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REDUCING POST-HARVEST LOSSES OF THE ARTISANAL DAGAA (*Rastrineobola argentea*) FISHERY IN LAKE VICTORIA, TANZANIA: *A COST AND BENEFIT ANALYSIS*

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ABSTRACT

The Lake Victoria dagaa constitutes over 38% of the total fish landings from Lake Victoria in Tanzania. The fishery supports a major artisanal fishery in the country, ranking second to the Nile perch. However, the dagaa fishery is associated with a high level of post-harvest loss (physical and quality losses) of approximately 59%. The overall objective of this study was to propose a cost effective management strategy to reduce dagaa post-harvest loss in Tanzania. To meet this objective a cost and benefit analysis was done to determine whether adopting drying dagaa on racks will reduce post-harvest loss, and hold positive public value in the future. Two categories of analysis were set, i.e. private (individual) and public (government) for a pilot district (500 fishers). The analyses were divided into five parts: 1) Assessment of all possible dagaa post-harvest losses, 2) Assessment of the cost of reducing the losses, 3) Assessment of the anticipated benefits associated with reducing the losses, 4) Evaluation of costs and benefits to determine net benefit and net present value (NPV), 5) A sensitivity analysis. From the analysis it was found that the drying racks project has positive NPV therefore it is worthwhile to be implemented in Tanzania to reduce dagaa post-harvest loss. Also, the sensitivity analysis indicated that NPV is sensitive and is likely to be affected by changes in sales price, while changes in investment and implementation cost were found to have no impact on NPV. By using drying racks productivity will be increased and provide a sustainable livelihood to fishers and as well as increase regional trade and foreign exchange earnings to the government.

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LIST OF ABBREVIATIONS

CCRF	Code of Conduct for Responsible Fisheries
DRC	Democratic Republic of Congo
DoFD	Department of Fisheries Development
EEZ	Exclusive Economic Zone
FAO	Food and Agricultural Organisation of the United Nations.
GDP	Gross Domestic Production
IFLAM	Informal Fish Loss Assessment Method
LT	Load Tracking
LVFO	Lake Victoria Fisheries Organisation
MLDF	Ministry of Livestock Development and Fisheries
MNRT	Ministry of Natural Resource and Tourism
NEPAD	The New Partnership for Africa's Development
PHFL	Post -Harvest Fish Loss
PHFLA	Post Harvest Fish Loss Assessment
QLAM	Questionnaire Loss Assessment Method
T.Shs	Tanzanian Shillings
USD	United State Dollars
URT	United Republic of Tanzania
UNU-FTP	United Nations University – Fisheries Training Programme
NRI	Natural Research Institute
NPV	Net Present Value
IUCN	International Union for Conservation of Nature
FDD	Fisheries Development Division
TAFIRI	Tanzania Fisheries Research Institute

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1. INTRODUCTION

1.1 Overview of Tanzania

Tanzania is a coastal state on the western Indian Ocean situated in the Eastern part of Africa. It is richly endowed with natural water bodies and fisheries play a very important role as a basis for subsistence and commercial livelihood (FAO 2007b).

The country has a total area of 947,300 km^2, water covers 61,500km^2, while land cover is 885,800 km^2, about 6.4 % and 93.6% respectively (Tanzania Government report 2010).

Tanzania shares three major inland lakes in Africa (Figure 1). Lake Victoria is by far the largest and economically most significant for the national fisheries (shared by Kenya and Uganda) and it is the second largest freshwater lake in the world. Lake Tanganyika (shared with Burundi, DRC and Zambia) is the second deepest lake in the world and Lake Nyasa is shared by Malawi, and Mozambique. There are also other inland water bodies, minor lakes, rivers, dams, ponds and wetlands (LVFO 2004).

Figure 2: Map of Tanzania showing major water bodies and rivers (Tanzania Government report 2010)

The population of Tanzania was estimated at 41 million in July 2010 (Tanzania Government report 2010). The country's economy depends heavily on agriculture which accounts for more than 25% of the GDP. Industries traditionally featured are the processing of food and other agricultural products. Within the food processing industries fisheries is the most important sub-sector.

1.2 Fisheries of Tanzania

It has been estimated that the country has the potential of harvesting about 730,000 metric tonnes of fish from its traditional sources of Lakes Victoria, Tanganyika, Nyasa, rivers, dams and the inshore marine waters. This estimate covers only the freshwater and territorial waters (MNRT 1997). The historical catch and effort data suggest that total fish production has never been above 60% of the existing potential. The highest landings were recorded in 1990, when 414,040 metric tonnes or about 57% of the potential yield were landed. The average annual production (1999 – 2010) is estimated at 337,212 metric tonnes.

The Tanzania fishing industry is divided into the artisanal (small scale) and commercial/ industrial (large scale) fisheries. The artisanal fishery in Tanzania is the most important fishery as it lands most of the inland and the marine catches and contributes about 98% of total landings. In terms of production volume (Figure 2), output value and employment, artisanal fisheries are much more important than industrial fisheries. Historically, artisanal fisheries have provided the economic base for the majority of people in Tanzania.

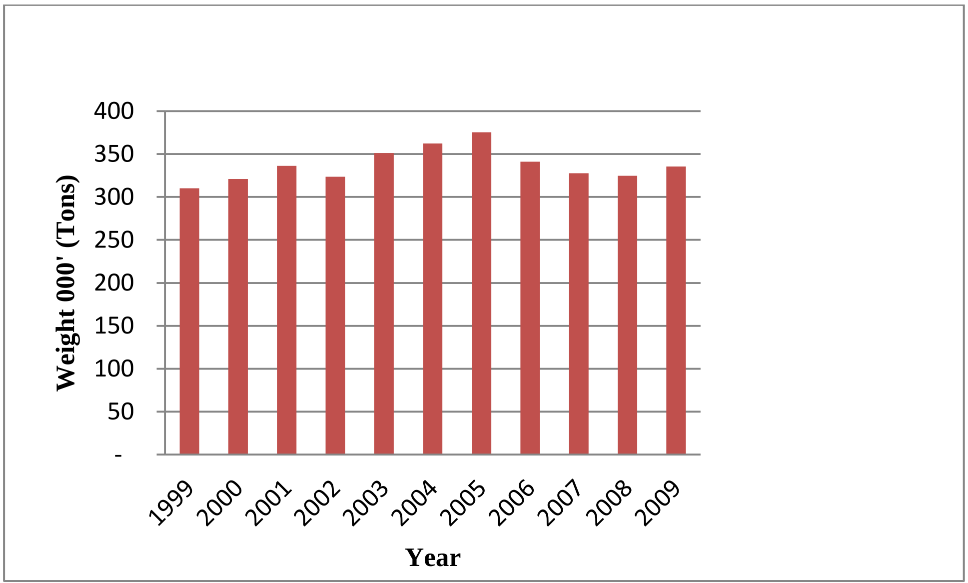

Figure 3: Total fish production (marine, lakes and rivers) for artisanal fisheries in Tanzania from 1999-2010 (FDD 2009)

1.2.1 Fish production

The capture fishery of Tanzania is divided into two components, freshwater and marine waters. Fisheries in freshwater are carried out in the major lakes (Victoria, Tanganyika and Nyasa), the minor lakes, dams and rivers. This fishery is dominated by artisanal fishers who use small boats of between 7 to 11 m long, mainly motorized by outboard engines and a few with inboard engines. Other crafts used include dugout canoes and dhows (Sobo 2006).

The total catch in 2009 was 335,674 metric tonnes (Table 1), of which about 86% was from freshwater sources and the remaining 14 % was from marine waters (FDD 2009).

Table 1: Total fish production from all major water bodies in Tanzania (marine and inland) for 2009 (FDD 2009)

FISHERY	WEIGHT IN M.TONS
GREAT LAKES & DAMS	
Lake Victoria	238,703
Lake Tanganyika	31,213
Lake Nyassa	10,422
Lake Rukwa	4,335
Mtera Dam	897
Nyumba ya Mungu Dam	1,021
Sub total	**286,591**
MINOR WATERS	
Lake Babati	135
Lake Jipe	12
Lake Kitangiri	71
Others	1,250
Sub total	**1,468**
TOTAL FRESH WATERS	**288,058**
MARINE WATERS	47,616
GRAND TOTAL	**335,674**

1.2.2 Economic importance of fisheries

The fisheries resources of Tanzania are of great economic and social significance to the country. The Fisheries Development Division collects revenue from the sector activities such as licensing of fish processing factories and the taxation of exporting fish products. In 2009 the country earned about 161 million USD from exported fish products.The sector contributes around 2.9% to national GDP (FDD 2009).

The fisheries sector also provides a source of employment and livelihood to a substantial number of people. About 172,000 people are engaged on a full-time basis and about 2 million people make their livelihoods through various fisheries-related activities, such as: boat building, net making, fish processing and food marketing.

In terms of animal protein availability, fish contribute about 30% of the total protein intake in the country. Currently the estimated fish consumption is 13 kg per person per year. This is significant, as the majority of the consumers are relatively low income earners who cannot afford other more expensive sources of protein.

1.3 General introduction to post-harvest loss in artisanal fisheries

Post-harvest fish losses occur at many stages of the distribution chain from capture to consumption. It has been of great concern for development practitioners who wish to improve the livelihoods of fishers, processors and traders, and the contribution that fish makes to food security. Recognition of the important problem fish loss poses is reflected in the FAO Code of Conduct for Responsible Fisheries (CCRF) under Article 11.1- Responsible fish utilisation (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 (Ward 1998).

The term post-harvest refers to a period of time from when a fish is separated from its growth medium (Morrissey 1998). This includes the time when a fish enters a net, is caught on hooks or in traps.

Post-harvest losses of fish can refer to physical, quality and market losses. Physical losses occur when fish is not sold for whatever reason, be it due to spoilage, damage or consumed by insects, birds or other domestic animals. Quality loss is the difference between the potential value of fish if no deterioration has taken place (best quality) and the actual value of the fish after it has undergone change due to spoilage (lower quality). A market loss is caused by unfair marketing practices (increasing the cost to the processor) and situations where fish operators have to sell their products (even of good quality) at a price below their expectation (Ward and Jeffries 2000).

All three types of losses have financial implications for fishers, processors, traders and at the macroeconomic level. Different approaches may be necessary to address these different types of losses (Akande and Diei-Ouadi 2010).

Field experience has shown cases of close relationship between these types of losses. Quality may deteriorate or fish thrown away because of market developments/oversupply. Market forces, such as oversupply, lead to physical, quality and market losses (Figure 3). Physical (material) and quality losses are both high in artisanal fisheries and these translate into losses in nutritional contribution of fish to the total diet and health of populations.

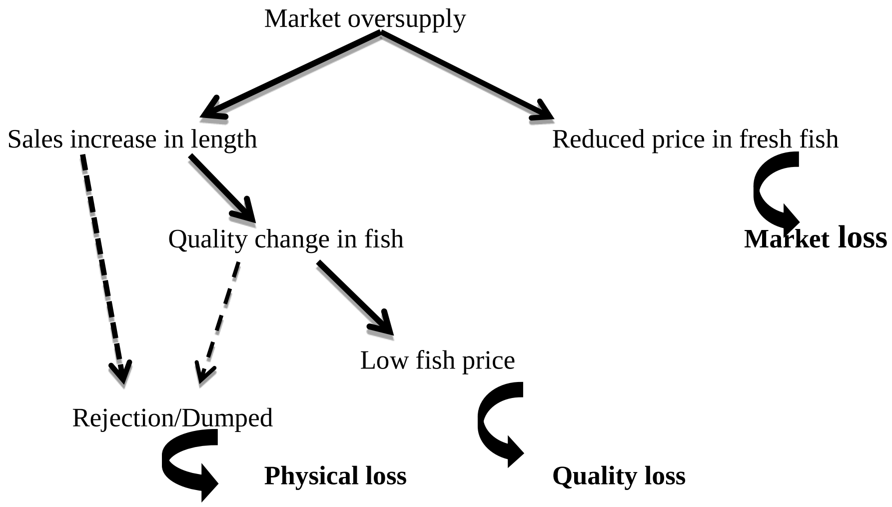

Figure 4: Occurrence and interrelationship of different types of losses in fisheries (Ansen and Diei-Ouadi 2008)

The latest estimates indicate that artisanal fisheries contribute over half of the world’s capture fisheries and aquaculture production of about 110 million tonnes, nearly all of which are used for direct human consumption (FAO 2008).

