Introduction

Small-scale fisheries in developing countries play a vital role in contributing directly to food and livelihood security, poverty reduction, wealth creation, foreign exchange earnings and rural development. The latest estimates indicate that small-scale fisheries contribute over half of the world's marine and inland fish catch of about 140 million tonnes, nearly all of which is used for direct human consumption (FAO, 2008). In Africa, over 60 percent of the fish supply to domestic and regional markets, as well as export-oriented processing units, is of artisanal origin. The New Partnership for Africa's Development (NEPAD) recognizes the vital contributions by African inland and marine fisheries to food security and income of many millions of Africans and to poverty reduction and economic development on the continent. Fisheries are an important part of food security, particularly for many poor people in developing countries. Small-scale fisheries employ over 90 percent of the world's estimated 28 million fishermen and support another approximate 84 million people employed in jobs associated with fish processing, distribution and marketing. At least half of these are women. In many cases these fisheries are responsible for between 50 and 70 percent of a nation's total catch, and nearly half of fishery exports derive from developing countries (FAO, 2008).

In spite of these economic, social and nutritional benefits, concerns are raised about the sustainability of small-scale fisheries in maintaining their role of filling the gap between an ever-increasing demand for fish and dwindling supplies from wild capture fisheries. Though there are numerous threatening factors, as acknowledged in the recently organized FAO Global Conference on Small-scale Fisheries,[1] securing post-harvest benefits through post-harvest fish loss control has long been a concern of development practitioners committed to improving the livelihoods of fishermen, processors and traders and the contribution fish makes to food security. In a region where aquaculture is still developing and against a backdrop of dwindling or static supplies of wild capture, African fisheries are at a turning point, which makes the problem of fish loss particularly acute (Ward, unpublished, Report of the Accra 2006 workshop).

Recognition of the important problem fish loss poses is reflected in the FAO CCRF under Article 11.1 – Responsible fish utilization (FAO, 1998a), which places an emphasis on loss reduction. The most obvious means of increasing supply of fish, even without increased landings, is by reducing post-harvest losses of what is presently caught. Yet, a rational use of already scarce development

[1] Securing sustainable small-scale fisheries: Bringing together responsible fisheries and social development, Bangkok, Thailand, 13–17 October 2008.

resources, and planning and implementation of effective loss reduction strategies, require that losses are thoroughly assessed and attention is given to reducing those that are significant.

Fish is an extremely perishable food commodity. No other food provides so much observed evidence of serious loss from harvest to consumption and so little documentation of the overall proportion of losses from fish production (ECA, 1984). Accurate assessment of post-harvest loss of fish in developing countries is an important challenge, which is made difficult by the fact that much of the artisanal catch is unrecorded and that fishermen may or may not be licensed. Additionally, it passes through many hands on its way from harvest to consumption.

It has been estimated that 10 percent by weight of world fish catch is lost by poor handling, processing, storage and distribution. However, losses in small-scale fish processing are said to be particularly high and figures as high as 40 percent are sometimes reported (FAO, 1984; Mills, 1979; Moes, 1980). In sub-Saharan Africa, recent investigations suggest that losses may be only around 5 percent of the total artisanal productions (FAO, 1996) while other studies put the figure for the West African Region at between 10 and 20 percent (McConnery, 1994). The dispersed nature of many small-scale and less developed fishing operations makes it difficult to make definitive estimates of post-harvest losses, but it is thought that in some developing country situations it could be as much as 25 percent of fish caught (FAO, 1998a).

However, while post-harvest fish losses occur all over the world in all fisheries from point of production to final sale to the consumer, even in more structured fisheries (industrial sector) the type of loss can vary. Three types of losses have been defined in Ward and Jeffries (2000): physical, quality and market force. Whereas physical losses are defined as fish that is thrown away (accidentally, voluntarily or as authorized) or eaten by insects, birds or animals, quality losses are associated with changes due to spoilage or physical damage but the fish is still sold, often for a low price. Market force loss refers to a loss induced/led by market changes or developments, where fish operators have to sell their product (even of good quality) at a price below their expectations. All three types of losses have financial implications (loss in revenue of the fish operator, macroeconomic impact at country level), in addition to the aspect of resource/fish as food wastage. Different approaches are also necessary to address different losses which can have complex causes.

Much of the early data on post-harvest fish losses, especially loss levels, had been derived from limited and unsystematic observations and studies. In many cases the way the data were collected and interpreted is not clear, and neither is the type of loss being described. Poulter *et al.* (1988) noted that very few quantitative studies of actual losses had been undertaken and much of the available data, therefore, was based on qualitative estimates sometimes involving rather massive extrapolation from single landing sites to whole countries, even regions.

A reason for this situation was the lack of a practical method or tools for assessing fish losses. The development of a method was complicated because

many fisheries, particularly tropical fisheries, are multispecies and catches lack uniformity in terms of composition, weight and shape. Spoilage rates under different conditions for different fish occur and fish enters complex distribution systems involving many stakeholders. Furthermore, often non-standardized units of measurement are used in landing sites and markets for trading and pricing purposes.

In 1990, FAO organized a symposium on post-harvest fish technology in Cairo. A paper on "The kinds and levels of post-harvest losses in African inland fisheries", commissioned by the former Fish Utilization and Marketing Service (FIIU) and now the Products, Trade and Marketing Service (FIPM), was the first to identify different types of post-harvest losses: material losses, value losses and nutritional losses (Ames, 1992). Before then, most work as mentioned by Poulter *et al.* (1988) referred to losses without identifying what was meant by "losses" and, willingly or not, suggested that all losses were either physical or material. An overview of physical losses of cured fish in the tropics is presented in Annex 1.

The Strategy for International Fisheries Research meeting in Paris in 1991 recommended that post-harvest fish losses should be a priority issue for future research. It was concluded that there were no tried and tested techniques by which losses could be assessed. As a result, the Natural Resources Institute of the United Kingdom of Great Britain and Northern Ireland embarked upon a project in 1992, funded by the Overseas Development Administration, in the United Republic of Tanzania to develop loss assessment methodologies. Ward (1996) reported that three fish loss assessment tools were developed between 1993 and 1996 in collaboration with the United Republic of Tanzania Fisheries Division and a draft manual for assessing post-harvest fisheries losses through the informal and questionnaire methodologies was prepared. The results of the work were presented at the Sixth FAO Expert Consultation on Fish Technology in Africa (FAO, 1998b), which recommended that the methodologies should be validated, documented and widely disseminated.

Following this, the Department for International Development (DFID), through its Post-harvest Fisheries Research Programme (PHFRP) and in conjunction with the European Union-funded West Africa Regional Programme (1994 to 1999) on "Improvement of post-harvest utilization of artisanal fish catches" implemented by the West African Association for the Development of Artisanal Fisheries, agreed to support validation of the methods and development of loss assessment tools in four countries in West Africa.

The field-based methods were used to assess losses in:

- Côte d'Ivoire: with fishermen and fish processors at the Chicago wholesale market in Abidjan;
- Ghana: with women fish smoker groups;
- Senegal: with the Collectif National des Pêcheurs du Sénégal in Mbour; and
- Nigeria: with economic operators in Dorobaga and Maiduguri fish markets, in collaboration with Tedak Fishermen's Co-operative Society of Nigeria.

This work, evaluated by FAO (Teutscher, 1999), led to the development of "A manual for assessing post-harvest fisheries losses" (Ward and Jeffries, 2000), a fish-loss computer-based model, and a database of information on losses from secondary and primary sources.

The FAO/DFID Sustainable Fisheries Livelihoods Programme (SFLP) in West Africa has supported community initiatives and pilot projects across 25 West African countries. The SFLP Post-harvest Livelihoods Pilot Project (PP3) aimed to bring visible sustainable social and economic benefits to the most vulnerable communities of the artisanal post-harvest fisheries sector. In November 2004, the SFLP began capacity development of regional stakeholders from Cameroon, Chad, the Gambia and Senegal in loss assessment and loss reduction based on the PHFRP loss assessment manual (Ward, 2007).

In 2006, FAO's FIIU (now FIPM) designed a regional PHLA programme to:

- develop a core of regional expertise in fish loss assessment;
- generate fish loss data in fisheries of socio-economic importance;
- produce practical guides for fish loss assessment for extension officers and the fishery operators;
- update the Ward and Jeffries (2000) manual; and
- provide normative guidance to support the implementation of the CCRF.

The regional programme began in October 2006 and lasted 18 months. It aimed to build on the past initiatives and to develop tools for practical loss assessment in artisanal fisheries. The programme provided training in qualitative and quantitative fish loss assessments methods, planned support, and supervised the implementation of loss assessment studies. The list of participants throughout the duration of the programme is presented in Annex 2.

This document presents data generated by the loss assessments of the PHLA in five sub-Saharan African countries, the lessons learned and key achievements. It is intended to support technical, policy and loss reduction planning processes and promote further interest by development agencies in loss assessment and reduction work. It will also contribute to the implementation of the CCRF. It also brings into focus the contribution of African fisheries to food security, the role of post-harvest in the livelihoods of many millions of stakeholders, poverty reduction and economic development of the continent.

This technical paper is directed towards people who are interested in the development of post-harvest fisheries and the food security of people in developing nations. For example, it is important for extension officers to be able to identify where fish losses occur, and be able to advise fishery operators and help implement loss reduction initiatives. Policy-makers and planners would benefit from being better informed regarding post-harvest loss reduction and contribution of fisheries to the alleviation of malnutrition and to national food self-sufficiency in coastal communities. It will also enable them to evolve appropriate policies to support small-scale fisheries' loss assessment initiatives and intervention programmes.

Methodology

Over an 18-month period from October 2006 to mid-2008, the programme provided capacity building for fishery officers from 12 African countries in fish loss assessment. Teams from five of the countries also carried out loss assessment fieldwork.

