9 (56.25)	5 (38.46)
Lack of marketing options	8 (61.54)	7 (43.75)	4 (30.77)
Consumption (waste)	8 (61.54)	3 (18.75)	7 (53.85)

Source: Key Informant Surveys.

Larger scale animal production operations generally have better access to information on best practices. They typically choose to invest in good quality feed, and provide proper sanitation and health care and are linked directly to the market.

When it comes to rearing of improved strains of backyard poultry, farmers have to acquire knowledge and skills necessary for taking appropriate decisions to reach their production potential. These include aspects such as:

- Artificial heating and brooding: readymade or improvised, temperature adjustments;
- Medication: medicines, dosage and route of administration;
- Feeding: completely on chick mash, completely scavenging or both;

- Watering: readymade waterers or improvised;
- Housing: type of housing and night shelter;
- Identification of poor growth or weak chicks and their management;
- Regular vaccination: for which diseases and when;
- Control of mortality: reasons for mortality such as disease, predator attacks or poor management;
- Post mortem of dead birds for proper diagnosis and control: whether to take the dead birds for post mortem or not, and if yes, where and how to get it done;
- Weighing the birds at different stages: how to weigh and approximate required weights at different ages;
- Recording of feed consumption and egg production.

Poultry farmers therefore need different types of advice and also the knowledge and skills to improve their on-farm practices (Sasidhar 2009).

4.1.5. Milk and Dairy

Key informants in the Arab, Asian and African Groups indicated that animal diseases were the most important of on-farm causes of losses for milk and dairy. In addition, for the Asian Group, the majority of key informants identified poor information and planning as an important cause of on-farm losses.

Regarding other possible causes, key informants in all three OIC Member Country Groups included poor temperature management, lack of proper storage, processing and packaging, transport, infrastructure, and marketing options. These are all commonly found causes of losses for perishable foods. In addition, one key informant in Gabon reported on the "lack of laboratories for assessing quality and safety" and for the UAE an important cause of losses for milk and dairy products is "decorative waste."

Table 4.7: Tally of Numbers and % of Key Informant Responses for Milk and Dairy

Possible Causes of Food Losses for Milk and Dairy	Arab Group N = 19 (%)	Asian Group N = 24 (%)	African Group N = 18 (%)
Pre-Harvest Causes			
Poor information and planning	7 (53.85)	12 (60)	6 (42.86)
Lack of inputs (feed, etc.)	3 (23.08)	4 (20)	5 (35.71)
Poor quality starting materials	1 (7.69)	0	1 (7.14)
Pests on the farm (weeds, insects, rodents)	4 (30.77)	4 (20)	3 (23.08)
Poor cultural practices (pruning, fertilizing, Pesticide spraying)	2 (15.38)	1 (5)	2 (14.29)
Poor water management or drought	4 (30.77)	4 (20)	1 (7.14)
Animal diseases on the farm (fungi, viruses, bacterial rots)	9 (69.23)	7 (35)	9 (64.29)

Possible Causes of Food Losses for Milk and Dairy	Arab Group N = 19 (%)	Asian Group N = 24 (%)	African Group N = 18 (%)
Harvesting Causes			
Poor harvesting practices (damaged by cuts, bruises, etc.)	5 (38.46)	5 (25)	3 (23.08)
Wrong time for harvest (immature, over-mature)	1 (7.69)	0	0
Mechanical damage during postharvest handling (rough handling, throwing, dropping)	1 (7.69)	3 (15)	3 (23.08)
Poor quality field containers or shipping packages	4 (30.77)	9 (45)	5 (35.71)
Other Causes			
Poor temperature management (too cold, too hot, no cold chain)	11 (84.62)	16 (80)	10 (71.43)
Lack of proper storage facilities	10 (76.92)	17 (85)	13 (92.86)
Lack of proper food processing and packaging	9 (69.23)	13 (65)	9 (64.29)
Delays in transport/distribution	10 (76.92)	10 (50)	10 (76.92)
Poor roads and related infrastructure	8 (61.54)	11 (55)	9 (64.29)
Lack of marketing options	11 (84.62)	10 (50)	7 (50)
Consumption (waste)	9 (69.23)	5 (25)	7 (50)

Source: Key Informant Surveys.

4.1.6. Fish and Seafood

Key informants in the Arab, Asian and African Groups indicated that poor information and planning and poor quality field containers or shipping packages were the most important causes of on-farm losses for fish and seafood.

Regarding other possible causes of losses, the majority of key informants in all three OIC Member Country Groups included poor temperature management, lack of proper storage, processing and packaging, transport, infrastructure, and marketing options. These are all commonly found causes of losses for perishable foods. In addition, one key informant in Burkina Faso reported on the "unhygienic conditions" and for the UAE an important cause of losses for fish and seafood products is "decorative waste."

Table 4.8: Tally of Numbers and % of Key Informant Responses for Fish and Seafood

Possible Causes of Food Losses for Fish and Seafood	Arab Group N = 15 (%)	Asian Group N = 18 (%)	African Group N = 13 (%)
Pre-Harvest Causes			
Poor information and planning	10 (66.67)	9 (50)	9 (69.23)
Lack of inputs (feed, etc.)	1 (6.67)	4 (22.22)	4 (30.77)
Poor quality seeds, fry	1 (6.67)	3 (16.67)	3 (23.08)
Pests on the farm (weeds, insects, rodents)	1 (6.67)	3 (16.67)	2 (15.38)
Poor cultural practices (feeding)	2 (13.33)	2 (11.11)	4 (30.77)
Poor water management or drought	2 (13.33)	7 (38.89)	4 (30.77)
Diseases (fungi, viruses, bacterial rots)	6 (40)	5 (27.78)	5 (38.46)
Harvesting Causes			
Poor harvesting practices (damaged by cuts, bruises, etc.)	2 (13.33)	3 (16.67)	5 (38.46)
Wrong time for harvest (immature, over-mature)	2 (13.33)	1 (5.56)	1 (7.69)
Mechanical damage during postharvest handling (rough handling, throwing, dropping)	4 (26.67)	6 (33.33)	5 (38.46)
Poor quality field containers or shipping packages	8 (53.33)	12 (66.67)	8 (61.54)
Other Causes			
Poor temperature management (too cold, too hot, no cold chain)	11 (73.33)	15 (83.33)	11 (84.62)
Lack of proper storage facilities	12 (80)	16 (88.89)	12 (92.31)
Lack of proper food processing and packaging	11 (73.33)	15 (83.33)	9 (69.23)
Delays in transport/distribution	10 (66.67)	11 (61.11)	11 (84.62)
Poor roads and related infrastructure	10 (66.67)	12 (66.67)	7 (53.85)
Lack of marketing options	9 (60)	11 (61.11)	11 (84.62)
Consumption (waste)	9 (60)	6 (33.33)	7 (53.85)

Source: Key Informant Surveys.

4.1.7. Summary of On-Farm Losses for All the Food Groups

Hussein in Kader et al (2012) summarized the major causes of on-farm losses for fruits, vegetables, roots, and tuber crops in the Middle East and North Africa region, and many of these apply to other food crops, food groups and regions of the world. There are many commonly encountered causes of food losses, including losses during production, harvesting and on-farm handling, which can be summarized by food group as follows.

Cereals

The main causes as identified by the key informant survey for on-farm losses of cereals are pests on the farm these include weeds, and striga especially is one of the most notorious weeds, insects such as stem and ear borers (Chabi-Olaye et al. 2005), and rodents. The poor water management and drought were identified, and this has been become more critical through climate change. The last cause of on-farm losses is lack of proper storage facilities leading to high losses in cereals, which have been documented to reach between 16.8 and 19.9 % for maize in Africa annually from 2003 till 2014 (APHLIS).

Roots and Tubers

Similar to cereals, pests on the farm were ranked as the top cause of on-farm losses for roots and tubers, with rodents and insects cited as particular problems. Especially in Africa and lately Asia some of the main insect pests, like cassava mealybug and cassava green mite have been controlled through biocontrol. Poor harvesting practices such as roots and tubers being damaged by cuts and bruises were leading to high losses. Additionally, many roots are left uncollected due to small size and a shortage of labour. Lack of proper storage facilities was the third reason for high losses as harvested roots and tubers, such as potatoes, sweetpotatoes, and taro, need to be stored properly or processed within 48 hours for cassava.

Oilseeds and Pulses

For oilseeds key informants felt that lack of proper food processing and packaging was leading to high on-farm losses. This is mainly canning of pulses and processing into. Also pests on the farm, due to a lack of pesticides that enable the farmers to control the pests, and poor cultural practices lead to high on-farm losses. Insects are especially known to cause high losses in pulses and legumes, and they are also vectors for viruses.

Fruits and Vegetables

The main cause for losses of fruits and vegetables as identified by the key informants was poor information and planning. At times this leads to a total loss when prices at harvest are so low that farmers would rather leave the crop unharvested. Also poor harvesting practices damage fruits and vegetables through poor handling and rough treatment. Lack of proper storage facilities, especially those with proper temperature control, leads to high losses. Unfortunately, very few countries have cold stores that are properly managed and accessible to farmers.

Meats and Eggs

Lack of storage facilities was cited by the key informants as the highest cause of on-farm losses. Also lack of proper processing and packing lead to losses, in many countries packaging material and processing facilities do not exist. The third reason for losses is poor temperature management which is also related to the two above loss reasons, most traditional markets and open air trading facilities in OIC have little facilities for temperature control.

Milk and Dairy

Lack of proper storage facilities and poor temperature management were cited as the reason for the highest losses in milk and dairy. These are actually related since temperature management during storage of milk and dairy products is crucial to reducing losses. Furthermore, key informants stated that delays in transport and distribution were leading to high on-farm losses in these products.

Fish and Seafood

Similarly, for fish and seafood poor temperature management was cited as highest reason for losses. This is further compounded by the lack of proper food processing and packaging. Delays in transport and distribution were also raised by the key informants.