In Africa, over 60% of the fish supply to domestic and regional markets, as well as export-oriented processing units, is of artisanal origin (NEPAD 2005).

A review of case studies on post-harvest losses in several countries in Africa indicates high levels of losses both in quantity (material or physical losses) and quality (mostly due to downgrading) of fishery products (Kabahenda *et al.* 2009).

In Tanzania, the artisanal fisheries sector is faced with many challenges including that of incurring high post-harvest fish losses, especially in the dagaa (*Rastrineobola argentea*) fishery on Lake Victoria.

Lake Victoria supports the most important fishery in Tanzania in terms of quantity and value. In 2009 the lake accounted for 238,703 metric tonnes (Table 1) which is 85% of total fish production in Tanzania. The fishery is based on three main important fish stocks, the Nile perch (*Lates niloticus*), dagaa and Nile tilapia (*Oreochromis niloticus*), which are the backbone of commercial fisheries in that order. In Tanzania over 75% of the Nile perch goes directly to the fish processing factories for export while dagaa and tilapia are sold on the regional and local markets (FFD 2009).

The Lake Victoria dagaa constitutes over 38% of total fish landings from Lake Victoria in Tanzania (Figure 4). The fishery supports a major artisanal fishery in the country, ranking second to the Nile perch. The large volume landed, its wide distribution, high nutritional value and low price are characteristics that have made dagaa the most important fishery to the great majority of Tanzanians in supporting food security and sustainable livelihood.

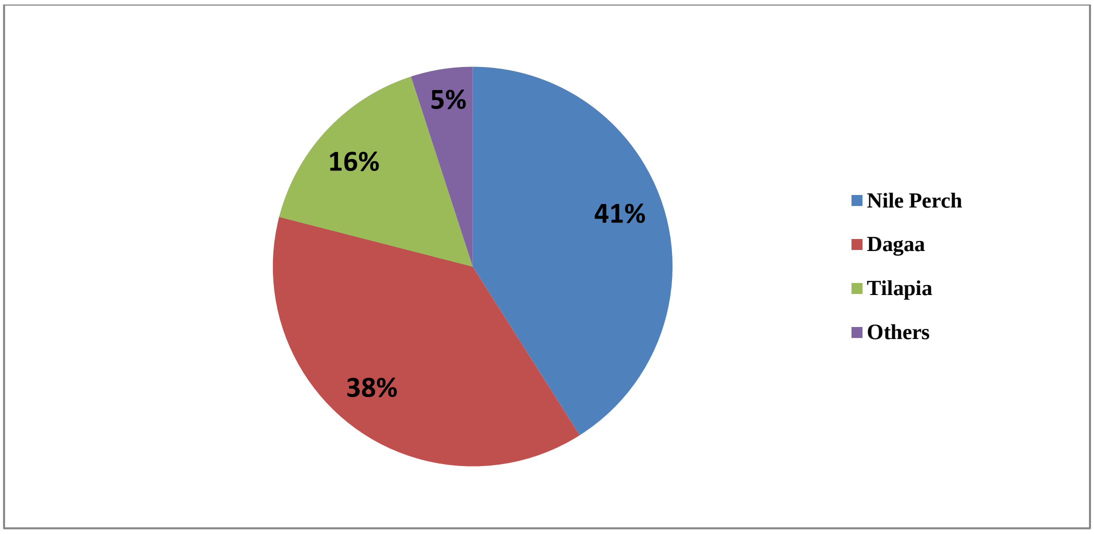

Figure 5: Percentages of total annual fish production by three major fisheries in Lake Victoria, Tanzania for 2009 (FDD 2009)

However, the dagaa fishery is associated with high level of post-harvest loss, both physical and quality losses. A recent post-harvest study conducted in Lake Victoria estimated losses in the dagaa fishery to be about 32 million USD per annum, which clearly suggests that reduction of losses in this fishery is a potential area for addressing food security and poverty alleviation (Mgawe and Mondoka 2008).

The demand for fish is increasing as populations increase. It does not appear that the supply of fish is able to meet this growing demand, especially in developing countries where a large proportion of captured fish is exported. One of the options for reducing this growing imbalance is to focus the attention on well planned loss reduction measures, increasing the amount of fish available and the value of the fish. According to James (1986) the control of fresh and cured fish loss could bring additional financial benefit to producers as well as extra contributions to supply, particularly in developing countries.

A better understanding of the basic economics (cost and benefit structures) of reducing dagaa post-harvest loss of artisanal fishers in Tanzania, is useful for setting national and regional fisheries strategies. This would help in managing effective trade-offs and better synergy in poverty eradication, food security and improved health for the sectors and in realising the Millennium Development Goals.

Moreover, the information gained would be equally beneficial to reduce post-harvest loss in other fisheries with similar constraints. This is particularly critical in designing efficient policies and programs for managing fisheries resources.

1.4 Significance of the study

There is a lack of information on the cost and benefit of management interventions that have been recommended for reducing dagaa post-harvest losses. Loss levels are often said to be between 20% and 40% in the dagaa fishery of Tanzania, but no study has been done on the cost and benefit of the proposed type of management interventions for reducing post-harvest loss.

Understanding the concepts and principles of cost and benefit analysis of post-harvest loss using the dagaa fishery as an example can be further applied to the remaining commercially valuable species.This study will therefore apply cost and benefit analysis and provide the bases for future analyses for other fisheries in Tanzania.

The overall objective of this study is to propose a cost effective management strategy to reduce post-harvest loss of Lake Victoria dagaa fishery in Tanzania for economic and nutritional benefit to the people. To reach this, five specific objectives will be tackled:

- To outline the structure of the fishery in terms of production, processing, marketing and distribution.
- To analyse the economic impact of post-harvest loss of the small-scale dagaa fishery.
- To suggest strategies for reducing post-harvest loss of the fishery.
- To conduct a cost and benefit study to assess the net economic benefit of the proposed strategy.
- To outline an implementation plan for reducing post-harvest loss in the dagaa fishery.

1.5 Structure of the study

The study is organised as follows: Chapter one provides background information on the overview of Tanzania’s fishery, an introduction of the study, objective and its significance. Chapter two and three discuss some existing academic literatures that are relevant to the subject, including some major works on the general theory of fish post-harvest loss. Chapter four gives the methodology by which the analysis was conducted, the cost-benefit analysis and sensitivity analysis of the proposed management strategy. The results, discussion and implementation time scale of the study is elaborated in chapter five. Conclusions on the proposed management strategies and policy recommendations are presented in chapter six.

2. DAGAA IN LAKE VICTORIA

2.1 Biology

The silver cyprinid, *Rastrineobola argentea*, is a species of ray-finned fish in the family Cyprinidae, the only member of the genus *Rastrineobola*. It is only found in Lake Victoria in Tanzania, Kenya and Uganda, where it is known as, *dagaa*, *omena*, and *mukene* respectively (Figure 5) (Bayona 2006).

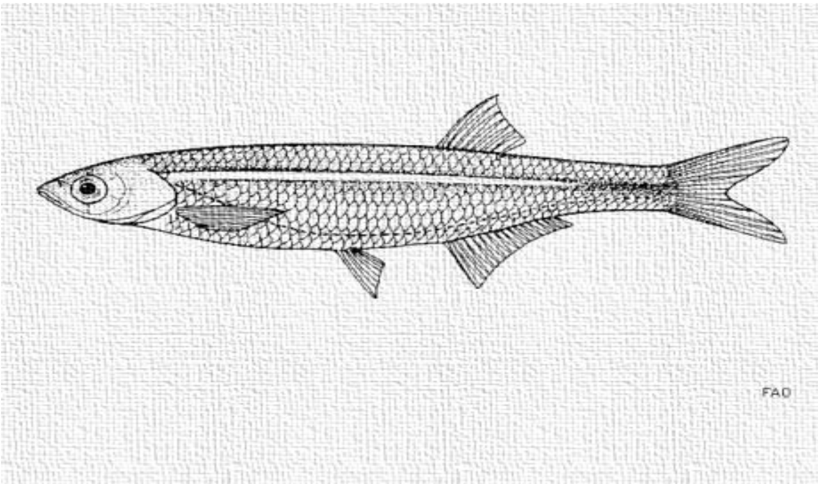

Figure 6: Rastrineobola argentea (FAO 2006)

Dagaa is found both inshore and offshore. The juvenile fish migrate away from the shore after spending their larval stage in shallow areas. Studies indicate that dagaa perform daily vertical migrations. The adults stay near the bottom of the water column during daylight hours and at night they migrate to the surface where they are fished. However juveniles and parasitised adults stay near the surface throughout the day (Wandera 1992).

Its food consists mainly of zooplankton, which is abundant in the environment and for which there is not much competition. It feeds on zooplankton during daytime supplementing this diet with insect larvae at night (Manyala and Ojuok 2007). Preliminary results on growth of the species indicate that dagaa grows fast and matures at ages varying from 16 to 25 months.

The dagaa breeds throughout the year but there is a major breeding peak in December-January and a minor one in August-September. It has low absolute[1] fecundity of a few thousand eggs, but its relative fecundity is 70 times higher than for Nile perch and almost 4,000 times that of the tilapia species.

Studies by Cowx *et al.* (2008) indicated that Dagaa is infected by a cestode (*Ligula intestinalis*) that destroys its gonads, reducing its reproductive potential by almost 10%, and affecting its annual recruitment.

Being a fast-swimming fish of the open waters, it has been able to withstand the ecological upheaval caused by the introduced predator Nile perch better than most other local species.

[1]Absolute fecundity is the total number of eggs in a female fish. On the other hand, relative fecundity is the number of matured oocyte in a female divided by its weight.

Dagaa is the only endemic fish species which has remained abundant in Lake Victoria since the introduction of Nile perch and Nile tilapia in the 1950s (Wanink 1988).

The decline in numbers and diversity of the native species especially the haplochromine cichlids, as a result of predation by the Nile perch, appears to have altered the lake's food web (Kazungu *et al.* 2008). This has led to an increase in biomass of dagaa (Figure 6) presumably due to a reduction in competition for food with the zooplanktivorous haplochromines (Ogutu -Ohwayo 1990).

