IMPROVING LIVELIHOOD SECURITY AND GENDER RELATIONS IN RURAL ZAMBIA AND MALAWI THROUGH POST – HARVEST FISH VALUE CHAIN INNOVATIONS AND SOCIAL CHANGE INTERVENTIONS

Short Title
IMPROVING FISH POST HARVEST MANAGEMENT AND MARKETING IN MALAWI AND ZAMBIA

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Location of Study: Lake Chilwa, Zomba, Malawi
Mongu, Nalolo and Senanga in Zambia

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ACRONYMS

ACIAR	Australian Centre for International Agriculture Research
AGRF	African Green Revolution Forum
BITEC	Bangkok International Trade and Exhibition Center
CCTV	Closed Circuit Television
CHANCO	Chancellor College
DOF	Department of Fisheries
EBAFOSA	Ecosystem based adaptation for food Security in Africa Assembly
EFLAM	Exploratory Fish Loss Assessment Method
GAF6	Gender in Aquaculture and Fisheries
GMA	Gross Margin Analysis
GTC	Gender Transformative Communication
HSSREC	Humanities and Social Sciences Research Ethics Board
ICT	Information and Communication Technologies
IDRC	International Development Research Centre
IFPRI	International Food Policy Research Institute
JKUAT	Jomo Kenyatta University of Agriculture and Technology
LCBCCAP	Lake Chilwa Basin Change and Adaptation Project
LUANAR	Lilongwe University of Agriculture and Natural Resources
MBC	Malawi Broadcasting Corporation
MFL	Ministry of Fisheries and Livestock
NCST	National Commission for Science and Technology
NGO	Non-Governmental Organisation
PAR	Participatory Action Research
PNA	Practical Needs Approach
QLAM	Quantitative Fish Loss Assessment Method
UNIMA	University of Malawi
UNZA	University of Zambia
WEAI	Women Empowerment in Agriculture Index
WEFI	Women Empowerment in Fisheries Index
ZANIS	Zambia National Information Services
ZCCP	Zambia Center for Communication Programme
ZNACS	Zambia National Agriculture and Commercial Show
ZNBC	Zambia National Broadcasting Corporation

1.0 EXECUTIVE SUMMARY

The project **IMPROVING FISH POST HARVEST MANAGEMENT AND MARKETING** was piloted in Barotse Floodplain of Zambia and Lake Chilwa in Malawi and was coordinated by the Department of Fisheries (DOF), Ministry of Fisheries and Livestock (MFL) of Zambia. Partners on the project included the University of Zambia (UNZA) and University of Malawi (UNIMA). Others included the WorldFish and Nono Enterprises as third party partners. The overall project objective is to identify and evaluate interventions to improve livelihood security and gender relations through post-harvest fish value chain innovations. The project is determining losses in post-harvest fish biomass, economic value and nutrient content. The project is also adopting innovative, participatory approaches to identify, prioritize and pilot technological and social change interventions to improve livelihoods and gender relations and optimize the performance of fish value chains from a range of perspectives – economic, technical, gender equality and food and nutrition security. The project is further addressing the root causes of women's perpetual position in lower-earning nodes of the value chains.

The project developed and piloted interventions aimed at reducing fish losses, through Participatory Action Research (PAR) groups. In order to estimate the biomass losses, and understanding people's experiences and attitudes around such losses a baseline survey was conducted using Exploratory Fish Loss Assessment Method (EFLAM) and a Quantitative Fish Loss Assessment Method (QLAM) as tools to collect data on physical losses. To understand the profitability of the fish value chain in both project sites, the gross margin analysis (GMA) tool was developed and administered.

In Zambia, the project partners together with the stakeholders selected the breams (*Oreochromis* and Tilapia spp), catfish and *Marcusenius* spp (bulldog) while *Oreochromis* spp (Makumba) and catfish were the only fish groups chosen in Malawi since there are in abundance. Technologies with the potential to reduce fish loss were identified for piloting in 6 fishing camps Barotse Floodplains in Zambia, (Nebubela, Tangatanga, Matula, Marana, Liyoyelo and Mukakani) and Mchenga fishing camp was the only site in Malawi. The fish processing technologies were (solar drying, smoking and salting) and the provision of access to cold chain facilities (use of ice and freezing facilities). Seventeen (17) Participatory Action Research (PAR) groups were formed in six (6) sites in Zambia and 134 men and 81 females were trained in the identified interventions.

To understand the demographic information regarding the fishing communities, a household survey was conducted in Zambia and Malawi. The average household size found was 4.9 persons although this ranged from 3.9 to 5.3 persons per household in the fishing villages. Results also showed that the fishing camps were dominated by fishers that represented 61.5% followed by the traders at 21.9%. Fishing is mainly conducted by the men (98.1%), while processing and trading were dominated by the women folk at 82.1% and 81.1% respectively.

In Zambia, the study found that physical fish losses occur at all the three nodes in the value chain and differ significantly ($P < 0.05$) between nodes. On average, the processors lose the largest volume of fish (7.42%) followed by the fish traders (2.9%). The fishers experience the least

physical losses at 2% although this is not significantly different ($P > 0.05$) from the fish lost at trading node. The major cause of physical loss was found to be breakages at processing and trading nodes. Women processors lost over three times the weight of their fish consignments than men processors indicating that it is not only the function of processing that leads to losses but that gendered differences exist within the nodes too. The gender-specific data results suggest women are functioning within (and outside) a relatively gender unequal value chain which creates an environment that lacks the support women might need to especially process higher-quality fish with minimal losses. In Lake Chilwa, the major cause of fish losses at processing node is over burning, followed by breakages. At trading node, breakage contributes the highest at 52.3%. The magnitude of fish losses vary along the vale chain with the processors having the highest losses estimated at 21.1% followed by the traders at 12.8%. Gross Margin (GM) results, showed that improved processing technologies and methods reduce fish losses significantly and consequently improving the income of the actors. Fish processors are able to reduce their losses to 10% while traders can reduce to 5.9%.

A Gender Transformative Communication (GTC) tool was piloted in Zambia using drama skits during the project implementation. Overall, there was a 28.6% increase in gender attitude scores for those who participated in the drama skits ($p < 0.0001$) versus a 11.7% for those who did not participate ($p = 0.0286$). There was a 35.7% increase ($p < 0.0001$) in gender attitude scores of men who participated in the drama skits, while gender attitude scores of men who did not participate increased by 13.3% (not statistically significant). Women who participated in the drama skits increased their involvement in fishing from baseline (5%) to endline (75%). Women who made large contributions to intra-household decisions regarding fish processing and the associated income generated from processing increased by 30% ($p = 0.0392$) and 49% ($p = 0.0025$), respectively for those women who participated in the drama skits.

Results on the nutrient composition of the fish indicate that the processed fish had protein levels of 32.2±0.14 to 55.8±0.40 (processed whole milled fish) and 31.9±0.42 to 43.1±0.82 % for the processed milled fillets. Fat content fresh whole milled fish had significantly higher ($P < 0.05$) fat content than the flesh only. Solar tent dried Matemba had significantly lower ($P < 0.05$)amount of fat (18.7±1.01%) as compared to open sun dried Matemba (26.6±2.56%) and this may be attributed to fact that oil may exude with moisture loss during drying in the solar tent driers as temperatures were higher in the solar tent driers than in open sun drying. Improved kiln smoked fish (catfish and Oreochromis spp) had significantly higher protein content ($P < 0.05$) 47.6±1.15 to 62.4±0.27% than the traditional smoked fish 38.3±1.67 to 53.7±1.03%. The moisture content for catfish had no significant differences whereas there were significant differences in moisture content for open sun dried and solar tent dried Matemba 30.4±2.03 and 23.3±1.13% respectively ($P < 0.05$). Overall, the fresh fish groups had significantly higher ($P < 0.05$) amounts of vitamin A than their processed fish counterparts. This was possibly due to the heat labile nature and also possible oil drip loss during the smoking period with *Clarias* spp having the highest level of vitamin A in both the fresh and processed fish samples. Sensory evaluation showed no significant differences ($P > 0.05$) between the fish processed using the improved technologies and traditional processing methods.

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2.0 THE RESEARCH PROBLEM

The fish resources of Africa are not achieving their potential to reduce poverty and improve food and nutrition security. Fish is the most important source of animal protein and contains a number of important micronutrients for many, especially poor, consumers (Beveridge *et al.* 2013). While per capita fish supplies will increase in most of the world over the next two decades, the supply/demand gap in Africa is widening rapidly. A 20% fall in per capita supply is anticipated, aggravating what is already the lowest regional supply in the world (World Bank 2013; http://bit.ly/1iE1Eiw). Addressing post-harvest losses and mismanagement, which together result in annual losses of $2 to $5 billion in sub-Saharan Africa (Béné 2011), offers an important means to address the issue. Post-harvest handling losses in nutrient content are also poorly understood, unrecognized in policy, and weaken the role that fish plays in the food and nutrition security of the most vulnerable (Longley *et al.* 2014). In Malawi and Zambia there are indications that gender norms and power relations constrain women's participation and securing of equitable benefits in fish value chains, further weakening the role that fish plays in economies at household, community and regional levels.

The project was implemented in two geographically distinct areas (Lake Chilwa in Malawi and the Barotse flood plain in Zambia), both heavily dependent on fish for income and food and nutrition security and where post-harvest losses of fish are important. However, two study areas differ in fish value chain structure, post-harvest technologies, and social and cultural contexts, offered strong opportunities for lesson learning and sharing.