PARTICIPATING COUNTRIES

Taking into account the resources available to the programme, 12 participating African countries were selected based on the volume of fish production, the importance of artisanal landings and the past experience in fish loss assessment (Table 1).

All the countries that participated in the loss assessment programme of FAO are among the region's top 20 fishing nations. Cameroon, Chad, Côte d'Ivoire, the Gambia, Ghana, Nigeria, Senegal and the United Republic of Tanzania have all had some fish loss assessment experience through programmes supported primarily by the DFID Post-harvest Fisheries Research Programme (PHFRP) and the DFID/FAO Sustainable Fisheries Livelihoods Programme (SFLP).

TABLE 1
Participating countries fish production and employment data

Country	Volume of fish production (tonnes)	Estimated employment	
		Primary sector	Secondary sector
Cameroon	108 121	122 000	75 000
Chad	70 000	220 000	80 000
Côte d'Ivoire	69 769	9 960	13 000
Gambia	36 864	6 000	32 000
Ghana	451 287	210 400	315 600
Kenya	120 534	55 000	800 000
Malawi	41 187	62 000	350 000
Mali	100 008	120 000	500 000
Nigeria	505 839	1 250 000	5 100 000
Senegal	405 263	52 000	600 000
Tanzania	355 807	171 793	2 000 000
Uganda	219 428	150 000	550 000

Source: FAO Fishery Country Profiles (2007).

TRAINING WORKSHOPS AND FIELDWORK

A total of three capacity-building workshops were held with set goals and objectives (Table 2).

TABLE 2
Summary of workshop objectives

Objectives		
First workshop	**Second workshop**	**Third workshop**
The first workshop focused on the qualitative post-harvest fish loss assessment methodology and was held in Accra, Ghana, from 30 October to 4 November 2006 at the FAO Regional Office for Africa.	A second workshop to review the previous work and provide capacity building in quantitative methods was also held in Accra, Ghana, from 2–8 May 2007 at the FAO Regional Office for Africa.	The third and final workshop of the current FAO Regional PHLA Programme for Africa was held at the Paradise Hotel in Jinja, Uganda, from 11–14 March 2008 and it was jointly organized with the Lake Victoria Fisheries Organization.
The workshop was organized by FIIU of FAO, Rome, in conjunction with the Regional Office for Africa. The objectives of this workshop were: – capacity building of fisheries officers in the region in the qualitative fish loss assessment methods (IFLAM); and – planning of the qualitative loss assessment phase to be conducted on some economically and socially important fisheries within the region.	The objectives of this workshop were to: – review and discuss the country IFLAM studies; – provide capacity building in quantitative loss assessment tools; and – develop country work plans for a quantitative phase of work.	The objectives of the final workshop in the series were to: – consolidate key data on post-harvest losses from the five country case studies; – determine modifications to the methods and how these are presented to end users; and – discuss other expected outputs and inform follow-up activities to the programme.
The workshop was attended by 19 participants from 12 African countries.	The workshop was attended by 16 participants from 11 African countries.	The workshop was attended by 18 participants from 10 African countries.

TYPES OF FISH LOSSES ASSESSED

The programme discussed different aspects and types of post-harvest fish loss as part of the capacity-building process. This showed that losses are associated with loss of income; loss of quality; the quantity of fish loss; loss of food; food insecurity; loss of nutritional value; food safety to consumers; underutilization of fish; loss of man-hour (wasted time); loss during processing (droppers); loss due to insect infestation; breakage in smoked/dried fish; use of fish for animal feed; low prices; bad publicity for the image of a country; loss of market; poor packaging; transport, poor handling and theft.

The programme focused on assessing three types of post-harvest fish loss: physical loss, quality loss and market force loss.

Physical loss is defined as *"fish that is thrown away (accidentally, voluntary or as authorized) or eaten by insects, birds/animals"*. Typical causes are:

- severe spoilage of the fish;
- over smoking of fish leading to severe burning;
- discards of juveniles and bycatch;

- chemical contamination of fish; and
- destruction of fish seized by authorities and destroyed because it is deemed unfit for human consumption.

Quality loss is defined as "*fish that has undergone changes (due to spoilage or physical damage) and is sold for a lower price than if no or minimum deterioration in quality had taken place.*" Causes of quality loss include:

- mishandling;
- bad/poor packaging;
- fragmentation of smoked fish; and
- lack of adequate storage facilities.

Market force loss is defined as "*any loss (physical or quality) induced by the market patterns, where fish operators have to sell at a price below their expectations at time of production.*

LOSS ASSESSMENT PROCESS

The programme focused on capacity building in, and the application of, three fish loss assessment methods described in the DFID PHFRP manual (Ward and Jeffries, 2000).

The IFLAM is based on the tools and principles associated with PRA research and development methods. It provides qualitative and indicative quantitative data on a wide range of issues related to loss such as where key losses occur and who is affected. It fosters participation of primary stakeholders in the development process and the use of indigenous knowledge.

The QLAM is a formal questionnaire survey approach to quantitatively understand the type of loss incurred, reasons for loss and the variables, which affect loss such as the type of fishing gear used or fish processing methods. It is used to give quantitative data on a wide range of issues and enables validation of data over a wide geographical area.

LT is used to give quantitative data on loss levels. These can be losses associated with an activity such as fishing, landing, icing, processing, storage and other stages of distribution and marketing. LT can also be used to determine the effectiveness of loss reduction interventions.

The key stages of the process followed by the programme were:

- secondary data review to generate background information on the national fishery sector and previous data on losses;
- site selection at country level;
- application of IFLAM to develop a qualitative understanding of losses at the sites;
- prioritization of losses;
- application of QLAM and/or LT to validate and quantify key losses; and
- data analyses and reporting.

SITE SELECTION

Due to resource and time limitations it is difficult or impossible to carry out loss assessment in all locations in all fisheries and at all stages of fish distribution chains in a particular country. With this in mind, the following criteria were used to guide where loss assessment fieldwork using IFLAM should initially be carried out:

- volume of fish landed, processed or traded;
- diversity of post-harvest fishery stakeholders;
- varying range of and access to services/facilities, e.g. markets, landing sites, roads, electricity;
- rural or urban location;
- presence of poor and vulnerable post-harvest stakeholders;
- evidence that losses are known to occur;
- comparable or different community population sizes; and
- likelihood of research fatigue affecting data collection.

Annex 3 presents the approach followed and Table 3 shows how different criteria were used by different country teams for site selection.

TABLE 3
Criteria used for site selection

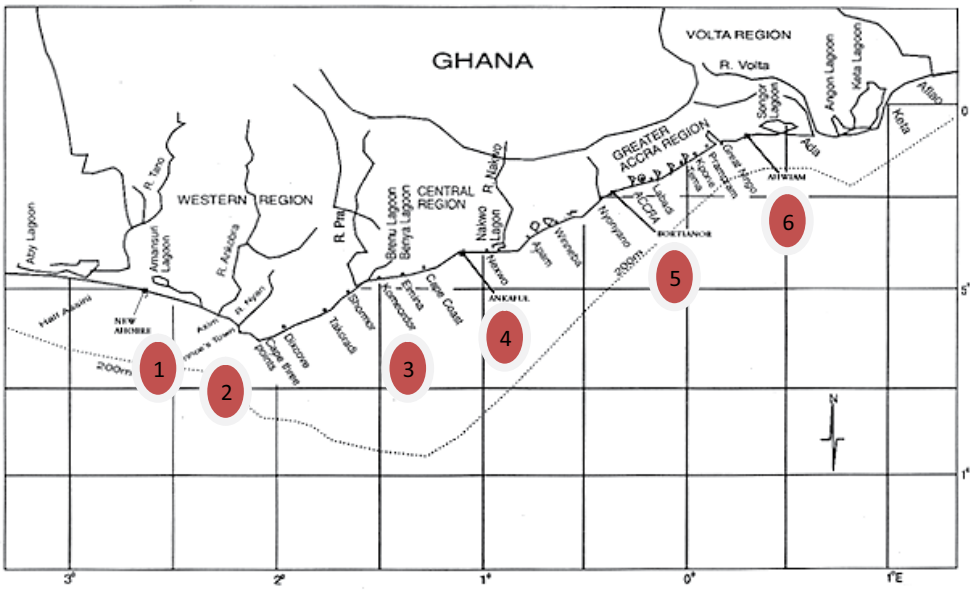
Tanzania	Uganda	Kenya	Ghana	Mali
Number of fishers and volume of landing	Diversity of stakeholders	Presence of poor and vulnerable post-harvest stakeholders	Peri-urban and rural	Volume of fish landings/off loaded for sale
Type of fish and processing methods	Volume of fish	Diversity of post-harvest fisheries stakeholders	Easily accessible	Diversity of post-harvest activities
Historical data	Population	Evidence that losses are known to occur	Familiar to researchers	
		Volume of fish landed	Volume of production	
		Varying range of and access to service/facilities, e.g. markets, landing, sites, roads, electricity	Diversity of stakeholders	
		Rural or urban location		
		Comparable or different community population sizes		
		Avoiding areas with a likelihood of research fatigue		

The Ghana team used the following criteria to help identify which of the 185 fishing communities along the coast and four coastal regions of Ghana would be the focus of loss assessment:

- rural or urban locations;
- volume of fish landed, processed and traded;
- diversity of post-harvest fishery stakeholders;
- level of anticipated cooperation with researchers (based on the experience of fisheries in the regions); and
- varying range of and access to services/facilities, e.g. markets, roads.