4.1.8. Summary of Pre-Harvest, Harvest and Other Causes of On-Farm Losses

Pre-harvest Causes of Food Losses

1. Small-scale farmers represent the majority of food suppliers to the supply chain and market channels which causes improper planning for suitable continuous production to cover the whole fresh or processing seasons, large variations in production practices as well as productivity and quality, and a difficulty in using machinery for planting, crop management or harvesting. Small farmers usually have limited resources, and lack needed infrastructure and marketing channels for distribution.
2. Production site is remote from market or processing plants leading to higher transport costs and increased chances to quantitative and qualitative losses especially when transporting the fresh produce on unpaved roads, in unsuitable containers and/or trucks, and under high temperature and low relative humidity conditions.
3. Choice of crop type is usually based on personal opinion for expected profitability without conducting market study or contracting with a buyer to ensure profitability which may lead to reduced crop price or loss of whole crop at farm gate due to high harvest costs during peak production time.
4. Lack of education, training and access to good agricultural practices in production.
5. Growers are vulnerable to unexpected climate changes due to lack of suitable equipment for weather prediction and early warning system.
6. Decisions on production practices are made in most cases by guesswork and site-specific experience due to lack of science-based extension services.
7. Planting genotypes in unfavorable environmental conditions and/or using unhealthy plant material leading to death of plant material, germination problems, weak growth or poor quality.
8. Over or under irrigation regimes resulting in increased disease or pest level, decreased productivity, quality and postharvest shelf life.

9. Unbalanced nutrition program, fertilization scheduling, or use of uncertified fertilizers leading to unbalanced crop load, poor crop quality, and short postharvest shelf life of produce.
10. Ineffective pest control programs causing increased pest damage to produce.
11. Incorrect or poor management for planting time, grafting, pruning, thinning, pollination or application of growth regulators which is a main source for decreased productivity, quality, and shelf life of produce.

Harvest Causes of Losses

Causes of harvest loss can be broken down in a variety of ways. Generally, they can be due to harvesting at an improper stage of development or mechanical damage caused by equipment and perhaps rough handling. Many losses can be accounted for by the presence of disorders such as sunburn, cracking, pest damage, sap damage, and frost damage, and in some cases spray residues or spray damage. On some occasions, spillage in the field during collection of the harvest means some crops are simply left in the field. Finally, high crop temperature and high water loss result in reduced crop quality and shelf life.

Many on-farm production, harvesting and handling practices can lead to higher losses later in the food supply chain. The practices that have been associated with on-farm losses include:

1. Poor Production Practices
    a. Pest and disease management
    b. Nutrition, feeding, and fertilization practices
    c. Irrigation management
2. Climate and Weather Events
    a. Rainstorms, hail and sunburn
    b. Moisture influx due to low night temperature; high altitude
    c. Cold night causing abortion of fruitlets in early season fruits such as loquat
    d. Warm nights causing lack of color development in some citrus
3. Poor Timing of the Harvest
    a. Harvesting too early can cause poor shelf life, poor eating quality
    b. Harvesting too late can reduce shelf life and market value
    c. Not having enough labor during harvest can increase unharvested portions
    d. Improper harvest indices (i.e. high moisture in cereals and pulses at harvest) can contribute to higher losses in storage due to fungal attack and aflatoxin contamination
    e. Improper harvest indices (i.e. too low moisture in cereals and pulses at harvest) can lead to losses due to shattering in the field
4. Rough Harvesting and Handling Practices
    a. Damaging the crop, livestock, or fish during harvesting can lead to rapid deterioration during the postharvest period
    b. Using poor quality containers for the harvest can increase physical damage and increase the rate of deterioration
    c. Using inappropriate tools for harvest can increase losses
5. Poor Temperature Management
    a. Leaving the harvested crop, livestock, or fish in the sun during harvesting

   b. Direct sun exposure during on-farm handling and delays can lead to rapid deterioration and moisture increase
6. Delays between harvesting and marketing
   a. Harvested crop remains in a heap or stack while awaiting loading and transport from the farm
   b. Crops, animals or dairy products are exposed to heat and direct sunlight during delays

Other Causes

In addition, the 64 key informants surveyed and interviewed for this analytical study reported on a wide range of on-farm causes of losses. Some of these causes are managerial in nature:

- Inadequate planning and information;
- Lack of needed agricultural infrastructure;
- Lack of awareness of technology options; and
- Lack of knowledge, education and training.

Other causes are technical in nature:

- Poor seed, poor quality planting material or poor quality fish or shrimp fry;
- Inappropriate cultivation practices;
- Inadequate pest and disease management;
- Poor water management; and
- Inappropriate harvesting practices.

An FAO synthesis report on food losses and waste in Europe and Central Asian countries introduced a new classification system (Koester et al 2013). The causes of losses are classified into six different categories, each of which relates to levels of types of on-farm losses found for different foods and in different countries:

1. Inadequate technology
2. Specific consumer preferences
3. High opportunity costs
4. Worldwide trends
5. High transaction costs
6. Education

The economic consequences of on-farm food losses can be extremely high. With a simplified summary of the case study findings and just a few examples from the major crops and countries covered in the literature reviews, Table 4.9 present the range and scope of the economics of on-farm losses in the OIC Countries.

Table 4.9: Examples of Economic Impacts of On-Farm Food Losses

Crop Country Population (pop) Market Value	Total Annual Production	Total Economic Value	Reported % On-Farm Losses*	Total Volume Lost (Estimated)	Economic Value Lost per Year
Maize Uganda 34 million pop US$250/tonne	2.8 million tonnes	$700 million	10%	280,000 tonnes	$70 million
Rice Bangladesh 151 million pop US$350/tonne	50 million tonnes	$17.5 billion	14%	7 million tonnes	$2.45 billion
Sweetpotatoes Nigeria 160 million pop US$87.50/tonne	3.4 million tonnes	$302 million	2%	69,000 tonnes	$6 million
Cassava Nigeria 160 million pop US$20/tonne	45 million tonnes	$900 million	5%	900,000 tonnes	$45 million
Cassava Guyana 0.8 million pop US$430/tonne	7600 tonnes	$3.2 million	6.5%	494 tonnes	$212,000
Groundnuts Mali 13.9 million pop US$400/tonne	220,000 tonnes	$88 million	20%	44,000 tonnes	$17.6 million
Plantains Uganda 34 million pop US$120/tonne	9 million tonnes	$1.08 billion	5%	450,000 tonnes	$54 million
Olives Morocco 33 million pop US$500/tonne	1.18 million tonnes	$590 million	30%	354,000 tonnes	$177 million
Tomatoes Egypt 78 million pop US$200/tonne	8.5 million tonnes	$1.7 billion	15%	1.27 million tonnes	$255 million

Crop Country Population (pop) Market Value	Total Annual Production	Total Economic Value	Reported % On-Farm Losses*	Total Volume Lost (Estimated)	Economic Value Lost per Year
Tomatoes Nigeria 160 million pop US$60/tonne	1.5 million tonnes	$90 million	20%	300,000 tonnes	$18 million
Tomatoes Turkey 72 million pop US$100/tonne	11 million tonnes	1.1 billion	28%	3.1 million tonnes	$308 million
Broiler meat Turkey 72 million pop US$1000/tonne	2 million tonnes	$2 billion	4%	80,000 tonnes	$80 million
Broiler meat Indonesia 740 million pop US$500/tonne	1.6 million tonnes	$800 million	6%	96,000 tonnes	$48 million
Milk Turkey 72 million pop US$550/1000L	18 billion L (18 million tonnes)	$9.9 billion	10%	1.8 million tonnes	$990 million
Milk Uganda 34 million pop US$200/1000L	1.9 billion L (1.9 million tonnes)	$380 million	10%	190,000 tonnes	$38 million
Shrimp Indonesia 740 million pop US$4000/tonne	400,000 tonnes	$16 billion	5%	20,000 tonnes	$80 million
Tilapia Indonesia 740 million pop US$1000/tonne	670,000 tonnes	$670 million	5%	33,500 tonnes	$33.5 million

Source: Case study findings; Key informants surveys, FAOSTAT; FISHSTAT; Kumar 1992; Umeh et al., 1999; Tewe et al. 2001; Nautiyal, 2002; Kasirye 2003; FAO, 2005; Sanni et, 2009; Olayemi et al., 2010; Gustavsson et al., 2011; WOR, 2012; DADTCO, 2012; USAID MARKET, 2012; World Aquaculture Society, 2013; Tatlıdil et al., 2013; AGRA, 2013; USAID, 2013; Fitzsimmons, et al., 2014; Aral et al., 2014; Salama, et al., 2015; Bounfour 2015; Muyinza, et al., 2015.

Since these are case studies of individual crops in individual countries, the findings cannot immediately be applied to all 57 OIC member countries. Determining the total on-farm losses in dozens of different crops and food groups would be rough guesswork, but based on these initial

findings and their general fit with the on–farm production and harvesting loss estimates provided by the FAO Global Food Losses and Food Waste report (Gustavsson et al., 2011; SIK (2013), an estimate of the amount of total economic losses can easily be expected to be US$ tens of billions per year.

Many of these on-farm losses can be reduced by making simple changes in traditional practices. It is especially important to provide training on proper harvest timing, signs of crop maturity and harvesting practices, since the quantity and quality of foods often will be determined at the point that they are harvested. In addition, improved seeds, starting materials and cultivation practices would go greatly mitigate on-farm losses. Specific practices include:

- Use of high quality seeds with evaluated post-harvest quality as many breeders do not evaluate harvest and post-harvest quality.
- Use of high quality chicks, shrimp fry or fish eggs/fingerlings.
- Use of good, quality feeds with appropriate dosages of fertilizers and feeds.
- Integrated pest management and biocontrol.

Finally, there are specific harvesting and handling practices that could be improved, including:

- Use of maturity indices for fruits, vegetables, roots and tuber crops or optimum moisture content for cereals, pulses and oilseeds to determine when to harvest.
- Gentle harvesting and handling on the farm as well as use of appropriate tools.
- Curing roots and tuber crops before sale and/or on-farm storage.

4.2 Consequences of On-Farm Losses in the OIC Member Countries

On-farm food losses can have long-reaching impacts on production, consumption, food security, the environment, and food safety.

4.2.1 Effects on Production

Lost food translates to lost revenue for producers and wasted resources for smallholder farmers who are already faced with limited land, time and money. It also results in increased pressures on these farmers to try to produce more food. On-farm food losses can result in yield gaps due to shortfalls in plant or animal nutrition, water management and pest management in the OIC Member Countries. These gaps can be closed without having to put more land into production.

On-farm losses, if sorted and left on the field, can be sources of inoculum and diseases to the next crop. A cycle of on-farm losses can be created, where each year the pests and diseases become more prevalent and further reduce potential yields.