The overall project objective was to identify and evaluate interventions to improve livelihood security and gender relations through post-harvest fish value chain innovations. The project determined losses in post-harvest fish biomass, economic value and nutrient content. The project adopted, participatory approaches to identify, prioritize and pilot technological and social change interventions to improve livelihoods and gender relations and optimize the performance of fish value chains from a range of perspectives – economic, technical, gender equality and food and nutrition security. The project further went into investigating the root causes of women's perpetual position in lower-earning nodes of the value chains.

Key research questions:

- How much fish is lost and what is the economic cost?
- What nutrients are lost during post-harvest handling and processing?
- Furthermore, what gender norms and power relations constrain women's engagement in fish value chains and how can these be effectively addressed?

Due to some differences in the value chain structures of Lake Chilwa in Malawi and the Barotse Floodplain in Zambia, technologies implemented were different. For instance the Barotse Floodplain floods on regular basis thereby imposing temporal fishing villages, while Malawi has large and permanent villages. Therefore, the permanent and large processing technologies are suited for Malawi while small and simple structure technologies are ideal for Barotse Floodplain in Zambia.

3.0 PROGRESS TOWARDS MILESTONES

3.1 Validate and implement results of gendered value chain

Milestone: Results of the gendered value chain analysis are shared and implemented
The baseline data on the assessment of the technical and social processing and social relations in both Lake Chilwa and Barotse Floodplain was collected and analysed. The information was shared in both international and local conferences for both countries. In Zambia, the project exhibited at the Zambia National Agriculture and Commercial Show (ZNACS) held from 27th July to 1st August 2016 in Lusaka. In Malawi, the project exhibited at the National Agriculture Fair in Blantyre from 8th to 10th September 2016 and at the Ecosystem based adaptation for Food Security in Africa Assembly (EBAFOSA) held on 6th June 2016 in Lilongwe. During this EBAFOSA meeting the President of the Republic of Malawi and Minister of Energy and Environmental Affairs interacted with the processors and received a sample of the products of the project. The project further made presentations at the 6th Global Symposium on Gender in Aquaculture and Fisheries (GAF6) Special Symposium at the 11th Asian Fisheries and Aquaculture Forum, Bangkok, Thailand from 3rd to 7th August 2016 at Bangkok International Trade and Exhibition Center (BITEC), Thailand. Another presentation was made at the side event organised by the International Development Research Centre (IDRC) during the African Green Revolution Forum (AGRF) conference in Nairobi, Kenya on 5th September 2016. The project also made a presentation at the policy, nutrition and trade workshop that was held at Chita Lodge in Kafue, Zambia from 17th to 18th March 2016.

The results of the baseline information demonstrated that there is need to: 1) target the processing node in the value chain to reduce losses and improve the quality of fish being processed; 2) pilot women-sensitive technologies that help decrease time and labor burdens of women; and 3) design and test social change interventions (for example the communication for behavior change) that highlight gendered roles and power relations in the value chain, and in particular within the processing node. The baseline data results thus informed the development of the loss-reducing processing technologies, the nature and content of the Gender Transformative Communication (GTC) tool (dramas) and the broader reflection sessions in Participatory Action Groups.

3.2 Evaluate social and technical innovations for their technical and economic feasibility

Milestone: Model/framework for evaluation of technologies developed and implemented
Two types of technologies were tested during the project cycle: the first was focusing on physical loss reducing technologies, and the second focusing on social change innovations (GTC) and Theatre for Change). In Barotse Floodplain, the project opted to use a load tracking method to trace consignments of fish as they were processed by women and men using the new/introduced and "traditional" processing technologies. The framework to evaluate the social change innovation in Barotse Floodplain is two-fold: 1) baseline and endline data on empowerment (decision making) using the WEFI; and 2) short gender attitude surveys were administered before and after each GTC session (in the three focal camps—Liyoyelo, Mukakani and Tangatanga).

Milestone: Most promising, locally acceptable innovative technologies agreed by target communities, implemented and evaluated
The promising and locally acceptable technologies being implemented were selected and profiled in both countries. These technologies or interventions included; the smoking kiln, salting, solar drying and the use of ice.

3.3 Disseminate information on fish handling and processing technologies and social change interventions

Milestone: Smallholder fisher folk and other stakeholders are aware of social change interventions and are implementing them
The GTC in Barotse Floodplain included: 1) gender training for a select group of PAR participants and DOF officers, which certified 27 gender activists from the three fishing camps where the GTC was implemented and 9 DOF officers); 2) mobile videos that showcased people/couples going through gender transformative change were shown in the three fishing camps to kick-start the GTC intervention; and 3) the three GTC sessions (dramas + critical reflection) carried out by a local NGO partner the Zambia Center for Communication Programmes (ZCCP).

Gender training was conducted for four PAR groups and theatre for development was used in Malawi to enhance adoption and care of solar tent driers and improved smoking kilns. Issues on how the improved technologies help reduce work load amongst participants especially women were discussed**.**

3.4 Conduct consumer and economic studies

Milestone: Acceptability of new fish products determined and documented
The survey on the acceptability of the fish products was conducted in Zomba, Malawi. Eighty three (83) panelists volunteered to participate and were involved in consumer sensory evaluation while 30 from the same group carried out difference test. These people were screened for product (fish) use and a brief description of what is involved in sensory evaluation.

In Zambia to determine knowledge, preferences, processes and cooking methods of fish a sensory evaluation was conducted in Lusaka, Mongu and Senanga districts with a total of 240 panelists. Three tests were applied namely: 9 Point hedonic test, Triangle test and Cooked and Visual test.

Figure 1: Panelists conducting sensory evaluation in Zambia

Milestone: Analysis of effectiveness of new fish processing and handling technologies on economics, fish biomass, nutritional content and shelf life
The data on the economics, fish biomass, nutritional content and shelf life were collected in August and September 2016. The report on biomass loss and gross margin in Gendered Value Chain analysis of post – harvest fish losses in the Barotse Floodplain, Zambia has already been submitted.

3.5 Identify potential for scale – up of social and technical innovations

Milestone: Social and technical innovations with potential for scale up identified and disseminated to different stakeholders
The social and technical innovations for potential scale – up have been identified and disseminated to the stakeholders during exhibitions and conferences within and outside Zambia. The technical interventions include the solar dryers, salting, chorker kilns and cold chain.

Milestone: Analysis of effectiveness of gender and social innovations on changing gender dynamics and power relations along the value chain completed
In mid-2015, the project modified the Women's Empowerment in Agriculture Index (WEAI, Uganda abridged version), which is a survey-based index that measures the state of empowerment and gender parity in the broad agriculture sector, identifies areas that empowerment-focused interventions could be strengthened, and enables projects to track progress implementing their interventions over time. WEAI measures the roles and extent of women's engagement in agriculture in five domains: decisions about agricultural production, access to and decision-making power over productive resources, control over use of income, leadership in the community, and time use. It also measures women's empowerment relative to men's within their homes. See Alkire et al. (2013), Sraboni, Quisumbing, and Akhter (2013) for more information on the WEAI.

The project partnered with Zambia Center for Communication Programmes (ZCCP) to develop the social innovation, which is a communication tool grounded in empowerment education and

transformative learning theory and comprises a manual and drama skits (three total) on gender-related issues in the natural fishery value chain. .

3.6 Disseminate results and promote uptake

Milestone: A local and commercial supply chain for fish handling and processing technologies is implemented

The local supply for ice was established within the project with Nono Enterprises the private partner on the project supplying the ice in all the project sites. Fishers have formed groups that are in contact with the suppliers of ice to deliver. The suppliers are only paid after the fish is sold. Furthermore, the traders of fresh fish who are near the ice plants take the fish for freezing to the established cold rooms.

Working with the African Entrepreneurship Hub (AEH) on the AIRBO Project, youth groups or individuals were identified to be suppliers of the materials for the technologies being implemented in both countries. The support was directed to cold chain, processing technology equipment or materials such as those for solar tent dryers or Information and Communication Technologies (ICTs) in linking up fishers to markets or logistics in the fish value chain.

Milestone: Stakeholders are made aware of fish biomass, economic and nutrient losses and gender issues within fish value chains and how to address these

The baseline fish biomass, economic and nutrient losses were disseminated through the exhibition at the national shows and AGRF conference. The project also attended the 6th Global Symposium on Gender in Aquaculture and Fisheries (GAF6) Special Symposium at the 11th Asian Fisheries and Aquaculture Forum, Bangkok, Thailand from 3rd to 7th August 2016 at Bangkok International Trade and Exhibition Center (BITEC), Thailand. At this conference a paper "A gendered value chain analysis of post-harvest losses in Barotse Floodplain, Zambia" was presented. Furthermore, the project aired the programmes on both radio and Television on the Zambia National Broadcasting Corporation (ZNBC), Chancellor College (CHANCO) radio and TV, Malawi Broadcasting Corporation (MBC) radio and TV. Zambia National Information Services also covered the project extensively. Furthermore, the project was also aired programmes on radios in Mongu, Zambia and Malawi.

The following programmes were broadcast on ZNBC:

1. Packaging technology in the Barotse Floodplains (Silozi Radio Programme)
2. Fish Traders' experience – Learning to reduce post-harvest fish losses (Silozi Radio Programme)
3. Adopting solar tent drying and salting technologies (English Radio Programme)
4. Fish processing using Chocker Kilns (Silozi Radio Programme)
5. Salting Fish to preserve good Quality (Silozi Radio Programme)
6. Viable Business funding in the Barotse Floodplains (English Radio Programme)

In Zambia, the project exhibited at the ZNACS held from 27th July to 1st August 2016 in Lusaka. In Malawi, the project exhibited at the National Agriculture Fair in Blantyre from 8th to 10th September 2016 and at the EBAFOSA held on 6th June 2016 in Lilongwe, Malawi.

