Improved Processing and Marketing of Healthy Fish Products in Inland Fisheries in Malawi

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University of Malawi - Chancellor College

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Peoples Trading Company

WorldFish Centre

Mangochi and Salima Districts in Malawi

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Final Technical Report

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Executive summary

The contribution of fish to food and income security is being threatened by the declining fish stocks and high post-harvest losses which are estimated at 40% by the Food and Agriculture Organisation of the United Nations. In Malawi, the losses are high during the peak fish production period which is between January and April when there are more rains and high humidity, which makes the traditional open sun drying almost impossible. The traditional open sun drying also exposes fish to microbial contamination and dust which makes the dried products unsafe for human consumption. The main objective of this project was to design, test and promote solar tent dryers to reduce postharvest fish losses while increasing economic gains and reducing the use of forest resources. The project was implemented in Mangochi and Salima districts in Malawi from October 2014 to June 2017.

A solar tent dryer that is able to dry *Usipa* (*Engraulicypris sardell*), *Utaka* (*copadichromis spp.)* and *Ndunduma (Diplotaxodon limnothrissa) was designed and tested*. Comparing with traditional open sun drying, the study findings show that that drying time for fish in solar tent dryers was similar, about 3 days 3 hours during the dry-cold season and about 1 day 15 hours during the rainy-warm season.

Solar tent dried fish was found to be of significantly higher quality than open sun dried fish in terms of ash content (21.97% vs 14.48%), moisture content (7.22% vs 16.31%), microbial load (more than three times better), and shelf life (7 -16 weeks vs 3-7 weeks depending on species) and similar quality in terms of crude protein and fat content.. The low moisture content and microbial load leads to longer shelf life than in open sun dried fish. . As a result of these superior qualities, the Malawi Bureau of Standards (MBS) to certify solar tent drying and solar tent dried fish as safe for human consumption.

Consumer preference analysis showed higher level of acceptability for cooked and uncooked solar tent dried fish than open sun dried fish. Before cooking, consumers' overall quality score for dried *Usipa* (4.35 vs 3.81) and *Ndunduma* (4.25 vs 3.55) were significantly higher than the scores for open sun dried fish. After cooking, preferences remained higher for solar dried *Usipa* (4.19 vs 3.67) and *Ndunduma* (4.17 vs 3.43) than open sun dried fish.

Fish processors are willing to pay US$132 as a contribution to a group owned solar dryer. Women are willing to pay US$132 while men are willing to pay US$ 151. The proportion of fish processors that were willing to pay reduced between the baseline survey and the end line survey but the amount of money fish processors were willing to pay increased because of the improvements in the information about the costs and benefits of a solar tent dryer. While women are more likely to pay for solar tent dryers, the average amount of money they are likely to pay is lower than what men are likely to pay. .

Fish processors attached high values to sensory quality improvements and postharvest loss reduction attributes of solar tent drying than other attributes such as reduction in labour needs, reduction in drying time, and safety of the fish. Overall, women attached higher values than men to attributes of solar tent drying. Improvements in sensory properties and reduction in postharvest losses are

assigned higher values by both men and women because they seemingly have a direct influence on the revenue from fish sales, and hence profit.

Economic assessment of the solar tent drier showed a net present value ofMK6, 014, 489 with an internal rate of return of 57% and a payback period of 1.8 years. A risk analysis on the investment on solar tent dryers shows that when uncertainty is factored, solar tent dryers have an 80% probability of being profitable. With these results, it is shown that solar tent dryers are economically viable

A gendered fish value chain analysis showed specific gender based constraints faced by men and women. Women in the fish value chain face many challenges such as higher postharvest fish losses in the form of fish being burnt or spoiled during drying and smoking because of workloads as a result of their multipole roles. Women also struggle to sell fish in the markets as they can only do so during the day due to their other domestic tasks and for fear of intra-household conflict. Men reported that they experienced the most income losses because they were manipulated by women in markets who would exploit them by offering sex in return for fish.

Fish loss assessments showed that total estimated postharvest fish losses along the value chain in Malawi is 22.25% which is lower than 30-40% which is normally reported in national and international literature. The highest losses are estimated at the fish processing node (8.90%) and the lowest is at the fish marketing node (5.49%). Economic losses during fish processing was estimated at 11.3% for open sun dried fish and 0.8% for solar tent dried fish implying that solar tent drying is reducing postharvest losses at the fish processing node by 10% to fish processors. .

Gender differences in the fish value chain are observed in terms of ownership of assets, involvement in the fish value chain, and inputs into production decisions and income utilisation. Men own more assets than women, more women involved in fish processing than men and less involved in fishing than men. Implementation of Gender Transformative Approaches (GTA) has resulted in more women than men adopting and using solar tent dryers. More women (78) than men (45) are using the four solar tent dryers that are owned by four men. More women (29) than men (19) are also involved in using solar tent dryers that are owned by groups. Additionally, more women (23) have started accessing formal lucrative markets than men (16). However, men (56, 830 kg still had higher output from solar tent dryers than women (11, 555 kg). Additional achievements include involvement of some women in active fishing in some parts of the project area, taking up of key leadership roles as chairpersons, secretaries or treasures by women in beach village committees (BVCs), and involvement of women in activities that are normally considered as men's activities and involvement of men in activities that are normally considered to be female's activities.

The project has increased awareness of solar tent dryers in the project area from 14% to 88% representing a 75% point increase. There are now 188 individuals that are using solar tent dryers out of which 123 are women, compared to 65 men. There was no user of a solar tent dryer at the start of the project. This implies that solar tent dryers are creating employment and that most of those using are women. Additionally, benefits of adoption of solar tent dryers are through improvements in the supply of quality fish to the country. From the start to date, the output from

solar tent dryers is estimated at 86,685.50kgwhich has a monetary value of over US$540, 000.00. The dryers have supplied fish to over 17,000 consumers.