4.2.2. Effects on Use

The majority of food production in the OIC Member Countries is for domestic consumption and/or for exports. When foods are produced for local consumption, lost food is lost calories and lower nutrition for consumers. In Bangladesh alone, an estimated 7 million tonnes of rice valued at $US 2.45 billion was lost on-farm in 2014 (Bala et al., 2010).).

When foods are produced for export, on-farm losses are lost potential revenue for farmers and marketers. In some cases, the OIC Member Countries have problems meeting quality standards for cereals or oilseeds (exceeding aflatoxin limits; IITA 2010), fresh produce (based upon grades due to size or appearance; Hussein, 2012) and dairy products (due to aflatoxin and high bacterial counts in milk (Bor, 2014)). Produce that is rejected may wind up on the domestic market at drastically reduced prices, be recycled on the farm as compost, or may go to waste.

4.2.3. Effects on Food Security

Food security is defined by FAO (2001) in The State of Food Insecurity 2001 as: "a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life". Lost food means lost calories and lowered nutrition for consumers in the OIC Member Countries, which immediately reduces food security for the community. On-farm food losses are of particular immediate impact, since these losses reduce the amount of available food that a smallholder farm family can keep for their own consumption. Also this can have a direct effect on malnutrition in the populations resulting in lower consumption of nutritionally valuable perishable foods such as vegetables and fruits, which are being replaced by more available foods such as cereals. This can have a direct effect on chronic and acute malnutrition rates. Also many small scale families reduce quantities consumed during certain times of the year (lean period) and in times of civil strife and insecurity.

4.2.4. Effects on the Environment

Lost food is also lost inputs like seeds, water, fertilizer, and labor and wasteful use of arable land or water resources. Many of the OIC Member Countries are in areas of the world with limited water resources, and on-farm food losses are an enormous waste of precious water. FAO (2013) has published a series of documents and videos on the "Food Wastage Footprint: Impacts on Natural Resources", reporting that production losses are responsible for about 15% of the total greenhouse gas emissions due the foot wastage.

For cereals, the production and application of nitrogen fertilizer are major contributors to the overall climate impact. Pulses, which fix nitrogen and therefore do not need added nitrogen fertilizer, have much lower impact. Roots and tubers, which have a very high yield per hectare will have lower impact per tonne of production than do cereals. For countries that utilize mechanization, the use of diesel fuel for agricultural operations, such as ploughing, harvesting and drying results in CO_2 emissions (FAO 2013). Additionally production of high energy consuming food production such as animals have a negative impact on the environment when they are being lost.

Foods lost on the farm, whether sorted out at harvest, or left in the field due to spillage, can contribute to global warming when heaps of rejected foods decay under anaerobic conditions and release methane gas. According to FAO (2013), almost 99% of food wastage at agricultural

production stage appears to be produced in regions whose soils are experiencing, on average, medium to strong land degradation. In addition, more than 50% of food wastage at the agricultural production stage appears to be occurring in regions whose soils are, on average, currently at a low or bad status in terms of soil degradation. In the OIC Member Countries, promoting composting would allow this wasted food to be recycled on farm and used as fertilizer, rather than allowing lost foods to decay and add methane to the atmosphere.

Recent studies have linked climate change mitigation with "climate sensitive" agricultural production and reduction of food losses. Action Line for Development in Uganda has made the following recommendations: "The overall efficiency, resilience, adaptive capacity and mitigation potential of the production systems can be enhanced through improving its various components," which are presented in Table 4.10.

Table 4.10: Enhancing the Efficiency, Resilience, Adaptive Capacity and Mitigation Potential of the Production Systems

Key Components	Means of Enhancement
Soil and nutrient management: the availability of nitrogen and other nutrients is essential to increase yields.	Composting manure and crop residues, more precise matching of nutrients with plant needs, controlled release and deep placement technologies or using legumes for natural nitrogen fixation.
Water harvesting and use: irrigation is practiced on 20% of the agricultural land in developing countries but can generate 130% more yields than rain-fed systems.	Improved water harvesting and retention (such as pools, dams, pits, retaining ridges, etc.) and water-use efficiency (irrigation systems) are fundamental for increasing production and addressing increasing irregularity of rainfall patterns.
Pest and disease control: climate change is altering the distribution, incidence and intensity of animal and plant pests and diseases as well as invasive and alien species.	Integrated pest management
Resilient ecosystems	Improving ecosystem management and biodiversity can provide a number of ecosystem services, which can lead to more resilient, productive and sustainable systems that may also contribute to reducing or removing greenhouse gases.

Source: Kabagoza (2015).

4.2.5. Effects on Food Safety

According to Kader et al (2012) in a study for FAO in the Region of the North Africa and the Middle East, food security and food loss reduction efforts go hand in hand with promoting improved food safety. Recommendations include the following:

- Assure consumer health and food safety through compliance with public health, food safety and other sanitary and phytosanitary standards (SPS) requirements.
- Establish policies and resources for control and prevention of trans-boundary animal diseases such as cross border control, certification, and zoonotic.
- Training and awareness building of the producers, food supply chain (FSC) stakeholders about food hygiene, handling and safety measures.
- Animal feed improvement including quality, safety, dry fish feeding for cattle (in southern Yemen and the coast of Oman), and preparation of fishmeal for poultry feeding.
- Creation of salmonella-free environments for the poultry sector; and mastitis free environment for the dairy sector.
- Promote the development of appropriate cold chain infrastructure from farm to market.
- Establish and implement an effective traceability system for all food products beginning on the farm.

5. CURRENT RESOURCE ASSESSMENT OF OIC MEMBER COUNTRIES FOR REDUCING ON-FARM LOSSES

The current status and availability of resources that are presently mobilized to reduce on-farm losses in the OIC Member Countries varies widely by the region, key crops and food products, per capita income, and degree and strength of linkages that have been established with the global community.

5.1 Global and Regional Resources

Many programs, projects and recent studies are focusing on the problem of food losses and waste. Traditionally 95% of agricultural research and extension efforts have targeted production and been aimed at increasing yields and reducing on-farm food losses via improved seeds and planting materials, cultivation practices, fertilization, irrigation, pest management and sustainable production practices (IFPRI study cited in Kader and Rolle 2005). Virtually every agricultural study and program includes these on-farm aspects, while in the past decade, a move toward consideration of the entire food value chain has emerged, and so postharvest handling, storage, processing, distribution and marketing aspects of agriculture have begun to gain more attention.

Globally there are currently many existing and new programs and projects targeting reduction of food losses and waste, each of which includes on-farm losses:

- FAO Postharvest Information Network (INPhO);
- SAVE FOOD Initiative on Global food losses and waste (joint effort of FAO, WFP, UNDP);
- Stop Food Waste (European Commission);
- World Food Programme mitigating food losses in food deficit countries;
- Rockefeller Foundation's Global Knowledge Initiative on reduction of postharvest loss;
- World Food Preservation Center;
- ADM Institute for Prevention of Postharvest Loss;
- Feed the Future Postharvest Innovation Labs;
- Consultative Group on International Agricultural Research (CGIAR); and
- Asian Vegetable Research and Development Center (AVRDC).

Studies and actions targeting on-farm losses continue to be a part of this new wave of programs and projects that work on research and extension to reduce food losses and waste along food supply chains. Staple foods like cereals and pulses are being given the vast majority of attention, and horticultural crops like roots, tubers, fruits, and vegetables are included in a few programs. But there are not many on the ground practical initiates that put real implementable solutions into the hands of smallholder farmers.

Individual OIC member countries are part of many other global and regional alliances. They have access to the CGIAR system and their many research institutes. One example is the on-going work of AVRDC and IITA. AVRDC and IITA develop effective and simple diagnostic tools for

characterizing and monitoring major insect pests and bacterial, fungal, and viral diseases. AVRDC also evaluates resistant lines, biological control methods, and cultural practices to develop integrated management technologies for major pests, and is a partner in developing the CGIAR Systemwide Program on Integrated Pest Management (IITA 2010).

5.1.1. International Projects and Programs

Many projects, programmes and studies on food losses have been implemented or are underway, mainly targeting staple foods or high value horticultural crops. Often the studies of on-farm losses are a small part of comprehensive value chain analysis or value chain development efforts.

FAO implemented a series of food loss assessments during 2010-2015 to determine the levels and causes of food losses for various crops and food produced in several OIC member countries including Turkey and Tajikistan. Field case studies recently performed on maize in Uganda, fish in Indonesia, and horticultural crops in Guyana, and others are planned for dry beans and sunflowers in Burkina Faso. The case studies include recommendations on measuring losses at CLPs and implementing improved practices and cost effective technologies that will reduce losses. The most recent fish loss assessment in Indonesia indicates that food chain actors have taken up the recommendations (gentler handling, use of ice on farm, and more rapid marketing) and losses for fish in Indonesia have been drastically reduced from 70% to 5-10%.

Other project may indirectly benefit the OIC Member Countries through their affiliation with other regional organizations. For example, the OIC Member Countries who are also members of the Economic Community of West African States (ECOWAS) benefit from the World Bank project named the West Africa Agricultural Productivity Program Adaptable Program Loan (APL) (WAAPP-1C). This project is targeted at improving the enabling conditions for sub-regional cooperation in the generation, dissemination, and adoption of agricultural technologies which will improve their ability to reduce food losses in their respective countries by 1) strengthening the institutional mechanisms and procedures for generating, disseminating, and adopting improved agricultural technologies and tools at the national level; and 2) strengthening national centers of specialization and strengthening of the research system and supporting demand-driven technology generation, dissemination and adoption. This project $83 million and runs from 2012-2016 in Niger, Benin, Togo, Sierra Leone, Liberia and Guinea.

There are also examples of organizations in the OIC Member Countries providing technical assistance to farmers in other OIC Member Countries. Turkish dairy farmers through the Turkish Technical Assistance Team (TIKA) provides technical assistance and training to members of the Kamuli Dairy Farmers Association in Uganda.

G20 member nations including Indonesia, Saudi Arabia and Turkey held a May 2015 meeting in Istanbul. Ministers expressed their support to countries and international organizations in promoting the implementation of the International Agreement on Responsible Investment in

Agriculture and Food Systems (October 2014). Agriculture Ministers also expressed their strong support to global efforts to ensure food security and agreed on the importance of establishing economically, socially and environmentally sustainable food systems. First, they underlined the importance of food losses and waste as a global problem with approximately US$ 1 trillion is spent each year to produce lost or wasted food. Second, they decided to set up a G20 platform to prepare a common framework to measure food losses and waste with a view to reduce food losses and waste. Third and finally, they called for the preparation of a G20 Action Plan on Food Security and Sustainable Food Systems which will be submitted to Leaders for their endorsement in Antalya Summit.