Three coastal regions (Greater, Western and Central Accra) with two sites in each region were identified. The percentage contributions of these regions to the national catch are: Greater Accra, 19.7 percent; Western Accra, 32.07 percent; and Central Accra, 37.3 percent. The three regions have a great variety of artisanal gears. Also field enumerators employed by the ministry have their sampling sites within the survey area and could be used as local translators. Figure 1 shows the coastal map of Ghana depicting the fieldwork locations.

FIGURE 1
Coastal map of Ghana showing fieldwork locations: 1- New Ahobre; 2- Axim; 3- Elmina; 4- Ankaful; 5- Bortianor; 6- Ahwiam



The Kenya team identified three landing sites on Lake Victoria and three sites on the coast using a review of secondary data and ranking based on the volume of fish landed, economic status of the community, diversity of post-harvest fisheries stakeholders and evidence that losses are known to occur. The six sites selected for the study were Vanga in Lamu District; Ngomeni in Malindi District; Amu

in Lamu District; Sori in Migori District; Mbita in Suba District; and Marenga in Busia District. Vanga, Ngomeni and Amu are in the marine fishery, while Sori, Mbita and Marenga are in the Lake Victoria basin.

Based on 2005 statistical data, the total fish production of 61 948 tonnes from all the six landing sites represents 46.2 percent of national fish production of 134 000 tonnes in 2005.

The Mali team chose two fish markets in Bamako. Médine, the central market in Bamako, which is a major fresh fish marketing centre, receives fish from the three main production areas in Mali (i.e. Mopti, Sélingué and Manantali); and Dibida market, a secondary market in Bamako. Dibida receives only fresh fish and is the second most important market in Bamako. Landing sites in each of the three main production sites of the country were chosen: Sélingué (Carrière and Faraba), Manantali, and the well-known Mopti fishing port in the Niger Central Delta.

The United Republic of Tanzania team selected sites based on the number of fishers, volume of catches and fishing gear type, as well as processing methods and commercially important species.

Lake Victoria was selected because it is the main source of fish production. The number of fishers, fishing crafts and landing sites are high. Again, the area was found suitable because of previous experience and studies that have been conducted. The assessment covered all the three regions: Kagera, Mara and Mwanza. The sites were:

- Kibuyi in Tarime District, Mara;
- Yozu in Sengerema, Mwanza;
- Kirumba-Mwaloni fish market, Mwanza; and
- Bukoba in Kagera region.

Two other coastal sites were included:

- Kariakoo market in Dar es Salaam; and
- Mafia Island, linked with Dar es Salaam Integrated Fish Market Complex.

The decision to have at least one study area in each region was reached after considering existing variations among the three regions in terms of fishing gear and method, distance to market and processing methods. For example, lake sardine fishers in Kagera prefer to use scoop nets whereas those in Mwanza are fond of using lift nets and small seine nets. Similarly, Lake Victoria sardine processors in Mara dry their fish on rocks, while those in Kagera use grasses (*kimfi)* and those in Mwanza dry fish on sandy beach.

In Uganda, fish loss assessment was carried out in six Lake Victoria landing sites in Kalangala and Mukono Districts. According to the catch assessment study of August 2006, Mukono District has the highest tonnage (82 568.3 tonne/year) of landed fish followed by Kalangala District (54 517.2 tonne/year) out of the total 219 430 tonne/year of the country's landings. The study areas/locations were Ggaba, Kasekulo, Mweena, Ssenyi, Kiyindi and Mabanga landing sites. The sites were chosen based on volume of fish landed, population and diversity of stakeholders. Table 4 shows the sites selected for IFLAM and LT/QLAM according to country.

TABLE 4
Sites selected by the five countries which participated in the PHLA

Country	IFLAM	LT/QLAM
Ghana	Bortianor, Axim, Ankaful, Elmina, Ahwiam and New Ahobre	– Axim is in the western region – Elmina is centrally located – Ahwiam is in the east
Kenya	– Vanga in Lamu District – Ngomeni in Malindi District – Amu in Lamu District – Sori in Migori District – Mbita in Suba District – Marenga in Busia District	– Mbita and Sori in Lake Victoria – Lamu in the Indian Ocean
Historical data	**Population**	**Evidence that losses are known to occur**
Mali	– Médine, the central market in Bamako, is the major fresh fish marketing centre – Dibida market is the second important market in Bamako – Sélingué (Carrière and Faraba) landing site is an important (mostly fresh) fish collection site supplying markets in Bamako – Manantali fish market is the third fish production centre in the country also supplying markets in Bamako in addition to other urban cities – Tondidji fishing village is located in the Manantali area – Mopti fishing port is the most important port and a major processed fish production zone in the country	– Sélingué landing site – Manantali market – Mopti harbour (smoked fish)
Tanzania	– Kariakoo market in Dar es Salaam – Mafia Island, linked with Dar es Salaam Integrated Fish Market Complex – Kirumba Mwaloni in Mwanza – Yozu in Sengerema in Mwanza – Kibuyi in Tarime in Mara – Bukoba in Kagera	– Yozu, a small island in Lake Victoria, is located in Sengerema District – Dar es Salaam is the commercial city of Tanzania
Uganda	Ggaba, Kasekulo, Mweena, Ssenyi, Kiyindi and Mabanga	Ssenyi, Kiyindi and Kasekulo

FISHERIES COVERED

Various types of fisheries were assessed for losses. Lake Victoria, the Niger Central Delta (Mopti area), Sélingué and Manantali dams in Mali are freshwater fisheries. Coastal Indian Ocean and Atlantic Ocean fisheries were assessed

on the marine side. Ghana and Mali focused on multispecies fisheries while other countries concentrated on single-species fisheries such as the Nile perch (*Lates niloticus*), Lake Victoria sardine (*Rastrineobola argentea)* and tilapia (*Oreochromis niloticus*).

RANKING OF LOSSES

IFLAM generated information on various types of losses affecting different stakeholders in different locations. These losses were then ranked in order of importance by the teams during the second workshop using the criteria in Table 5 as a guide. The teams then focused on the most important or prioritized losses during the second phase of fieldwork using QLAM and LT.

After the fieldwork, the sorting of data and development of the matrices helped to identify gaps in data and this formed the basis of IFLAM fieldwork where matrices were developed early in the fieldwork process and updated and revised as the process continued.

TABLE 5
Prioritization criteria

1	Magnitude of fish losses in the fishery	Indicative quantitative data on fish losses from IFLAM – volume and value over a period (e.g. per year)
2	The number of fisheries economic operators that are directly affected by the losses identified	Information on this from estimates derived from fieldwork semi-structured interviews (SSIs), literature and statistics review
3	The frequency of occurrence and seasonality of the losses	Whether these take place throughout the time the operations are carried out or occur on a one-time accidental basis. These have implications both on the significance of the losses to the fishery and hence the actions that may be necessary for mitigating them

DATA ANALYSES AND REPORTING

It became evident during the workshop that there was a need to develop a reporting structure to guide the write-up of the IFLAM and QLAM/LT works. As a consequence, a guide has been developed which builds on the reporting format provided in the fish manual (Ward and Jeffries, 2000).

The reporting structure guided the write-up by country teams. It helped to standardize the country reports and facilitate the FAO review process (see Annexes 3, 4 and 5 for examples of report structures for IFLAM, QLAM and LT).

QLAM and LT generate quantitative data and the successful application of these methods requires a good survey design and a satisfactory level of replication. Initial data analysis and summary statistics can be performed without the use of statistical software. More in-depth analysis can be carried out using software packages such as Mstat, Cstat, Systat, Statgraphics, SPSS, GenStat, SAS, S-plus,

Minitab and MS Excel; see *Data Management Guidelines for Experimental Projects: Biometric Guidelines* (University of Reading, 2000) for more details of data analyses. Examples of how quantitative data from the programme were analysed are described below.

In Ghana, the paired t-test was used to assess whether the losses were significantly different from zero, at the 5 percent level. Also analysis of variance (comparing of means) was used to see whether the quality changes from hour to hour were significant from each other. Histograms were used to compare variables.

In Uganda, data from the QLAM were entered in a spreadsheet and coded for analysis. The coded data were analysed using the SPSS software to yield basic summary statistics and analysis of variance. The LT data were analysed using GenStat software.

In Kenya, QLAM data were entered in a spreadsheet and coded for analysis. The coded data were analysed using the SPSS software to yield basic summary statistics and analysis of variance.

Key data on fish losses

Key findings from the fish loss assessments in Ghana, Kenya, Mali, United Republic of Tanzania and Uganda are now presented in terms of the magnitude of losses, causes of loss, variables influencing loss, coping strategies adopted to mitigate losses, trends and variability reported, as well as the stakeholders affected in the process. Opportunities for intervention to reduce losses are also covered.

Capacity building and other achievements are also described. The limitations and challenges experienced from the use of the methods and further research studies are also outlined.

TYPES AND MAGNITUDE OF LOSSES

The data show that there are huge losses of fish landings annually. Physical losses are estimated to range from hundreds of tonnes in dry catfish production in Mali to up to 28 000 tonnes (20–40 percent physical loss) in Lake Victoria sardine fishery.

The programme has generated baseline data on the magnitude of the losses at the macro level (Table 6), which raises concerns in terms of resource sustainability, food security and economic development. Losses also vary within communities along the same waterbody and for the same fish species. There are differences in root causes of losses and hence the type of loss reduction intervention needed. In Uganda, the Lake Victoria sardine physical losses are above the average of 5 percent. Quality losses in all the countries ranged, in most instances, between 20–40 percent. In the United Republic of Tanzania, for example, stepping or trampling on sardine and causing belly burst accounts for physical loss of 0.9 percent, which translates to a financial loss of T Sh 1 750 per trip. On a macro level, this translates to T Sh 550 million when it is calculated in terms of the 197 200 tonnes total catch in 2005/2006. Physical and quality losses are T Sh 12–20 billion (US$10 million to US$17 million) loss per annum for sardine. In Mali, the loss of processed fish from Mopti is 16 million FCFA (US$38 000).