From 2015, over 10 formal markets have been accessed by fish processors. Price of *Usipa* was selling at MK2300 (~US$3) on the local markets, whereas at the supermarket, the same quantity was selling at MK4500 (~US$6). These include Peoples Trading Center (PTC), Chipiku Plus, Spendrite, Stella Maris Secondary School and Malindi Secondary Schools. Fish processors have also been supplying fish to special functions like weddings and religious functions which was not the case before they started using solar tent dryers. One of the fish processors has received an order to supply solar dried fish to constituents of Monkey Bay Constituency for about 18 months. Solar tent dried fish is also sold in the local markets in central and southern regions of Malawi and even in Chipata, Zambia.

1 The research problem

The importance of fish to individuals, society, and environment has been well documented (Lynch, et al., 2016). Fish provides more than one billion poor people with most of their daily animal protein and that more than 250 million people depend directly on fisheries and aquaculture for their livelihoods and millions are employed in fisheries and aquaculture value chains in roles such as processing[1]. In Malawi fish contributes about 70% to animal protein and it is a good source of essential fatty acids and micronutrients (Kawarazuka, 2010). Small fish species in particular, eaten whole (head, organs and bones) are rich in calcium, vitamin A, iron and zinc, and these nutrients are more effectively absorbed than those in plant-source foods (WorldFish, 2011). However, the contribution of fish to food and income security is being threatened by the declining fish stocks and high post-harvest losses which are estimated at 40% by the Food and Agriculture Organisation of the United Nations (FAO, 2012). The losses are high during the peak fish production period which is between January and April when there are more rains and high humidity, which makes open sun drying almost impossible. The main objective of this project was therefore to improve the adoption of solar tent dryers to reduce postharvest fish losses while increasing economic gains and reducing the use of forest resources.

This research project adapted and promoted fish solar dryers to three Lake Malawi small fish species namely *Usipa* (*Engraulicypris sardell*), *Utaka* (*copadichromis spp.)* and *Ndunduma (Diplotaxodon limnothrissa).* The project targeted small fish species because production of these in Malawi has increased from 56,463 tons in 2004 to 98,299 tons in 2010 (FAO, 2012). Since the small fish species are mostly consumed by the poor, increasing supply of these fish species through reduced post-harvest losses would improve animal protein consumption by the socioeconomic groups of our population that would not normally have access expensive sources of animal protein such as large fish species or meat.

The project adapted the solar tents for fish drying developed for *Barbus species* on Lake Chilwa to Lake Malawi small fish species. Additionally, the project assessed qualitative, quantitative, and economic costs and benefits of solar drying tents. To strength the fish value chain and improve incomes of actors in the chain, the project promoted value adding activities such as packaging. The project also promoted access to non-traditional fish markets such as supermarkets through the Peoples Trading Centre (PTC) without abandoning the traditional markets.

In the course of implementing the project, some areas of research evolved. The first activity that emerged was the need to generate reliable estimates of fish losses along the value chain. Presently, there are different values that are found in the literature but none of these are supported by a clear methodology. Secondly, the scaling out approach also changed to include building business capacity to sustain adoption of the technology after the project. Initially, the project planned to subsidize construction costs of the dyers in the project sites. The project then modified the approach by constructing the dryers to fish processors (groups or individuals) that demanded the technology on an understanding that they will pay back the money.

[1] https://www.worldfishcenter.org/why-fish

The project has made a lot of contributions to knowledge and development. One of the major contributions made include the design of the solar tent dryer which is conducive for commercialisation of fish processing. The project has also generated scientific knowledge that includes assessment of effects of solar tent drying on the quality of dried fish, economic viability of solar tent dryers and solar tent drying, and generation of new estimates of postharvest fish losses. The project has also generated knowledge on best practice for out-scaling solar tent dryers. The report covers the period from October 2014 to June 2017.

2 Progress towards milestones

2.1 Conduct fish drying experiments, shelf life, and nutrient analysis

The aim of this milestone was to adapt fish solar tent dryer for drying fish from Lake Chilwa to small fish species of Lake Malawi and test the effectiveness of the dryer in terms of fish drying rates, microbial contamination, nutrient content, and shelf life. This milestone was 100% completed. The solar tent drier was adapted to Lake Malawi fisheries, drying rates, microbial load and nutrient content of solar dried fish determined and compared to open dried fish. Five scientific papers and an MSc thesis have been produced as indicators for the achievement of this milestone. A summary of the status of the various scientific reports/papers that are addressing these milestones is presented in Table 1.

Table 1: List of papers on the milestone on conducting fish drying experiments, shelf life, and nutrient analysis

	Title	**Status**	**Reference**
1	Nutrition, microbial and sensory quality of solar tent dried (*Samva Nyengo*) and open sun dried C. *virginalis* (Pisces; cichlidae)	Published, International Journal of Marine Sciences	Annex 1
2	A comparative analysis of the quality of solar tent dried (*Samva Nyengo*) and Open Sun dried Usipa fish (*Engraulicypris sardella*) Pisces; Cyprinidae	Ready for submission	Annex 2
3	Shelf life of solar tent dried and open sun dried *Diplotaxodon limnothrissa*	Under Review, Journal of Food Processing and Preservation	Annex 3
4	Nutrition and safety of solar tent dried and open sun dried *Diplotaxodon limnothrissa*	Under Review, African Journal of Food, Agriculture, Nutrition and Development	Annex 4
5	Assessing the effectiveness of an adapted solar tent dryer in drying Lake Malawi's *Engraulicypris sardella* (Usipa)	Completed manuscript	Annex 5
6	Quality and shelf life of solar tent dried and open sun dried *Diplotaxodon limnothrissa* (local name Ndunduma)	MSc thesis ready for submission	Annex 6

2.2 Evaluate economic viability of solar tent dryers in processing small fish

Evaluation of economic viability of fish solar tent dryers aimed at assessing the willingness to pay for solar tent dryers and solar tent drying and assessing the profitability of investments on solar tent dryers. The project analysed the economic viability of solar tent dryers by assessing the willingness to pay to own solar tent dryers, willingness to pay to use solar tent dryers, and appraised the investment on solar tent dryers. The indicators of these achievements are through one manuscript under review, two completed manuscripts, and two unpublished MA theses presented in Table 2.