The project furthermore posted project progress and activities on its blog (www.fishmalawizambia.wordpress.com) and tweeter account (@fishmalawizam) to share progress and results of the project. The project has also attracted media houses such as Reuters News Agency, Aljazeera News Network and the Closed Circuit Television (CCTV) and Inter Press Service (IPS) (http://www.ipsnews.net/2015/11/improved-post-harvest-fish-handling-brings-hope-to-western-zambia/).

3.7 Conduct end of the project evaluation

Milestone: Changes in incomes, fish consumption and gender norms are documented
The project conducted studies to track the changes in incomes, fish consumption and gender norms (Refer to 3.2). In Malawi, an endline study was conducted to establish the changes that have been manifested and the report is attached in annex I. However, in Zambia this was not done because by the end of the project, the sites were flooded with water and the fishing activities had not begun.

3.8 Dissemination of the results

Milestone: Stakeholders including fisher folk, consumers, policy makers and scientific community access information on technologies and social innovations
The project published a paper and posted it on its tweeter account and blog. The title of the paper is Socio-Economic determinants of profitability of capture fisheries trade in Barotse floodplain of Zambia which was published in the International Journal of Fisheries and Aquatic Studies.

The project has also submitted the following manuscripts:

- Physical losses of fish along the value chain in Zambia: a case study of Barotse floodplain. *International Journal of Fisheries and Aquaculture* (Annex II)
- Fish losses for whom? A gender assessment of post-harvest fish losses in the Barotse Floodplain, Zambia. The paper will be submitted to the *Fisheries Research* Journal (Annex III)
- Combing technical and social innovations to enable a shift in pathway out of the social-ecological trap in the Barotse Floodplain fishery, Zambia. *Ecology and Society*. This paper will also be presented at the Resilience 2017 conference in Stockholm (http://resilience2017.org/) (Annex IV)
- A review of post-harvest fish loss assessments: a case study of a novel participatory technology evaluation from the Barotse Floodplain fishery, western Zambia. This will be submitted to *Agriculture and Food Security* (Annex V)
- Gender transformative change along the natural fishery value chain: Panel evidence from the Barotse Floodplain, Zambia. The paper will be submitted to the *Agricultural Systems*.
- Modern methods of fish processing can help reduce postharvest losses and increase rural incomes and food security in sub-Saharan Africa. The paper has been submitted to the *Food science and nutrition Journal* (Annex VI)

Furthermore, the project supported three Master of students at the Jomo Kenyatta University of Agriculture and Technology (JKUAT), Nairobi, Kenya and the Lilongwe University of Agriculture and Natural Resources (LUANAR). The following theses have been produced:

- Profitability and post-harvest loss assessment along key fish value chain associated with Barotse Floodplain, Zambia

- Nutritional and microbial quality of fish *(Clarias gariepinus, Barbus paludinosus* and *Oreochromis shiranus chilwae)* using different processing methods
- Sensory characteristics of traditional smoked, improved kiln smoked, solar tent dried and open sundried fishes of Lake Chilwa.

The project held the dissemination workshops in Malawi on 6th June 2017 in Mangochi District while in Zambia the same was held on 21st June 2017 as shown in Annex VII. The dissemination was covered widely by the media and the results were disseminated through the radio, TV (ZNBC) and print media (*Times of Zambia*)

3.7 Project and research management

Milestone: Technical and financial report finalized

The project updates and financial reports respectively, were prepared and submitted timely during the project cycle.

4.0 SYNTHESIS OF RESEARCH RESULTS AND DEVELOPMENT OUTCOMES

4.1 Objective 1 participatory gendered fish value chain analyses

The baseline and endline surveys were conducted to estimate the biomass losses, costs and profits margins, people's experiences and attitudes around such losses. An Exploratory Fish Loss Assessment Method (EFLAM) was administered to generate qualitative and indicative quantitative post-harvest fish losses data. The data collected was used to plan for the quantitative assessment methods and the Quantitative Fish Loss Assessment Method (QLAM). The QLAM involved interviewing fish value chain actors. A total of 385 fishers, processors and traders responded to the administered aforementioned data tools. Women's Empowerment in Fisheries Index (WEFI) was used to collect data on the women's and men's decision-making powers, access to productive assets and fisheries extension services, time allocation, and gender attitudes was administered in the six fishing camps (Tangatanga, Marana, Nebubela, Matula, Liyoyelo and Mukakani) to 150 respondents. Results and discussion of the surveys are presented below.

4.1.1 Physical losses and causes of fish losses along the value chain

The study found that physical fish losses occur at all three nodes in the value chain and differ significantly ($P < 0.05$) between the nodes. On average, the processors lose the largest volume of fish (7.42%) followed by the fish traders (2.9%). The fishers experience the least physical losses at 2% although this is not significantly different ($P > 0.05$) from the fish lost at trading node. The major cause of physical loss was found to be breakages at processing and trading nodes. In conclusion, there is need to introduce improved processing technologies that can reduce breakages. Furthermore, economic and nutrient losses should also be profiled to fully understand the total losses that occur within the Barotse Floodplain value chain. The survey revealed that fishers experience major fish losses through spoilage (45.5%) while breakages (63.6%) were their major cause of fish losses as indicated by the processors and for traders they experience fish loses through both spoilage and breakages. The high fish loss through spoilage could be as a result of lack of ice and insulated transportation system by the fishers and traders respectively.

Table 1: Percent physical losses (Mean±SD) of fish along the value chain

Node	Fish loss (%)	Minimum (%)	Maximum (%)
Fishing	2.03±7.70[a]	0	50
Processing	7.42±12.73[b]	0	50
Trading	2.87±8.26[a]	0	50
Total	2.03±7.70	0	50

Values with superscripts in a column are significant different ($P < 0.05$)

Causes of fish physical losses at fishing node along the value chain

The reasons for the losses mentioned were spoilage, squashing due to poor handling and pest infestation.

Causes of fish physical losses at processing node along the value chain

Three major causes of physical fish losses were identified by the processors. The study revealed that breakages contributed significantly ($P < 0.05$) to the fish losses. Of the sample, 72.2% of the respondents indicated breakages as the main reason for loss whilst 19.4% attributed the losses to spoilage, although this was not significant different ($P > 0.05$) from pest infestation x%) (Figure 2).

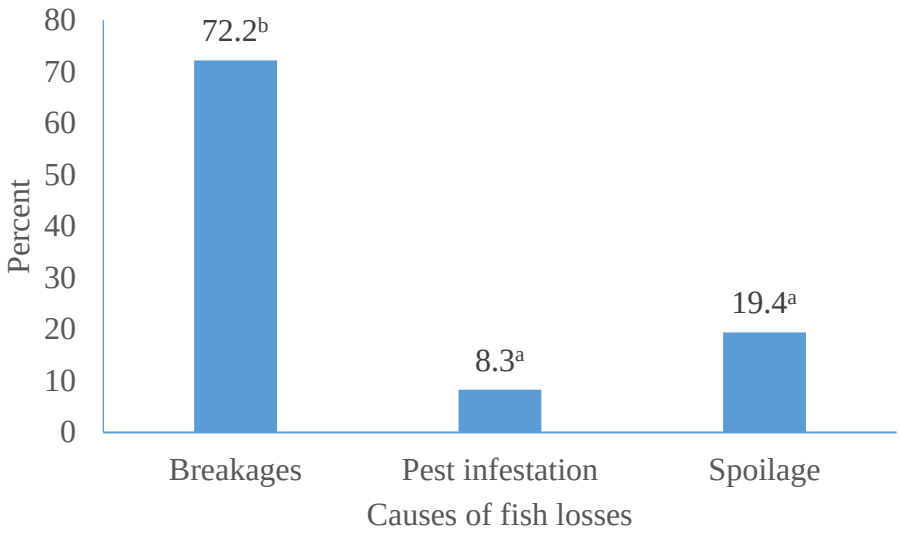


Figure 2: Causes of fish losses at processing along the value chain (values with superscripts at the top of the bars are significant different ($P < 0.05$))

Causes of fish physical losses at trading node along the value chain

The survey revealed that there were only two causes of fish losses during trading and these were breakages and spoilage. Although there were no significant differences ($P > 0.05$) between the two causes of fish loss, the former (58.2%) contributed more to losses than the latter (41.8%).

In Lake Chilwa, the highest fish losses at processing node is incurred through over burning the fish followed by breakages. This could be as a result of poor processing methods coupled by lack of information on the time of processing and amount of firewood. At trading node the major cause

of fish losses is breakage probably due to poor processing methods done by the processors (Figure 3).