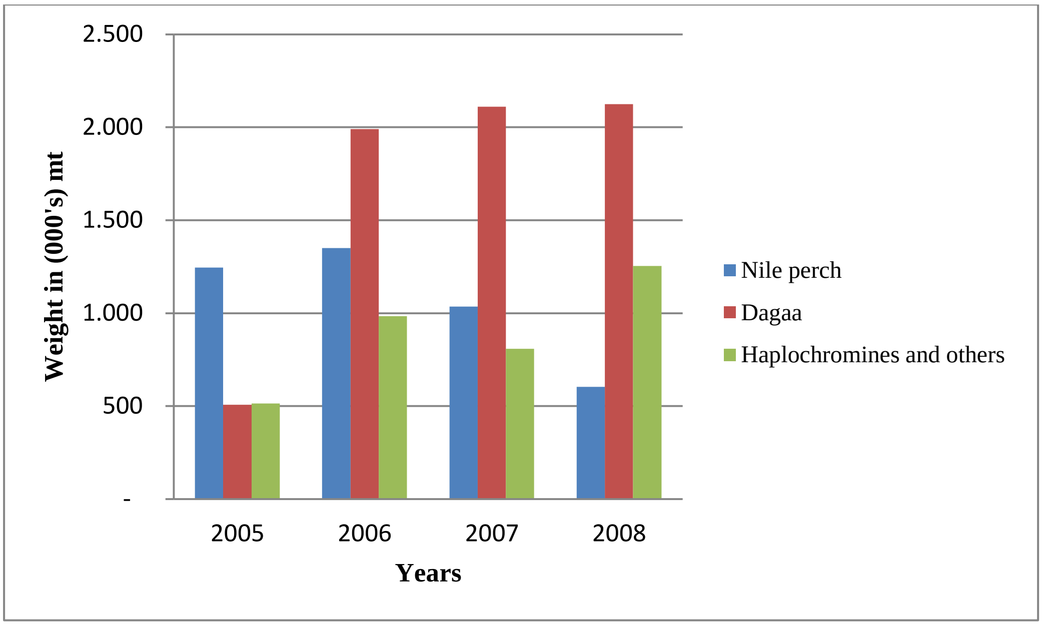

Figure 7: State of three important fish stock in Lake Victoria from 2005-2008 (TAFIRI 2009)

2.2 Dagaa fishing, processing and marketing

2.2.1 Fishing

Dagaa fishing is mostly done by purse seines, scoop nets, lift nets and beach seines, using light to attract the fish. Fishers use an average of 4–5 pressure lamps tied on rafts constructed out of dried reeds and dagaa nets ranging between 6–8 mm mesh-size. Fishing is usually done during the dark moon period, which is about 15–20 days per month (Wandera 1992).

Good harvest is experienced between November and April; the production of dagaa declines during the lean season (May-October). Wind and bad weather are the main constraints to dagaa fishing because lamps are easily lost in rough conditions (Mgawe and Mondoka 2008).

2.2.2 Processing

Sun drying is the simplest and cheapest method of fish preservation. Traditionally, most of the dagaa catch is processed by sun drying for 10 hours. The fish are spread on the ground (sandy beaches), rocky areas, old fishing nets and on grass locally known as *kinshwi*. Such techniques are totally dependent upon the weather conditions, and dagaa dries within a day in ideal weather (low humidity and clear skies).

Artisanal processors at landing sites and the surrounding areas prefer drying dagaa on the ground so as to speed up the drying processes. Many believe that it is the heat from the sand that dries dagaa faster. Drying on the ground is also favoured because it results in sand sticking on fish and thereby increasing the weight of the dried product, which is an important attribute since dagaa is sold by weight in retail market (Kabahenda and Husken 2009). The method has little control over contamination by dirt and attacks from insects and pests. As a result the end product tends to contain a lot of sand, the quality suffers and the product fetches low price due to quality loss.

During the rainy season the method becomes ineffective in handling large volume. The dagaa does not dry in one day and sometimes the entire batch is lost as processors are sometimes not able to gather their product on time, causing some of it to be swept away or soaked by rain. The high humidity associated with the rainy season also precipitates rotting and growth of mould especially when the product has not fully dried. Even during dry periods the drying may be inadequate. Artisanal processors in the Lake Victoria reported that they sun dry dagaa for only one day to avoid loss in weight. This usually results in products that are susceptible to degradation of proteins, increased lipid oxidation and loss of vitamins and thus reduce the nutritive value of dagaa (Kabahenda and Husken 2009).

The other threat to the nutritive value of dagaa is during storage. Dried dagaa, including the partially dried product, is packed in gunny bags (also called poly bags) that lack aeration and hence renders the product susceptible to degradation. The problem is intensified by the practice of stacking bags atop slabs of cement. Bags at the bottom are subject to rotting from slabs condensation, and the heat that accumulates inside the bags favours microbial activity and growth of mould. Dagaa stored under such conditions requires regular airing but this is often not possible because bags are heavy and stacked high which makes it hard to access bags that need airing (Masette 2005).

2.2.3 Marketing

There is no effective central marketing agency in the villages. Traders buy fish at low prices from fishers located far from major urban centres. They visit different fish landing sites daily, buy fish and transport to markets in major towns. The local price is set depending on the demand of fish and distances of villages from the major coastal towns. The market price of dagaa is determined by quality, size and weight, season, market structure, supply and demand. Dagaa prices are known to follow a seasonal pattern. Prices also vary from market to market, and in town markets tend to be higher than in village markets due to a larger concentration of consumers and superior family income (Abila 2003).

Dagaa is commonly distributed in local and regional markets (Figure 7). Local agents supply the dagaa to the town markets, the largest transit market for the repacking and resale of dagaa in Tanzania is Kirumba and Bukoba custom. There are three main markets for dagaa:
i) Local market for local consumption
ii) Regional markets in Zambia, DRC, Burundi, Rwanda, Kenya and Malawi
iii) Fishmeal industry (both local and regional)

Degraded dagaa and dagaa dust are often converted to fishmeal for animal feed but some rotten dagaa occasionally ends up in local markets, where it becomes a potential health hazard for local populations.

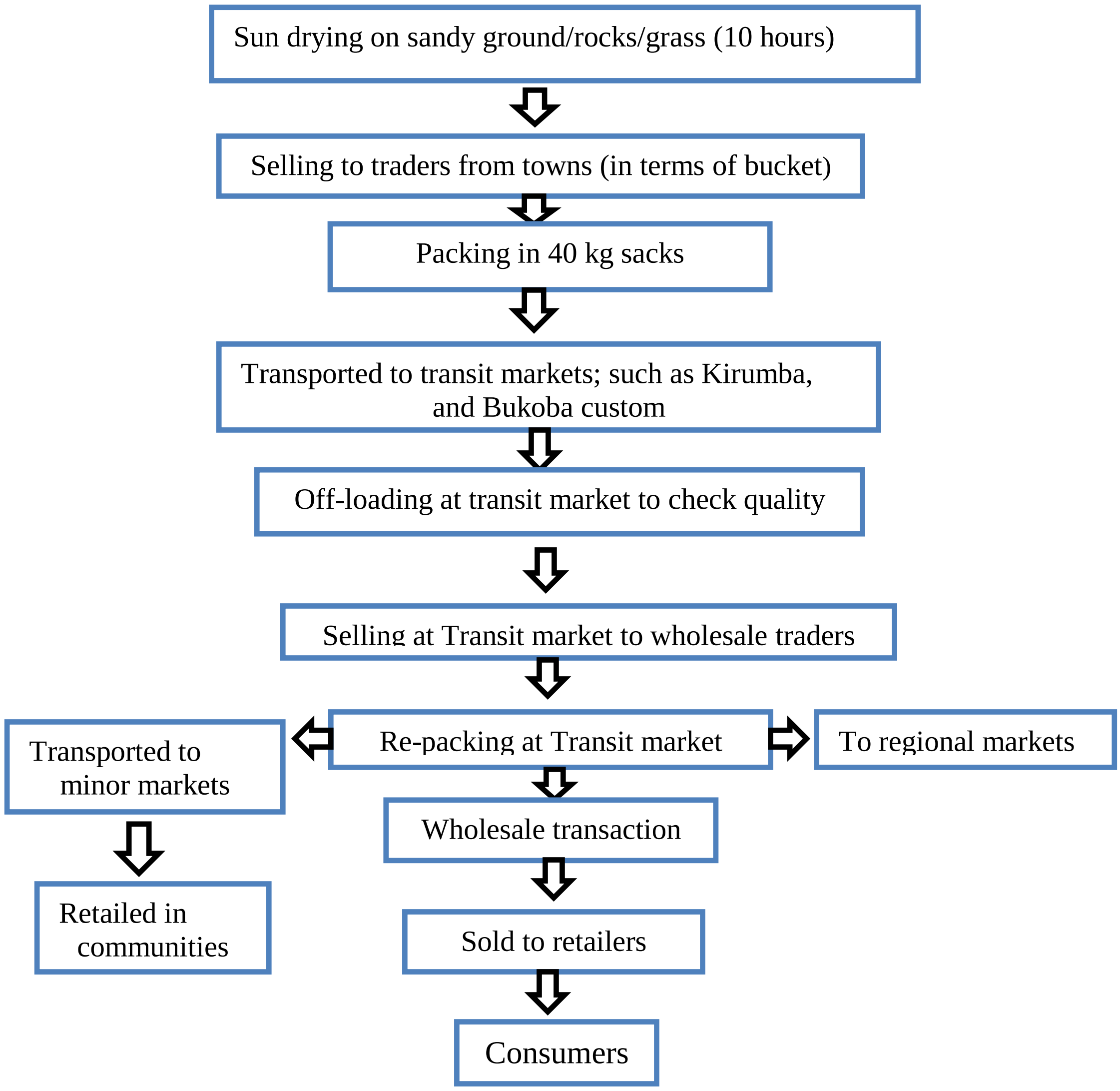

Figure 8: Flow diagram showing dagaa processing path and its distribution route to local and regional markets (Mgawe and Mondoka 2008).

2.2.4 Consumption

Dagaa is consumed all over Tanzania. It is estimated that 91% of dagaa harvested is marketed for domestic use, while the remaining 9% is exported to regional markets (FDD 2009).

Because of its small size, dagaa is eaten whole, including head, fins, scales, and bones, which make this fish a major source of calcium and magnesium. The viscera give the product a slightly bitter taste and the bitterness is more pronounced when it is not well dried. It is this bitterness that makes dagaa less desirable to some people. The cooking methods vary, but in general dried dagaa is fried with tomatoes and onions to make a stew or is mixed with ground nut (peanut butter) sauce and used as a relish. Dagaa is now popular due to declines in Nile perch and tilapia catch and is increasingly used by populations around the country (Kirema-Mukasa and Reynolds 1991).

2.3 Economic importance of dagaa fishery

Fisheries economic benefits are defined as the gains in relation to wealth acquisition from fisheries products and its distribution to the nations, households and individuals.

In Tanzania economic importance of dagaa is reflected in several activities at the national and community level. At the national level the main economic benefits are production and its contribution to GDP, employment, foreign exchange earnings and collection of government revenue. At the community level, the benefits take the forms of earnings, employment and contribution to diet (FAO 2007).

In artisanal fisheries there are a relatively large number of positions/jobs from the fishing of dagaa to the selling of the fish. Dagaa is rated first in terms of employment opportunities and second in terms of economic gains to Nile perch. Fishing on Lake Victoria is carried out by more than 98,000 full time small-scale fishers using about 29,000 small canoes with an average crew of 3–4 fishers per canoe. Approximately another million people make their livelihoods through various dagaa fishery-related activities as part time jobs. Such activities include transporting, unloading, boat building, net mending, fish processing (sun drying), retailing and other petty business.

Dagaa fisheries contributes as a source of revenue gain from its different stages of activities like export levy charges. The money collected is used to develop the sector in terms of management, training and monitoring of the resource utilization. Some of the revenue is also used for human resource development in the fisheries sector (Abdalah 2004).

In 2009 Tanzania exported to the regional markets a total of 7,650 metric tons of dagaa, which earned the country foreign exchange of about 2.7 million USD (Table 2). Fish and fisheries products are the main foreign exchange earner after tourism and mining in the country.

Table 2: Estimated dagaa export and its value from 2005 to 2009 (FDD 2009)

Year	Weight (Tons	Value 000' T.Shs	Value 000' US $
2005	1278	1,403,110	1,403
2006	2227	2,149,961	2,150
2007	4694	4,689,217	4,689
2008	9991	9,207,903	9,208
2009	7651	3,430,892	3,431

The dagaa fishery is significant for food security and sustainable livelihood. In 2000 Tanzania conducted a survey on poverty and nutrition (URT 2002), where the nutritional value of different food stuffs was analysed in relation to cost and economic efficiency. It was found out that dagaa from Lake Victoria had the highest score (200) followed by soy beans (172). This shows that dagaa is a food item of extremely high economic importance, and can contribute to Tanzania's endeavour to improve nutritional intake through securing an inexpensive, nutritionally rich food item (Mgawe and Mondoka 2008).