Table 2: List of papers as indicators for milestone on evaluating economic viability of solar tent dryers

	Title	Status	Reference
1	Gender Differences in Willingness to Pay for Capital Intensive Agricultural Technologies: the case of Fish Solar Tent Dryers in Malawi	Under review	Annex 7
2	Application of choice experiments to willingness to pay for solar tent fish dryers in Malawi	Completed report	Annex 8
3	Willingness to pay for fish solar tent drying by Lake Malawi Fish Processors	MA thesis	Annex 9
4	Economic assessment of fish solar tent dryers in Malawi	MA thesis	Annex 10
5	An economic appraisal of fish solar tent dryers used on small fish species on Lake Malawi	Completed Manuscript	Annex 11

2.3 Conduct a gendered value chain analysis of small fish species

With this milestone, the project aimed at conducting a value chain analysis of small fish species from Lake Malawi to analyze the main occupations of fisheries in Malawi, their economic value, gender issues, employment and nutrition, and to explore specific interventions for key constraints along the value chain. While the milestone only covered Lake Malawi, discussions with other projects led to collaboration and eventually included four Malawian lakes: Lake Malawi, Lake Malombe, Lake Chilwa, and Lake Chiuta. This study was implemented in collaboration with the Malawi-Zambia CultiAF project and the Fisheries Integration of Society and Habitats (FISH) project funded by USAID. A further study looked at the levels of post-harvest losses in the fish value chain and where these losses occur. This was done to provide more accurate estimates as the country has been using old fish loss estimates from FAO. Two indicators for this milestone include the completed fish value chain report that identifies areas of improvements (Annex 12) and a report on sources and magnitude for fish postharvest losses in Malawi that presents new estimates of postharvest fish losses (Annex 13).

2.4 Conduct market research and consumer acceptability of produced fish products

This milestone aimed at conducting and documenting market analysis, consumer preference analysis, and developing marketing plans for solar dried fish. Indicators for the achievements of the

milestones include a scientific report on marketing of fish in super markets, a marketing study report (Annex 14) and a paper on "A comparative analysis of the sensory quality of *Engraulicypris sardella* fish species (Usipa) and fresh *Diplotaxodon limnothrissa* (Ndunduma) dried using solar tent and open sun methods" (Annex 15).

2.5 Implement innovative business model for fish marketing

The aim under this milestone was to develop and test business models for promoting fish marketing. The project developed business models for promoting the adoption of fish solar tent dryers and the solar tent dried fish. The project looked at solar tent dryers as a complete package that includes value addition such as packaging and marketing. The project tested three business models through which solar tent dryers would be adopted. These included individual ownership, group ownership, and government/project ownership. A scientific product for this milestone is an MSc thesis titled: "Assessing options for out scaling solar tent fish dryers for fishing communities along Lake Malawi" which is about to be submitted for examination (Annex 16). A paper related to this milestone is planned.

2.6 Promote proven gender transformative and empowerment strategies

With this milestone, the project aimed at addressing gender disparities in accessing fisheries resources, markets and technologies with complementary actions to address underlying social norms and power relations for increasing women's productive potential. The project conducted training sessions, group discussions and use of role models in their respective communities in pursuing the transformation process. The project also trained Gender Transformation Champions who facilitate Gender Transformative Activities (GTA) in the communities. A gender analysis report has been written as a scientific indicator for the attainment of this milestone (Annex 17). The project also included gender analysis both in the baseline survey report and the end line survey report (Annex 18). The project also developed a gender outcome story (Annex 19).

2.7 Conduct end of project evaluation

The milestones for this activity included the documentation of the changes in incomes, fish consumption, and gender norms. To establish these changes, the project implemented the baseline and an end line survey. These changes have been assessed and are reported in the end line survey report (Annex 20).

3 Synthesis of research results and development outcomes

The project had five specific objectives and this section presents the major findings under each of these objectives. The section relates the results to development outcomes taking into account social, gender and environmental dimensions.

3.1 To test the effectiveness of solar tent dryers for processing of small fish, in terms of shelf life and product quality

The project adapted solar tent dryers to Lake Malawi fisheries by changing the type and position of air vents to moderate air circulation, varying the size, and determining the optimal carrying capacity of the dryers through double decking of the drying racks. After testing for various parameters such as meteorological conditions in the dryer, drying rate and sensory properties of the fish, the design of solar tent dryer presented by Figure 1 was selected. The fish solar tent dryer is made up of an ultraviolet (UV) treated polythene 200 μm sheet fixed over a wooden frame. The design has a carrying capacity of about 850kg of fresh fish per drying cycle, has in-let vents (30 cm × 30 cm) located below the racks and out-let vents (40cm × 40 cm) on the vertex (triangular part) of the tent to serve as outlet of the hot air from the dryer. This allows for free movement of air in and out of the solar tent dryer to prevent high humidity and constant removal of moisture from the surface of the fish. Both vents are screened against flies with galvanised fine meshed gauze wire. A screening portion (1m × 1m) is attached on the entry door to serve as an access opening into the solar tent for the processor to handle and inspect the fish during the drying process. It also screens off flies and maintains the ambient temperature within the tent during the drying process. The drying racks are made of galvanized mesh wire with plastic gauze wire on top and are framed with wood.

Figure 1: Picture of outside and inside view the design of the solar tent dryer that was adopted

Results of drying time experiments showed that drying time for fish in this dryer and on open sun drying during the dry-cold season were similar at about 3 days and 3 hours. Shorter but similar drying time (about 1 day and 15 hours) was observed during the rainy-warm season between the solar tent dryer and open sun drying. Results for quality analysis for *Utaka* are presented in Table 3 and Table 4 while results of shelf life analysis are presented in Table 5. The findings show that the quality of solar tent dried fish was significantly superior quality to the quality of open sun dried fish in terms of ash content (21.97% vs 14.48%), moisture content (7.22% vs 16.31%), microbial load (more than three times better), and shelf life (7 -16 weeks vs 3-7 weeks depending on species) and similar quality in terms of crude protein and fat content

Table 3: Proximate composition of solar dried fish and open sun dried fish

Parameter (%)	Fresh	Solar dried	Open Sun dried
Crude protein	60.06 ± 0.38^{b}	62.89 ± 0.05^{a}	62.73 ± 0.09^{a}
Fat	15.82 ± 0.41^{b}	23.24 ± 0.66^{a}	23.41 ± 0.59^{a}
Moisture	90.11 ± 0.63^{a}	7.22 ± 0.02^{c}	16.31 ± 0.36^{b}
Ash	12.48 ± 0.76^{c}	14.48 ± 0.08^{b}	21.97 ± 0.36^{a}