Data indicate that quality losses as a result of downgrading the product are the most frequent and, whatever the season or fishery type, they account for more than 70 percent of all types of losses. In Ghana, for example, quality loss for all locations after landing was put at an average of 63.3 percent. In Mali, percentage losses vary between 11.3 percent in Sélingué and Manantali and 21 percent in Mopti for catfish, which is the predominant smoked product accounting for about 95 percent of production. In Uganda, percentage losses vary from 2.5 percent for fresh tilapia traders to 5 percent for Nile perch traders. For fresh tilapia marketing in Kiyindi, Kasekulo and Ssenyi, the percentage losses are 4.2 percent, 3.4 percent and 5.2 percent, respectively. The results from Uganda indicate that according to the information gathered during IFLAM, fresh tilapia traders incur a high level of

TABLE 6
Summary of losses and macro impact by country

Country	Fisheries/products	Physical loss %; estimated tonnes (t) per year	Quality loss %; estimated tonnes (t) per year	Macro impact US$
Ghana	Smoked fish	3–17%	37.5%; 5 206 t	60 million
	Watsa (purse seine) fisheries	16–20%	30.7%; 5 742 t	9.4 million
Kenya	*Rastrineobola argentea*/sardine before processing	0–7.5%	1.5–18.9% (7)*; 3 600 t	350 015
	Jarife (gillnet) fisheries (Indian Ocean)	1–5%	28%; 33.6 t	19 110
	Fresh tilapia traders	Minimal	27%; 12.3 t	36 760
Mali	Fresh fish	2–3%	7.5–25% (17)*; 1 190–6 630 t	572 550
	Smoked Clarias	1–3%	8.5%; 327 t	364 400
Tanzania	*Rastrineobola argentea*/sardine	20–40%; 14 000–28 000 t	20%; 14 000 t	30 million
Uganda	*Rastrineobola argentea*/sardine	26–40%; 3 400–11 000 t	2–5%; 340–850 t	300 000–1.5 million
	Fresh tilapia traders	Minimal	2.5–5.2%	105 000–220 000

*Mean average.

losses, but from the QLAM it indicates that it is only 2.7 percent which is not as high as it had been reflected in the IFLAM study (16 percent).

In Kenya, while the sardine fishermen incur losses of about 7 percent, tilapia fish traders and gillnet fishermen incur losses of about 27 and 28 percent, respectively. The scenario is not different in the United Republic of Tanzania, where the levels of losses reported vary between 20 and 40 percent. Results from IFLAM suggest that huge physical and quality losses in United Republic of Tanzania fisheries of Lake Victoria and in-shore marine waters are found in small-sized fish, especially sardine. Also, there was a significant relationship between the type of losses and gender of operators, which can be explained by the observation in the descriptive statistics that men are affected by physical and quality losses while women incur market force losses.

For LT in the United Republic of Tanzania, the data analysis was done using the SPSS software. The analysis of variance null hypothesis examined whether the weights of the good quality fish samples for the wet fish and the dry fish were similar ($p > 0.05$) from the final dried product. Homogeneity of the variance was found to be normal.

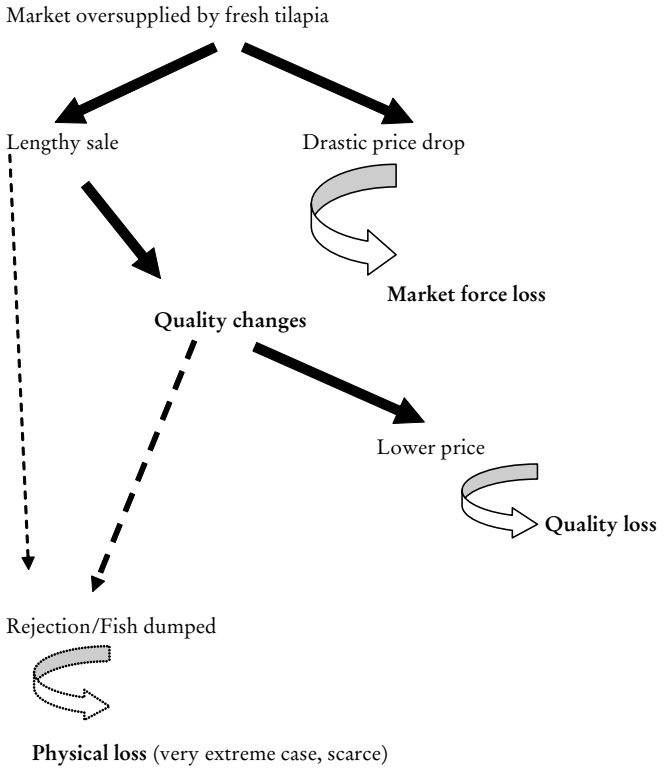
In addition, a significant relationship between the losses and stakeholders was observed. This can be explained by the earlier observation that all the stakeholders are affected by losses and the only difference is the magnitude and type of loss experienced.

The loss is heavily associated with the rainy season, when sun drying is extremely difficult. The study has estimated that during this season, 5 percent of low value small fish is discarded as physical loss and another 80 percent is sold at less than 20 percent of the best price for good quality product. The total loss for small-sized fish, in terms of monetary value, was put at US$30 million annually.

There is a significant relationship between the losses and the causes of the losses. The explanation centred on the fact that various causes of losses influence the extent to which the loss will result in only quality changes or an eventuality of physical loss.

Market force losses are generally low. By definition, *market force loss is any loss, physical or quality induced by the market patterns, where fish operators have to sell at a price below their expectations at time of production.* This may be the reason why it has been recognized by most of the loss assessment teams as difficult

FIGURE 2
Occurrence of different types of losses during fresh tilapia marketing in Kenya and Uganda



to accurately appraise. This relationship and the implication in terms of loss of resource can be schematized, as shown in Figure 2, drawn from loss information in fresh tilapia trading in Kenya and Uganda case studies, where a cause of market force loss (e.g. oversupply) leads to both quality and physical losses but also to market force losses.

The implication of the macro impact of losses incurred as enumerated in Table 6 by the various economic operators in all the countries studied is the financial loss or loss of income, reflected in reduction in the gross domestic product (GDP) per head. For example, and based on FAO economic data for the United Republic of Tanzania, where an average of US$13 million was reported to be monetary loss as a result of post-harvest fishery losses in a given fishery (lake sardine), it follows that the GDP for fisheries which was put at US$324.2 million will be reduced to US$311.2 million, which in turn will affect the GDP per head from US$308 to US$295.6. The decrease in GDP would be much higher if losses in other significant fisheries (Nile perch, tilapia) were taken on board.

In Kenya, fisheries account for 0.5 percent of the US$18 billion GDP, which translates to mean a GDP of US$90 million for fisheries. The implication, therefore, is that the GDP per head, which was put at US$530 based on 2005 FAO economic data of Kenya fishery profile, will be marginally reduced to US$529.76 when situated against the US$406 000 as macro impact loss in dollars in the fishery subsector.

Table 7 (at the end of this section) summarizes key aspects of different losses in different fisheries, such as the different causes of loss, as well as stakeholders affected, seasonality, the impact of losses, trends and the perceptions of traders, fishermen and processors.

CAUSES OF LOSSES

More data subjected to a straight analysis of variance at 95 percent confidence levels show a significant relationship between the causes of loss and the season. This was, however, explained by the fact that weather is a very important factor in the Lake Victoria region in terms of sun drying of sardine and also in terms of access to markets, especially during the rainy season because of the poor conditions of roads.

The recurrent causes of losses have been reported to be poor handling of fish, inadequate fish icing, processing techniques and transport conditions. But also losses are intimately linked to the upstream post-harvest practices, the socio-economic context and several contributing factors.

• Lack of ice and poor icing practice, poorly-designed and insulated containers, mishandling of fish on board fishing canoes or during auctioning

These are the identified causes of losses incurred by fishermen and fish processors, either for multispecies fisheries in Mali and Ghana or mono-species fisheries in Uganda, United Republic of Tanzania and Kenya.

The cause of the loss to fresh tilapia traders is lack of ice and the non-insulated/refrigerated transport system. In Ghana, quality loss was caused by fish not being properly preserved on board fishing canoes and being mishandled; quality loss ranged from 42 to 87 percent depending on the species, condition and size of the fish.

The quality loss incurred by fish smokers after purchase and just before smoking using the Chorkor oven in Ghana ranged between 11 and 17 percent due to long bargaining/auctioning of poorly- or non-iced fish.

• Equipment and infrastructure

Lack of drying racks and the use of traditional rather than improved smoking ovens contribute to losses. The magnitude of these losses varies from one fishing location or country to another. The Department of Fisheries, Ghana and the Central and Western Fish Improvement Association (CEWEFIA) introduced the Chorkor[2] smoker oven as a means of reducing post-harvest losses. Its introduction has led to smoking large quantities of fish and at the same time producing good quality final products. These ovens have also improved the working conditions for women processors by exposing them to less smoke and heat.

The use of drying racks in Uganda has resulted in a reduction in loss to a negligible level as compared with the high level of losses in lake sardine for fishmeal because of poor handling and drying on bare floors. During the pilot drying in LT which was conducted by the Ugandan team to compare both methods, the team realized that in terms of quality the product dried on racks (Figure 3) was a better quality product than the one dried on the ground. The fish dried on racks

FIGURE 3
Mukene drying on racks in Uganda

[2] Please note as additional information that the Chorkor smoker oven was developed in 1968 by FAO in collaboration with the Food Research Institute, Ghana.

fetches a better price: 7 000 to 8 000 U Sh per basin/pan as compared with 4 000 to 5 000 U Sh for fish dried on the ground. The stakeholders are aware of this price difference but the challenge of drying fewer quantities hinders them from using the racks, as drying on bare ground can averagely dry 40 basins/pans as compared with 4 basins/pans for drying on the racks; moreover, a rental fee is charged for using the racks while drying on the ground is free.