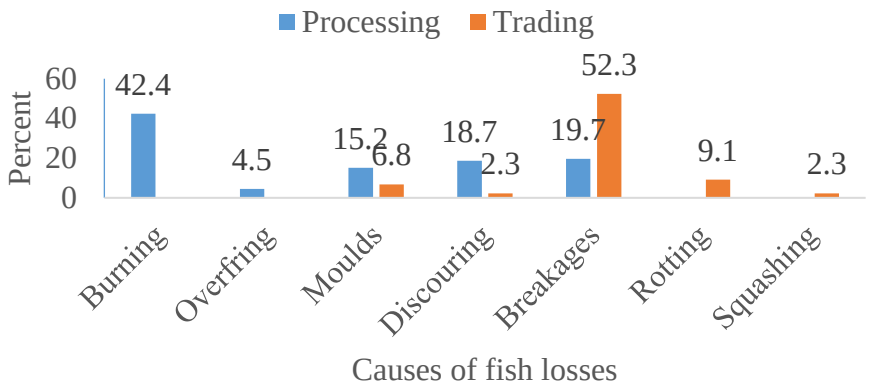


Figure 3: Causes of fish losses in Lake Chilwa

4.1.2 Physical losses of fish along the value chain

The baseline survey results showed that physical losses are as high as 38% cumulatively along the value chain. The most hit value chain node being processing at 21%. By imploring the improved processing methods, fish physical losses reduce significantly. Fishers are able to reduce losses from 4.1% to 3.3%, processors record a decline from 21.1% to 10% while traders reduce the losses from 12.8% to 5.8%. Cumulatively, the physical losses are able to decline from 38% to 19.3% by applying the new piloted technologies of improved smoking kilns, salting, use of ice and solar tent drying. The reduction in fish physical losses implies an increase in fish consumption levels without necessarily increasing in fishing pressure (Figure 4).

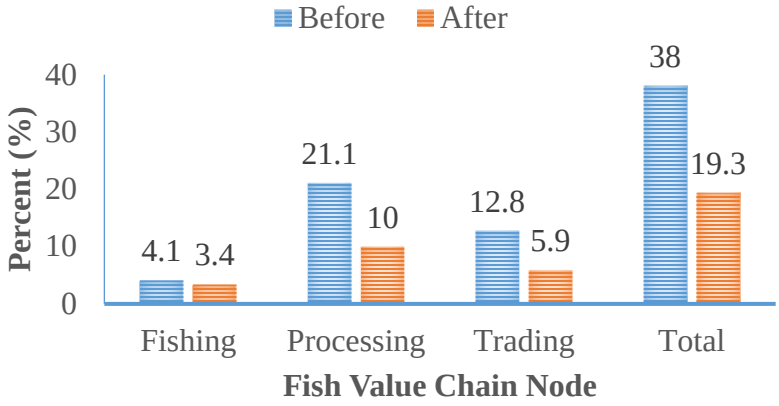


Figure 4: Physical losses in fish along the fish value chain nodes in Barotse Floodplain

4.1.3 Gross Margin Analysis (GMA)

The gross margin (GM) analysis was employed to determine the profitability of the fishing industry at every node in the pilot sites. This was done by analysing the total income less the direct and variable costs (expressed as a percentage) at every Fish Value Chain Node. Gross margin analysis results showed that implementation of both technical and social change interventions can significantly improve the profitability of the actors within the fish value chain. This is because the

GM of the people involved increased by utilising the improved technologies without necessarily increasing the fish prices but by reducing the losses that they incur during fishing, processing and trading. The processors increased their GM from 4.7% to 25.26% while traders increased to 25.3% from 22.8% (Figure 5). However, processing is the least profitable activity along the value chain due to many direct costs. Fishing still remains the most profitable node along the value chain because it does not involve direct costs such as transport or storage as they try to offload fish onto processors and traders. They also do not buy fish and only have marginal labour costs. Although men sold on average larger amounts of fish (42.67 kg) compared to women (21.76 kg), the latter fetched a slightly higher price per kilogram at ZMW27.83/kg compared to men at ZMW25.79/kg. As a result, women traders were slightly more profitable with a gross margin of 13.79% compared to men at 12.21 percent (Figure 5).

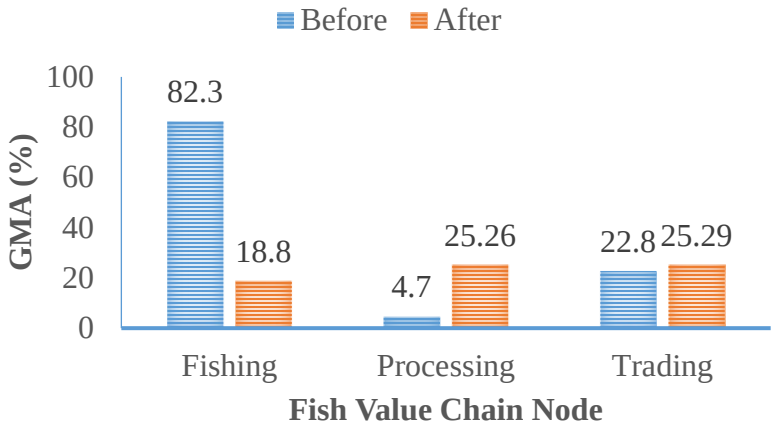


Figure 5: Gross margin analysis of fish value chain nodes before and after the use of improved technologies

4.1.4 Nutrient Sampling and Analysis

In summary, the results of the nutrient analyses of the work carried out on the three groups of fish selected for Zambia and processed by the commonly used traditional method (open sundrying – smoking – sundrying, SD-SM-SD) have shown the following trends:

1. The protein levels of the fresh flesh in this study was between 15.6±0.22 to 24.5±0.42 % and that of the whole milled fresh fish ranged from 16.2±0.59 to 24.3±0.41 %. Statistical differences among the fresh fish in each category (whole milled fish and fillet) were observed at $P < 0.05$. The processed fish samples had protein levels of 32.2±0.14% to 55.8±0.40% (processed whole milled fish) and 31.9±0.42% to 43.1±0.82 % for the processed milled fillets. While the results show a significant drop in protein levels, these should not be mistaken with nutrient losses. This apparent loss in moisture is indicative of a negative correlation between proteins and moisture content, a trend that has also been observed in fats and minerals during different cooking and processing processes.
2. Fat content in the fresh whole milled fish ranged from 3.50±0.49 to 15.2±0.72 % on wet weight basis (11.6±1.62 to 49.0±2.33 % on dry weight basis). In the fish flesh (fresh fish), the fat content ranged from 0.96±0.02 to 9.90±0.23 % on wet weight basis (4.78±0.65 to

37.5±0.86 % on dry weight basis). Fresh whole milled fish had significantly higher fat content than the flesh only ($P < 0.05$).

3. Overall, the fresh fish groups had significantly higher ($P < 0.05$) amounts of vitamin A than their processed fish counterparts. This was possibly due to the heat labile nature and also possible oil drip loss during the smoking period. The fresh whole fish samples had vitamin A levels of 993 to 1791 mg / 100 g fresh fish sample while the processed fish had 448 to 1881 mg / 100 g vitamin A levels. *Clarias* spp had the highest level of vitamin A in both the fresh and processed fish samples.

4.2 Objective 2. Identify, select, develop and pilot technical and social change interventions

4.2.1 Identify, select, develop and pilot technical interventions

The project worked on the fish species selected by the stakeholders. These include the Breams (*Oreochromis* and *Tilapia* spp) (Lipapati), *Clarias* spp (Ndombe) and *Marcusenius* (Nembele) in Barotse Floodplain and in Malawi *Oreochromis* spp (Makumba), *Barbus paludinosus* and *Clarias* spp. Technologies with the potential to reduce fish loss were identified for piloting in the Barotse Floodplains in Zambia and Lake Chilwa in Malawi. These included three fish processing technologies (solar drying, smoking and salting) and the provision of access to cold chain facilities (ice and freezing facilities).

4.2.2 Social change interventions

4.2.3.1Women's Empowerment in Fisheries Index (WEFI)

The WEFI baseline and endline helped to determine the positive (perhaps neutral or negative) contribution the GTC made on various social/gender outcomes in the fishery value chain. Another assessment was conducted during implementation of the GTC sessions (drama + critical reflection). A short gender attitudes questionnaire was administered to randomly selected women and men on three fishing camps (Liyoyelo, Mukakani and Tangatanga) before and again after each GTC session. The questionnaire was also administered to women and men on the other three camps (Nebubela, Marana, and Matula) that did not receive the GTC intervention. The survey comprised 15 gender attitudes that respondents were asked to indicate "agree", "partially agree", or "disagree", with the highest score being 45 (gender equal attitude) and the lowest score being 15 (gender unequal attitude).

There was no statistical difference ($p = 0.5134$) between mean scores for people who did not receive GTC and baseline score for those who were to receive the GTC sessions, which suggests both groups of people on average started with roughly the same gender attitudes. There was a statistically significant difference ($p = 0.0217$) between mean scores for people at baseline and after receiving the 1st GTC session, but no statistically significant difference between mean scores for people after receiving the 1st GTC session and after receiving the 2nd GTC session or after receiving the 2nd GTC session and after receiving the 3rd GTC session.

Women's mean score at baseline was 40.91, increased to 42.27 after the 1st GTC session, to 44.00 after the 2nd GTC session, and to 44.73 after the 3rd GTC session. Men's mean score at baseline was higher than women's at 42.00, increased as well after the 1st GTC session to 44.00, but then declined slightly to 43.29 after the 2nd GTC session, and increased to 43.93 after the 3rd GTC

session. Together, these results showed that women's mean gender attitudes scores increased significantly throughout implementation of the GTC sessions, while men's also increased overall but decreased slightly from the 1st GTC session to the 2nd GTC session and then increased again after the 3rd GTC session (Figure 6).