Table 4: Bacteria isolates for solar dried and open sun dried fish

Bacteria species	Bacteria colony forming units (CFU/g)		
	Fresh	Solar Tent Drying	Open sun drying
Total coliform	3.5×10^{2}	1.2×10^{1}	5.0×10^{3}
Escherishia coli	2.1×10^{2}	0	1.0×10^{4}
Salmonella	4.0×10^{1}	0	6.1×10^{3}
Shigella	2.3×10^{1}	0	3.8×10^{3}
Psuedomonas	7.0×10^{1}	5.2×10^{2}	5.1×10^{4}
TVC	3.0×10^{3}	2.2×10^{2}	4.1×10^{5}

Table 5: Shelf life of solar tent dried and open sun dried fish (weeks)

Fish species	Solar tent dried	Open sun dried
Ndunduma	7	3
Utaka	16	5
Usipa	11	7

These desirable qualities have made the Malawi Bureau of Standards (MBS) to certify solar tent drying and solar tent dried fish as safe for human consumption. The certification has allowed fish processors to supply fish at supermarkets. Apart from the certification, supermarkets and other formal markets are attracted to solar tent dried fish because of the longer shelf life. The project further assessed consumer's preferences of uncooked and cooked solar dried and open dried fish. Three attributes were assessed and the findings are presented in

Table 6: Sensory quality of solar tent dried and open sun dried fish products

Sensory Attribute	Dry Usipa				Dry Ndunduma			
	solar tent (n=37)	std. error	open sun (n=37)	std. error	solar tent (n=36)	std. error	open sun (n=29)	std. error
Smell	4.05	.102	3.89	.181	4.17	.135	3.72	.221
Texture	4.06[a]*	.112	3.61[b]	.179	4.17[a]**	.119	3.5[b]	.209
Colour	4.46[a]***	.092	3.73[b]	.188	4.22[a]**	.144	3.52[b]	.231
Overall quality	4.35[a]**	.097	3.81[b]	.189	4.25[a]**	.146	3.55[b]	.246

Means in the same row and type of fish column followed by different letters are significantly different at * $p<0.05$, ** $p<0.01$ and *** $p<0.001$

Solar tent dried fish has better sensory qualities than open sun dried fish. Consumers have shown higher levels of acceptability for cooked and uncooked solar tent dried fish than open sun dried fish in terms of smell, color and taste. Before cooking, consumers' overall quality score, taste quality score, and colour quality score for solar dried fish were significantly higher than the scores for open sun dried fish. After cooking, consumers also showed significant higher acceptability for solar tent dried fish products had in terms of smell, color and taste as a result (Table 7).

Table 7: Sensory quality of processed and cooked fish products

Sensory Attribute	Cooked *Usipa*				Cooked Ndunduma			
	solar tent (n=37)	std. error	open sun (n=37)	std. error	solar tent (n=36)	std. error	open sun (n=29)	std. error
Smell	4.05	.155	3.70	.208	3.94	.138	3.41	.279
Taste	4.16	.148	3.65	.227	4.11[a]***	.142	3.00[b]	.248
Colour	4.3[a]*	.128	3.81[b]	.197	4.36[a]*	.133	3.83[b]	.211
Overall quality	4.19[a]*	.125	3.67[b]	.225	4.17[a]**	.126	3.43[b]	.249

[a]Means in the same row and type of fish column followed by different letters are significantly different at * $p<0.05$, ** $p<0.01$ and *** $p<0.001$

3.2 To evaluate the economic viability of solar tent fish processing

Evaluation of economic viability of solar tent fish processing was based on willingness to pay to own solar tent dryers, willingness to pay to use a solar tent dryer, and appraisal of investments on solar tent dryers. Contingent valuation method was used to assess the willingness to pay to own a solar tent dryer as a group during the baseline survey and the end line survey (refer Annex 7 and Annex 18). During the baseline survey, the probability that women will be willing to pay to own a solar tent dryer as a group was 76% and for men it was 72% while the average willingness to pay to own a solar tent dryer as a group US$21 (US$ 19 for women and US$24 for men). After implementation of the project, the proportion of men and women that were willing to pay for a solar tent dryer to be owned by a group was 59% and 64%, respectively. The average amount of money women were willing to pay was US$132 and men were willing to pay US$151. With the estimated cost of constructing a standard solar dryer at US$2000.00, the estimated willingness to contribute to construct a group owned solar dryer implies that it would require about 15 individuals to put together US$152 each to construct a solar tent dryer. This means that efforts of development practitioners need to be geared towards forming the groups, mobilising resources within the groups, and providing technical assistance in the construction process. The decline in the proportion of respondents that were willing to pay and the increase in the average willingness to pay between the baseline and end line survey were due to improvements in the knowledge about the cost and benefits of the dryers. The higher average amount of money men were willing to pay than women was seen as the project was promoting the adoption of the technology. The project did not identify a woman that demanded a private solar dryer but many women demanded as a group. This confirms that the average amount of money women are willing to invest in a solar dryer is lower because private ownership of the solar dryer implies bearing a high cost of constructing the dryer.

The project used choice experiments to determine the value of different attributes of solar tent drying (see Annex 9). The findings showed that fish processors attach highest values to fish appearance enhancing and post-harvest loss reduction abilities of the solar tent drying. Sex disaggregated analysis of the values are presented in Figure 2.