Other causes of physical losses in Ghana include net destruction by other fleets and net entanglement on rocks. The net destruction is an indication of limited resources, encroachment of vessels, overcapacity of fishing effort and poor management of resources. Also, the lack of proper indicators on nets and entanglement in rocks are generally seen as lack of sophistication of the artisanal fleet, as they rely on rudimentary methods of sounding the fishing area before setting their nets.

• Packaging and transportation

Makeshift packaging materials and practices and inappropriate transport facilities cause substantial quality as well as physical post-harvest losses. Figures 4, 5 and 6 show some of these practices.

FIGURE 4
Packaging of dried Mukene/Dagaa in sacks

• Harmful fishing methods in Ghana

Although not widespread, the illegal practice of combining light fishing with the use of dynamite or carbide incurs considerable losses to women fish processors. When purchased in the early hours after landing, fish caught by this method has a good organoleptic appearance and it is difficult to differentiate it from legally caught fish. However, it produces poor-quality processed products, which are sold

FIGURE 5
Press packing *(lumbesa)* lowers the transport cost charged per sack, although it increases physical damage to fish

FIGURE 6
Fresh fish loaded in open trucks for long-distance transportation in Mali

for a lower price causing quality losses of thousands of Ghanaian Cedis. Proper enforcement of fishery laws would help eradicate the practice and reduce these losses.

• Sardine losses related to processing and pricing

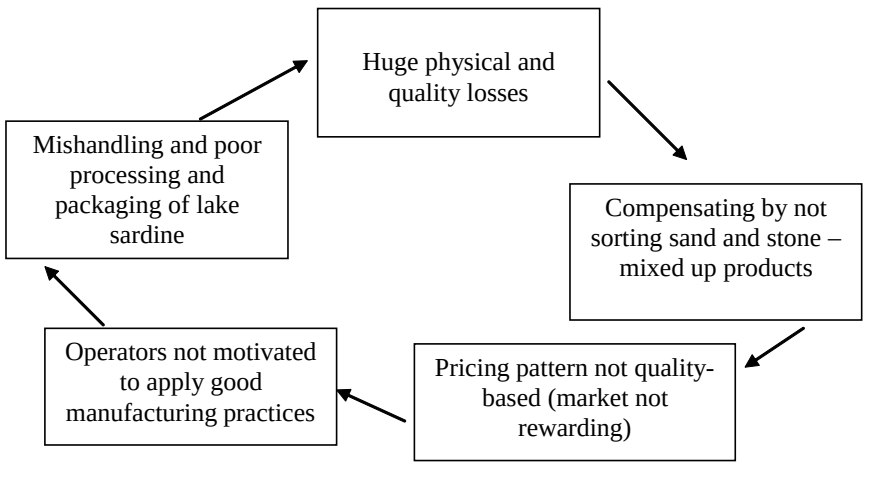
The Lake Victoria sardine *(Rastrineobola argentea)* is a very important resource supporting thousands of livelihoods in the region and beyond. According to the Department of Fisheries Resources in Uganda, 80 percent of the estimated 76 587 tonnes of sardine landings are processed for animal feed and only 20 percent are marketed for human consumption.

Lake Victoria sardine for human consumption is usually dried on raised racks, properly handled and sold according to the quality grade. There is a negligible physical loss. Fishmeal is dried on bare sand, rocks and grass and is mishandled during storage, packaging and distribution, resulting in quality losses of 26 to 36 percent. Pricing is not related to quality, but rather to the weight of the consignment or batch. This leads to fewer loss control measures during processing (e.g. chasing the birds and animals, preventing the drying fish from being washed back into the lake during rain) and encourages careless practices such as not sorting out sand and stones from the dried product.

In the United Republic of Tanzania, sardine processors know that fish dries faster on raised platforms and the end products are free from sand. The buyers see that the quality is good and are prepared to pay a good price but, unlike in Uganda, the same product does not attract a better price. This may be due to limited awareness among consumers of the quality and safety advantages of rack-dried versus ground-dried fish.

Sardine losses are high during the rainy season. The poor practices in fishmeal production are leading to continuous losses, as shown in Figure 7. There is now a social stigmatization of sardine among middle- and upper-class consumers in Uganda. As such, sardine is usually associated with low-income consumers who, by virtue of their limited economic outlay, rarely demand high-quality products.

FIGURE 7
Fish loss patterns in lake sardine fishmeal production in Uganda



The stakeholders' perception is that they would not mind changing processing practice to produce better quality products for human consumption, but their biggest challenge is investing in infrastructure such as adequately sized drying racks that would help encourage changes in practices. This introduces the issue of access to credit, which is often a constraint faced by small-scale fishery stakeholders.

• Utilization and marketing of fresh fish and consumer purchasing power

Data from the programme suggest there are limitations to a purely technical approach to reducing fish losses, namely the assumption that maintaining quality will increase the value of the fish and income of the operator. In the United Republic of Tanzania and Uganda increased returns to the fishermen or trader are dependent upon the purchasing power of the fishmonger, fish processor or the final consumer. Good quality fish is often denied to low-income operators who in certain communities form the majority of buyers. In some cases they will refrain from buying (or intentionally delay the transactions) until the seller/fisherman in a desperate search for customers is forced to lower the price in order to get rid of a by now low-quality and deteriorating consignment of fish, as shown in Figure 8. This is also related to market access issues given that if the sellers had access to different buyers – perhaps in a city – they would be able to fetch higher prices.

FIGURE 8
Interview of fresh fish retailers desperately awaiting buyers in one of the biggest fish markets in Dar es Salaam, United Republic of Tanzania

These examples of causes of losses stress that reducing post-harvest fish losses will most likely rely on a combination of improvement in awareness, market access, knowledge and skills, as well as technical, financial, infrastructural and policy support.

VARIABLES INFLUENCING LOSS LEVELS

This section describes some of the main factors identified by the programme, which can influence when losses occur and to what extent they occur.

Seasonality of fish landings is a major influence on losses. Peak fishing seasons with bumper catches are often linked to high losses, although this is not always the case. In Mali, for instance, the quality loss of fresh fish during the peak fishing season (mid-November to March) was recorded as 17.1 percent (about 6 631 tonnes) and 27.7 percent (466.62 tonnes) in the lean season (April to October). The difference is the result of less fish during the lean season and, as a long time is spent for the collection of adequate quantities to be transported to the market, this affects the quality of the already poorly iced fish.

In Uganda, during the peak season, the supply of fish exceeds demand and forces fishermen to sell their fish at reduced prices resulting in market force losses. Most of the losses occur all year round apart from market force losses which occur during the bumper season. Likewise, sardine losses are high during the rainy season because of limited sunshine and as soon as it starts to rain the fish needs to be removed from the drying areas.

In Kenya, physical and quality losses vary with the season, with high losses occurring during peak season (March to August) for sardine traders, August to October for tilapia traders, and April, May and August to October for Nile perch agents. The reason is that the little fish that is caught during the lean season is protected from high quality losses and sold to customers (unlike in Mali where fish is first assembled at production sites before being sent to markets in Bamako).

The more sunny and rain-free days, the less the chance of losses in processed fish. But for fresh fish where small-scale operators lack ice and basic facilities to protect the fish from the sun, the resulting temperature abuse leads to quality deterioration. In the United Republic of Tanzania (Figure 9), huge physical and quality losses occur in the rainy season when sun drying is extremely difficult and also as a result of delays in fishing and transportation of catches. Findings in all the countries corroborated that the rainy season is a major contributing factor to losses of traditionally dried fish.

The type of fishing gear used also influences the occurrence of losses in the fishing ground. It was found that the gillnet fishermen (e.g. Ali in Ghana, Jarife in Kenya) and purse seine fishermen incurred greater losses than the others (e.g. hook and line, trap fishermen). This is regardless of the country or type of fishery (multispecific or monospecific, Nile perch, sardine-like species or tilapia). This might be linked to the duration of the net in the water before hauling and the amount of fish caught.

FIGURE 9
Drying soaked fish following a heavy rain

The remoteness of fishing villages from the market, type of packaging materials and means of transportation as well as the type of fish also influence losses although there is variation from one country to another. Losses are encountered during packaging, storage and transportation. During packaging and storage, losses are mainly due to heat, insect infestation, flies and humidity during rainy season causing mould growth, fragmentation during stacking, and stepping on the packaging sacks when loading and off loading. During transportation, losses are mainly due to breakdown of vehicles on the road (especially for untarred roads or portions of roads linking fish landing sites to the markets).

In Mali, for example, fresh fish is transported by truck over bad roads and breakdown of vehicles is common. Because of bad roads, truck owners ask for a payment warranty before transporting the fish and, in the process of haggling, quality loss sets in. Accidents due to reckless driving by truck drivers are common and when these accidents occur there are physical losses and yet the fishmongers will still have to pay for the cost of transport. Women incurring such losses are usually those who transport fresh fish from production areas.

In the United Republic of Tanzania sacks of sardine are transported first by canoe and then ferried to the main fish market in Mwanza. The ferry operates thrice a week and the fish traders prefer using the ferry because of safety and also because losses are more common in leaking canoes. However, ferry services are not reliable and have frequent breakdowns. Alternatively, the road network from Mwanza to Dar es Salaam is good and losses due to fragmentation are low. However, trucks are hired by fish traders on a sharing basis which involves prolonged negotiation and sorting out organization hurdles before departure. Quite often the shared truck will go to different destinations. These factors cause delays that extend transportation from two to four days and thereby causing

quality loss as fish change their colour from silver to brown as a result of lipid auto-oxidation.