Through Feed the Future, USAID funds many Innovation Labs with a focus in the OIC member countries, each targeting a different crop or issue related to improved food production or reduced food losses, mostly along a specific value chain. Each Innovation Lab focuses on several countries, including one or more OIC Member Countries, and provides funding for research, extension and education for the focus countries in specific topic areas. Some of the Innovation Labs focus on a specific crop, while others on a technology or best practice, covering the entire range of production, postharvest handling and marketing. Climate resilient production is one of the major aims of the programme.

One example of a Feed the Future funded project is in Uganda. As a sub-contractor to UC Davis, WFLO is providing assistance in postharvest training and capacity building activities under the Horticulture Innovation Lab. As part of a program designed to increase the capacity of small holder farmer groups in the Nkokonjeru region of Uganda in the production, postharvest handling and marketing of vegetables, commodity systems assessments have been conducted for tomatoes and leafy vegetables, and WFLO provides on-going advice in the development of training materials on appropriate harvesting, postharvest handling, cooling, storage and processing practices for Ugandan fruit and vegetable crops. The project has just been extended for another 3 years.

Another example is in Pakistan. In 2016, a new U.S.-Pakistan Center for Advanced Studies in Agriculture and Food Security, funded by the U.S. Agency for International Development, will link the University of California at Davis with the University of Agriculture, Faisalabad. The US$17 million project will make it possible for faculty members and graduate students from both countries to study and do research at each other's campuses. The project also is designed to update curriculum and technical resources at Pakistan's University of Agriculture, Faisalabad, in agricultural production, postharvest technology and agricultural extension.

5.1.2. Projects and Programs for the Arab Group (North Africa/Middle East)

In Morocco, the French National Institute for Agricultural Research (INRA) is launching a new project in partnership with FAO to develop a national strategy and an action plan to reduce food losses and waste. FAO's food loss assessments include the analyses of the causes and solutions

for production, harvesting, and handling losses for many types of food crops and animal-based foods.

The Capacity Building for Food Loss Reduction in the Near East (FAO) covers Lebanon, Egypt, Jordan and Iran with different value chain selected for each country. It is scheduled to begin in 2015-16. In addition, key informants provided information on activities targeting reduction of food losses in seven OIC Member Countries in the Arab Group.

5.1.3. Projects and Programs for the Asian Group

The Central Asia and the Caucasus Regional Network for Vegetable Systems Research and Development was established by AVRDC in 2005. It aims to assist the development of market-oriented vegetable production systems and promote improved national vegetable research strategies. The network includes Azerbaijan, Armenia, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan.

A national workshop on post-harvest fish losses in Indonesia entitled Fish Loss Assessments: Causes and Solution Case studies in the Small-scale Fisheries in Indonesia was organized in November 2015 under the partnership between Koperasi Artha Mina (KAM) of the Research and Development Center for Marine and Fisheries Processing Product and Biotechnology (RDCMFPPB), Agency for Marine and Fisheries Research and Development (AMFRD), the MMAF, and FAO as an activity of the FAO program "Global Initiative on Food Loss and Waste Reduction."

In addition, key informants provided information on activities targeting reduction of food losses in seven OIC Member Countries in the Arab Group.

5.1.4. Projects and Programs for the African Group (Sub-Saharan Africa)

AVRDC has been working on a project to improve vegetable production in 10 West African countries including the OIC Member Countries of Benin, Burkina Faso, Gambia, Guinea, Mali, Niger and Senegal mainly focusing on new varieties. During the last six years about 2,500 African Market Garden units were disseminated with the technical support of ICRISAT.

Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) is a program funded and managed by Feed the Future, IITA, IFPRI, CGIAR and the International Livestock Research Institute (ILRI). Two of their three projects cover many countries including the OIC Member Countries. Project 1 looks at cereal-legume-livestock based farming systems in the Guinea-Sudano-Savannah Zone of West Africa and Project 3 examines maize-legume-livestock integrated farming systems in East and Southern Africa focusing on more productive systems with seeds and production practices.

The Rockefeller Foundation's Global Knowledge Initiative (GKI) to reduce food losses in Africa recently led a series of workshops and loss assessments in Nigeria, Uganda and several other countries, then identified and vetted hundreds of potential solutions for losses of fruits,

vegetables, roots, tubers, cereals, and pulses. Many of the solutions focused on reducing on-farm losses, including the use of ICT apps for distribution of agricultural inputs such as fertilizer and seeds in Nigeria (SlimTrader), the use of plastic crates for collecting the harvest of tomatoes and reducing damage related losses to less than 5% in Nigeria (GEMS4 project), Project Nuture's efforts to improve mango fruit production in Uganda, and Africa RISING's promotion of improved seeds and production practices for cereals in Mali. Mango farmers specifically have seen their production costs reduced by more than half, and their marketable volume jump from 36% to 89% in just three years via participation in one project. The full GKI report "Reducing Food Waste and Spoilage: Assessing resources needed and available to reduce postharvest food loss in Africa" was published in June 2014.

In addition, key informants provided information on activities targeting reduction of food losses in seven OIC Member Countries in the Arab Group.

5.2 Educational Opportunities

Educational opportunities for participants in the OIC Member Countries are being offered by a range of private and public sector organizations. On the horizon are many more programs, to be offered via the newly launched Technical Platform on the Measurement and Reduction of Food Loss and Waste. This web-based interactive platform, launched by FAO in December 2015, is a repository of knowledge on measuring food loss and waste and will facilitate information-sharing and coordination among a diverse set of key stakeholders such as international organizations, private sector actors, financial institutions and non-governmental organizations. Training manuals and e-courses are being developed for FAO by The Postharvest Education Foundation, for cereals, pulses, roots, tubers, fruits, and vegetable crops, and for field practitioners, extension workers and academics working with smallholder farmers in the regions of Sub-Saharan Africa, Asia/Pacific, Near East/North Africa and Latin America/Caribbean. The technical platform will also reinforce current efforts to measure food loss and waste developed by FAO and other institutions.

There are also short course or study tours such as the two week general postharvest handling programme at the University of California, Davis entitled Postharvest Technology of Horticultural Crops Short Course offered each June. This course is a two-week intensive study of the biology and current technologies used for handling fruits, nuts, vegetables and ornamentals in California. It is designed for research and extension workers, quality control personnel in the produce industry, and business, government or academic professionals interested in current advances in the postharvest technology of horticultural crops. It is particularly of interest to technical professionals responsible for quality assurance, research and extension activities related to fresh produce quality, safety and marketability.

There is a one month general postharvest handling programme at Wageningen University Research Centre for Development Innovation (WUR, Netherlands), on Lost Harvest and Wasted

Food (on campus). The program includes the topic of on-farm losses, and provides details on production practices, pest management and improving yields. "While in developing and transition countries food losses mainly happen post-harvest, in the urban and wealthier communities good food is wasted in retail stages of the supply chain and by consumers. Optimising the 'farm to fork' chain can contribute significantly to food security and sustainable food production."

Several e-courses and e-learning programs are available annually via the internet:

- Global Postharvest Loss Prevention: Fundamentals, Technologies, and Actors is a program offered by ADMI / University of Illinois managed by Coursera.
- Global Postharvest E-learning Program offered by PEF. The program focuses on fruits, vegetables, cereals, pulses in different countries including ten OIC Member Countries (Bangladesh, Benin, Cameroon, Egypt, Iran, Lebanon, Nigeria, Pakistan, Togo, Uganda).
- EuroTier in Hanover, Germany and featured an event series "Animal Production in Eastern Europe and Central Asia" but also covers countries of Central Asia, covering Ukraine, Russia, Kazakhstan, Uzbekistan, Kyrgyzstan and Turkmenistan.
- World Poultry Science Association offered a program on the Potential for Poultry Production in Developing Countries.

World Veterinary Education in Production Animal Health (WVEPAH) is a new branch of the "European Association for Veterinary Specialization" (EAVS) created the "European School for Advanced Veterinary Studies". ESAVS and is also affiliated with and supported by the World Organization for Animal Health (OIE) and includes OIE standards and regulations in its training programs.

5.3 Resources Needed for Reducing On-Farm Losses

Along with the projects and programs listed in Section 5, the OIC Member Countries have an opportunity to build on existing activities or to launch supporting programs. Many more resources are needed in terms of technology, farmers' training to address consumer preferences and investment costs, institutional supports to assist growers to manage and adapt to changing worldwide trends and costs for reducing losses, and for improved education, communication and knowledge sharing.

5.3.1 Technology

Adaptive research and extension programs can bring proven technologies for reducing on-farm food losses to the target groups in the OIC member countries. Universities, research centers and NGOs in the OIC Member Countries take part in Feed the Future Innovation Lab projects, and there are on-going opportunities to partner with existing projects and plan new ones, targeted to on-farm loss issues for specific crops and foods. The types of needed technologies will depend on the crop/food product and scale of operation, so any research into new technologies should include consideration of local conditions, barriers or constraints and cost/benefits.

5.3.3 Institutional Supports

University faculty members and leaders of research institutions in the OIC Member Countries must participate as stakeholders in planning and implementing research, extension and farmer training programs. Formation of an initiative, such as an OIC Member Countries Working Group on on-farm loss reduction may be a practical approach to coordinating future efforts. Institutions must be able to help producers manage and adapt to changing worldwide trends and understand the costs involved in selecting improved practices or technologies and decision making strategies for making investments for reducing losses,

Efforts to create an initiative or platform would fit well with the efforts already being mounted by FAO AGS, SAVE FOOD, the European Commission (EC) and other global organizations including the Rockefeller Foundation, APHLIS, and BMGF. PEF presented on this topic in October 2015 at the First International Congress on Postharvest Loss Prevention in Rome, Italy, and specific capacity building recommendations are listed below. Please note that the ongoing efforts are on national programs, while the OIC would need to expand to the entire OIC membership.

Recommendations to build capacity include:

- Review current status in the country;
- Select one or two focus crops to begin with;
- Assess needs of key clientele groups via participatory appraisals along the value chain;
- Assess training needs of extension/advisory service personnel;
- Make any needed investments and upgrades, and provide training opportunities for extension staff;
- Plan and fund educational and outreach programs to provide extension/advisory services for clientele; and
- Plan and conduct monitoring and evaluation.