3. POST-HARVEST LOSS

Post-harvest losses occur all over the world in any type of fishery from production to point of final sale to consumer. The loss begins immediately after the fish has been caught, hence it includes all human activities at all stages from capture to consumption. It involves a number of groups of stakeholders playing different roles in handling fish onboard, unloading, processing, storing and during distribution. The type and level of loss as well as who is affected varies according to the type of fishery, post-harvest activities, skills, knowledge, infrastructure and access to equipment and facilities (FAO 2008).

The FAO Code of Conduct for Responsible Fisheries (CCRF) urges states to achieve full utilisation of aquatic resources particularly those suitable for direct human consumption, by improving practices throughout the production and supply chain in fisheries and eliminating wastage (FAO 1998). This statement has been adopted by a number of countries including Tanzania, where a fisheries policy (URT 1997), recognizes the existence of several constraints in the fisheries sector to include poor fish handling practices and inadequate processing methods. The policy statement number 7 states the aim of the country on improving fisheries product utilization and their marketability (Mgawe and Mondoka 2008).

It is well known and documented that a large percentage of the fish caught in developing countries are lost through poor handling. Globally, the post-harvest loss of fish has been estimated to be between 3 (Esser 1991) and 4.2 (James 1986) million tons annually. Most of the losses are said to occur in artisanal fisheries with estimates ranging from 15% to 75% (Mills 1980, Moes 1980) of the catch being lost.

Nevertheless, getting beyond declarations of exact impact of fisheries post-harvest loss has been a problem, partly owing to lack of data and concrete information regarding type, causes of fish losses and indicative quantitative loss levels. Such data and information are crucial in understanding the magnitude of losses before deciding appropriate and cost-effective intervention, given limited resources available especially in developing countries. Collection of PHFL data and information on artisanal fisheries is considered to be a difficult undertaking due to the dispersed nature of many small-scale and less developed fisheries operations. Also, lack of simple and cost-effective fish loss assessment methods has been a stumbling block to conducting regular assessment of the losses.

However, FAO and the Natural Research Institute (NRI) of the University of Greenwich United Kingdom have come up with a manual which describes three methods of assessing post-harvest fisheries loss. The methods are; the Informal Fish Loss Assessment Method (IFLAM), Load Tracking (LT) and Questionnaire Loss Assessment Method (QLAM). They are designed to give the user a quantitative and qualitative understanding of post-harvest fish losses required for planning loss reduction measures (Ward and Jeffries 2000).

The three post-harvest fish loss assessment (PHLA) methods were field tested in Tanzania through a study conducted by FAO from 2006 to 2008. The study focused on the dagaa fishery of Lake Victoria and the marine fisheries. The study identified different types of losses in the dagaa fishery that 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 wholesale markets to retail levels, as presented below.

Results from IFLAM suggested high physical and quality losses in the Lake Victoria and in-shore marine fisheries of Tanzania occur most in small-sized fish, especially dagaa. Post-harvest losses due to quality deterioration accounts for more than 50%; also there was a significant relationship between the type of losses and gender of operators. Men are affected by physical and quality losses while women incur market force losses. This is the direct consequence of different gender roles in the distribution chain.

3.1 Causes of dagaa post-harvest loss

Fishing stage

PHFL in this stage is largely caused by stepping on fish by crew on board the canoe due to the lack of separating boards. The weight measurements taken during the study suggested that about 0.9% of dagaa total catch weight per year is thrown overboard due to physical damage caused by this practice.

Animal predation

The method of drying dagaa in the sun on sandy beaches, rocks or drying on grass provides little control over attacks from insects, birds and domestic animals. Fishers employ different tactics to deal with the problem including placing watch-keepers and butchered birds as scaring mechanism for the growing flock of birds roaming around drying places. These coping strategies notwithstanding, about 2% of dagaa total catch weight per year is lost through animal predation.

Discarded after prolonged rain

Dagaa takes about ten hours to dry and get sold in the evening if the weather is favourable. However, the situation is very challenging during the rainy season. The quality of dagaa is heavily degraded if it rains before completion of the drying process. The grade of the product is lowered from that for human consumption to animal feed. When there is prolonged rain on two consecutive days, the whole lot rots and gets discarded as nyambore (unsuitable for human consumption and animal feed). In addition, a big portion of dagaa placed on rocky areas adjacent to the lake is easily washed in the lake.

Theft

Theft is the least of physical losses identified during the study which accounts for about 0.1% of dagaa total catch weight per year.

Sinking sacks during transportation

After the drying process, the product is transported to major transit markets by using transport canoes. Most of the canoes are propelled by outboard engines but they are small and unable to withstand strong winds. Splashes of water enter the canoe and soak the fish; in such cases the load becomes heavier compelling a skipper to throw sacks over-board for the sake of stability and safety.

Occasionally these canoes capsize dropping the whole load of dagaa. Such a scenario occurs about four times per transport canoe per annum. The problem is more evident during windy seasons, mostly in February, May, June and December of each year. It was estimated that 0.7% of total weight catch per year is lost in this way.

Presence of by-catch

An increased level of by-catch (mostly *Haplochromis* spp.) is another cause of losses to fishers and traders. The volume of by-catch in dagaa landings seems to be increasing over time probably due to the decreasing population of the Nile perch, its main predator. Most of it is sorted out and given free of charge to people who happen to be at the landing site. Failure to sort it out lowers the quality of the dried product resulting in low prices. Despite the effort to sort out the by-catch at the fishing village, it represents about 2.5% of dagaa total catch weight per year reaching the wholesale market (Mgawe and Mondoka 2008).

Quality degradation caused by rain

In addition to physical loss caused by rain, the rainy season also creates drying and storage difficulties because most of the days are unfavourable drying conditions (low temperature and higher relative humidity). Therefore higher volumes of poor quality products are produced during the rainy season. As if that is not enough, demand declines mainly due to declining number of traders visiting fishing villages during the rainy season to avoid the risk involved in quality loss. Consequently, increased proportion of dagaa is degraded, selling as animal feed as opposed to human food. A study by Mgawe and Mondoka 2008 estimated the quality loss due to rain is about 11% of the catch weight landed in per annum 2008.

Change in colour before being sold

Colour change from silvery to brownish, as a function of biochemical processes including fat oxidation and autolysis is a major indicator used by customers in determining the quality of dagaa. High water content and prolonged storage are some of the factors that accelerate the rate of change. The colour tends to change after a period of about 5-10 days depending on drying conditions. The dagaa dried on rocks seems to take a bit longer before it changes colour, compared to the ones dried on sand or grass (kinshwi). The study estimated that 30% of the dried product change in colour before being sold. As the colour change of dagaa may reduce the selling price by one third (Akande and Diei-Ouadi 2010), the overall loss by the colour change is probably the largest single loss factor in the whole value adding chain.

Fragments/drying grass

Fragmentation is another cause of high post-harvest loss. Initially, it was being assumed that the problem was closely related to poor road and bad transportation. However, the study found that this could hardly be the case for areas connected with improved tarmac roads such as Lake Victoria area and Dar es Salaam. Rather, it was found that the problem rests with government regulations on levy per sack instead of per kg and the arrangement of charging transport cost by using sacks as units. These two arrangements invite traders to over-pack the dagaa into large sacks through a practice locally known as lumbesa. In the process of pressing up the dried fish into the sacks, some of the fish is broken, which increases the proportions of fragments.

Large quantity of grass found in dried dagaa is another problem causing quality degradation. This is mostly associated with dagaa dried on grass (kinshwi), a common practice in the Kagera region of Lake Victoria.

Loss through levy evasion

Over 50% of dried dagaa from the Tanzanian side of Lake Victoria is believed to be exported in the regional market. A common practice is that a trader purchases dried dagaa from fishing villages or at a transit market declaring to be sending it to towns located in border areas but within the country. This enables him to evade paying the export levy. On getting to border towns he stores his product in large warehouses constructed in respective areas to facilitate the cross-border trade. The actual crossing takes place at night when law enforcers are out of sight. This practice makes the government lose potential revenue from cross-border trade (Mgawe and Mondoka 2008).

A review of case studies on post-harvest losses in several countries in Africa estimates high levels of losses both in quantity (physical losses) and quality (mostly due to downgrading) of fishery products. Losses may vary within communities along the same water body and for the same fish species; there are differences in root causes of losses and hence the type of loss reduction intervention needed. According to Kabahenda *et al.* (2009), postharvest losses in Lake Victoria dagaa fisheries are valued at:

0 – 7.5% physical loss and 1.5 – 18.9% quality loss in Kenya,
20 – 40% physical loss and 20% quality loss in Tanzania, and
26 – 40% physical loss and 2 – 5% quality loss in Uganda.

These losses have major implications on the nutritional quality and availability of fish products to local populations. The comparison between countries shows that the potential for improvement is very high in Tanzania.

3.2 Post harvest loss intervention strategies

Studies on dagaa post-harvest loss have recommended different intervention strategies for reducing loss. Mgawe and Mondoka (2008) suggested processing methodologies such as using drying racks, smoking, and production of value added products like brined and salted-dried. Masette (2005), based on field observations, also acknowledged these methods as low-cost processing technologies for reducing dagaa post-harvest loss.

It has been recognized that the use of drying racks can reduce post-harvest loss at 50% and it has many advantages over traditional methods, such as:

- Reduction in post-harvest losses as fish can easily be protected from rain and groundwater by covering with a sheet of plastic or other waterproof material.
- A higher quality product since pests and domestic animals cannot easily reach to contaminate the fish.
- A shorter drying time because air can pass over both sides of the fish, and
- A cleaner product is obtained as there is no contact with dust and dirt. (Mwambazi 1992)

Though fishers, processors and traders experience losses, it has been found that people use various coping strategies to control or minimise loss as much as possible. Some of these strategies can form the basis of interventions while others are potentially harmful.

The use of drying racks in Uganda has resulted in a reduction of loss to a negligible level as compared with the high level of losses in drying dagaa on bare floors, ground and grasses (Figure 8). It has been realized that dagaa dried on racks are better quality product than the ones dried on the ground. The fish dried on racks fetches a better price as compared to fish dried on the ground (Masette 2005).

Figure 9: Sun drying of dagaa on racks

In Tanzania physical losses are frequent and high. Often children are employed to prevent birds and animals from reaching the drying sites. Similarly tying string or twine above the racks is used as protection or hanging dead birds up is also used as a scaring mechanism against birds and animals (Mgawe and Mondoka 2008).

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 (Akande and Diei-Ouadi 2010).

3.2.3 Stakeholders affected

Most stakeholders are affected by post-harvest losses, e.g. fishers, fish traders, fish processors and ancillary labourers such as boat builders and net makers as well as consumers. Losses are a serious socio-economic problem leading to tons of highly nutritious fish being left to rot, thus contributing to food insecurity (Poulter *et al.* 1988).

In Tanzania children guard drying dagaa against animal predation and theft. They are paid in dried fish for their services, but there is an opportunity cost incurred by these children as they have to leave school. Certainly this is the outcome of post-harvest loss to society, an integral part of PHFL and socio-economic aspect (Mgawe and Mondoka 2008).

In Uganda, the socio-economic implication revolves around the poor who buy poor quality fish. 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 (Akande and Diei-Ouadi 2010).