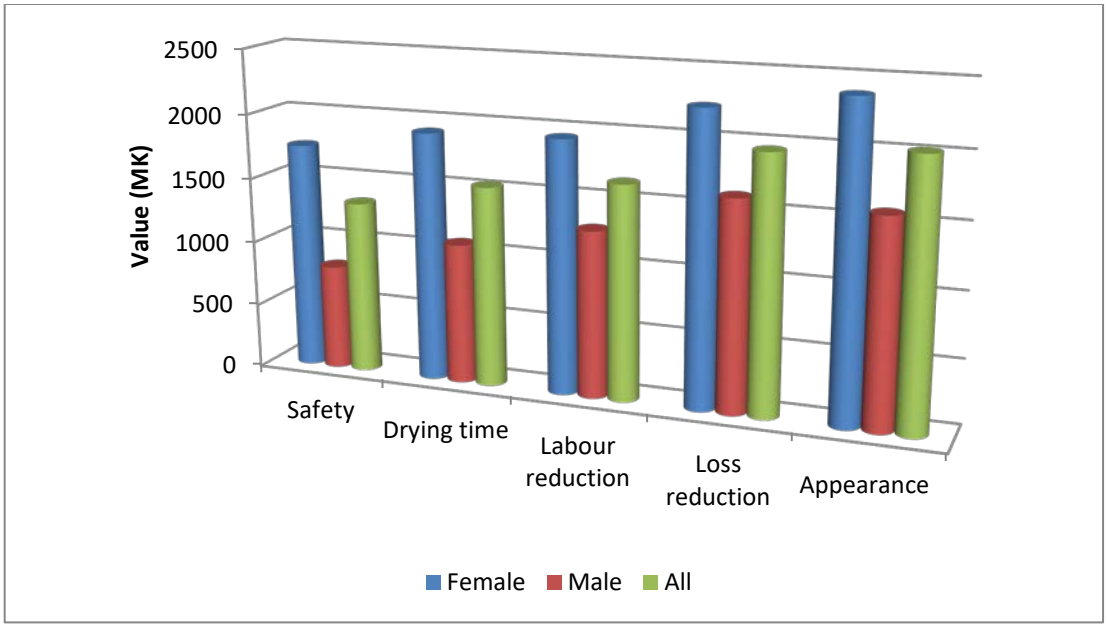

Figure 2: Value of attributes of solar tent drying

The results show that women attach higher values to the attributes of solar tent drying than men. Women place the highest value on improvements on sensory properties and this is followed by the reduction in postharvest losses. Men place the highest value on reduction in postharvest losses and this is followed by the improvements in the sensory properties of dried fish. Improvements in sensory properties and reduction in postharvest losses are assigned higher values by both men and women because they seemingly have a direct influence on the revenue from fish sales, and hence profit.

The study used net present value, internal rate of returns and payback period to appraise the investments on a solar tent dryer with a carrying capacity of 850 kg per drying cycle (refer to Annex 11). The estimated net present value was MK6, 014, 489 with an internal rate of return of 57% and a payback period of 1.8 years. A risk analysis on the investment on solar tent dryers shows that when uncertainty is factored in the values of the variables, solar tent dryers have an 80% probability of being profitable. With these results, it is shown that solar tent dryers are economically viable. However, the payback period of about 2 years makes the fish processors hesitant to invest in a solar tent dryer because the working capital for most them is small. It has however, been noted that when they see the returns from their own solar tent dryers or colleagues' solar tent dryers, fish processors are willing to invest. Presently, a youth group that is not directly supported by the project is constructing their own solar tent dryer after seeing the benefits of the dryer accrued to some of the adopters. Additionally, one of the first adopters of the solar tent dryers is constructing a second dryer without the support of the project. This validates the findings of the economic appraisal of the investment in the dryer but these needs to be communicated with fish processors and potential investors in a in a more accessible way including the development of investment and plans.

3.3 To assess and developing the value chain for preferred fish products through linkages with formal and informal value chain actors

The purpose of the value chain assessment was to characterize the main occupations of fisheries in the four lakes (Lakes Malawi, Malombe, Chiuta and Chilwa), determine their contribution to the economy, assess gender and employment issues, and explore areas of interventions. The study found that the fish value chains are complex comprised of many actors - fishers, crew members, processors, traders, fish transporters, firewood sellers, fisheries associations, traders of fishing gear and equipment (see Figure 3).

A gender analysis showed that although both men and women are involved in fish processing, it was found that 58% women are involved in sun drying of smaller fishes such as *Usipa, Utaka, Kambuzi* and *Ndunduma* compared to 42% men. Men were more involved in smoking of both smaller and bigger species such as tilapias and catfish. Selling of firewood for fish processing was mostly (70%) done by women while transportation of fish was mostly done by men who either drive vehicles to various destinations or paddle boats on behalf of fish buyers.

Women were found to dominate the post-harvest processing of smaller fish species as such they faced many challenges such as higher postharvest fish losses in the form of fish being burnt or spoiled during drying and smoking because of workloads as a result of their multipole roles. Women also indicated that they struggled to sell fish as they could only do this during the day to avoid intra-household conflicts if they stayed late at the market. The findings from the fish value chain show that solar tent drying would potentially eliminate the marketing challenges that are mostly faced by women. One of the important attributes of solar tent drying is the ability of fish processors to sell fish at supermarkets. This would eliminate waiting time on the market for the fish to be sold thereby not forcing women to sell fish at lower prices. Additionally, solar tent dryers significantly reduce the time required to look after the fish while drying.