Supporting institutions and agencies such as banks, extension and advisory services, regulatory agencies, and local NGOs working in the field requires including their representatives as stakeholders when planning and implementing research, extension and farmer training programs. Input suppliers may require regulation to make sure inputs such as seeds and feed are of good quality. Farmers' organizations may need support to learn about organizational management, bookkeeping, to gain technical skills in production and reduction of on-farm losses, and negotiation sales contracts.

5.3.4 Education, Communication and Knowledge Sharing

Education is a very broad topic area, covering formal approaches such as trade schools and universities and informal methods like extension and advisory services. These traditional educational methods can be very expensive and can be left without adequate funding whenever resources are limited.

Knowledge sharing via the internet is growing at a rapid pace, with website based agriculture libraries, and the use of free services for face to face meetings. On-line, free to access libraries on crop production, animal health, fisheries and more include:

- http://postharvest.ucdavis.edu
- http://www.fao.org/inpho/
- http://irrec.ifas.ufl.edu/postharvest/
- http://journeytoforever.org/farm_library.html
- http://teeal.org/journals
- http://www.omafra.gov.on.ca/english/crops/index.html
- http://www.spc.int/en/activities/324-fisheries-digital-library.html

Interactive websites, webinars and live chats can make learning across long distances simple for learners and easier to provide for many audiences. Internet-based sessions using a growing list of applications such as Skype, Facebook chat, WhatsApp Messenger, Facebook Messenger, Viber, and Google Hangouts are replacing telephone calls for long distance communications. International Skype to Skype calls are growing at annual rate of more than 50%, and currently account for 40% of all international telephone calls (Typhina et al, 2014).

Use of modern internet communications and outreach programs using mobile devices can help communicate agricultural production and food loss prevention information to more people at lower cost. An example of a successful programme is SAWBO (Scientific Animations Without Borders) which develops and distributes free short animated videos on improved agricultural practices and has them recorded using a wide assortment of local languages. SAWBO actively seeks collaborators who can record the voice tracks in new languages and in accents most appropriate for their country/culture. Sample videos can be viewed on YouTube by searching for the following topics:

- Solar Treating of Cowpea Seeds;
- Natural Insecticide from Neem Seeds; and
- Postharvest Loss: Salt Testing for Grain Moisture Levels.

When initiating education and knowledge sharing, the same efforts for capacity building as those listed for institutional supports should be encouraged. However, there may be additional needs for technological training and facilitation should be made to allow for periods when needed internet connectivity becomes problematic.

6. POLICY RECOMMENDATIONS

The opportunity to reduce on-farm losses and recover some of the tens of billions of dollars being lost by farmers in the OIC Member Countries can be a simple and straightforward endeavor. Investing a small portion of these potential additional profits as seed money is what is required by global leaders and policy makers in order to make enormous impacts on the lives of smallholder farmers and rural communities.

The FAO identified many micro, meso and macro level causes of food losses and waste (HLPE 2014), and similar categories can be identified for the causes of on-farm losses occurring in the OIC Member Countries.

Micro-level causes of on-farm losses result from actions or non-actions of individual actors of the same food supply chain stage such as use of improved seeds, proper harvesting practices, and gentle handling in response to external factors. Typically these factors are market prices and consumer demand, which are closely related to the costs and benefits of making investments or changes in on-farm practices. Connecting farmers with remunerative markets will also have a profound effect on their food security.

Meso-level causes of on-farm losses include secondary or structural causes, such as those that exists in other stages of the chain. Meso-level could include poor quality seeds, lack of fish fry suppliers, and poor veterinary services or could result from how different actors are organized together, different relationships along the food chain, availability of needed infrastructure, the cost for electricity or fuel, and access to technical advice and extension support.

Macro-level causes of on-farm losses can be explained by systemic issues, such as a lack of institutional or policy conditions to facilitate the coordination or support of food supply chain actors like producer organizations, or for securing contracts to enable on-farm investments and the adoption of good agricultural practices. Systemic causes include the lack of adequate agricultural extension or financial services and set the stage for the emergence of all the other causes of on-farm food losses, including meso and micro causes.

6.1. General Recommendations

Based on the CSAM process used for conducting the eight case studies, some general recommendations can be made on the following three aspects of reducing on-farm losses.

- **Research Needs:** Technical issues appear to be well addressed, within available resources. Global research institutes readily share their findings and solutions with other potential users. A few serious on-farm loss problems in the OIC Member Countries are under current study (Tuta absoluta in Egypt and SSA; aflatoxin prevention, detection and management for cereals, pulses and oilseeds) and these will require additional resources in coming years. Diagnostics and control of pests and diseases in fruits and

vegetables, commodities that are under-researched, within this context also the development of locally adapted varieties and planting material.

- **Extension or Training Needs:** Most of the causes of on-farm losses identified in this study can be addressed via improved training, extension and outreach activities. It is highly recommended that the OIC Member Countries focus attention on providing farmers with information and demonstrations of the basic practices that protect foods from on-farm losses such as integrated pest management, sanitation and hygiene, use of maturity indices, gentle harvesting and handling, proper curing of roots and tubers or drying of cereals, pulses, and oilseeds, use of protective containers and providing shade and cooling during delays after harvesting. Teaching farmers about costs and benefits can be a key factor in their understanding of and willingness to try out and adopt new on-farm practices and technologies.

- **Advocacy issues:** These are problems found at the macro level, and that must be addressed by policy makers and investors. In the various OIC Member Countries, these include missing infrastructure, lack of access to extension services, poorly regulated input suppliers (i.e. poor quality seeds or feeds), poorly regulated contracting practices, and lack of access to credit. Farmers may require information and benefit from support for the formation and/or strengthening of producer groups.

The following policy recommendations and proposals for solutions for the OIC Member Countries are provided for fighting against on-farm food losses. These recommendations relate to the identified research and extension needs and advocacy issues. They are intended to be practical, concrete, and open to collaborative efforts. They are consistent with available resources since they can be implemented on a small, medium or large scale, over the short or longer term, as resources allow.

6.2 Domestic Policies

The following recommendations are provided for direct action of the OIC Member Country governments and implementing agencies on issues related to domestic policies.

6.2.1. Closing Knowledge and Data Gaps

This study compiled the existing data and conducted eight case studies, but found many gaps for countries, crops and food products. There is a lot of missing information in every OIC Member Country.

Full scale food loss assessment studies for specific foods have been completed for too few OIC Member Countries. To date, this list includes on Guyana, Nigeria, Tajikistan, and Turkey. These studies generally require 3-4 weeks per commodity, and $20,000-$30,000 to field a team of experts. The field visits for the case studies undertaken for this analytical study added useful

information on on-farm losses in Egypt, Nigeria and Uganda, but were not comprehensive in scope due to time and budget limitations. It is recommended that additional data be collected on on-farm losses for the crops and animal foods of highest interest to the OIC Member Countries.

Recommendation 1: Each OIC Member Country (or group of similar regionally located countries) should identify the gaps in knowledge and information on the levels and specific causes of on-farm food losses for key crops and food products.

The OIC Member Countries can offer to lead similar loss assessments and/or can participate in FAO-sponsored food loss assessment case studies. Currently the SAVE FOOD Initiative is working on case studies in Uganda for maize, Burkina Faso for dry beans, and Indonesia for fisheries, which include assessment of on-farm losses. Many more case studies are being planned, and the crops and foods of key importance to the OIC Member Countries such as wheat, rice, tomatoes, potatoes, milk, meats and eggs could become a part of these studies at little or no cost. The SAVE FOOD Initiative is developing food loss assessment training manuals and e-courses that will be available online in several languages.

6.2.2. Investments in Upgrading the Food Supply Chain

Agricultural investments can take many forms, from providing improved infrastructure for electricity and roads, to providing loans for better access to production inputs like fertilizer, pesticides, and farm equipment. Furthermore anytime these investment shorten the food supply chain by helping farmers connect more directly to the buyers, whether they are wholesalers, food processors, or directly to consumers, farmers can benefit by directly linking with output markets and reducing losses. They also will benefit by receiving more of the potential earnings from their produce. One way to do this is through direct marketing to processors or consumers, thereby reducing the number of intermediaries involved.

Recommendation 2: The OIC Member Countries should assess their local food supply chains and determine when and where to invest directly to better connect farmers to buyers. Shortening the chain between farmers and end-users will reduce on farm food losses and increase the money that producers receive for products as middlemen are cut out, time for spoilage is reduced, and potential risk from spillage and infestations are reduced.

Nigeria provides an example of a potential direct investment by government in upgrading the food supply chain and improving linkages between the farm and the buyer. Cassava on-farm losses as reported in the case study conducted for this report (see Section 3) were very low when compared to the global average, since the buyers came to the farm, supervised the harvest, and immediately collected the produce to bring it to the cassava flour production facility. Nigeria has mandated that flour include 10% cassava, which has encouraged more of these direct farmer-to-buyer linkages to develop.

6.2.3. Capacity Building

In order to implement the needed food loss assessments and then to support the development and improvements of food supply chains, the OIC Member Countries will need to address any gaps in local capacity to address on-farm food losses. This means building capacity in national research and extension systems and advisory services.

Recommendation 3: The OIC Member Countries should address gaps in the technical and training capacity of on-farm food loss researchers and extension specialists. These key resource persons are the providers of practical information be it written, oral, audio, visual, or online on best practices in local languages for use by extension workers and producers.

There are many existing opportunities for participation in conferences, trade shows, workshops, certificate and e-learning programs, short courses and study tours on food loss assessment and reduction. Typically programs deemed as postharvest technology begin on the farm, with pre-harvest considerations like harvest practices and water, fertility, and pest management. Historically, the programs focused on agricultural production include cultivation practices, pest management and harvest management practices that are related to on-farm losses. Sponsoring food loss researchers and extension specialists from the OIC Member Countries to attend these events and educational programs can be a low-cost way to build local capacity and network with experts and field practitioners from other parts of the world.

The World Food Preservation Center (WFPC) partners with 11 universities and research centers to offer graduate programs on the entire range of food science, extension and innovative technology for food loss reduction for all types of foods. WFPC university partners include two organizations that are located in the OIC Member Countries. There are the Federal University of Agriculture, Abeokuta in Nigeria and the University of Agriculture, Faisalabad in Pakistan.