4. METHODOLOGY

4.1 Data collection

A literature review was done to acquire the necessary information and secondary data were extracted from different articles (reports and journal) related to the topic of study. Data were collected from the following organisations, institutions and technical working groups:

- Food and Agriculture Organization of the United Nations (FAO)
- Lake Victoria Fisheries Organization (LVFO)
- Regional Technical Committee Reports on Frame Surveys, Lake Victoria, Tanzania
- Fisheries Departments (Tanzania and Uganda)

A study on Post-Harvest Fish Loss Assessment (PHFLA) of dagaa was conducted in Lake Victoria by FAO in 2008 (Table 3), within the framework of the regional post-harvest loss assessment (PHLA) programme in small-scale fisheries in Africa. The study was designed to generate a practical guide for dagaa loss assessment in Tanzania, by providing benchmark data for types of losses, percentages of loss in each categories and the dry weight equivalent.

Table 3: Indicative quantitative post-harvest loss in dagaa fishery Tanzania (FAO 2008)

REASONS FOR LOSS		Fresh wt. (tons)	Dry wt. (tons) Equivalent	Loss (Million Tshs.)
Estimated dagaa landing	100	197,200[2]	35%	
Types of loss				
i) Physical loss	% Loss			
Physical damage during fishing	0.9%	1,775	621	1,242
Animal predation	2%	3,944	1,380	2,761
Discarded after prolonged rain	4%	3,155	1,104	2,209
Theft	0.1%	197	35	70
Sinking sacks during transportation	0.7%	1,380	520	1,040
ii) Quality loss				
Presence of by-catch	2.5%	4,930	1,750	3,500
Quality degradation through rain	11%	22,400	7,840	14,112
Change in colour before being sold	30%	59,160	21,000	10,500
Fragments/drying grass	8%	15,776	5,600	10,080
TOTAL PHYSICAL AND QUALITY LOSS				45,514
iii) Market practices				
Unfair marketing practice			7,700	15,400
Loss due to insect infestation		Not quantified		
Loss in terms of levy evasion		Not quantified		

[2] There is conflicting information from data sources (the fisheries research institute and fisheries development division) on average dagaa catch per year. The FAO study used data from fisheries research institute, and data for this study was obtained from the fisheries development division.

Enquiry was done in Tanzania and Uganda through the fisheries department to get data on the design, dimension of drying racks and price differences between the product dried on ground and that dried on drying racks. Table 4 provides estimated price per 1 kg of different products of dagaa.

Table 4: Estimated price (USD[3]/T.Shs.) for 1 kg of different products of dagaa in Tanzania

Dagaa Product	Price USD/kg	Price Tshs./kg
Dried on racks	2.7	4,000
Dried on ground	1.7	2,500
Salt-sun dried	3	4,400
Low quality dried dagaa	1	1,500
Estimated price of fresh weight/kg	0.8	1,200

The rack design, dimension and material descriptions were sent to Tanzania, to obtain the actual cost quotation as the project will be implemented in Tanzania.

4.2 Construction of drying racks

Drying racks can usually be made either from locally available materials such as bamboo, tree branches, chicken wire, mosquito netting, old fishing nets (at very little cost) or by using expensive but durable materials like metal wire mesh, tie wire and square pipe (angle post). The use of durable drying racks was proposed in this study; Figure 9 shows a picture of the drying racks used in Uganda to dry the same species.

Figure 10: Picture of a proposed design of dagaa drying rack to be used by dagaa fishers in Tanzania

To construct this rack of 2 m width, 8 m length and 1.6 m height, square steel pipe (1.5” diameter) are used. The pipes are welded together to make the structural framework. The top

[3] 1 USD is set equivalent to 1480 Tanzanian shillings

is then covered with wire mesh or chicken wire, depending on preference. The racks of 16 m^2 can manage 80 kg fresh weight of dagaa.

4.3 Cost and benefit analysis

Cost benefit analysis has the objective to systematically compare both private and public costs and benefits from a project to evaluate its net profitability, with time differences taken into account. This method was chosen because it is the most straightforward, organised and analytical method of comparing benefit and cost in evaluating the desirability of a project or programme often of social nature (Robert *et al.* 1997). The analysis of management strategy was narrowed to sun drying by using drying racks. The analysis was used to determine whether adopting drying dagaa on racks to reduce post-harvest loss will hold positive public value in the future. Two categories for each analysis were set i.e. private (individual fisher) and public (government) for a pilot district (500 fishers). The analyses were divided into five parts:

1. Assessment of all possible dagaa post-harvest losses
2. Assessment of the cost of reducing the losses, including implementation cost
3. Assessment of the anticipated benefits associated with reducing the losses
4. Evaluation of costs and benefits to determine net benefit and NPV
5. A sensitivity analysis and breakeven analysis

4.3.1 Assessment of all possible dagaa post-harvest losses

Post Harvest Fish Loss Assessment standards (Indicative quantitative PHFL) of Lake Victoria dagaa fishery from a previous study by the FAO (Table 3) and information on the weight and price of fish were used to calculate the monetary loss.

Determination of total dagaa catch weight per year for private (individual fisher) and for a pilot district (500 fishers) was done. The project is deemed good if aggregate private benefits exceed implementation (public) costs. The percentage of loss data based on physical and quality loss from the FAO study was used to find the fresh weight after loss that will be dried on racks.

The dry weight equivalent was calculated based on an output ratio of 35% of the total fresh dagaa weight. Then the dry weights in each category were multiplied with the price per kg to get the monetary value. The monetary values were summed up to get the total loss.

4.3.2 Assessment of the cost of reducing the losses

Costs can be described as the intended or unintended negative effects of a project. Construction costs for drying racks and implementation cost are the most direct costs to individual fisher and the government for a public improvement project respectively.

Total anticipated cost of drying racks for private, public (government) and for a pilot district (500 fishers) project were evaluated.

Estimated price of construction materials i.e. wire mesh, square pipe, tie wire, along with labour cost and transport cost were used to calculate the cost of construction.

The monetary cost of reducing loss was calculated as

$$C\ (t) = \sum_{j=1}^{j} w\ (j,t)\ x\ (j,t) \qquad \text{Equation 1}$$

Where;

C = cost of different items, i.e. construction materials, implementation, transport, etc.,
t = time of year when cost was assessed,
∑= summation of all cost,
w= the price of one unit of input *j* at time *t*,
x= quantity of input *j* at time *t*. (Boardman *et al.* 2006)

4.3.3 Assessment of the benefits associated with reducing the losses

Direct benefits accrued from drying dagaa on racks are income generation (economic gain) through acquiring best price of the improved product and government increase of revenue collection from local, national and regional trade. There may also be other benefits, such as improved nutritional value or increased food supply. These are however not taken into account in this study due to lack of data.

The analysis of benefit of using racks was done as follows: the total quality loss and physical loss weight for private drying on ground and drying on racks project were deducted from average catch per fisher (private) for one year to obtain the total weight left for selling. The total weights left for selling were then calculated by 35% which was later multiplied by price (better price 2.7 USD/kg) for one kg to obtain the monetary gain. Quality loss weight was also taken into consideration by multiplying with the reduced price (1 USD/kg). The same procedure was done for a pilot district (500 fishers) project.

The monetary gain was calculated as

$$B\ (t) = \sum_{i=1}^{I} P\ (i,t) q(i,t) \qquad \text{Equation 2}$$

Where;

B = Benefit of drying dagaa on racks and salt sun-drying processing,
∑= Summation of all monetary gain,
p = price of output *i* at time *t*,
q = quantity of output *i* at time *t*,
t = time when the benefit was evaluated. (Boardman *et al.* 2006)

To obtain the total benefit of using racks, the sum of monetary gain from weights left for selling and weight from quality loss for private drying on ground and on racks projects were deducted from the monetary loss (refer 4.3.1 assessment of loss) for drying on ground and drying on racks. The same was done for the pilot district (500 fishers) project.

4.3.4 Evaluation of costs and benefits to determine net benefit and NPV

The cost and benefit analysis was done by subtracting all identified costs of management interventions for reducing post-harvest loss from the expected benefits gained after reducing the losses, so as to determine whether the positives outweigh the cost.

To compare the changes in benefits and costs, they are discounted back to the present period given present values. The weighting of these flows at different time periods is possible by using the price of holding money (the discount rate). The discount rate of 0.172 was used in this study; it is the rate the central bank of Tanzania charges in determining the present value of future cash flows.

The overall economic net-benefits of using racks for private (individual) as well as for a pilot district (500 fishers) was therefore determined as follows:

Net-benefits to society = NPV (benefits – costs)

The following formula was used

$$NPV = \sum_{t=0}^{T} \frac{B(t) - C(t)}{(1+r)^t}$$ Equation 3

Where;

NPV is the net present value of the items of subtracting benefits to costs.
r = the discount rate,
B (t) = benefit at time *t*, as described above,
C (t) = cost of items at time *t*, as described above,
T = number of years of implementation. (Boardman *et al.* 2006)

4.4 Sensitivity analysis

The cost and benefit analysis is subject to substantial uncertainty, therefore a sensitivity analysis was used to check the robustness of the calculated Net Present Value for the drying racks project. The sensitivity analysis was categorised into two parts, private and public drying racks project.

The analysis was conducted by working out the percentage change from -50% to 50% in NPV, different scenarios of assumptions were set to investigate how changes in values of implementation cost, investment cost, quantity of fresh dagaa and sales price of dagaa would impact the Net Present Value. It was done by varying a single assumption while holding others constant.

This makes it possible to gain a better understanding of the nature and level of impact the actual outcome of a particular variable will have, if it differs from what was previously calculated.

4.4.1 Break even analysis

The break even analysis presented in this study represents a long term breakeven point for the 10 year implementation plan of the public drying dagaa on racks project.

The cumulative present values in each year was used to indicate the breakeven point, at which cost or expenses of implementing drying racks to the community will be equal to the profit gained.

5. ANALYSIS AND RESULTS

This study assessed the feasibility of drying dagaa on racks as an intervention strategy to reduce post-harvest loss. Sun drying as suggested here is familiar to Tanzanian artisanal fishers.

5.1 Loss available when drying dagaa on ground (before using racks) and after drying on racks

5.1.1 Private (individual) post-harvest loss for drying racks

The average catch per year for one fisher was estimated (Table 5). Dagaa fishing is commonly done during the dark moon period, about 15-20 days in each month. The data on percentage composition of loss categories (physical and quality loss) from the FAO study of 2008, on the assessment of PHFL of Lake Victoria dagaa was used to determine the fresh weight to be dried. The dry weight equivalent was calculated based on dagaa output ratio of 35% of the total fresh weight (Table 6).

Table 5: Estimated dagaa catches per fisher/day/month/year

Average catch/day/kg/fisher	day of fishing/month	Average catch/month	Average catch (tons.)/year/fisher
21	20	420	5

The FAO PHLA data identified 59% of dagaa post-harvest loss (physical and quality loss) per year (Table 3). Based on an average catch of 5 metric tonnes per year, fishers will incur financial losses of approximately 1,139 USD per annum when dagaa is dried on ground (Table 6, Appendix 1 and 2). According to Mwambazi (1992) using racks can reduce post-harvest loss by half. Therefore dagaa post-harvest loss (physical and quality loss) will be reduced at 30% after using drying racks per fisher/year;, this loss is equivalent to 662 USD financial loss. The price of dried dagaa is expected to increase from 1.7 USD/(kg) to 2.7 USD/(kg) as the product of dagaa dried on racks will be of better quality.

Table 6: Summary of estimated post-harvest loss of dagaa dried on ground and dagaa dried on racks private (individual) weight (kg) and price in USD

Processing method	Total catch/fisher/year/(kg)	Post- harvest loss %	Fresh wt (kg)	Dry wt.(kg) Eqv. 35%	Loss (USD)
Drying on ground	5,040	59%	2,984	1,044	1,139
Drying on racks	5,040	30%	1494	523	662

5.1.2 Pilot district (500 fishers) project post-harvest loss for drying racks

To determine loss for a pilot district (500 fishers), 10 villages/communities in a pilot district were selected for introducing drying racks. It was assumed that 50 dagaa fishers in each village will be sensitised and trained on using drying racks. It is known that one fisher can catch a total weight of 5 tonnes per year, therefore 500 fishers are expected to catch 2,520 tonnes of dagaa per year.