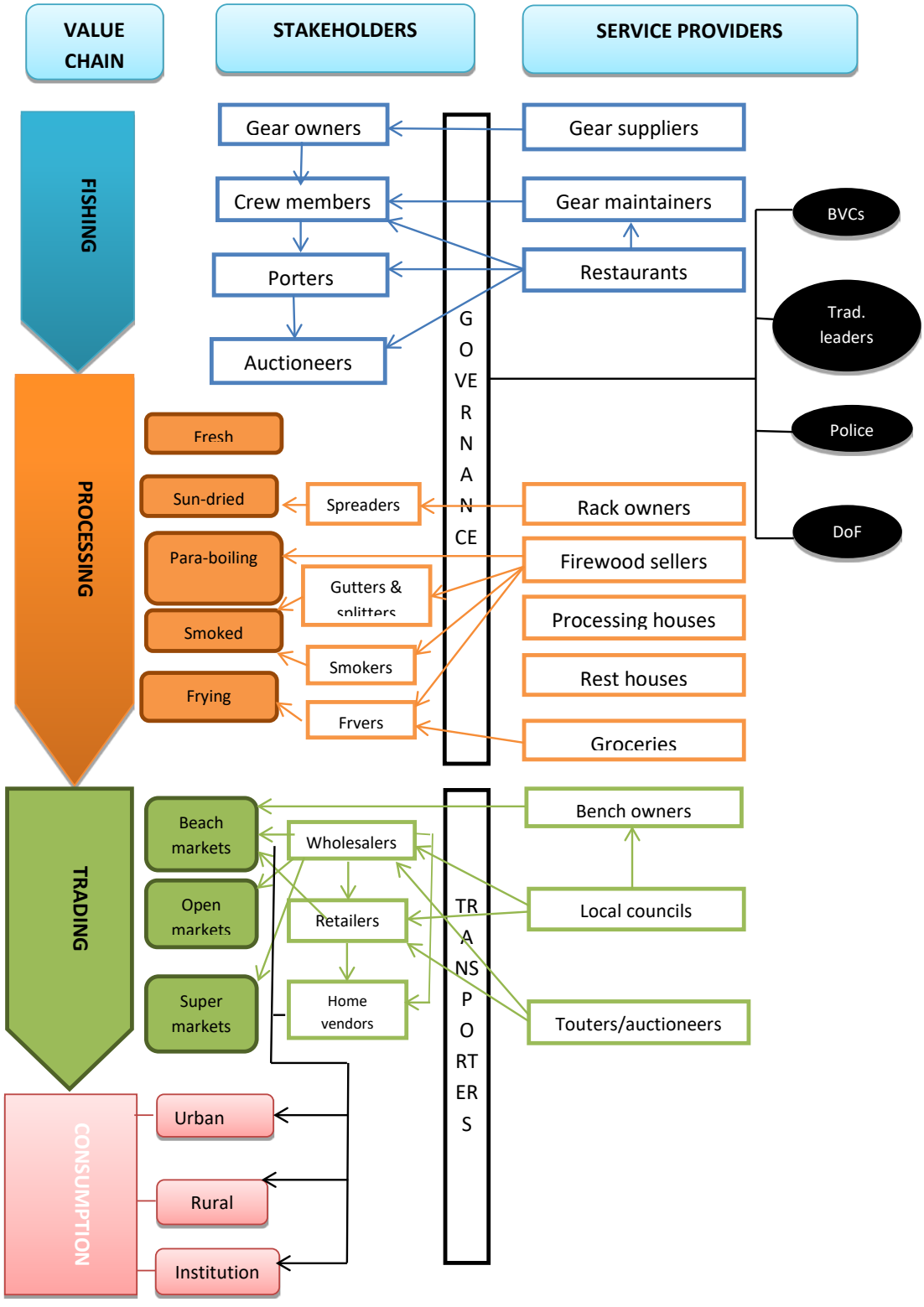

Figure 3: Fish value chain for small pelagics in Malawian Lakes

The value chain study estimated that fish postharvest losses based on subjective assessments by respondents at 33% of the fish catch. A detailed postharvest loss assessment was also conducted by using load tracking approaches along the fish value chain. The summary of physical and quality losses is presented in Table 8.

Table 8: Estimated fish physical and quality losses along the value chain (%)

	Physical and quality loss classification		
Value chain node	Good	Average	Poor
Fishing	56.0	18.6	25.4
Processor	46.2	29.0	24.8
Market	32.3	32.0	35.8
Overall	46.1	25.2	28.7

Overall, 29% of the fish was classified as poor in terms of physical and quality losses and 25% were in average state. These can crudely be seen as the extent of physical and quality losses although the fish of poor quality is still used in most cases. Highest quality and physical losses are registered at the marketing node of the fish value chain and lowest losses are registered at the processing node. Since both average and physical losses have some use value, estimating economic losses by use of the prices for different classification assisted in aggregating the losses. The findings of this analysis are presented in Table 9.

Table 9: Estimated fish economic losses along the fish value chain

Fish value chain node	Absolute loss per node (%)	Loss per catch (%)
Fishing	18.0	18.0
Processor	13.5	11.1
Market	6.8	4.8
Total		33.9

The dominator for absolute loss per node is the volume of fish handled at that node which makes this a measure of the loss to the value chain actor while the denominator of the loss per catch is the total volume that was caught which was attained by factoring the losses in the previous nodes making this a measure of the loss to the entire chain. The sum of loss per node per catch thus gives the total loss along the value chain. The total estimated postharvest fish losses along the value chain is estimated at 33.9% which is within the 30-40% which is normally reported in national and international literature (FAO, 2012; GoM, 2017). The highest losses are estimated at the fishing node at 18% of the total catch. Fishing processing and fish marketing nodes which were directly targeted by the project registered losses at 11.1% and4.8%, respectively. A sub-study of the post-

harvest losses study compared the losses that result from open sun drying and solar tent drying and these results are presented in Table 10.

Table 10: Comparison of estimated fish physical and quality losses for fish dried in open sun and solar tent dryers (%)

Drying method	Physical and quality classification		
	Good	Average	Poor
Open sun drying	54.8	24.6	20.6
Solar tent drying	93.8	6.2	0.0

For the fish that was dried in open sun, about 20.6% of the fish was classified as poor and 24.6% was classified as average, which are lower than the estimates presented in Table 8. The differences in the values may be due differences in seasons. Nevertheless, the estimated physical and quality losses are lower than those estimated for the solar tent dryer. Using market prices for the first survey, economic losses were estimated at 11.3% for open sun dried fish and 0.8% for solar tent dried fish implying that solar tent drying reduces postharvest losses at the fish processing node by 10% to fish processors.

One of the objectives of the project was to improve access to lucrative markets. Fish processors were grouped to process, pack, and supply fish to supermarkets. A marketing study conducted to assess the marketability of solar tent dried fish in People' Trading Center (PTC) supermarkets showed that the sales for solar dried fish increased with time. Figure 4 shows that there was higher frequency of purchase of 100g packets than the purchase of 500g. It terms of revenue, there was higher revenue generated from the 500g packets than from 100g packets. These results suggest that there is demand for dry packaged fish in the supermarkets and that the sales patterns depend on the size of packages and the location of the supermarket. The results from this study have also shown that fish processors and traders can improve their profitability and reduce risk of spoilage by selling through supermarkets. For example, 1kilogram of *Usipa* was selling at MK2300 (~US$3) on the local markets, whereas at the supermarket, the same quantity was selling at MK4500 (~US$6).