A woman processor has multiple roles. She is a mother, trader, processor, and also takes care of household chores. The more help she has in processing or taking care of children, the more attention she can give to taking care of her fish being smoked or dried, hence minimizing the risk of loss. Therefore, help from household members and/or neighbours can allow more attention to be devoted to processing and reduce the risk of loss through poor control of the fire (during smoking) or animal predation (during drying).

The less time the processed product spends in storage, the less likely there will be losses. Shorter storage time reduces losses and risks. The more the processor checks her stocks for quality deterioration (and takes corrective action such as adding more salt, re-smoking or drying), the less chance of losses. In the United Republic of Tanzania, for example, most sardines are stored during the period of the dark moon, which corresponds to 8 to 15 days. Organoleptic assessments indicate that dried sardine maintain a silver colour for up to five days of storage and that a less desirable brown colour sets in after eight days of storage (Figure 10).

FIGURE 10
The rate of change in colour reduces the price of sardine from T Sh 1 500 to T Sh 1 000 per kilogram

Sardine being packaged 6 days after production.

Appearance of sardine 15 days later.

COPING STRATEGIES

Although fishermen, processors and traders incur losses, the programme found that people use various coping strategies to try and control or minimize loss as much as possible. Some of these strategies can form the basis of interventions while others are potentially harmful.

In the United Republic of Tanzania physical losses are frequent and high at the Yozu landing site because hygienic and sanitary conditions are poor, which is conducive to insect infestation, especially by blowflies. Waste is not removed and

FIGURE 11
Animal and bird predation cause physical losses during drying of sardine on bare ground

FIGURE 12
Birds being kept away from the drying fish by tied threads

disposed of properly and attracts predators such as pigs and birds (Figure 11). The bird population on the island is also high and guards, often children, are employed to scare the birds away from the drying sites. Other strategies to scare the birds away are tying string or twine above the racks as protection (Figure 12) or hanging dead birds up as a scaring mechanism (Figure 13).

In Ghana, some fish fermenters in Ankaful, Axim, Ahwiam, New Ahobre and Elmina experience losses. However, those in Bortianor in the Ga South district of the Greater Accra Region do not experience any significant loss. Their

FIGURE 13
Bird predation checked by employing guards and using dead birds to generate deterrence

coping strategy is to use high concentrations of salt in air tight fermentation vats covered with polythene. This ensures total exclusion of maggots in the vats. The implication here is that based on the operators' vast and long experience they were able to design a simple technical solution to losses.

OTHER COPING STRATEGIES

- Fishers will increase fishing effort to compensate for the lost income due to the quality loss. In so doing they tend to increase the pressure put on fishery resources producing a threat to sustainability – a potential loss to all.
- Drying fish in accessible places, for example, in front of the house or within their immediate neighbourhood, so that if it rains the fish can be quickly gathered.
- Processors also get returns from the sale of by-products or bycatch such as Lake Victoria ciclid (*Haplochromis* spp) which are caught with sardine in Lake Victoria. The production of by-products from Nile perch processing activities has increased the utilization of this species and reduced potential losses.

- Fishermen tend to remain in fishing with the hope of counteracting losses by subsequent fishing, borrowing money and migrating to better fishing areas. Few fishermen cope with losses by relying on their own savings. In Elmina, in Ghana, fishermen are using different types of gear such as a set net so that in case of losses or poor catches from their normal fishery they can access another fishery.
- Women often cope with losses by borrowing money, which is later paid back. They also engage in other livelihood-sustaining activities.
- The use of mobile phones has helped improve fish marketing enabling traders to understand demand and supply situations more quickly and reducing delays by speeding up handling, distribution and processing after landing.

TRENDS OF LOSSES

Trends in losses vary according to the economic operator or location. The trends in losses are such that they cut across the entire chain of fishing, loading and unloading, processing stage, during the selling arrangement, storage stage, transportation to transit and terminal markets, during selling and repacking at retail levels but they are sometimes not sharply defined. Operators interviewed in Manantali, Mali, for instance could not agree whether losses had decreased or increased over the past three to five years. Some said that losses are increasing over time because more fish is sold fresh and there are no preservation facilities (no ice plants, no cold rooms). But some asserted that they now sell more fresh fish than processed fish, which is more profitable.

STAKEHOLDERS AFFECTED AND THEIR PERCEPTIONS

Most stakeholders are affected by losses, e.g. fishermen, fresh and smoked fish traders, fish processors, fish marketers and ancillary labourers such as boat builders and net makers as well as consumers.

Respondents in the United Republic of Tanzania and Uganda believe that the lake sardine fishery requires an immediate technical intervention. Losses are a serious socio-economic problem leading to tonnes of highly nutritious fish being left to rot, thus contributing to food insecurity.

In Ghana, fishermen perceive that fish loss leads to a loss of income, followed by food insecurity and indebtedness, then poverty and domestic tension caused by lack of income to adequately cater for the household. In their view, this is the main reason why they are unable to educate their children to a high level in order to help them obtain alternative livelihoods. Poor education levels perpetuate poverty in their communities.

In the United Republic of Tanzania school-aged children guard drying anchovy against animal predation and theft. They are paid in dried fish for their services. Needless to say, there is an opportunity cost incurred by these children as they have to leave school. Certainly, this is a socio-economic loss and an integral part of PHFL.

In Uganda, the socio-economic implication revolves around the poor who buy poor quality fish for economic reasons. This, of course, exposes them to potential health hazards or unwholesome products because, unknowingly, they may be consuming fish unsafe for consumption or which has lost its nutritional value through poor handling and time/temperature abuse. This, therefore, increases the poor's vulnerability to disease.

Fresh fish traders perceive that quality losses are more important than market forces and physical losses because of the interplay of prices, as dictated by the fishermen and what the traders are prepared to buy from them. On the other hand, stakeholders in salting and sun drying perceive that physical losses affect them all year round compared with market forces and quality losses which are seasonal. This is logical, as salting, drying or smoking is often the ultimate means for preserving low-quality raw materials.

Processing cannot improve the low quality which is also reflected in processed products prone to insect infestation and to other factors of quality change. Furthermore, fish disposed of as per the definition of physical loss (accidental, voluntary, authorized or eaten by insects) is noticed more than quality loss, as confirmed by the study in all the countries.

TABLE 7
Summary matrix of losses for the different fisheries

Fishery/ product/ specific operation	Type of loss	Cause of loss	Stakeholders affected by the loss	Time/season the loss occurs	Impact of the loss	Trend (changes in loss over time)	Perception of stakeholders
Lake sardine	Physical loss in wet and dried sardine	Limitation of sun during rainy season Poor storage conditions Transportation Animal predation Capsizing, bad transport by canoe during storms Sacks of sardine get wet and sink	Crew members Canoe owners Consumers who cannot afford to buy high-value species Fishers, transporters, traders	During rainy season, when sun drying is extremely difficult Year round Stormy days (50 days per annum)	Reduced food fish availability and security Deny efforts to reduce poverty and improve livelihood	The losses are on the increase as little is being done to address them while fishing effort is increasing Losses are increasing as the number of transport canoes is increasing	Government assistance is not enough to address problems Improvement on drying racks to cater for larger quantities of fish Credit facility to buy stronger canoes
	Quality loss	Colour change of dried products during storage and distribution Bycatch	Processors and traders	All year round, heavier during rainy season When there is a high catch of Haplochromis spp.	Reduction in income	The situation is worsening because of lack of intervention	Assistance in terms of technological innovation

Fishery/ product/ specific operation	Type of loss	Cause of loss	Stakeholders affected by the loss	Time/season the loss occurs	Impact of the loss	Trend (changes in loss over time)	Perception of stakeholders
Nile perch	Physical loss	Lack of technical know-how to maximize utilization of fish by-products which are discarded	Factory owners, fish traders and consumers	All year round. It is only 40 percent of the by-products from the Nile perch industry that is utilized	It impairs food fish availability, denies opportunity for increased income and aggravates environmental problems	This type of loss has remained the same over the past decade	There must be concerted effort to search for innovative solution to the problem
	Quality loss	Long fishing hours Long collection time Poor use of ice Poor containers	Fish traders, crew and consumers	All year round	The loss is huge because the amount of fish involved is big. The loss affects income, food supply and livelihood in communities	The trend is increasing as the organizational and technical problems are yet to be resolved	Something must be done to improve the situation
	Market force loss	Oversupply of sardines and other fish during dark-moon period	Fishermen and canoe owners	During dark-moon periods and during harvesting season of vegetables	This loss can cause exhaustion of capital and fishermen to lose their business	There are signs of declining trend as a function of increased use of mobile phones to diversify market	There must be efforts to improve storage facilities at landing sites and in markets

Fishery/ product/ specific operation	Type of loss	Cause of loss	Stakeholders affected by the loss	Time/season the loss occurs	Impact of the loss	Trend (changes in loss over time)	Perception of stakeholders
Fresh Tilapia	Physical loss	Lack of market and no chilling/frozen facility, fish stolen, spoils completely thus thrown away	Fresh fish traders	Seasonal	Loss of income, capital, fish protein	Increasing with time	Use of ice and storage facility are the most important issues so that fish can be sold at any time
	Quality loss	Spoilage due to lack of ice, use of open wooden containers, poor/unhygienic handling of fish during auctioning, time/ temperature abuse during auctioning, lack of storage facility	Fresh fish traders	All year round	Loss of income capital, loss of fish protein, increased poverty	Increasing with time	Aware that loss affects them highly but believe they are too poor to do anything
	Market force loss	Supply exceeding demand, festive seasons (e.g. in Uganda during Christmas people prefer beef), fish supply (though not in excess) coincides with other foodstuff, low business resilience exposing to vulnerability	Fresh fish traders	When catches are high April–June and October–December Season of crop harvests Compelled to sell at lower price when it is time for kids to go back to school	Loss of income	Recurs same time every year – constant	Diversifying activities would lessen this type of loss