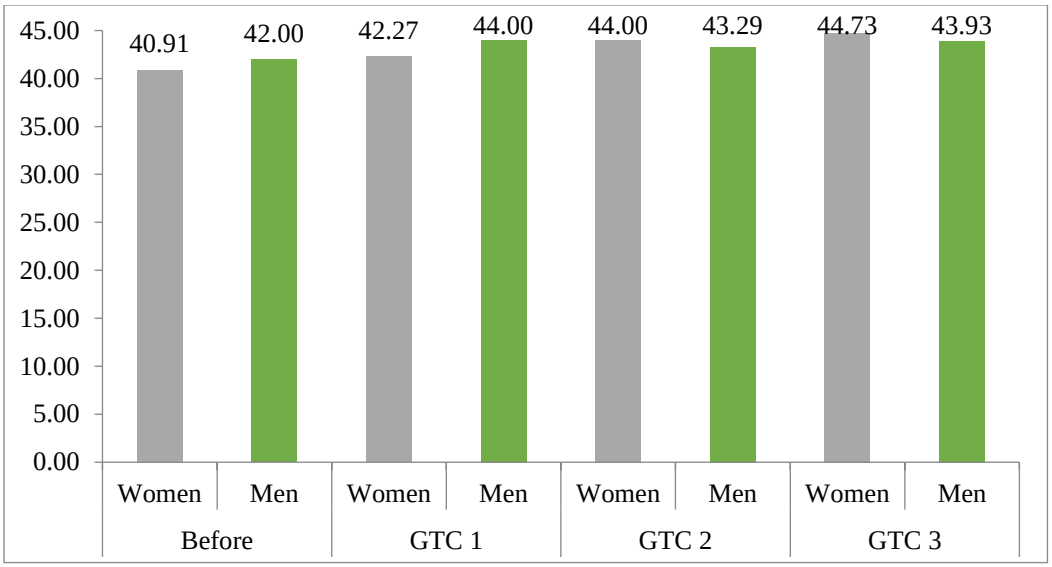


Figure 6: Mean gender attitude scores of women and men before and after implementing the three GTC sessions, Barotse Floodplain

Changes in empowerment over the course of the project

Roughly the same percentage of women comprised those who received PGA only and who received PGA+GTC (40% and 44%, respectively) in the WEFI sample. Those who received PGA only were on average 36.9 years old, while those who received PGA+GTC were on average slightly older (39.7 years old). Mean years of education for people who received PGA only was 6.38 and for those who received PGA+GTC was 7.18. Household size between the two groups was roughly the same at 5.7 and 6.0, respectively. Close to 89% of people who received PGA only were married, 2.9% female living on her own, and 8.6% male living on his own. For those who received PGA+GTC, 80% were married, 11.1% female living on her own, and 8.9% male living on his own. Fifty-nine percent of people who received PGA only indicated they were on the camp to fish, 35% to trade fish, and 6% to process fish. Sixty percent of people who received PGA+GTC indicated they were on the camp to fish, 24% to trade fish, 11% to process fish, and 4% to do something else (e.g., agricultural production). This analysis reveals that on the whole the two groups of people had similar demographic profiles.

At endline, those who received PGA only attended on average 5.5 PAR sessions (out of a total of 8) and those who received PGA+GTC attended 6.2 sessions. Those who received PGA+GTC on average attended 2.6 GTC sessions (skits + reflections). These results suggest the sample was very active in activities during the project period.

Table 2: Levels of participation in and inputs into decisions made on key fishery value chain activities

Role in household decision making on key fishery value chain activities	Baseline	Endline	p-value
Fishing past 12 months (1=yes)			
PGA only	0.57	0.60	0.8116
PGA+GTC	0.58	0.89	0.0007
Large input into making decisions about fishing			
PGA only	0.75	0.57	0.2386
PGA+GTC	0.96	0.93	0.5504
Large input into making decisions about income generated from fishing			
PGA only	0.85	0.67	0.1804
PGA+GTC	0.65	0.88	0.0320
Processing past 12 months (1=yes)			
PGA only	0.31	0.80	0.0000
PGA+GTC	0.53	0.91	0.0000
Large input into making decisions about processing			
PGA only	0.91	0.75	0.2802
PGA+GTC	0.63	0.88	0.0163
Large input into making decisions about income generated from processing			
PGA only	1.00	0.79	0.1000
PGA+GTC	0.58	0.90	0.0026
Marketing fish past 12 months (1=yes)			
PGA only	0.63	0.91	0.0040
PGA+GTC	0.60	0.89	0.0014
Large input into making decisions about marketing fish			
PGA only	0.91	0.72	0.0911
PGA+GTC	0.78	0.78	0.9791
Large input into making decisions about income generated from marketing fish			
PGA only	0.91	0.81	0.3355
PGA+GTC	0.74	0.85	0.2742

Table 2 presents the levels of involvement (interpreted as percentages) the two groups of people[1] had in fishing and processing and marketing of fish 12 month prior to the baseline/endline surveys being administered. It also presents the proportion of people within each group who made large inputs into decisions about the activities and the income generated from fishing and processing and trading fish. People who received PGA+GTC increased their involvement in fishing over the course of the project from 58% to 89% ($p = 0.0007$), and the increase was the result of women's participation increasing from 5% to 75% from baseline to endline ($p < 0.0001$). Importantly, those who received PGA+GTC increased their involvement in making large inputs into decisions about income generated from fishing from 65% to 88% ($p = 0.0320$). For those who received PGA only, their participation in making large inputs about income generated from fishing actually decline from 85% to 67%, although the difference was not statistically significant.

[1] Sex-disaggregated results not presented in the table but reported in the text.

As would be expected in a project focused specifically on reducing losses in the processing node, both groups significantly increased their participation in processing, from 31% to 80% with those who received PGA only and from 53% to 91% with those who received PGA+GTC. A greater percentage of women who received PGA+GTC made large inputs into decisions about processing and about income generated from processing over the course of the project and the differences were statistically significant at the 1% levels. For women who received PGA only, changes in their involvement in making large inputs into decisions about processing were much smaller and not statistically significant.

Concerning marketing of fish, overall participation significantly increased for both groups. For women, their participation was quite high at baseline and remained the same at endline. The change in participation over the course of the project is thus the result of more men trading fish. In both groups, men's participation in trading fish increased from baseline to endline and the differences were statistically significant. Women's involvement in making large inputs about income generated from trading significantly increased in the PGA+GTC group, from 65% to 94% ($p = 0.0280$).

On the whole, these results suggest that women who received PGA+GTC became more active in these key value chain activities and their decision-making powers increased during the project. In the processing and trading nodes, women who received PGA+GTC increased their participation in making larger inputs into financial decisions[2].

The percentage of people who own fishing gears increased over the course of the project, although only the increase in the percentage of men who received PGA+GTC was statistically significant ($p = 0.0376$). When examining who owns the fishing gears in the household[3], it was found that a large percentage of men who received PGA+GTC shifted their ownership status from self- to jointly-owned. At baseline 50% responded that they owned the fishing gears outright, and at endline only 19% stated they were the sole owners of the fishing gears ($p = 0.0419$). Forty-four percent responded they jointly-owned the fishing gears at baseline and this increased to 76% at endline ($p = 0.0433$). While how this change in framing of ownership status plays out in practice remains to be explored, the significance of the finding is that a greater percentage of men in the PGA+GTC group regard the fishing gears they primarily use (or possibly now share) as jointly-owned with their spouses.

The overall percentage of people owning fish processing equipment for the sample increased from 61% to 80% ($p = 0.0090$). The increase in the PGA+GTC group was especially significant. The significant overall gains are explained using the disaggregated results from men. The percentage of men owning processing equipment increased from 59% to 83% ($p = 0.0115$), and even more so

[2] The absolute number of women who received PGA+GTC and who responded they participated in fishing over the past 12 months increased from 1 (out of 20) at baseline to 15 (out of 20) at endline. The number of women who received PGA+GTC and who indicated at baseline they fished in the past 12 months and who made large inputs into financial decisions about fishing was 1 (out of 1), and at endline was 14 (out of 15). Therefore, the percent change from 1 individual to 14 individuals who made large inputs into decisions about income generated from fishing is very significant, and indicates impressive gains in economic empowerment for women in this group.

[3] Analysis on who owned the asset was carried out only with those in the sample who indicated they were married/cohabiting.

for men who received PGA+GTC (60% to 92% compared to just a 14% increase with men who received PGA only) and the difference was statistically significant at the 1% level. The vast majority of men in this group (95%) stated at endline they jointly own the equipment with their spouse.

Unsurprising, given the project was implemented primarily by fisheries extension officers, people's access to extension services increased dramatically over the course of the project from 36% to 93% ($p < 0.0001$). People who indicated they received training on fish-related topics increased from 31% to 94% ($p < 0.0001$). Similar results were found when the analysis was disaggregated by group and by sex.

While increases in the percentages of people who felt very comfortable speaking in public to help decide on projects and issues affecting the fishing camp or to protest the use of illegal fishing gears or activities were found, very few differences between baseline and endline were statistically significant. Only the increase in the percentage of women who received PGA only was statistically significant at the 5% level concerning their comfort speaking in public to protest the use of illegal fishing gears or activities.

Table 3 presents the overall and disaggregated results from the analysis of the data collected using the gender attitudes scale in the WEFI. It comprised 8 statements[4] with identical response options as the gender attitudes scale described above. This scale underwent the same scrutiny to determine its reliability and dimensionality. The alpha value for the scale was 0.83, which indicates good internal consistency. After conducting the factor analysis, there was only one eigenvalue >1, the factor's eigenvalue was 3.24, and the loadings of scale items of the factor ranged from 0.49 to 0.82. It is clear from this analysis that the scale included in the WEFI was internally consistent and unidimensional.