The analysis indicated that for a pilot district (500 fishers) dagaa post-harvest loss (physical and quality loss) is about 57 thousand USD for dagaa dried on ground (Table 7, appendix 1 and 2) and 33 thousand USD after using drying racks.

Table 7: Summary of estimated post-harvest loss of dagaa dried on ground and dagaa dried on racks for a pilot district (500 fishers) weight (kg) and price in USD

Processing method	Total catch(Tons)/500 fisher/year	Post- harvest loss %	Fresh wt (Tons)	Dry wt.(Tons) Eqv.35%	Loss (000'USD)
Drying on ground	2,520	59%	1,491	522	569
Drying on racks	2,520	30%	747	261	331

5.2 Estimated cost of reducing the post-harvest losses in Tanzania

The cost for implementation of the drying racks project to the community is the largest and most direct cost of the project to the government. Potential costs to fishers includes investment costs of construction and operational cost for drying racks.

5.2.1 Implementation costs

It is estimated that implementation of drying racks will cost 636 thousands USD (Table 8). The plan will be executed in 10 villages/communities (50 fishers in each village) in a pilot district.

It should be noted that the criteria for estimating costs were based on current market prices and public service policy.

Table 8: Estimated cost for the implementation of dagaa drying project

Programe Component	Program Activity	Unit	Time scale	Item	Quantity	Unit Cost($US)	Total Cost ($US)
1. Preparatory Stage		Village	5	months	10		
1.1. Consultations to inform communities, Local leaders &Govt.officials	Hold Meetings	10	1	Days	2	100	2,000
	Participants (Fisheries Division)	10	4	Days	10	65	26,000
	Partipants(Community level)	10	4	Days	25	20	20,000
	Hold Workshops	10	2	Days	5	100	10,000
	Prepare Operational plan for implementation	Consultant	3	month	1	5,000	15,000
Sub-Total							**73,000**
2. Management cost							
	Stationary(notebooks&pens)	25	1		5	5	625
	Fuel		1	litres	800	2	1,600
Sub-Total							**2,225**
3. Implementation			12months				
	Community mobilization & Awareness	10	10	Days	25	40	100,000
	Training in construction & use of drying Racks	10	20	Days	25	50	250,000
	Participants (Fisheries Division)	10	30	Days	10	65	195,000
Sub-Total							**545,000**
4. Operational	Fuel (1000L*3 vehicles*2 Trips)	1		litres	6000	2	12,000
Sub-Total							**12,000**
5.Monitoring and Evaluation		10	2		2	1,000	4,000
Sub-Total							**4,000**
GRAND TOTAL							**636,225**

5.2.2 Estimated investment cost for drying racks private and for a pilot district (500 fishers) project

Table 9 indicates the investment cost of constructing 1 rack (pipes, mesh wire and tie wire) along with operation cost (labour and transportation cost). It was estimated that construction of one rack will cost 98 USD for one year.

Table 9: Estimated investment cost of constructing one rack per year (USD)

Construction Materials	**Price USD**
Pipes	24
Mesh wire	26
Tie wire	5
Sub -total	55
Operational cost	
Labor	34
Transport	9
Sub-Total	43
Total	**98**

It has been estimated that one fisher is capable of catching 21 kg of dagaa per day (Table 5); one rack was used to compute the total investment cost per year for one fisher (Table 10). For a pilot district (500 fishers) project there were 500 drying racks for 500 fishers (Table 11).

Table11: Estimated private (individual) investment cost for dagaa racks project (USD)

Table11:Estimated investment cost to a pilot district and implementation cost to the government for drying racks project

Investment cost	Price /USD	
Construction Materials	Year 1	Year 2-5
Pipes	24	
Mesh wire	26	26
Tie wire	5	5
Labor	34	34
Transport	9	9
Sub -Total	98	74
Capital cost for 1 rack	17	13
Material cost for 1 racks	98	74
Capital cost for racks	17	38
Total investment cost	**115**	**112**

	Price USD	
Construction Materials	**Year 1**	**Year 2-5**
Pipes	24	
Mesh wire	26	26
Tie wire	5	5
Labor	34	34
Transport	9	9
Total investment for I rack	98	74
Capital cost for 1 racks	17	13
Investment 500 racks	49,000	37,000
Capital 500 racks	8,428	6,364
Total investment for 500 racks/500 fishers	**57,428**	**43,364**
Initial Implementation cost to the Govt.	636,225	
Subsequent implementation cost to the Govt.		12,000
Total implementation cost to the Govt.	**636,225**	**12,000**

Materials for construction of racks can last for one year with the exception of pipes, so there is recurrent cost for rehabilitation of racks in subsequent years. It was estimated that, for the first year of the private project fishers will incur a total cost of 115 USD. Likewise for the pilot district (500 fishers) costs will initially be 57 USD thousands for racks construction and 636 USD thousands to the government as implementation cost, while in subsequent years it will cost 112 USD for private (individual fisher), 43 thousands USD for the pilot district (500 fishers) and 12 thousands USD to the government as implementation cost for the public project in a pilot district.

5.3 Expected benefit after reducing post-harvest losses

Benefit evaluation on this study was grouped into private (individual) in a pilot district (500 fishers) and public (government) benefit. Direct benefit evaluated was improvement of income generation (economic), expected through acquiring best price for the improved product and increased productivity after reducing post-harvest loss.

5.3.1 Benefit for the private (individual), pilot district (500 fishers) and to the government

To derive the benefits attained by individual fisher/(500 fishers)/government from the dagaa drying racks project; the total quality loss and physical loss weight for private drying on ground and drying on racks were deducted from average catch per fisher (private) for one year to obtain the total weight left for selling.

Monetary gain from weights left for selling for private/public drying on ground and drying on racks projects were deducted from the monetary loss (4.3.1 assessment of loss) for drying on ground and drying on racks both for public and private respectively; this was also done for the public project (table 12 and table 13).

Table12: Anticipated private benefit after using racks, weight in kg and price in USD

Table 13: Anticipated total benefit for the pilot district (500 fishers) after using racks, weight (ton) and price in 000' USD.

Category/catch/loss/benefit	Wt/Kg	Quantity in USD	Category/catch/loss/benefit	Weight/Tonnes	Quantity/000' USD
Total catch available/fisher/year	5,040		Total catch available/500 fisher/year	2,520	
Physical loss/wt/kg	388		Physical loss/wt/Tons.	194	
Quality loss wt/kg	2,596		Quality wt./Tons.	1,298	
Total loss/wt/kg	**2,984**		Total loss/wt./Tons	1,492	
Left for selling in wt/kg	2,056		Left for selling in wt/Tons.	1,028	
Revenue from Quality loss product /USD		908	Revenue from Quality loss goes to the market/USD		454
Revenue from left wt for selling/USD		1,224	Revenue from left wt for selling/USD		612
Total benefit/USD		**2,132**	**Total benefit/USD**		**1,066**
Loss occurred when drying on ground		1,139	Loss occurred when drying on ground		570
Loss occured after using dying racks		662	Loss occured after using dying racks		331
Benefit drying on racks		1,470	Benefit using drying on racks/USD		735
Benefit drying on ground		993	Benefit drying on ground/USD		496
Total benefit after using racks		**477**	**Total benefit after using racks**		**238**

The total benefit after using racks was 477 USD for the private project and 238 USD for the pilot district (500 fishers) project.

Benefit to the government will be an increase in revenue collection from local, national and regional trade. The analysis indicated that 109,835 thousand USD will be gained from revenue collection each year during the period of the project implementation.

5.4 Evaluation of private/public costs and benefits for drying racks to determine net benefit and NPV

The overall financial net-benefits of using drying racks to individual fisher (private) as well as to the public (government) were done.

It was found that the net benefit for the drying racks project is 142 USD per fisher (private) for the first year; the benefit will then increase to 145 USD for the subsequent years. The present value for each year was calculated and summed up to get the NPV 460 USD (Table 14). For the public project the first year of implementation, the project will be in loss approximated at -607 thousand USD. Then it will make profit for the rest of implementation period; the NPV will be 9,049 USD (Appendix 5).

Table 14: Drying racks (individual) private project cost and benefit analysis for five years

Drying racks private project	YEAR				
COST/USD	**1**	**2**	**3**	**4**	**5**
Investment cost 1 racks	115	112	112	112	112
Taxes	220	220	220	220	220
Total cost	**335**	**332**	**332**	**332**	**332**
BENEFIT/ USD					
Benefit drying on rack	1,470	1,470	1,470	1,470	1,470
Benefit drying on ground	993	993	993	993	993
Total benefit	477	477	477	477	477
Net Benefit	**142**	**145**	**145**	**145**	**145**
Present Value	121	106	90	77	66
NPV /USD	**460**				

Figure 10 displays the breakeven point of the implementation plan for the public drying rack project by the government. The project will experience loss from first year to the fourth year, then it will break even and generate profit from fifth year to the last year. Therefore it will take four years for the project to reach its full potential.

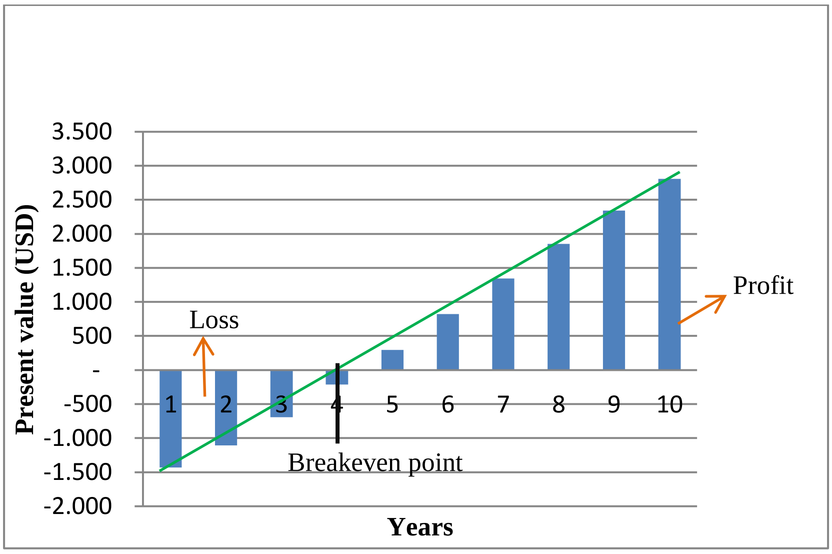

Figure 12: Breakeven point of public drying racks project for ten years

5.5 Sensitivity analysis results

Percentage change under a given set of assumptions of implementation cost, investment cost, quantity of dagaa and sales price of dagaa was done to examine their impact on NPV (Appendix 6 for private and Appendix 7 for public project in a pilot district).

Analysis of the drying racks project both private and public revealed that NPV is most sensitive to changes in sales price (Figure 11 and Figure 12). However the results showed that NPV is not sensitive to quantity of catches and investment cost.