Fishery/ product/ specific operation	Type of loss	Cause of loss	Stakeholders affected by the loss	Time/season the loss occurs	Impact of the loss	Trend (changes in loss over time)	Perception of stakeholders
Fishing and landing	Physical loss	Theft of fish from nets	Fishermen	Once in a while	Loss of income	Constant	Institute security on the lake
	Quality loss	Spoilage due to lack of ice, change in water temperature, traveling long distances, landing late as customers have left	Fishermen	All year round	Loss of income	Increasing with time	Provision of ice, motorized boats to reduce time between fishing grounds and landing site
	Market forces loss	Supply exceeding demand, selling on credit	Fishermen	Seasonal when catches are high	Loss of income, and loss of capital and exacerbated poverty	Constant	Aware of the loss but no idea on how it can be handled
Smoked tilapia and Nile perch	Quality loss	Oversmoking, spoilage, mould growth due to poor storage, product being soaked by rain, poor roads, breakdowns during transportation	Fish smokers, processors and traders	All year round	Income loss leads to food insecurity, low protein supply to community	On the increase with time	Assistance in proper handling practices
	Physical loss	Fire outbreak, eaten by rats, dogs and birds, breakages during transportation and handling, theft	Fish smokers/ processors	All year round, but fire outbreak once in a while	Loss of fish, income, capital. Brings poverty, food insecurity	Generally on the increase	Provision of proper storage facilities
	Market force loss	Supply exceeding demand	Fish smokers/ processors	Seasonal: April–June and October–December	Loss of fish, capital and income	Constant	Diversified activities

Loss reduction intervention initiatives

The artisanal post-harvest fishery sector is highly labour-intensive and stakeholders incur losses which are associated with fishing, processing and marketing. The type of losses in fish and fishery products and the reasons for them have been discussed. Understanding how stakeholders cope with losses and learning from past and current interventions will inform the loss reduction planning process. Practical loss reduction initiatives may be based on existing coping strategies or ideas from specialists. Intervention may be related to technical or socio-economic change, institutional capacity building and research. The following provides information from fieldwork reports on coping strategies used by post-harvest operators, past loss reduction interventions and ideas from the loss assessment teams on how losses could be addressed in the future. Some of the existing and potential intervention ideas mentioned by stakeholders, as well as others seen by the programme teams during the fieldwork, are presented in Tables 8 and 9. The potential interventions to reduce the losses that strengthen the economic operators' assets or their access to assets will go a long way in sustainable livelihoods of the operators.

Solutions to post-harvest losses may not necessarily always be technical and may rely on actions outside the post-harvest or the fisheries sector as a whole. Some losses may be controlled as a result of better law enforcement to deter illegal fishing, encouraging changes in fish utilization such as less fishmeal and more fish for human consumption. The following are examples which highlight some loss reduction issues.

In the United Republic of Tanzania, some of the initiatives to reduce loss include:

- construction of the ultra-modern market facility at Kirumba, Mwaloni, has been a great initiative to reducing PHFL. A large part of the lake sardine is today stored under a shed and drying of Nile perch by-products is done on raised platforms;
- use of outboard engines which has greatly reduced the time from catch to landing and therefore has led to a drastic reduction in the amount of fish loss from fishing grounds to landing sites;
- the use of mobile phones has improved flow of market information among different stakeholders, a development that enables the practitioners to operate quickly saving time and reducing wastage;
- infrastructural development, especially the upgrading of trunk roads and landing sites, has led to quality improvement of fish sold at some markets close to these roads;

TABLE 8
Strategies to reduce post-harvest fish losses

Physical loss	Physical and quality loss	Quality loss	Others
Use of separation boards or containers to prevent stepping on the fish	Good hygiene and sanitary conditions in the environment and processing areas to reduce insect infestation, e.g. blowflies	Improve colour of dried sardine and control of rancidity by reducing storage period/exposure of fish and the adequate moisture (further research required)	Cutting costs of production, i.e. setting up cooperative societies
Hang dead bird to scare away predators during drying	Use of mats to move fish out of the rain quickly	Submerge sardines in brine before drying to reduce time lag between loading and effective drying period	Fermented products and pickle curing of fish
Tying threads above the racks	Appropriate packaging	Appropriate packaging	Awareness of government, savings and credit schemes
Securing the platform properly underneath the boat to prevent leaking	Low cost drying rack with facility for cover when it rains, e.g. plastic sheet	Reduction in fishing time and improved transportation	Introduction of solar tent driers or improving on the size of the racks to encourage large quantity of sardine to be dried
Improving on fish protection against rain and rodents during drying	Reduction in drying time by turning the fish more often to speed up drying	Redrying of sardine when space is available	Sorting out bycatch species (e.g. *Haplochromis* spp.) for better utilization into value-added products. Trials could be conducted for products such as salted fish cakes, fish balls, etc.
Use of tarpaulin during spread of fish before packaging	Vigilance when drying using guards with canes		Smoking of sardine as an alternative to sun drying Use of Brazilian salt-press technology to add value to small pelagic fish species

- production of by-products out of Nile perch processing activities has increased utilization and reduces potential losses;
- respondents recommend the use of mechanical dryers to be the most authentic solution to huge post-harvest losses for fish that is sold at market. The use of machines will facilitate production of consistent product quality and can also be complemented with proper packing to attract a premium price;
- alternatively, respondents recommend the solar drying method by using transparent sheets instead of easy-to-tear polythene sheets;
- fish traders have benefited from the limited training programmes and seminars aimed at improving quality;
- fishing on nearby grounds in order to get quick assistance in case of problems, such as a breakdown of an engine;

TABLE 9
Existing and potential loss reduction intervention initiatives

Physical loss	Causes or nature of losses	Existing intervention strategies	Where in use and by whom	Potential intervention strategies
Physical	Discarded trampled fish	Use of separation board on board canoes	Tanzania, by lake sardine fishermen	Redesigning of canoes
	Bird predation and pilferage	Use of camouflage to scare away the birds and watch person during sun drying of the fish	Tanzania, by sun-dried fish processors	Solar tent driers
	Fragmentation	Use of boxes instead of baskets	Ghana, by sardinella fish smokers	Packaging in sturdy wooden container
	Net entanglement in rocky areas	Indigenous knowledge of fishing area	Ghanaian fishermen	Use echo sounder
Quality	Deterioration	Use of ice	Ghana and Kenya, by fishermen and fish traders	Introduction of customized insulated boxes
	Insect infestation	Brining of fish before drying or smoking	Ghana, Mali and Tanzania, by processors of smoked fish	Use of pirimiphos-methyl (Actellic ND) and other recognized natural and synthetic insecticides
	Rancidity and colour change	Reduce storage period	Tanzania, by lake sardine sun drying	Immersion in antioxidants
	Poor drying	Drying on bare floor or in some cases racks	Uganda and Tanzania, by lake sardine processors	Use of mechanical driers Smoke drying option or Brazilian salt pressing technology
	Light and carbide fishing	Regulations on obnoxious methods of fishing	Ghana, by some fishermen	Enforcement of fishing regulations against obnoxious methods of fishing

- the use of boxes for storage of smoked fish instead of baskets. This reduces the problem of fragmentation and enhances quality of the smoked products;
- use of perforated polythene sacks to allow for improved drainage of water that could accelerate spoilage; and
- fishing at night to reduce keeping time of lake sardine on board vessels.

Technically, the intervention of drying lake sardine on raised racks offered some advantages over drying on sandy ground. Fishers acknowledge that sardine dries faster on raised platforms and that the product from this method is more palatable and free from sand. On the other hand, some of them observed that, although the innovation is good, the end product hardly attracts any increased price. The price tends to be similar whether one has dried the sardine on the ground or on raised platforms.

Various techniques and strategies are used by post-harvest operators in Ghana to avoid losses. The fishermen, for example, manage losses by:

- redesigning canoes;
- preserving fish at sea with ice;
- regulating fishing among fishermen;
- relying on making up losses in subsequent fishing expeditions as a means to counteract fish losses and sometimes borrowing money from fish processors to stay afloat in business;
- in Elmina, for example, fishermen construct nets for other fisheries, especially set nets, so that in case of losses or if catches from their normal fishery are not very good they can shift to another fishery, at least to earn their living;
- some of the fishermen also try to cope with losses by engaging in other trades that they have learned in the past such as carpentry and masonry; and
- fishermen migrate to other fishing grounds as a coping strategy for improving their income.

On the other hand, fresh fish traders and fish processors who are engaged in smoking, fermentation, sun drying and frying of fish manage losses by:

- use of ice blocks made from household freezers to chill the fish in uninsulated containers and also using disused refrigerators/deep freezers;
- introduction of bigger capacity Chorkor oven which enables women processors to smoke large volumes of the landed fish rather that resorting to sun drying on bare ground;
- introduction of wooden and plastic crates for storage of fish at landing sites;
- for the fermentation process, the loss intervention initiative includes regular interval observations of worms and blowflies and reimmersion of the product in a higher concentration of brine solution;
- making up for losses in subsequent purchases from fishermen who also usually borrow money from them as well when they are faced with the similar situation;
- borrowing money from their cooperative societies with interest on the amount borrowed and the payback period;
- reduction in capital that is pumped into the business so as not to incur huge losses, especially as a result of power outages in the case of fresh fish traders; and
- engaging in other petty trades such as selling food items and in some cases working as porters on market days.