Overall gender equal attitudes increased over the course of the project from 18.68 to 22.67. The difference was statistically significant at the 1% level. Importantly, gender equal attitudes increased in both groups and the differences were statistically significant at the five- or one-percent level. This suggests that the approach used by the project had some influence on positively changing gender equal attitudes of people on the three camps that received PGA only. The increase in gender attitude scores was over two-fold for those who received PGA+GTC, which indicates that the use of a transformative approach led to greater gains compared to using an approach that empowers yet accommodates existing gender norms and power relations. Perhaps most striking about these results is the finding from the group of men who received PGA+GTC. Their scores increased the most of any other group, from 17.60 to 23.88 (a +6.28 increase), and the difference was statistically significant at the 1% level. For men in the PGA only group, the change from baseline to endline was 2.42 and was not statistically significant at or below the five-percent level.

[4] Examples of statements: "women should not get involved in fishing fulltime, this is a man's responsibility" or "men should primarily be the ones who control the earnings obtained from the sale of fish" or "women should primarily be the ones who prepare meals (including fish) for the family or if guests come to visit."

Table 3: Mean gender attitude scores, by group and by sex

Gender attitude scores	Baseline	Endline	p-value
Total (n=80)	18.68	22.67	0.0000
PGA only (n=35)	18.97	21.18	0.0286
PGA+GTC (n=45)	18.47	23.76	0.0000
Women (n=34)	19.76	23.06	0.0000
PGA only (n=14)	20.07	22.17	0.1014
PGA+GTC (n=20)	19.55	23.60	0.0000
Men (n=46)	17.87	22.39	0.0000
PGA only (n=21)	18.20	20.62	0.0913
PGA+GTC (n=25)	17.60	23.88	0.0000

The module comprised 8 gender attitude statements that people were asked to respond to: "agree" = 3, "partially agree" = 2, "disagree" = 1. Responses to the 8 statements were summed with the highest score = 24 (perfect gender equal attitude) and the lowest score = 8 (perfect gender unequal attitude).

The final module in the WEFI attempted to quantify average daily time use by women and men value chain actors[5]. The number of hours dedicated to fishing for the sample decreased from 4.17 to 2.84 ($p = 0.0323$), and the change was mostly because of the significant decrease in men's time devoted to fishing (6.75 to 3.89). Men who received PGA+GTC decreased their time fishing the most (by 3.45 hours, $p = 0.0020$). Overall, women increased the time they dedicate to fishing from 0.82 hours to 1.42 hours. The difference, however, was not statistically significant. The amount of time men devote to processing fish increased significantly from 0.42 to 0.77 hours ($p = 0.0205$). The increase by men who received PGA only explains the significant increase as their time processing increased by 0.53 hours ($p = 0.0006$), while men who received PGA+GTC increased by only 0.19 hours and the difference was not statistically significant. Time devoted to trading fish declined slightly, from 1.21 to 1.14 hours for the sample overall. Only for women who received PGA only was the decline significant at the 5% or below level (from 2.11 to 0.90 hours, $p = 0.0467$). This may reflect that women in the PGA only group were relatively disempowered during the course of the project in their abilities to trade fish or simply reflects the timing the data were collected (end of the fishing season, beginning of the fishing ban). Same applies for the decline in time people indicated they fish on average on a daily basis.

Turning to the unpaid, home-based tasks, some interesting results were found. Overall, people's involvement in domestic duties (collecting firewood and water, sweeping, washing clothes, etc.) increased slightly from 1.09 to 1.30 hours, although the difference was not statistically significant. The increase for women was slightly more than was the increase for men. The fact that the time men devote to doing such work increased (from 0.97 to 1.17 hours), is an important results, albeit the difference found from baseline to endline was not statistically significant. The time people devote to cooking increased significantly from 0.91 to 1.61 ($p = 0.0015$). Much of the increase is attributed to the amount of time men devote to cooking from baseline to endline (an increase of 0.67 hours, $p = 0.0021$). Importantly, the increase by men who received PGA+GTC was almost

[5] Outliers were excluded during analysis of their respective activity: fishing > 15 hours (2 outliers), processing > 6 hours (4 outliers), trading > 9 hours (2 outliers), and domestic work > 11 hours (1 outlier), caregiving > 20 hours (10 outliers), and cooking > 7 hours (2 outliers).

double compared to that by men who received PGA only (0.85 versus 0.47 hours, respectively). The differences found from baseline to endline were both significant at the 5% or below level.

4.2.3 Assess acceptability of new fish products and gender dimensions

4.2.4.1 Sensory Evaluation

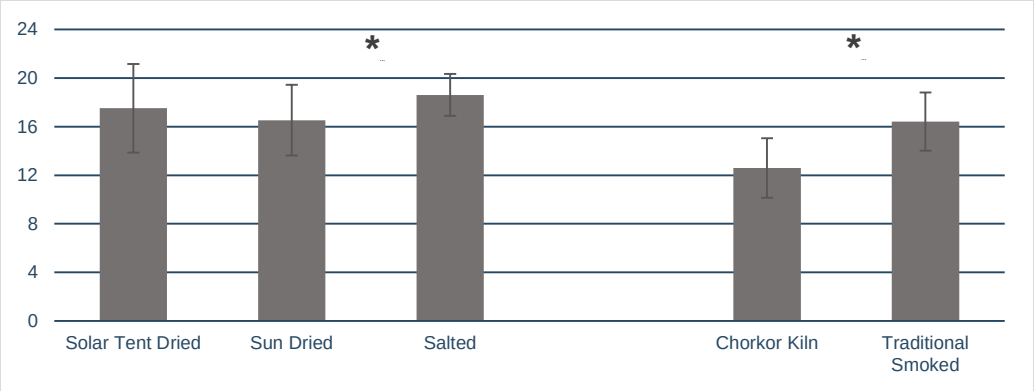
Assessment of the sensory acceptability of different fish products obtained from existing and new technologies was conducted too during the project implementation.

Smoked fish in bafa with number for sensory evaluation (left photo), salted fish

Figure 7: *Bafas* of fish processed during the load tracking assessment ready for sensory evaluation

Figure 8: Panel judges (traders) evaluating processed fish based on a number criteria

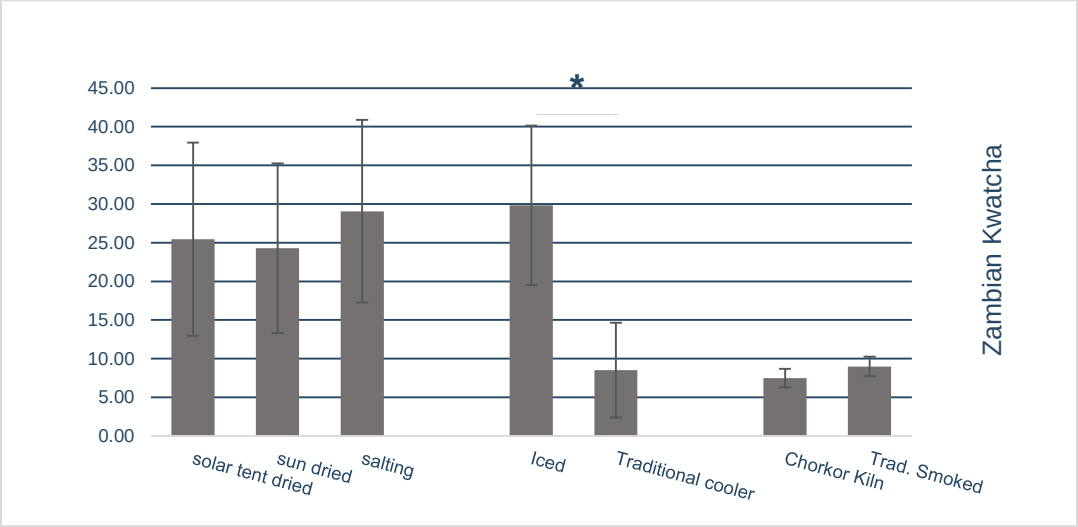
Fresh fish characteristics included skin appearance, gill color/odor, eye appearance, body texture, and uniformity. The first four characteristics are common indicators of fresh fish quality. Maximum total score for each assessment was 25 and the minimum possible score was 5. Patterns are similar to those found for weight retention. Salted fish had the highest average score of the true processed fish (average score = 18.6), which was significantly greater than sun dried fish ($p = 0.0063$). Solar tent dried fish also had a higher average score than sun dried fish, but the difference was not statistically significant. Chorkor kiln processed fish received significantly lower average sensory scores than fish smoked using existing smoking methods ($p = 0.0208$) (Figure 9). Sensory scores for iced fish were on average more than double than for fish that was preserved using the traditional cooler method (18.58 vs. 7.61, respectively), a difference that was statistically significant ($p < 0.0001$).



Quality categories included overall appearance, odor, color, durability, and uniformity of bafa. Bars with an (*) represent differences that are statistically significant.

Figure 9: Comparison of mean sensory scores from the dried fish sensory evaluation

Panel judges were also asked to estimate the monetary value of each *bafa* of fish that they evaluated. The difference in estimated value can be seen in Figure 10. Both salted and solar tent dried fish had a higher average value than sun dried fish, but the differences were not statistically significant. Chorkor kiln smoked fish had a lower estimated value than traditionally smoked fish, but again the difference was not statistically significant. The only significant finding was the dramatically greater value on average given to the fish that had been kept on ice versus using the traditional cooler/preservation techniques.



Units are in ZMK. Bars with an (*) indicate differences which are statistically significant.

Figure 10: Average value based on estimates by sensory panel members

The fish processed by the improved and introduced processing methods had higher scores than the traditionally processed fish in the breams (*Oreochromis* spp) and Bulldog (*Marcusenius* spp). However, the catfish processed by traditional methods had similar scores to those processed by improved and introduced technologies.