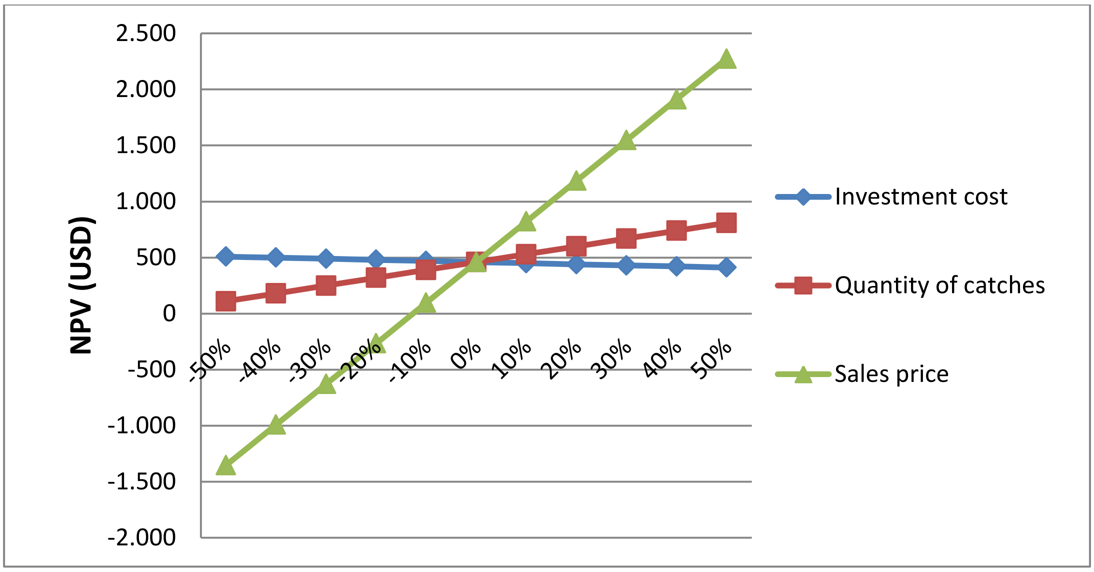

Figure 13: Sensitivity analysis chart on different % changes of cost, price (USD) and quantity of dagaa (kg) private project

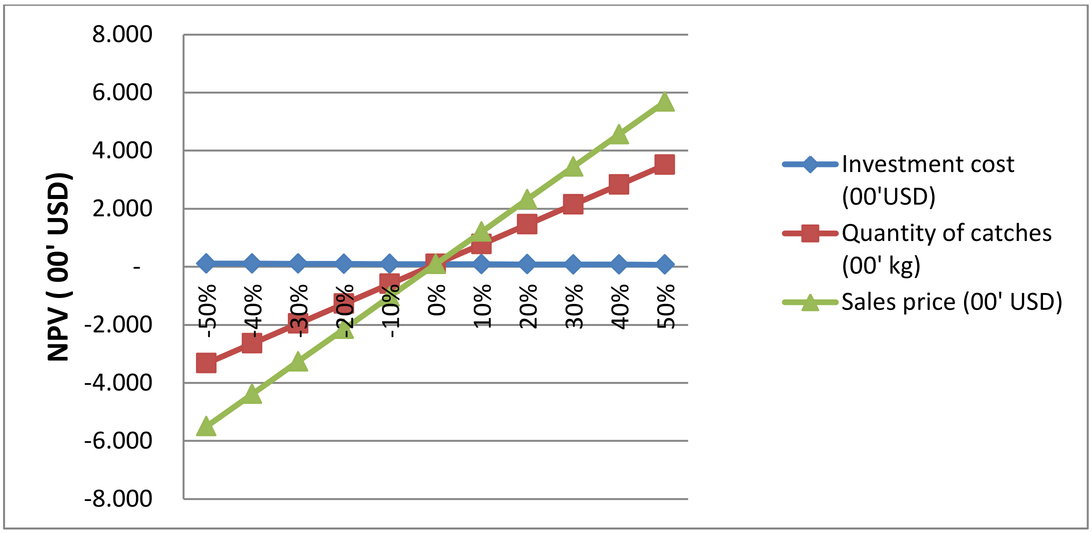

Figure 14: Sensitivity analysis chart on different % changes of cost, price (USD) and quantity of dagaa (kg) public project

5.6 Discussion

5.6.1 Reducing post-harvest loss of dagaa fisheries in Tanzania

The current rate of dagaa post-harvest loss was estimated to be 59% by the FAO study, and the use of drying racks could reduce this loss by half (FAO 2008).

Based on average catch per fisher for year (5 tons) for the individual fisher and 2,520 tons for a pilot district (500 fishers) in aggregate, the use of drying racks will lessen the post-harvest loss from 1139 USD (drying on ground) to 662 USD when drying on racks for the individual fisher and 57 thousands USD to 33 thousands USD for the pilot district (500 fishers). Drying racks are beneficial because they can reduce losses, decrease drying time and process a cleaner product of higher quality.

The construction of proposed dagaa drying racks may seem high for fishers, but this study revealed that investment cost per year is negligible when it is compared to the profits that will be gained. It is expected that the cost will be recovered quickly as losses will be lower and prices will be higher for the good quality products. If improvements are demonstrated by producing a good product, with reduced losses in a shorter time, then fishers will adopt the use of drying racks.

It was found that the net benefit for a private (individual) dagaa drying racks project will initially be low (142 USD/year), but it is anticipated to increase in the subsequent years at 145 USD per year. This is because the initial investment cost is also high. The analysis indicates that drying racks will offer fishers higher profit margins.

When operated at similar capacities, the overall project of the dagaa drying racks for a pilot district (500 fishers) will similarly give higher economic returns to the government. It has been documented that demand for the quality product is high and is driven by its principal markets of DRC, Zimbabwe, Zambia, Sudan, Rwanda and Burundi (Masette 2005). Consumers are willing to pay a premium price for a high quality product, therefore there are prospects of increasing sales price from 2.7 USD/kg (estimated in this study) to 4 USD/kg and make better profit.

The positive NPV further confirmed good financial performance, both for private (individual) benefits as well as for a pilot district (500 fishers) drying dagaa racks project. This strongly supports the proposal that the drying racks project is worthwhile and should be implemented in Tanzania. By using drying racks, dagaa post-harvest loss will be reduced, productivity will be increased and provide sustainable livelihood to fishers and processors, as well as increase regional trade and foreign exchange earnings for the national government.

Furthermore, the sensitivity analysis results indicated that the NPV of the drying racks project is heavily affected by changes in sales price. This is not surprising for the reason that when sales price is increased, the net benefit will be equally increased hence positive NPV.

On the other hand it was presented that the NPV of the drying racks project was not sensitive to change in investment and implementation costs. Percentages increase or decrease in investment and implementation costs had no effect on NPV. This suggests that fishers and government should not take investment and implementation cost as an obstacle for the project, but rather considers it as an attractive investment opportunity.

It is therefore anticipated that implementing the drying racks project will significantly support the fisheries sector in meeting one of its objectives stated in the national fisheries policy and strategic statement of 1997, which is ‘to put into efficient use of available resources in order to increase fish production’.

5.6.2 Limitations of this analysis

In the reduction of post-harvest loss some of the benefits are indirectly gained by a third party.

There were several intangible benefits in the analysis that were difficult to quantify in monetary terms, including improvement of food security, nutrition status to the society and contribution to employment.

The lack of accurate investment cost of dagaa drying racks was a problem that this analysis was not truly able to overcome. However, the framework of the analysis should enable one to come up with the exact cost of the two projects when precise figures are available.

There is conflicting information from data sources (the fisheries research institute and fisheries development division) on average dagaa catch for individual fisher per year. The study used conservative estimated average catch of 5 tons/fisher; this was according to the approximated catch for artisanal fishers for one year in Africa (Kolding *et al.* 2008).

5.7 Implementation time scale for proposed project to reduce post-harvest loss in Tanzania

The main objective of this study project is to propose cost effective management strategies to reduce post-harvest loss in the Lake Victoria dagaa fishery in Tanzania. Simple and cheap post-harvest technologies that build on fishers' own indigenous knowledge need to be developed and adapted to local conditions in order to reduce post-harvest losses by at least 50% during the 10 years of project implementation. The use of drying racks was recommended to meet the objective.

Effective participatory planning processes involving all legitimate stakeholders (dagaa processors, fishers, private sector and the Fisheries Department) need to be put into place and supported with appropriate legislation. Adoption of new technological innovation in dagaa processing hinges on how to promote a new technique in the dagaa processing method and how to increase at least proportionately the net benefits to all stakeholders involved in the fishery.

The overall goal of the implementation plan will be to contribute to food security and income improvement of fishers in Tanzania by reducing dagaa post-harvest loss.

To attain this goal, the following intermediate objectives are defined:

- Improve dagaa processing from drying the product on the ground to the use of new appropriate drying technology of drying racks.
- Strengthen/create professional organisations of fresh and dried dagaa traders.
- Mobilise human and other resources to assist the sector and utilise such resources effectively.
- Provide support to dagaa processors and traders to further develop their enterprises.

Time scale for the implementation plan will be in phases (stepwise). Table 10 shows the implementation stages with cost for the drying racks project.

The implementation plan will be organized into three stages: preparatory stage, implementation stage and monitoring and evaluation stage. It was identified that the preparatory stage in a pilot district will take five to six months. Time is needed for consulting local leaders and government authorities. Sensitisation and creating awareness by holding meetings and workshops will be done in selected villages/communities, as well as the operational plan will be set up to start the actual implementation.

It will require 1 to 2 years for the project to be implemented in a pilot district. Community mobilisation and awareness, as well as training in construction and use of drying racks will be done during actual implementation of the project. The implementation phase covering all communities will probably take anywhere from one to five years.

In the last stage of monitoring and evaluation, the retrospective assessment of project benefits and costs need also to be done, as it may play a part in this project by providing valuable information about the appropriate design of future projects (Figure 13).

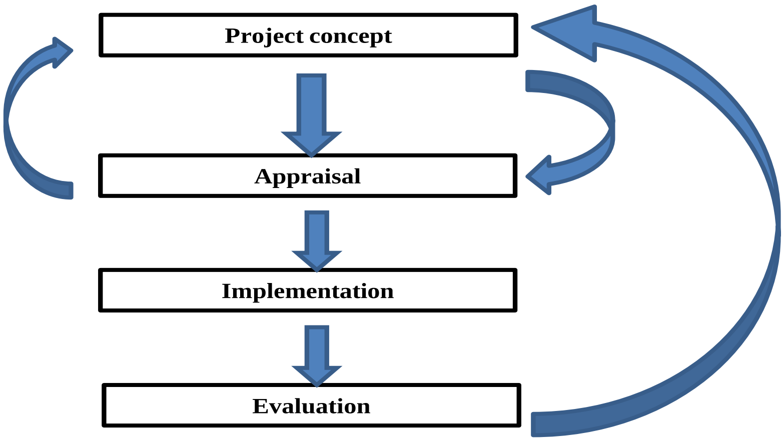

Figure 15: Project cycle assessment stages as a continuous process for drying on racks

The initial phase of implementation will involve 10 pilot fishing villages in a pilot district, followed by full scale implementation in all communities and fishing villages.

For successful diffusion and acceptance of these technologies by the communities, the following multidisciplinary approaches would be studied.

- Economic and social aspects

It is necessary to include data on variables such as earnings, employment, and contribution to food security and resource rent. Special care must be taken in defining and measuring income and profitability indicators for artisanal fisheries. It is essential to understand their needs, opportunities and constraints.

- Legal and regulatory aspect

This session is directed to decision makers in governments and agencies providing technical assistance in the formulation of policies to reduce dagaa post-harvest fishery losses and in requesting assistance to address the problem in the post-harvest field (Fegan 1994).

Tanzania fisheries policy (URT 1997) recognizes existence of several constraints in the fisheries sector, including poor fish handling practices and inadequate processing methods. The policy statement number 4 states the aim of the country on improving fisheries products utilisation and their marketability. Policy statement number 7 aims at encouraging and supporting all initiatives leading to the protection and sustainable use of fish stock and aquatic resources.

The reduction of post-harvest fishery losses, although a goal in itself, would best fit in these policy statements if directed toward maximising the utilisation of fishery resources for direct human consumption.