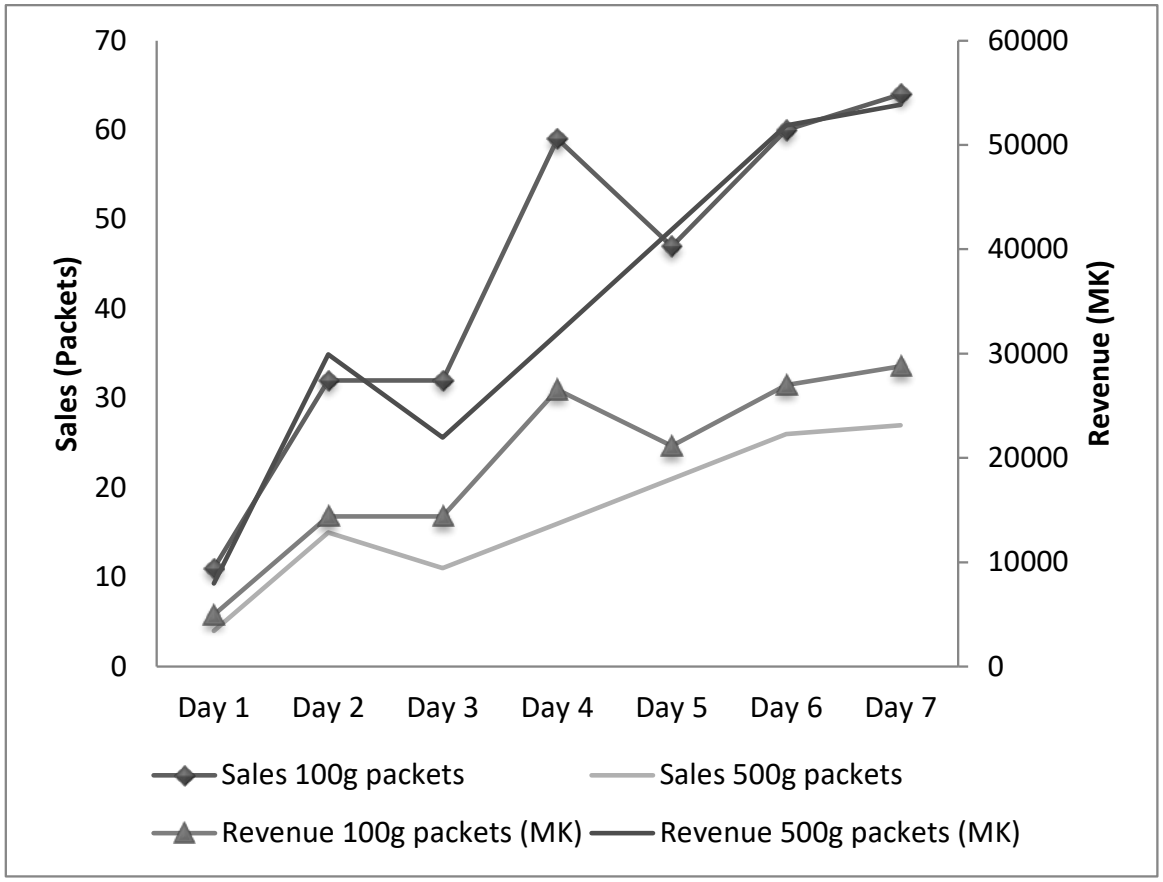

Figure 4: Trends in *Usipa* sales at PTC super markets

3.4 To evaluate and promote gender-equitable systems and structures that enhance access to technologies and markets, and improve the wellbeing of women, men and youth

3.4.1 Gender issues in fisheries

Gender Transformative Approaches (GTA) were used to promote gender equitable systems in the project sites. GTA (as opposed to just mainstreaming gender issues) in the project assessed gender disparities in decision making over fisheries resources, access to markets and fish processing technologies. GTA further engaged women, men and the youth through theatre, role modelling and case studies to address underlying gender stereotypes and norms for increasing women's productive potential.

There were clear disparities of participation between men and women in the fisheries sector. The findings show that 42% of men were involved in fishing compared to only 4% of women (Table 9). Women participation in fishing meant that either they own the fishing gears or they hired men to do the activity. This was confirmed with qualitative data where women indicated that they do not go fishing because of dressing codes where fishers dress only to cover private parts when fishing and also that fishing is mostly done at night. Focus Group Discussions in Chikombe - Salima district also revealed that there are cultural stereotypes that limit women's participation in other fisheries

activities. For example, it was indicated that women are not allowed to go to the Mbenje Island where most of the fishing in the areas is done, because it is against the spirits.

"*Ingakhale pa dooko apo, sitimaloredwa kukagula nsomba, chifukwa cha zikhulupiliro ngati zimenezi (Even at the beach we were not allowed to buy fish, because of the cultural beliefs)*" – stated one of the participants during the FGDs at Chikombe.

As such the type of assets owned by men and women are based on gender roles. On one hand, larger proportions of women than men own locally produced fishing equipment, fish storage equipment, and drying rack. On another hand, larger proportions of men than women owned externally produced fishing equipment such as hooks, synthetic nets, and lines; canoe for fishing, fishing boat, gill net and engine boat (Table 11).

Table 11: Asset ownership between men and women in the fisheries sector in southern Lake Malawi

Type of Asset	Male		Female	
	n	%	n	%
Locally-produced fishing equipment (e.g., baskets)	77	44.3	86	48.0
Externally-produced fishing equipment	53	30.5	19	10.6
Canoe for fishing	54	31.0	19	10.6
Canoe or boat for transportation	4	2.3	1	0.6
Fishing boat	15	8.6	4	2.2
Gill net	33	19.0	13	7.3
Engine boat	40	23.0	15	8.4
Fish storage equipment	27	15.5	41	22.9
Drying rack	82	47.1	106	59.2

Gender analysis also looked at involvement of men and women in decision making and the results are presented in Table 11. The table shows that sex of the individual significantly influences decisions related to fishing and fish processing with more men (46%) than women (7%) making inputs in the decisions related to fishing and more women than men making decisions related to fish processing. These results are also revealing that a larger proportion of men (82%) and women (77%) made decisions on income from fishing than those that made decisions about the fishing activity itself. This may mean that while there are some members of households who are involved in fishing, decisions on use of income from fishing is largely made at household level. This result may be explained by the fact that most fishing assets are owned as a household asset.