In Kenya, coping strategies usually adopted by stakeholders varied between recouping in the subsequent trips for the market force losses, to doing nothing for the quality and physical losses and vice versa for quality and physical losses. Some of the coping strategies for loss reduction initiatives are:

- provision of cold storage facilities and ice plants, use of ice to chill fresh fish and cold store for frozen fish;
- provision of coolers for the local beach management units;

- introduction of mechanical driers to improve quality, thereby attracting premium prices and international markets; and
- fishermen using indigenous knowledge of the wind direction to manage time and avoid delay and thereby reducing losses.

In Uganda, quality losses are more important to fresh fish traders than market and physical losses. Fish traders try to control their losses by selling their fish as quickly as possible, but this affects the prices because they cannot bargain for better results. They also make up for losses in subsequent purchases and sometimes have to borrow money to finance them.

Fishermen do not seem to have any coping strategy in place to control or reduce losses much as they admitted that they incur losses. Instead they appealed to the government to provide more security on the lake and to provide loans with affordable interest rates so that they could improve their businesses. They have some ideas about diversifying activities so that the number of fishermen is reduced, but they do not have time to engage in other income-generating activities. For the fish smokers, one of their means of reducing losses is resmoking the products in case of any signs of spoilage; however, this means an added cost in terms of fuelwood and the fish shrinks in size thus fetching a lower price as prices are based on the size of fish and not the weight.

Additional outputs of the PHLA

CAPACITY BUILDING

One of the main outputs of the programme is that twenty regional experts were developed in fish loss assessment in twelve African countries.

The final workshop supported the idea of consolidating the results of the programme to help develop:

- an illustrated guide for fish operators to assess their own losses and learn how to reduce them;
- an extension officer's manual for fish loss assessment;
- a comprehensive and user-friendly research manual updating Ward and Jeffries (2000); and
- a publication of normative guidance to support the CCRF.

SPECIFIC COUNTRY OUTPUTS

It was concluded that in addition to the contribution to the FAO programme, the United Republic of Tanzania work led to:

- a student dissertation paper on fish post-harvest losses;
- donors providing machinery for experimental production of value-added products; and
- improved post-harvest assessment knowledge, skills and data.

The data collected have been a powerful tool, raising the awareness of fishery stakeholders and fisheries officers and especially in convincing development institutions to support loss reduction programmes. In the United Republic of Tanzania, the Mbegani Centre for Fisheries Education and Training used the results to help secure funds to promote the production of added-value products from low-value fish species (Figure 14). The application, which was submitted to the Overseas Fishery Cooperation Foundation of Japan was granted, and equipment worth US$60 000 was procured and installed at Mbegani Centre (Figure 15).

The machines are now being used to provide practical training and demonstrations to students and potential entrepreneurs. The training also aims to improve access to credit by raising awareness in formal institutions of the need to increase the availability of formal credit to value-addition initiatives.

If successful then low-value fish will have improved market opportunities with benefits to fishermen, processors, traders and consumers.

Furthermore, the programme findings encouraged ten diploma students to assess post-harvest fish losses in fishing villages as part of their field training and

FIGURE 14
Value-added products from low-value fish species

FIGURE 15
Equipment provided by the Overseas Fishery Cooperation Foundation of Japan

a staff member of the centre completed a project on a post-harvest fish losses assessment for a Bachelor of Science degree.

The loss assessment data in the Lake Victoria sardine in Uganda raised awareness for a holistic approach to the production and post-harvest management of this fish. This led to the government's request for technical assistance to FAO through the Technical Cooperation Programme (TCP).

Lessons learned

This section summarizes some of the lessons learned as a result of the usage of the three methodologies based on the perceptions of the researchers and the stakeholders.

The informal method should therefore be applied before either LT or a questionnaire. Although the informal method may not produce statistically acceptable data on loss levels, it will show the researcher where losses occur, why they are occurring, seasonality of losses and who is affected. It also helps establish a rapport between the researcher and the community. After the use of the informal method it will be easier to plan and implement either LT or the questionnaire method to generate statistically sound quantitative data.

In future and with availability of resources, the research should be spread over time to cater for seasonal changes. After the IFLAM, either LT or QLAM should be applied to quantify losses. For example, although LT can be expensive it can give accurate measurement. QLAM is good for validating data from IFLAM over a wide geographic area thus giving useful data for policy-makers. It was discovered that both can verify information gathered from IFLAM, although LT is more precise. The fisheries staff who are based in those areas of study should conduct the research because they are the ones who are in daily contact with the stakeholders and who are familiar with the situations on the ground, thus they can obtain more information than the researchers who spend less time in these communities.

Physical and quality loss of fresh fish was identified as an important seasonal loss at sites in all the five countries and is associated with the peak fishing seasons. Lack of ice, time and temperature abuse of fish before and after landing, and a lack of adequate processing capacity, are the main reasons why the quality of fresh fish deteriorates and why fish is discarded.

A number of coping strategies used by post-harvest operators to control losses were identified. These ranged from simple use of high concentrations of salt in airtight containers covered with polythene to ensure total exclusion from maggots, protecting drying fish from rain with polythene sheeting, and tying string or twine above racks as protection or hanging up dead birds as a scaring mechanism.

Market force loss is one aspect of the loss assessment measurement that was found to be difficult to quantify. By definition, market force loss is a situation where a fish seller makes a loss in income, not because of quality problems, but because of the reaction of the market. In some countries, market force loss is caused by an oversupply of fish during peak season, demand and supply, lack of market information, lack of organization of operators, and consumer preferences.

This loss can cause low prices, low income, debt burden to stakeholders and, in some cases, outright exhaustion of capital which may force them out of business.

The issue of statistical analysis in LT and QLAM results was not well understood by the team and, as such, the team advocates the inclusion of a biometrician from the inception and the design of LT experiments and questionnaires.

Part of the lessons learned was the issue of assessing the quality of fish, which was subjective and mostly price related without any in-depth approach to make it more objective and, possibly, showing some level of credibility to quality loss assessment.

Some of the results of fieldwork activities provided some lessons and culminated as a set of recommendations, as shown in Annex 6, meant for researchers, stakeholders, non-governmental organizations, development agencies and policy-makers.

Conclusions

All three methodologies have been tested and have produced results. Of the three methodologies, IFLAM has generated the most interest because of its rapidity and the ability of the community members to be part of key responsibilities during the process of usage. LT and QLAM have proved to be useful methods in PHFLA because they can be used to confirm IFLAM findings.

The programme has generated baseline data on the magnitude of the losses at the macro level, which raises concerns in terms of resource sustainability, food security and economic development. The data show that there are huge losses of fish landings annually. Losses also vary within communities along the same waterbody and for the same fish species. The implication of the macro impact of losses incurred by the various economic operators in all the countries studied is the financial loss or loss of income reflected in the reduction in GDP per head.

The recurrent causes of losses have been reported to be poor handling of fish, inadequate fish icing, processing techniques and transport conditions. But losses are also intimately linked to the upstream post-harvest practices, the socio-economic context and several contributing factors. Other causes of physical losses include net destruction by other fleets and net entanglement on rocks. The net destruction is an indication of limited resources, encroachment of vessels, overcapacity of fish effort and poor management of resources.

Seasonality of fish landings is a major influence on losses. Peak fishing seasons with bumper catches are often linked to high losses, although this is not always the case. During the peak season, the processing capacity is overwhelmed: the supply of fish exceeds demand forcing the fishermen to sell their fish at reduced prices, resulting in market force losses. Most of the losses occur all year round, apart from market force losses which occur during the bumper season. Likewise, sardine losses are high during the rainy season because of limited sunshine and the need to gather and remove them from the drying areas as soon as it starts to rain.

Although fishermen, processors and traders incur losses, the programme found that people use various coping strategies to try and control or minimize loss as much as possible. Some of these strategies can form the basis of interventions while others are potentially harmful. Most stakeholders are affected by losses, e.g. fishermen, fresh and smoked fish traders, fish processors, and ancillary labourers such as boat builders and net makers as well as consumers.

Fishermen perceive that fish loss leads to a loss of income, followed by food insecurity and indebtedness, then poverty and domestic tension caused by lack of income to adequately cater for the household. Fresh fish traders believe that quality losses are more important than the market force and physical losses because of the interplay of prices as dictated by the fishermen and what the traders

are prepared to buy from them. On the other hand, stakeholders in salting and sun drying perceive that physical losses affect them all year round compared with market force and quality losses which are seasonal.

Practical loss reduction initiatives may be based on existing coping strategies or ideas from specialists. Intervention may be related to technical or socio-economic change, institutional capacity building and research. Also, most importantly, solutions to post-harvest losses may not necessarily always be technical and may rely on actions outside the post-harvest or the fisheries sector as a whole. Some losses may be controlled as a result of better law enforcement to deter harmful fishing and encouraging changes in fish utilization such as less fishmeal and more fish for direct human consumption.

The informal method should therefore be applied before either LT or a questionnaire. Although the informal method may not produce statistically acceptable data on loss levels, it will show the researcher where and why loss occurs, seasonality of losses, who is affected and guidance with the loss-ranking process. It also helps establish a rapport between the loss assessor and the community. After the IFLAM, either LT or QLAM should be applied to quantify losses. For example, LT can be expensive but it gives accurate measurement, and QLAM is good for validating data from IFLAM over a wide area.

Having used the three methodologies contained in the manual by the five countries who participated in the programme, the participants recognized that the manual is a practical and good guide for research, and the role of national governments' planners and policy-makers is crucial to the funding of activities that will lead to the reduction of post-harvest loss of aquatic products. The manual should also be reviewed taking into consideration the peculiarity of extension officers and economic operators, with funding from FAO, other development agencies and national governments for training, further loss assessment research and dissemination in other African countries.

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