6.3 Collaborative Efforts

Formation of an OIC Member Countries Working Group on on-farm loss reduction may be a practical approach to coordinating future efforts. In order to build capacity for reducing on-farm food losses in field level practitioners and farmers, the OIC Member Countries can offer any number of practical, targeted educational programs, in collaboration with research and extension institutions and international NGOs.

Recommendation 4: It is recommended that a core group of the OIC Member Country based resource personnel be developed, since they can contribute towards capacity building for farmers and undertaking work on food loss prevention initiatives.

This core group can plan collaborative research projects, design and implement extension programs and provide advisory services for their own countries as well as for the OIC Member Countries that produce the same crop or foods products. The core group should be linked to existing global resources, via internet websites including libraries and advisory services,

networking groups and membership in professional organizations. Important networks already exist in Egypt, Indonesia, Turkey and Pakistan.

Recommendation 5: The OIC Member Countries should address gaps in the technical and managerial capacity of national extension workers, farmers, fishers, ranchers and food supply chain workers.

It is highly recommended that the OIC Member Countries focus attention on providing farmers with information and demonstrations of the basic practices that protect foods from on-farm losses. Recommended practices include integrated pest management, sanitation and hygiene, use of maturity indices, gentle harvesting and handling, proper curing of roots and tubers or drying of cereals, pulses, and oilseeds, use of protective containers and providing shade or cooling during delays after harvesting. These production guidelines could be edited for major crops and distributed to the OIC member countries.

There are a few examples of collaborative efforts that should be considered:

1. **A series of workshops for farmers on reducing on-farm losses for the various food groups.**

The OIC Member Countries can sponsor an in-house workshop series on different food groups and/or a workshop series held in different regions over time on the topic of reducing on-farm food losses. The individuals sponsored for international conferences and workshop would be a good source of instructors and resource persons, technical experts and trainers for such a programme. During 2-3 days of classroom instruction and field visits, participants could be exposed to the causes of on-farm losses and many potential solutions. Ideally each member country would be able to design and provide their own version of the workshop series, focusing on their key crops and foods.

2. **An e-learning programme designed for participants in the OIC member countries and key foods and crops.**

International NGOs such as WFLO, PEF and ADMI have designed and successfully provided several e-learning programs on food loss assessment, reduction of food losses, and the costs and benefits of making changes in harvesting and handling practices, with graduates in African, Asian and Arab countries. The OIC Member Countries could sponsor a customized e-learning program of 6-10 months in duration including training materials, online mentoring, a tool kit and 3 days of closing workshops held in each region, focused specifically on identifying and reducing on-farm food losses for foods and crops produced in member countries. NRI, WUR, ADMI, Global Cold Chain Alliance (GCCA) or WFLO experts can provide this type of service.

Recommendation 6: OIC Member Countries should develop projects to address losses in either durable or perishable value chains. These 'type projects' should describe key actions, technology packages and include budgets that could be used to develop projects on reducing losses in the value chains.

Lack of funding is an important constraint for many OIC member countries. Members should be able to access funds for specific multi-country and multi-institutional projects to reduce on farm losses in major crops of importance to OIC countries.

Recommendation 7: OIC Member Countries should implement a cycle of competitive funds where countries could receive funding for specific research and development projects to reduce on-farm losses.

A core group could be used to develop such type projects and budgetary plans that could be implemented by line ministries in the OIC Member Countries either through country budget support or via donors.

CONCLUSION

Despite the global progress in the field of food loss assessment and food loss reduction there remain many gaps in the knowledge base and data available on on-farm food losses for the food groups of interest in the OIC Member Countries. Past studies reported on food losses under a variety of definitions and boundaries, sometimes undefined or overlapping. For the purposes of this analytical study, a hybrid definition of on-farm losses was utilized, with boundaries from production to farm gate (including growing, harvesting and on-farm handling). Furthermore not many concrete actions have been implemented in the OIC Countries to reduce losses and improve food security, especially in the more perishable crops and animal products.

Of the 57 OIC Member Countries, published reports of on-farm losses for cereals are available for only one study for six: Bangladesh (rice), Cameroon (rice), Iran (maize), Tajikistan (wheat), Turkey (wheat) and Uganda (maize). Published reports of documented on-farm losses of oilseeds and pulses are available for only two OIC Member Countries: Mali (groundnuts) and Uganda (dry beans). The reported range of on-farm losses for roots and tuber crops in Nigeria are relatively high. Published reports of on-farm losses are available for only five OIC member Countries: Benin and Guyana (cassava), Nigeria (cassava and yams) and Tajikistan and Turkey (potatoes).

For fruits, information is available only for seven OIC Member Countries: Bangladesh (litchis), Benin (citrus and bananas), Guyana (mangoes), Morocco and Turkey (olives) and Egypt (citrus). Published reports of on-farm losses of vegetables are available for only eight OIC Member Countries, with the most of the studies on tomatoes and peppers for Bangladesh, Benin, Guyana, Nigeria, Pakistan, Turkey and Egypt. There was one study that included on-farm losses of cabbage and cauliflower in Bangladesh, two studies on leafy greens (amaranths) in Benin, and one study that included on-farm losses of onions in Tajikistan.

Overall, the limited information for on-farm crop losses indicates that losses are lower for cereals, pulses and oilseeds, which are less perishable crops, than for fruits and vegetable crops in the OIC Member Countries. On-farm losses for perishables – the roots, tubers, fruits, and vegetables – are high, with a range of losses that are similar to FAO estimates. Furthermore the economic value of perishable crops is often much higher resulting in overall higher losses.

The highest levels of losses for meats and eggs are related to uncontrolled diseases for poultry and eggs or unsold milk. Data is available for only eight OIC Member Countries for cattle, poultry, milk and/or eggs. Overall, the limited information for on-farm losses for meats and dairy products in the OIC Member Countries shows a range of losses that are similar to FAO estimates. Very limited information is available on aquaculture fish losses, and the quantity on-farm losses for fish is reported to be relatively low (0-5%) while quality losses can be very high (up to 70%).

The ranges of food losses as reported for the six commodity groups are very large, varying from very low losses to extremely high losses, which reflects the reality since these kinds of local assessments and case studies provide only a snap-shot view of the current conditions, which can vary widely by location and change rapidly over time. With so many gaps in the available information it is not possible to generalize to all the OIC Member Countries, but with key informant surveys and case study field visits filling in some of the missing information, on-farm losses for crops can be organized into three categories.

- **Production:** lost yield due to pests (insects, weeds, fungi), poor planning, poor water management, lower quality due to poor quality seeds, irregular fertilization practices;

- **Harvesting:** physical damage, poor quality due to improper maturity or moisture content, smallholder farmers using manual labor or rudimentary mechanization; and

- **On-Farm Handling:** physical damage on-farm after harvesting, use of poor quality containers, spillage, exposure to sun, heat, pests, conditions that promote contamination with aflatoxins.

For broiler meat in Turkey and for aquaculture in Indonesia, on-farm losses were relatively low since more modernized production practices were being implemented on relatively large scale operations, along with proper sanitation, good quality feeds, pest control and rapid handling/marketing after harvesting.

From the CSAM process used for conducting the eight case studies, some general recommendations can be made on the following three aspects of reducing on-farm losses.

General Recommendations

1. **Research Needs:** Technical issues in general appear to be well addressed, within available resources. Global research institutes readily share their findings and solutions with other potential users.

2. **Extension or Training needs:** Most of the causes of on-farm losses identified in this study can be immediately addressed via targeted training, extension and outreach activities.

3. **Advocacy Issues:** These are problems found at the macro level, and that must be addressed by policy makers and investors. In various OIC Member Countries, these include missing infrastructure, lack of access to extension services, poorly regulated input suppliers (such as poor quality seeds or feeds), poorly regulated contracting practices, and lack of access to credit.

Specific Recommendations

Seven specific recommendations were made for reducing on-farm food losses in the OIC Member Countries, the first three related to domestic policies and the others related to collaborative efforts. These recommendations relate to the identified research and extension needs and advocacy issues.

a. Recommendations regarding the Domestic Policies

Recommendation 1: Each OIC Member Country (or group of similar regionally located countries) should identify the gaps in knowledge and information on the levels and specific causes of on-farm food losses for key crops and food products.

Recommendation 2: The OIC Member Countries should assess their local food supply chains and determine when and where to invest directly to better connect farmers to buyers. Shortening the chain between farmers and end-users will reduce on farm food losses and increase the money that producers receive for products as middlemen are cut out, time for spoilage is reduced, and potential risk from spillage and infestations are reduced.

Recommendation 3: The OIC Member Countries should address gaps in the technical and training capacity of on-farm food loss researchers and extension specialists. These key resource persons are the providers of practical information be it written, oral, audio, visual, or online on best practices in local languages for use by extension workers and producers.

b. Recommendations regarding the Collaborative Efforts

Recommendation 4: It is recommended that a core group of the OIC Member Country based resource personnel be developed, since they can contribute towards capacity building for farmers and undertaking work on food loss prevention initiatives.

Recommendation 5: The OIC Member Countries should address gaps in the technical and managerial capacity of national extension workers, farmers, fishers, ranchers and food supply chain workers.

Recommendation 6: OIC Member Countries should develop projects to address losses in either durable or perishable value chains. These 'type projects' should describe key actions, technology packages and include budgets that could be used to develop projects on reducing losses in the value chains.

Recommendation 7: OIC Member Countries should implement a cycle of competitive funds where countries could receive funding for specific research and development projects to reduce on-farm losses.

Implementing these general and specific recommendations will allow the OIC Member Countries to identify the priority focus areas in their countries, and provide needed research and extension information on best practices for reducing on-farm food losses for key crops and food products.