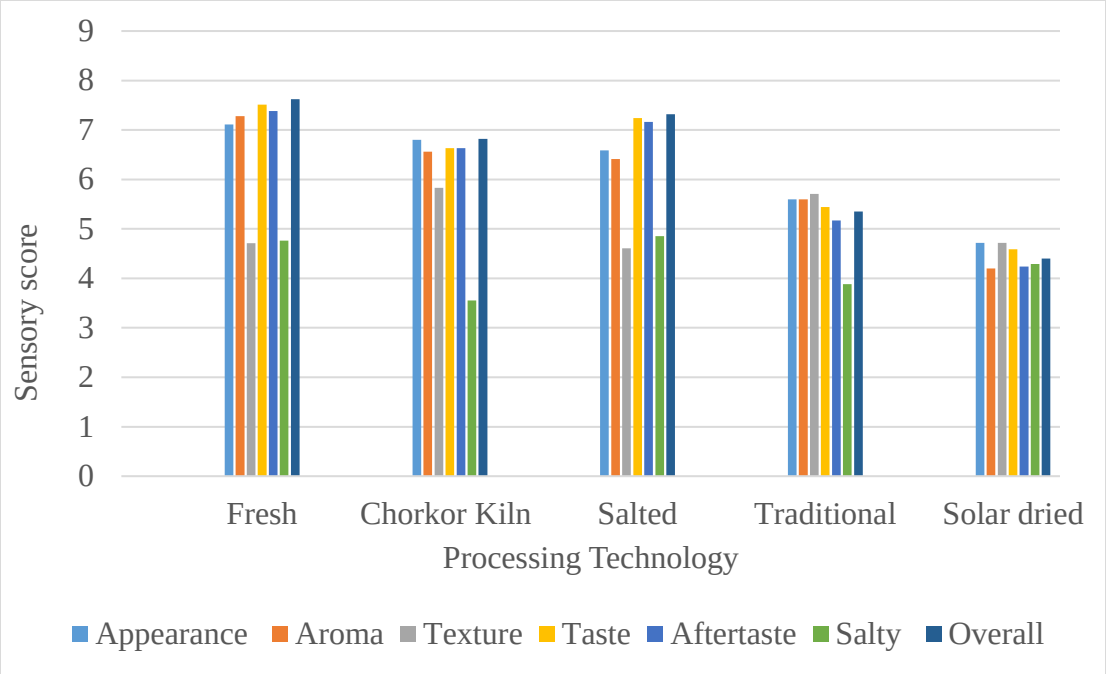


Figure 11: Sensory evaluation of the breams

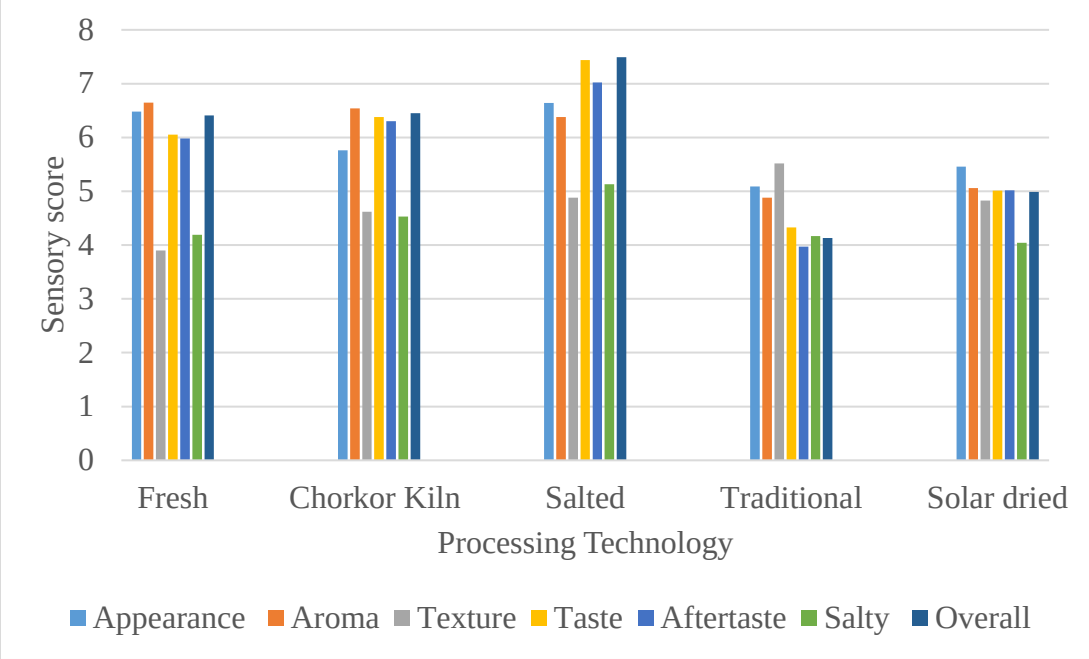


Figure 12: Sensory evaluation of the bulldog

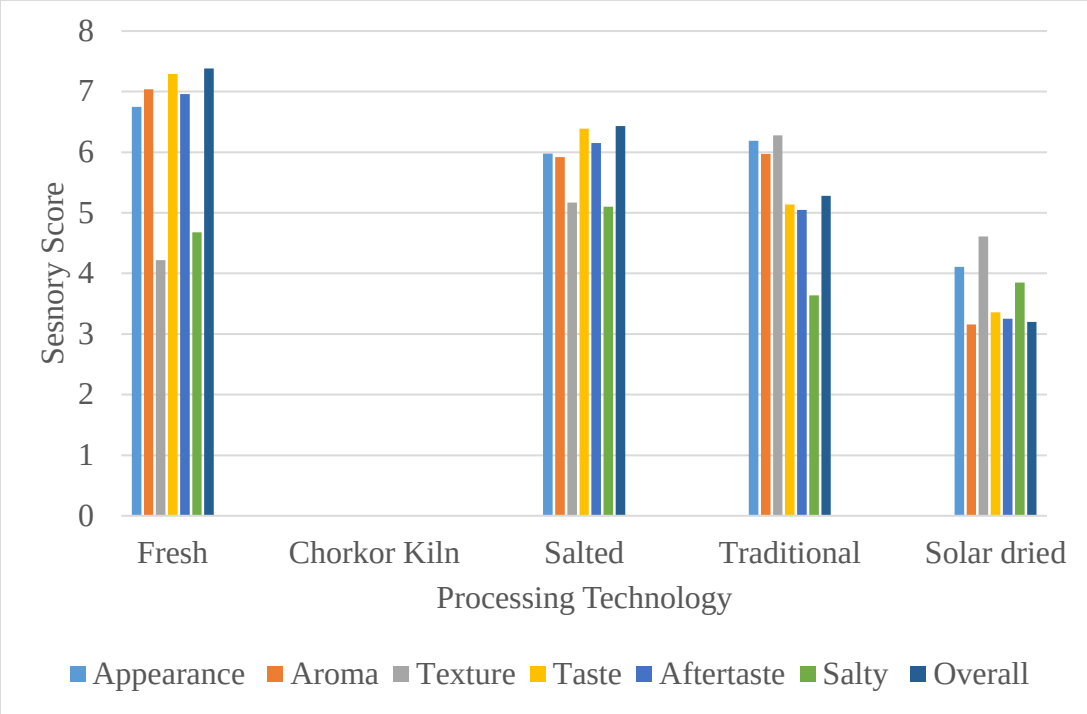


Figure 13: Sensory evaluation of the catfish

4.3 Objective 3. Capture and share project learning and develop scale-out strategy

4.3.1 Entrepreneurial workshops with private sector business women and men to assess private sector interest in supplying processing equipment and inputs

The project conducted the entrepreneurial workshop in Zomba, Malawi from 20th July to 24th July, 2016. The participants included all actors in the fish value chain from Lake Chilwa. The aim was to orient them on best practices that can be followed to properly manage their businesses profit maximization and improve their livelihoods. A total of 40 participants attended the workshop of these 18 were women.

A similar workshop was held in the Barotse Floodplain in conjunction with AEH Project with the main focus on women and the youths. The main objectives were:

1. To assess business opportunities within the identified innovations piloted and develop business plans for possible funding
2. To develop portfolio of youth managed businesses.
3. To document business opportunities and scale up entrepreneurship skills through mapping and profiling key actors and their roles, in the fish value chain.
4. To help grow and popularize businesses.

4.3.2 Unexpected, surprising or interesting innovative results

In both project sites (L. Chilwa and the Barotse floodplains) it was interesting to see how communities were utilizing the solar tent driers, (i.e. drying vegetables and meat products) other than drying the fish. In the Barotse floodplains, the solar driers were also

constructed outside the project sites a clear indication that there has been sharing of knowledge by the people who were trained.

4.3.3 Research partnerships as a result of IDRC funding

The project was corroborating with an IDRC and ACIAR funded project in Malawi which is working in the marketing of fish (**Improved processing and marketing of healthy fish products in inland fisheries in Malawi).** The project is also working with the Lake Chilwa Basin Change and Adaptation Project (LCBCCAP) in Kachulu in piloting the solar tent dryers. Furthermore, the project is working with ZCCP in the implementation of the GTC tool in the six sites of the Barotse Floodplain. In Malawi the FISH project is the partner in project implementation. The project has also established research links with African Entrepreneurship Hub on the AIRBO Project which is an IDRC/ACIAR funded project.

4.3.4 Governance

The project afforded equal opportunities to the beneficiaries both men and women. Men and women and the youth were not discriminated against any programme that the project undertook in the project areas.