- Social-political aspect

Implementation of the dagaa salted sun-drying processing and drying racks project requires capacity building for the fishing communities in Lake Victoria: this is the key factor in the implementation of the technology. Under this circumstance, the Fisheries Development Division as a key partner will be responsible for fostering community awareness and sensitising communities, community leaders and other political leaders to the new processing method. It will also conduct training programmes for fishers, women and fisheries officials who will work with the communities.

- Socio-cultural aspects

Research has demonstrated the importance of social and cultural factors in the transfer of technology and information.

Many applied social scientists agree that effective programs of technology and information transfer consist of several interrelated steps: 1) development of a technology must be compatible with the existing traditional motor skills, beliefs, attitudes, and availability of capital, 2) communication of idea of the new technology to intended beneficiaries, and 3) recognition by the intended beneficiaries that the new technology will fulfil their livelihood needs (Chambers 1983).

The success of technological reduction of the dagaa post-harvest loss (PHFL) project depends on the effective transfer of technology and information and sustained use by the intended beneficiaries; hence, social and cultural factors must be accounted for in the design and implementation of the project.

- Financial implications

Project implementation is costly, and it will require funding for logistics to travel to the communities to create awareness, training and construction of racks and to transport the materials. A mutual understanding is required between the Fisheries Division, fishing communities, stakeholders such as non-governmental organisations and donor agencies that could provide training, technical and financial support.

- Monitoring and Evaluation

The Fisheries Division will be responsible for overall implementation, monitoring and evaluation. The retrospective assessment of the project may provide valuable information about the appropriate design of future projects (Morrisey 1988).

6. CONCLUSIONS AND RECOMMENDATION

Lake Victoria dagaa in Tanzania is traditionally processed by sun drying on the ground, on the grass, and mats or on old fishing nets. The process offers no protection to the product from rain, animals or contamination by insects, sand and dirt. As a result dagaa fishers suffer greatly from excessive post-harvest loss. In addition to the post-harvest loss experienced by fishers, the government is similarly affected by post-harvest loss through reduction of fisheries revenue, food insecurity, and unsustainable fisheries resource management. This is reflected in decline of fisheries sector contribution to GDP as well as to foreign exchange earnings (Mwambazi 1992).

Reducing post-harvest losses in artisanal fisheries will increase productivity, profitability and secure access of the dagaa fishery to local and regional markets. In future much needs to be done in Tanzania to reduce the high percentage of post-harvest losses, in quality and also in quantity.

The main objective of this study was to propose a cost effective management strategy to reduce post-harvest loss of the Lake Victoria dagaa fishery in Tanzania. Therefore cost and benefit analysis of dagaa drying racks, including public implementation cost, was done so as to determine its feasibility.

From the analysis it was found that the drying racks projects have positive NPV hence they are worthwhile to be implemented in Tanzania to reduce dagaa post-harvest loss. Also, the sensitivity analysis indicated that NPV is sensitive and is likely to be affected by changes in sales price while investment and implementation cost changes were found to have no impact on NPV.

For the project to be operational, it requires that all stakeholders (government officers, development practitioners, policy makers and local government leaders, etc.) have a common understanding on the matter and are involved in the decision making processes regarding loss reduction.

6.1 Suggestions and recommendation

Detailed implementation plans need to be developed for the proposed project to reduce post-harvest loss in the Lake Victoria dagaa fishery of Tanzania.

The fisheries development division should implement the use of drying racks to help the sector in realising the Millennium Development Goals of poverty eradication, food security and improved health.

Government and development agencies should set a comprehensive post-harvest loss, intervention fisheries related policy that covers the future development of the fishery.

Post-harvest loss assessments should be incorporated into national data collection systems and used to inform stakeholders.

Sun drying is weather dependent and most effective during the dry season. There is need to conduct a comprehensive value-chain analysis for technical innovation for development of new dagaa products. Use of low processing technologies like fermentation, smoking and deep frying would play a pivotal role in increasing profit margins for dagaa processors.

The government should revise the regulations of charging a levy per sack instead of per kg and the arrangement of charging transport cost by using sacks as units. The two arrangements tempt traders to over-pack the dagaa into large sacks and in the process they increase sizes of dagaa fragments which affect dagaa quality.

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APPENDICES

Post-harvest loss assessment of dagaa dried on ground and that dried on racks

Appendix 1: Estimated post-harvest loss of dagaa dried on ground (private) weight (kg) and price in USD

REASONS FOR LOSS	Total catch (Tons) /fisher/year		Output % after drying	Expected price in USD /(Kg)
Estimated dagaa landing/fisher	51	100	35	
Best Price				1.7
Reduced Price for low quality				1
Types of loss				
i).Physical loss	**Total annual % loss**	**Fresh wt.(kg)**	**Dry wt. (kg)Equivalent**	**Loss (USD.)**
Physical damage during fishing	0.9	459	161	273
Animal predation	2	1,020	357	607
Discarded after prolonged rain (nyambore)	4	2,040	714	1,214
Theft	0.1	51	18	30
Sinking sacks during transportation	0.7	357	125	212
ii).Quality loss				
Presence of by-catch	2.5	1,275	446	446
Quality degradation through rain	11	5,610	1,964	1,964
Change in colour before being sold	30	15,300	5,355	5,355
Fragments/ drying grass (chekencha)	8	4,080	1,428	1,428
Total	**59.2**	**30,192**	**10,567**	**11,529**

Appendix 2: Anticipated (private) post-harvest loss reduction after using drying racks

REASONS FOR LOSS	Total catch(Tons.)/fisher/year		Output % after drying	Expected price in USD/ (Kg)
Estimated catch (kg)/fisher	51	100	35	
Best Price				2.7
Reduced Price for low quality				1
Types of loss	% Reduction of post harvest loss			
i).Physical loss	**Total annual % loss**	**Fresh wt.(kg)**	**Dry wt.(kg) Equivalent**	**Loss in USD**
Physical damage during fishing	1	459	161	434
Animal predation	1	510	179	482
Discarded after prolonged rain (nyambore)	2	1,020	357	964
Theft	0	26	9	24
Sinking sacks during transportation	1	357	125	337
ii).Quality loss				
Presence of by-catch	2	765	268	268
Quality degradation through rain	6	2,805	982	982
Change in colour before being sold	14	7,140	2,499	2,499
Fragments/ drying grass (chekencha)	4	2,040	714	714
Total	**30**	**15,122**	**5,293**	**6,704**

Appendix 3: Post harvest loss of dagaa dried on ground in a pilot district (500 fishers) project (Government/public)

REASONS FOR LOSS	**Total catch(Tons.)/500 fisher/year**	**Fresh wt.(Tons.)**	**Dry wt. (Tons) Equivalent %**	**Expected price in USD/ (Tons)**
Estimated catch (Tons)/500 fisher/year	25,500	100	35	
Best Price				1.7
Reduced Price for low quality				1
i) Physical losses				**Loss in 000' USD**
Physical damage during fishing	0.9	2,295	803	1,366
Animal predation	2	5,100	1,785	3,035
Discarded after prolonged rain	4	10,200	3,570	6,069
Theft	0.1	255	89	152
Sinking sacks during transportation	0.7	1,785		1,062
ii).Quality losses			-	-
Presence of by-catch	2.5	6,375	2,231	2,231
Quality degradation through rain	11	28,050	9,818	9,818
Change in colour before being sold	30	76,500	26,775	26,775
Fragments/ drying grass	8	20,400	7,140	7,140
Total	**59**	**150,960**	**52,836**	**57,647**

Appendix 4: Anticipated post-harvest loss reduction after using drying racks in a pilot district (500 fishers) (Government/public)

REASONS FOR LOSS	**Total catch(kg)/500 fisher/year**	**Fresh wt.(Tons.)**	**Output after % drying**	**Expected price in USD/ (Kg)**
Total catch(kg)/500 fisher/year	25,500	100	35	
Best Price				2.7
Reduced Price for low quality				1
i).Physical losses	Total annual % of loss		Dry wt.(kg) Equivalent	Loss in 000' USD
Physical damage during fishing	1	2,295	803	2,169
Animal predation	1	2,550	893	2,410
Discarded after prolonged rain	2	5,100	1,785	4,820
Theft	0	128	45	120
Sinking sacks during transportation	1	1,785	625	1,687
ii).Quality losses				
Presence of by-catch	2	3,825	1,339	1,339
Quality degradation through rain	6	14,025	4,909	4,909
Change in colour before being sold	14	35,700	12,495	12,495
Fragments/ drying grass	4	10,200	3,570	3,570
Total	**30**	**75,608**	**26,463**	**33,518**

Cost-benefit analysis for the drying on racks.

Appendix 5: Drying racks public project in a pilot district (500 fishers) cost and benefit analysis for ten years.

Drying on racks public project	**YEAR**									
COST/USD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Investment cost for 1500 racks	4,900	7,400	11,100	14,800	18,500	22,200	25,900	29,600	33,300	37,000
Capital cost for 1500 racks	843	1,273	1,909	2,546	3,182	3,818	4,455	5,091	5,728	6,364
Implementation cost	636,225	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Total cost	641,968	20,673	25,009	29,346	33,682	38,018	42,355	46,691	51,028	55,364
BENEFIT/ USD										
Benefit using drying on racks	73,475	146,950	220,425	293,900	367,375	440,850	514,325	587,800	661,275	734,750
Benefit drying on ground	49,630	99,260	148,890	198,521	248,151	297,781	347,411	397,041	446,671	496,301
Taxes	10,984	21,967	32,951	43,934	54,918	65,901	76,885	87,868	98,852	109,835
Total Benefits	34,828	69,657	104,485	139,314	174,142	208,970	243,799	278,627	313,456	348,284
Net Benefit	-607,139	48,984	79,476	109,968	140,460	170,952	201,444	231,936	262,428	292,920
Present Value	-518,037	35,661	49,369	58,285	63,521	65,964	66,323	65,155	62,902	59,906
NPV	**9,049**									

Sensitivity analysis

Appendix 6: Sensitivity analysis table of drying racks (public) project (NPV) under different assumptions of investment cost, price and quantity of catch

NPV	460				
% changes	Investment cost	% changes	Quantity of catches	% changes	Sales price
-50%	509	-50%	110	-50%	-1,355
-40%	499	-40%	180	-40%	-992
-30%	489	-30%	250	-30%	-629
-20%	479	-20%	320	-20%	-266
-10%	469	-10%	390	-10%	97
0%	460	0%	460	0%	460
10%	450	10%	530	10%	822
20%	440	20%	600	20%	1,185
30%	430	30%	670	30%	1,548
40%	420	40%	739	40%	1,911
50%	411	50%	809	50%	2,274

Appendix 7: Sensitivity analysis table of drying racks (public) project (NPV) under different assumptions of investment cost, implementation cost, price and quantity of catch

NPV	9,049						
% changes	Investment cost	**% changes**	Quantity of catches	**% changes**	Implementation cost	**% changes**	Sales price
-50%	11,139	-50%	- 332,681	-50%	280,476	-50%	- 549,913
-40%	10,721	-40%	- 264,335	-40%	226,190	-40%	- 438,121
-30%	10,303	-30%	- 195,989	-30%	171,905	-30%	- 326,329
-20%	9,885	-20%	- 127,643	-20%	117,620	-20%	- 214,536
-10%	9,467	-10%	- 59,297	-10%	63,334	-10%	- 102,744
0%	9,049	0%	9,049	0%	9,049	0%	9,049
10%	8,631	10%	77,395	10%	- 45,237	10%	120,841
20%	8,213	20%	145,740	20%	- 99,522	20%	232,634
30%	7,794	30%	214,086	30%	- 153,808	30%	344,426
40%	7,376	40%	282,432	40%	- 208,093	40%	456,218
50%	6,958	50%	350,778	50%	- 262,378	50%	568,011