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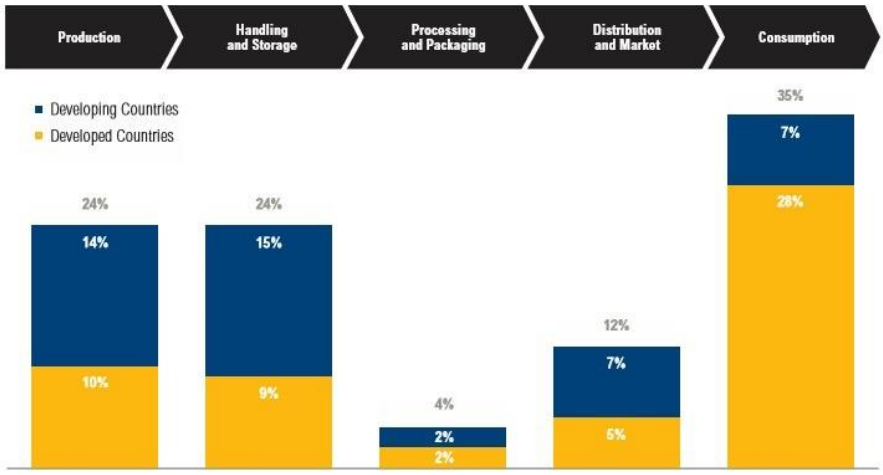
ANNEXES

Annex A. Key Informant Survey and OIC Member Country Response

COMCEC project/57 OIC countries/WFLO August 2015
Name:
Country:
Email address:

Recent reports from the UN FAO provide a summary of global food losses and waste. Food losses have been categorized by the types of foods, and by the various stages of the food value chain for developed (shown in yellow on the graph below) and developing countries (shown in blue).



Source of images: UN FAO SAVE FOOD Initiative and the World Resources Institute (WRI)

1) Please rate overall the **level of total food losses** for these food groups **in your country**, where:

Rating scale
5 = very high (more than 50%)
4 = high (30 to 50%)
3 = moderate (10 to 30%)
2 = low (5 to 10%)
1 = very low (less than 5%)

TOTAL LOSSES	Cereals	Milk and Dairy	Fish and seafood	Fruit and Vegetables	Meat and Eggs	Oilseeds and pulses	Roots and Tubers
Level of losses: Rating from 1 to 5							

2) What do you think are **important causes or sources of food losses** in your country for each type of food?
(Many possible causes are listed from production through marketing: please mark one or more of the boxes in each column with an X, marking as many as you like for each type of food.) Skip any food groups with which you are unfamiliar regarding food losses (leave the column blank).

Possible causes of food losses	Cereals	Milk and Dairy	Fish and seafood	Fruit and Vegetables	Meats and eggs	Oilseeds and pulses	Roots and Tubers
Poor information and planning							
Lack of inputs (fertilizer, feed, etc.)							
Poor quality seeds, planting material or fry							
Pests on the farm (weeds, insects, rodents)							
Poor cultural practices (pruning, fertilizing, Pesticide spraying)							
Poor water management or drought							

Plant or animal diseases on the farm (fungi, viruses, bacterial rots)							
Poor harvesting practices (damaged by cuts, bruises, etc.)							
Wrong time for harvest (immature, over-mature)							
Mechanical damage during postharvest handling (rough handling, throwing, dropping)							
Poor quality field containers or shipping packages							
Poor temperature management (too cold, too hot, no cold chain)							
Lack of proper storage facilities							
Lack of proper food processing and packaging							
Delays in transport/distribution							
Poor roads and related infrastructure							
Lack of marketing options							
Consumption (waste)							
Other (please specify)							

3) Please rate your estimation of the **level of ON-FARM food losses** for various food groups in your country, where:

Rating scale
5 = very high (more than 50%)
4 = high (30 to 50%)
3 = moderate (10 to 30%)
2 = low (5 to 10%)
1 = very low (less than 5%)

ON FARM LOSSES	Cereals	Milk and Dairy	Fish and seafood	Fruit and Vegetables	Meats and eggs	Oilseeds and pulses	Roots and Tubers
During production							
During harvesting							
On-farm handling damage							
Other (please specify)							

4) Do you know of any activities or projects aimed at reducing food losses in your country?
YES ___ / NO ____

If yes, please provide some details or examples.

Name of project/target food group	**Name of organization**	**Starting year**	**website**

Thank you for your time and consideration of our questions. Please feel free to add any comments below or contact us if you have any questions or concerns. Our report will be a summary of the information provided by all the key informants. Your name will not be associated with any specific responses.

Return your completed survey by email to:
Dr. Kerstin Hell, IITA k.hell@cgiar.org
Dr. Lisa Kitinoja, World Food Logistics Organization (WFLO) kitinoja@hotmail.com
Amanda Brondy, WFLO abrondy@gcca.org

Comments:
Key Informant Countries

Table A.1: Key Informant Respondents in 30 of the 57 the OIC Member Countries

Arab Group	Asian Group	Africa Group
Algeria	Afghanistan*	Benin
Bahrain	Albania	Burkina-Faso
Comoros	Azerbaijan	Cameroon*
Djibouti	Bangladesh*	Chad
Egypt*	Brunei Darussalam	Cote d'Ivoire
Iraq*	Indonesia*	Gabon
Jordan	Iran*	Gambia
Kuwait	Kazakhstan	Guinea
Lebanon	Kyrgyz Republic	Guinea-Bissau
Libya	Malaysia*	Mali
Mauritania	Maldives	Mozambique
Morocco	Pakistan*	Niger
Oman	Tajikistan	Nigeria*
Palestine	Turkey*	Senegal
Qatar	Turkmenistan	Sierra Leone
Saudi Arabia	Uzbekistan*	Togo
Somalia	Guyana	Uganda*
Sudan	Suriname	
Syria		
Tunisia		
UAE		
Yemen*		

Source: Key Informant Surveys.

Annex B. Top Crops, Livestock Products and Fisheries in OIC Member Countries

A characterization of the types of key foods, crops and livestock produced in OIC countries was developed via online searches, FAO STAT and key informant provided information.

Crops

The major cereals in the Arab Group include wheat, barley, rice and sorghum. The major roots and tuber crops are potatoes, and forages are important crops used as animal feeds.

Table B.1: Major Crops in the Arab Group by Highest Volume in Tonnes

Arab Group	Pop. (Mill-Ions)	Rur al Pop	% Arable Land	Top 5 Crops -2011			Top Global Crop Producers *		
Algeria	37.00	10.4	3.10	Forages	Wheat	Potatoes	Barley	Tomatoes	
Bahrain	1.20	0.14	2.10	Forages	Dates	Tomatoes	Fruits	Vegetables	
Comoros	0.68	0.49	46.70	Coconuts	Cassava	Bananas	Paddy Rice	Pulses	
Djibouti	0.83	0.19	0.10	Vegetables	Lemons /Limes	Dry Beans	Tomatoes	Tropical Fruits	
Egypt	78.10	44.2	2.80	Forages	Sugar Cane	Tomatoes	Wheat	Maize	*
Iraq	30.90	10.4	8.40	Wheat	Tomatoes	Barley	Dates	Forages	*
Jordan	6.40	1.10	2.00	Tomatoes	Potatoes	Forages	Cucumbers	Olives	
Kuwait	2.90	0.05	0.60	Tomatoes	Cucumbers	Vegetables	Potatoes	Forages	
Lebanon	4.30	0.56	11.90	Potatoes	Tomatoes	Oranges	Cucumbers	Grapes	
Libya	6.00	1.40	1.00	Forages	Potatoes	Melons	Tomatoes	Onions	
Mauritania	3.60	2.10	0.40	Rice	Sorghum	Dates	Pulses	Maize	
Morocco	31.60	13.7	17.50	Wheat	Sugar Beet	Forages	Barley	Potatoes	
Oman	2.80	0.75	0.10	Forages	Dates	Vegetables	Tomatoes	Bananas	
Palestine	4.00	1.00	7.40	Cucumbers	Tomatoes	Olives	Oranges	Potatoes	
Qatar	1.75	0.02	1.10	Forages	Dates	Tomatoes	Vegetables	Pumpkins/ Squash	
Saudi Arabia	27.30	4.80	1.50	Forages	Wheat	Dates	Silages	Vegetables	*
Somalia	9.60	6.00	1.80	Sugar Cane	Fruits	Maize	Sorghum	Cassava	
Sudan	38.00	25.8	15.70	Sugar Cane	Sorghum	Forages	Groundnuts	Onions	
Syria	21.50	9.50	25.40	Wheat	Fruits	Tomatoes	Tomatoes	Seed Cotton	

Tunisia	10.60	3.60	18.30	Mixed Legumes	Wheat	Tomatoes	Olives	Barley	
UAE	8.40	1.30	0.50	Forages	Dates	Silages	Tomatoes	Sorghum	
Yemen	22.70	15.5	2.20	Forages	Silages	Sorghum	Tomatoes	Potatoes	

Source: http://faostat3.fao.org/browse/area//E.*

For the Asian Group, the major cereals are wheat and rice, and the major roots/tubers are cassava and potatoes. Forages and silages are important crops for animal feeds.

Table B.2: Major Crops in the Asian Group (Highest Volume in Tonnes)

Asian Group	Pop. (Mill-Ions)	Rural Pop	% Arable Land	Top 5 Crops			Top Global Crop Producers *		
Afghanistan	28.40	21.80	11.90	Wheat	Paddy Rice	Vegetables	Grapes	Maize	
Albania	3.20	1.50	22.70	Forages	Silages	Wheat	Maize	Melons	
Azerbaijan	9.10	4.20	22.80	Mixed Legumes	Wheat	Potatoes	Forages	Barley	
Bangladesh	151.10	108.9	59.00	Paddy Rice	Potatoes	Sugar Cane	Wheat	Vegetables	*
Brunei	0.40	0.09	0.80	Vegetables	Fruits	Cassava	Cucumbers	Legume Vegs	
Indonesia	240.67	120.52	13.00	Oil Palm Fruit	Paddy Rice	Sugar Cane	Cassava	Coconuts	*
Iran	74.40	23.10	10.80	Forages	Silages	Wheat	Sugar Beets	Tomatoes	*
Kazakhstan	15.90	7.38	8.90	Wheat	Mixed Legumes	Potatoes	Barley	Potatoes	
Kyrgyzstan	5.30	3.40	6.70	Mixed Legumes	Potatoes	Wheat	Forages	Maize	
Malaysia	28.30	7.90	2.90	Oil Palm Fruit	Oil Palm	Palm Kernels	Paddy Rice	Rubber	
Maldives	0.33	0.19	10.00	Coconuts	Roots/Tubers	Bananas	Fruits	Vegetables	
Pakistan	173.10	111.0	27.60	Sugar Cane	Wheat	Paddy Rice	Seed Cotton	Cotton Seed	*
Tajikistan	7.60	5.60	6.10	Potatoes	Wheat	Forages	Seed Cotton	Silages	
Turkey	72.10	21.30	26.70	Wheat	Sugar Beet	Forages	Tomatoes	Barley	*
Turkmenistan	5.04	2.60	4.10	Mixed Legumes	Wheat	Seed Cotton	Forages	Cotton Seed	
Uzbekistan	27.80	17.70	10.10	Mixed Legumes	Wheat	Seed Cotton	Forages	Cotton Seed	
Guyana	0.79	0.56	2.10	Sugar Cane	Paddy Rice	Coconuts	Cassava	Roots/Tubers	
Suriname	0.53	0.16	0.40	Paddy Rice	Sugar Cane	Bananas	Vegetables	Plantains	

Source: http://faostat3.fao.org/browse/area//E.*

For the African Group, the major cereals are maize, millet, rice and sorghum. Roots/tubers are of primary importance for these countries, with high production of cassava, sweet potatoes, yams and other root crops (cocoyam, taro, and dasheen). Bananas and plantains, cowpeas, groundnuts and oil palm fruits are all major crops.