4.3.5 Research ethics

The project got ethical clearance was sought from the University of Zambia, Humanities and Social Sciences Research Ethics Board (HSSREC) in Zambia while in Malawi the clearance was given by the National Commission for Science and Technology (NCST). The clearance in both Zambia and Malawi was provided for having satisfied all the ethical, scientific and regulatory requirements, procedures and guidelines for the conduct of research in the social sciences sector.

4.3.6 Use of research results

In Malawi, Lake Chilwa Basin Change and Adaptation Project (LCBCCAP) is using the results project to improve and change the design of solar tent dryers in Kachulu. The project has also introduced the improved smoking kilns in the area.

In Zambia, the Fish Trade Programme is using the solar tents and an improved method for fishi processing Luangwa District. Traders also being trained fish handling and hygiene using the project team members. WorldFish is also promoting the use of improved methods especially the solar tent in the Northern Province of Zambia.

The Department of Fisheries (DOF) in Western Province is also promoting salting to the fish producers (fish farmers) who are very far from the markets. It is proposed that the same is considered in other parts of the country. Furthermore, the Department of Fisheries has adopted the entrepreneurship manuals developed by the project for future entrepreneurship trainings.

From research results, AEH in Zambia in partnership with the project has since considered and sponsored 6 groups from the innovations piloted in the six sites in the Zambezi floodplains in Zambia and these are as follows:

1. Mbeta Island project in Senanga, dealing in post-harvest initiatives through provision of freezing facilities.

2. Wayama group in Senanga, dealing in Solar Tent Driers
3. Liyoyelo Zambezi in Mongu, dealing in Solar Tent Driers
4. Liyoyelo Lyambai in Mongu, also dealing in Solar Tent Driers
5. Ms. Lina in Mongu, involved in fish farming activities
6. Maraana Cooperative dealing in salting

The results generated have also been proposed to be used in the following manner:

7. Incorporation of data into the final national statistics of the fish consumption
8. Incorporation of the project results into the extension messages by the Department of Fisheries (DOF).

5.0 SYNTHESIS OF RESULTS TOWARDS AFS THEMES

5.1 Increasing agricultural productivity

The project has contributed to development and testing of new improved solutions for increasing food security and reducing postharvest losses. This is because the technologies developed and piloted aim at reducing the losses in the fish being caught, processed and traded. According to the results, the people in the fishing communities lose fish through the breakages, spoilage, accidents and pest infestation. Addressing the causes of the losses through interventions that reduce the losses has increased the amount of fish that is available to people for consumption, therefore, increasing food security.

The technologies also targeted at the preservation and processing of the fish thereby increasing the shelf life of the fish. This helps the fishers, processors and traders keep the fish for a long time without losing the fish products. This shields them from price volatility as they keep the product even when the prices are low and sell it when the prices pick up.

The interventions implemented are based on Practical Needs Approach (PNA) taking into account the gender issues among the people in the fishing communities. The technologies are mainly reducing the women's budgetary and drudgery in the fisheries business. For instance many women selected salting, solar tent dryers and the use of ice in their business probably due to simplicity. This may allow the women to have enough time for their domestic chores. Working in groups allows for collective marketing allowing some women to trade in processed fish even if they don't travel to the markets themselves.

Although some of the interventions such as smoking kilns require the use of fuelwood, the interventions that were piloted use less fire wood. This is a positive intervention in the environmental sustainability in the communities. Furthermore, the use of ice and salting pose little negative impacts on the environment.

5.2 Improving access to resources, markets and income

The project's partners included the Department of Fisheries (DoF) whose presence is in all the fishing camps both in Malawi and Zambia. The frontline staff who are the extension officers are working with the PAR group members on a weekly basis thus increasing the contact time and providing extension services.

Furthermore, the reduction in fish losses improves the income of the people involved in the fish business. This is because reduction in physical losses through processing methods adds value to the product and reduce the traders panic when the forces of market set in.

The project has installed an ice plant and cold room in Senanga Zambia, which provides ice and freezing facilities to the fishers, processors and traders in the area. This provides a direct input to the preservation of the fish to the fish value chain actors involved in fresh fish.

The project was composed of five partners (Department of Fisheries, WorldFish, Nono Enterprises, University of Malawi and University of Zambia). Furthermore, the project fostered partnerships with Non-Governmental Organisations (NGOs) such the ZCCP and CARITAS Zambia in the implementation of the project activities. Other partnerships included the sister project in Malawi **Improved processing and marketing of healthy fish products in inland fisheries in Malawi** and **the FISH project.** The other partner was the AEH Project which is an IDRC/ACIAR funded project.

5.3 Improving nutrition

Fish is an important animal source that provides vital amino acids to humans. The project introduced innovations aimed at reducing the nutrient losses that occur in the process of deterioration of the fish within and across the value chain. The post-harvest fish processing and storage techniques aims at reducing the losses in the nutrient levels of the fish. Furthermore, the project implemented processing methods and practices that promote food safety.

5.4 Informing policy

The project directly engaged the policy makers (President of the Republic of Malawi and Cabinet Ministers in Malawi, Permanent Secretaries, Directors, Councillors, Barotse Royal Establishment (BRE) and Department of Fisheries,) during the inception workshop and during the agriculture shows. The project results and proposals will be integrated into policy.

6.0 PROJECT OUTPUTS

During the project period, the following have been the outputs:

1. Socio – Economic Determinants of Profitability of Capture Fisheries Trade in Barotse Floodplain of Zambia" in the International Journal of Fisheries and Aquatic Studies (International Journal of Fisheries and Aquatic Studies 2016; 4(3): 367-371)
2. The manuscripts that have been submitted to the journals
    a. Physical losses of fish along the value chain in Zambia: a case study of Barotse floodplain. *International Journal of Fisheries and Aquaculture*
    b. Fish losses for whom? A gender assessment of post-harvest fish losses in the Barotse Floodplain, Zambia. The paper will be submitted to the Fisheries Research Journal.
    c. Combing technical and social innovations to enable a shift in pathway out of the social-ecological trap in the Barotse Floodplain fishery, Zambia. *Ecology and Society*. This paper will also be presented at the Resilience 2017 conference in Stockholm (http://resilience2017.org/.

d. A review of post-harvest fish loss assessments: a case study of a novel participatory technology evaluation from the Barotse Floodplain fishery, western Zambia. This will be submitted to *Agriculture and Food Security*.
e. Gender transformative change along the natural fishery value chain: Panel evidence from the Barotse Floodplain, Zambia. *Agricultural Systems*.
f. Modern methods of fish processing can help reduce postharvest losses and increase rural incomes and food security in sub-Saharan Africa. The paper has been submitted to the Food science and nutrition Journal.

3. Theses submitted by the students on the project
   a. Profitability and post-harvest loss assessment along key fish value chain associated with Barotse Floodplain, Zambia submitted to Jomo Kenyatta University of Agriculture and Technology (JKUAT), Nairobi, Kenya.
   b. Nutritional and microbial quality of fish *(Clarias gariepinus, Barbus paludinosus* and *Oreochromis shiranus chilwae)* using different processing methods submitted to Lilongwe University of Agriculture and Natural Resources (LUANAR), Lilongwe, Malawi (Annex IIX)
   c. Sensory characteristics of traditional smoked, improved kiln smoked, solar tent dried and open sundried fishes of Lake Chilwa submitted to Lilongwe University of Agriculture and Natural Resources (LUANAR), Lilongwe, Malawi
4. Infographics and posters (Annex IX)
5. Entrepreneurship manual
6. Gender transformative Communication manual

7.0 PROBLEMS AND CHALLENGES

I. Seasonality of the fishing activities

Implementation of activities were affected by the seasonal variations in the fishing industry. In the Baroste floodplains, due to the flooding nature of the study area, most interventions were semi-permanent - e.g. construction of solar tent driers and cholker kilns. In Lake Chilwa, permanent settlements made it relatively easier for project implementation.

II. Flooding of fish camps

The high rainfall experienced in the 2016/2017 rain season affected the project completion evaluation in Zambia since the project sites were still flooded by the time of project completion. Fishers, traders and processors had not gone back to the camps for the project to conduct an endline evaluation.

III. Delayed funding

Delayed funding was experienced during the change of the financial system and that affected implementation of some of the activities.

IV. Failure to recruit a Master of Science Student in Zambia

The project desired to engage the student to fulfill some project objectives particularly nutrient composition of fish processed by the introduced and improved technology but could not find any suitable ones due to difficulties in the synchronization of the

programme at the University of Zambia. The project depended mainly the researchers and technical staff within the project partners who were equally committed to their daily duties.

V. **Delay in the procurement process**

Delay in the procurement of certain laboratory materials and equipment in the sample analysis was mainly attributed to the beau acratic nature of procurement process especially with then two Universities.

8.0 OVERALL ASSESSMENT AND RECOMMENDATIONS

The following are recommended:

I. The project has helped to foster a strong relationship between the fish value chain actors and the government. This is both the parties worked together in redefining the research. Government officers were seen as partners rather than enforcers of the law which resulted enmity between the two.

II. From this experience, a lot more would have been achieved if all the funds were released timely as fishing industry is seasonal.

III. The project learnt a great deal considering the responses from the communities that participated and how these innovations have changed the lives of the people in the targeted fishing villages.

IV. Need to scale – up the project results to other fishing areas in both countries since the problems are similar.

V. For future projects there is need to consider employing full time project coordinators for them to fully concentrate on the project. The project required a lot of time to fulfill the project outcomes.

VI. A lesson learnt is that there is need to define clearly the role of the private sector on the project since the interests of the private sector and of the researchers seemed to differ in the process of project implementation.