Table B.3: Major Crops in the Africa Group by Highest Volume in Tonnes

Asian Group	Pop. (Mill - Ions)	Rural Pop	% Arable Land	Top 5 Crops			Top Global Crop Producers *		
Benin	9.5	5.3	22.9	Cassava	Yams	Maize	Seed Cotton	Oil Palm Fruit	
Burkina-Faso	15.5	11.5	20.8	Sorghum	Maize	Millet	Sugar Cane	Seed Cotton	
Cameroon	20.6	10	13.1	Cassava	Plantains	Oil Palm Fruits	Sugar Cane	Cocoyam	*
Chad	11.7	9.2	3.9	Sorghum	Groundnuts	Millet	Sugar Cane	Yams	
Cote D'Ivoire	18.97	9.4	9.1	Yams	Cassava	Sugar Cane	Plantains	Oil Palm Fruit	
Gabon	1.6	0.22	1.2	Plantains	Sugar Cane	Cassava	Yams	Cocoyam	
Gambia	1.68	0.73	41	Groundnuts	Millet	Paddy Rice	Oil Palm Fruits	Maize	
Guinea	10.9	7.1	11.8	Paddy Rice	Cassava	Oil Palm Fruits	Plantains	Maize	
Guinea-Bissau	1.5	0.9	8.2	Paddy Rice	Cashews	Oil Palm Fruits	Roots/Tubers	Coconuts	
Mali	13.9	9.1	5.6	Paddy Rice	Millet	Sorghum	Maize	Seed Cotton	
Mozambique	23.9	16.5	6.4	Cassava	Sugar Cane	Maize	Sweet Potatoes	Coconuts	*
Niger	15.9	13.1	12.3	Millet	Cow Peas	Sorghum	Onions	Groundnuts	
Nigeria	159.7	81.5	37.3	Cassava	Yams	Oil Palm Fruits	Sorghum	Maize	*
Senegal	12.95	7.5	17.4	Sugar Cane	Groundnuts	Millet	Paddy Rice	Melons	
Sierra Leone	5.7	3.5	23.4	Cassava	Paddy Rice	Vegetables	Oil Palm Fruits	Sweet Potatoes	
Togo	6.3	3.9	45.2	Cassava	Yams	Maize	Sorghum	Vegetables	
Uganda	33.98	28.8	34.3	Plantains	Cassava	Sweet Potato	Sugar Cane	Maize	*

Source: http://faostat3.fao.org/browse/area//E.*

Livestock

For all three of the OIC country groups, eggs, cow milk and chicken meat are of primary importance. In the Arab group camel and buffalo milk are among the top food products, while in Asia it is indigenous chicken meat and in Africa it is cattle meat that are among the top produced livestock based foods.

Table B.4: Top Three Live Stocks for the Arab Group (2011)

Algeria	Eggs	Cow Milk	Chicken Meat
Bahrain	Eggs	Sheep Meat	Cow Milk
Comoros	Cow Milk	Eggs	Cattle Meat
Djibouti	Cow Milk	Cattle Meat	Camel Milk
Egypt	Cow Milk	Buffalo Milk	Eggs
Iraq	Eggs	Cow Milk	Sheep Milk
Jordan	Eggs	Cow Milk	Sheep Skins
Kuwait	Cow Milk	Eggs	Sheep Meat
Lebanon	Cow Milk	Chicken Meat	Eggs
Libya	Eggs	Cow Milk	Chicken Meat
Mauritania	Eggs	Cow Milk	Goat Milk
Morocco	Eggs	Cow Milk	Chicken Meat
Oman	Eggs	Goat Milk	Cow Milk
Palestine	Cow Milk	Chicken Meat	Eggs
Qatar	Eggs	Sheep Meat	Cow Milk
Saudi Arabia	Eggs	Cow Milk	Chicken Meat
Somalia	Camel Milk	Sheep Milk	Cow Milk
Sudan	No Data		
Syria	Cow Milk	Eggs	Sheep Milk
Tunisia	Eggs	Cow Milk	Chicken Meat
UAE	Eggs	Goat Milk	Camel Milk
Yemen	Eggs	Cow Milk	Chicken Meat

Source: http://faostat3.fao.org/browse/area//E.*

Table B.5: Top Three Live Stocks for the Asian Group (2011)

Afghanistan	Eggs	Cow Milk	Sheep Milk
Albania	Eggs	Cow Milk	Sheep Milk
Azerbaijan	Cow Milk	Eggs	Cattle Meat
Bangladesh	Goat Milk	Hen Eggs	Other Bird Eggs
Brunei	Eggs	Chicken Meat	Indigenous Chicken
Indonesia	Chicken Meat	Hen Eggs	Other Bird Eggs
Iran	Cow Milk	Indigenous Chicken	Eggs
Kazakhstan	Eggs	Cow Milk	Cattle Meat
Kyrgyzstan	Cow Milk	Eggs	Indigenous Cattle
Malaysia	Indigenous Chicken	Chicken Meat	Eggs
Maldives	Meats		
Pakistan	Eggs	Buffalo Milk	Cow Milk
Tajikistan	Eggs	Cow Milk	Goat Milk
Turkey	Cow Milk	Eggs	Indigenous Chicken
Turkmenistan	Cow Milk	Eggs	Cattle Meat
Uzbekistan	Cow Milk	Eggs	Cattle Meat
Guyana	Cow Milk	Chicken Meat	Indigenous Chicken
Suriname	Chicken Meat	Indigenous Chicken	Eggs

Source: http://faostat3.fao.org/browse/area//E.*

Table B.6: Top Three Live Stocks for the African Group (2011)

Benin	Cow Milk	Cattle Meat	Eggs
Burkina-Faso	Cow Milk	Cattle Meat	Eggs
Cameroon	Cow Milk	Eggs	Cattle Meat
Chad	Cow Milk	Indigenous Cattle	Cattle Meat
Cote d'Ivoire	Game Meats	Hen Eggs	Eggs
Gabon	Game Meats	Eggs	Chicken Meat
Gambia	Cow Milk	Eggs	Cattle Meat
Guinea	Eggs	Cow Milk	Indigenous Cattle
Guinea-Bissau	Eggs	Cow Milk	Pig Meat

Mali	Goat Milk	Eggs	Cow Milk
Mozambique	Eggs	Pig Meat	Indigenous Pigs
Niger	Cow Milk	Goat Milk	Eggs
Nigeria	Eggs	Cow Milk	
Senegal	Cow Milk	Cattle Meat	Eggs
Sierra Leone	Cow Milk	Eggs	Cattle Meat
Togo	Eggs	Chicken Meat	Indigenous Chicken
Uganda	Eggs	Cow Milk	Indigenous Cattle

Source: http://faostat3.fao.org/browse/area//E.*

Fisheries/Aquaculture

Aquaculture is growing at a rapid pace in the Arab Group, especially in Egypt and Jordan, and in the Asian Group (Bangladesh, Indonesia, Malaysia and Turkey). It is defined as breeding (production of seeds or fry), controlled feeding and controlled harvesting of fish or crustaceans. This normally requires capital and is mostly out of reach for small scale or artisanal producers.0020

Table B.7: Arab Group Fisheries: % Captured vs % Farmed

Arab Group	Fisheries % Captured	% Farmed	Major Producers
Algeria	98%	2%	
Bahrain	100%		
Comoros	100%		
Djibouti	100%		
Egypt	20%	80%	***
Iraq	80%	20%	
Jordan	50%	50%	
Kuwait	99%	1%	
Lebanon	75%	25%	
Libya	100%		
Mauritania	100%		
Morocco	99%	1%	***
Oman	100%		
Palestine	99%	1%	

Qatar	100%		
Saudi Arabia	75%	25%	
Somalia	100%		
Sudan	98%	2%	
Syria	60%	40%	
Tunisia	90%	10%	
UAE	99%	1%	
Yemen	100%		

Source: http://www.fao.org/fishery/statistics/global-aquaculture-production/en.

Table B.8: Asian Group Fisheries: % Captured vs % Farmed

Asian Group	Fisheries % Captured	% Farmed	Major Producers
Afghanistan	50%		
Albania	70%	30%	
Azerbaijan	80%	20%	
Bangladesh	45%	55%	***
Brunei	85%	15%	
Indonesia	62%	38%	***
Iran	64%	36%	
Kazakhstan	99%	1%	
Kyrgyzstan	1%	99%	
Malaysia	85%	15%	***
Maldives	100%		
Pakistan	76%	24%	
Tajikistan	75%	25%	
Turkey	62%	38%	
Turkmenistan	100%		
Uzbekistan	38%	62%	
Guyana	100%		
Suriname	100%		

Source: http://www.fao.org/fishery/statistics/global-aquaculture-production/en.

In the African Group, only Nigeria and Uganda are actively promoting aquaculture production of fish and seafood.

Table B.9: African Group Fisheries: % Captured vs % Farmed

African Group	Fisheries % Captured	% Farmed	Major Producers
Benin	99%	1%	
Burkina-Faso	99%	1%	
Cameroon	99%	1%	
Chad	100%		
Cote d'Ivoire	95%	5%	
Gabon	99%	1%	
Gambia	100%		
Guinea	100%		
Guinea-Bissau	100%		
Mali	98%	2%	
Mozambique	99%	1%	
Niger	100%		
Nigeria	72%	28%	***
Senegal	99%	1%	
Sierra Leone	100%		
Togo	100%		
Uganda	80%	20%	

Source: http://www.fao.org/fishery/statistics/global-aquaculture-production/en.