Table 12: Level of input on decisions on fishing related activities and incomes by males and females

		Decision on activity			Decision on income		
Activity	Level of input	Male	Female	Chi square	Male	Female	Chi square
Fishing	No input	1.1	0.6	72.9***	2.3	0.6	69.9***
	Little input	3.4	1.1		4.0	3.4	
	Moderate input	3.4	1.7		36.8	2.8	
	Large input	38.5	3.9		0.0	0.0	
	Not applicable	39.7	72.1		41.4	70.4	
	Missing	13.8	20.7		15.5	22.9	
Fish processing	No input	0.6	2.2	18.70***	0.6	1.1	30.40***
	Little input	8.6	18.4		3.4	21.2	
	Moderate input	58.6	63.7		58.0	54.7	
	Large input	22.4	10.1		25.9	13.4	
	Not applicable	9.8	5.6		12.1	9.5	
	Missing	0.0	0.0		0.0	0.0	
Fish storage	No input	0.0	1.1	3.6	0.0	0.6	10.5***
	Little input	4.0	5.6		2.9	10.6	
	Moderate input	32.2	36.3		27.6	29.6	
	Large input	0.0	0.0		48.9	40.2	
	Not applicable	46.6	40.8		20.7	19.0	
	Missing	17.2	16.2		0.0	0.0	
Fish transportation	No input	1.7	0.6	7.6	1.1	0.6	15.37***
	Little input	3.4	6.7		2.3	11.7	
	Moderate input	42.5	51.4		38.5	40.8	
	Large input	39.1	27.9		42.5	30.2	
	Not applicable	13.2	13.4		15.5	16.8	
	Missing	0.0	0.0		0.0	0.0	
Fish marketing	No input	1.7	0.0	7.7	1.1	0.6	7.70
	Little input	5.7	12.3		6.9	13.4	
	Moderate input	69.0	62.0		66.1	55.3	
	Large input	16.7	17.9		16.1	22.3	
	Not applicable	6.9	7.8		9.8	8.4	
	Missing	0.0	0.0		0.0	0.0	

Note: *** denotes significant association at 1%

3.4.2 Gender transformative approaches and outcomes

A total of 413 participants (202 males and 211 females) have been engaged in gender transformative approaches (GTA) by the project. Gender Transformative activities such as such as role plays, drama, case studies and role models were implemented in all the project sites through trainings and establishment of platforms. The platforms were meant to provide space for local discussions and sharing best practices of gender transformation. Eleven GTA platforms have been formed which meet weekly to share and discuss these best practices. To promote the gender transformative approaches at community level, 18 (10 women and 8 men) gender champions were trained on how to lead discussions on gender transformative approaches using the John Hopkins' "African Transformation Toolkit". The toolkit provides women and men with the means to explore how gender norms and social roles operate in their lives by offering tools to begin changing norms and roles that are negative, while reinforcing ones seen as positive. Table 11 shows that the gender champions conducted a total of 136 sessions involving 860 people (345 males and 525 women). These sessions are conducted independent of project support which shows that the gender champions will continue to transform the communities.

Table 11: Number of training sessions conducted by GTA Champions

District	**Champions Team**	**No. of Sessions per Team**	**Men**	**Women**	**Total**
Salima	Lifuwu	15	65	95	160
	Chikombe	10	50	75	125
Mangochi	Malembo	96	110	165	275
	Msaka	10	80	120	200
	Madzedze	5	40	60	100
Totals		**136**	**345**	**515**	**860**

Results from these meetings indicate a positive transformation of attitudes and behaviors towards division of labor between males and females at household level. Some reported and observed transformations resulting from the gender transformative activities include but not limited to:

- Women engaging in active fishing in some parts of Malembo.
- Women now leading BVCs as chairpersons, secretaries or treasures. This has been reported in Msaka and Malembo.

- Women openly engaging in dialogue to break embedded gender-dominated cultural beliefs such as access to fish landing sites in Chikombe.
- Women getting involved in construction of pit latrines, grass security fences and bathing fences.
- Men getting involved in cooking while their spouses are engaged in other activities (labour sharing) that has improved on efficient use of time.
- Men washing clothes for the household including those of their spouses and children
- Men caring for their sick children.

3.5 To assess the uptake and impact of improved fish processing and marketing on the livelihoods of fisher folk

The development outcomes for this project were improvements in income and food security. There are also a number of outputs which we targeted to influence with the interventions. Table 13 the summary of the changes in development outputs and outcomes.

Table 13: Status of key project indicators

Indicator	Before	After	% Change
Value of assets owned (US$)	2,750.30	7,323.08	166.26
Monthly per capita food expenditure (US$)	12.69	11.73	-7.57
Savings account (%)	38.25	78.69	105.73
Knowledge of solar tent dryers (%)	13.5	88.1	552.59
Number of users of solar tent dryers	0	188	-
Number of male users of solar tent dryers	0	65	-
Number of female users	0	123	-
Number of fish processors using solar tent dryers	0	52	-
Number of individuals with access to chain stores	0	23	-
Value of solar tent dried fish (US$)	0	429,353.13	-
Quantity of fish sold through super markets (kg)	0	38,272.00	-

The findings show that there were positive changes in value of assets and proportion of respondents with savings accounts and negative change in monthly per capita food expenditure. The analysis applied at this stage for these indicator variables may not reflect the influence of the project on

these variables. We could not apply econometric analysis which could have measured the treatment effects because very few respondents in the sample (9) used solar tent dryers which is the major treatment in the survey. However, information from case studies show that solar tent dryers are improving incomes, savings and more likely food consumption. For example, one of the early adopters of a solar tent dryer is constructing another solar tent dryer which shows that he is able to have more savings and build his asset base.

For the rest of the indicators included in Table 13, the observed values can be attributed to the project because of their nature. The project has increased awareness of solar tent dryers in the project area from 14% to 88% representing a 75 percentage point increase. This knowledge change provides the platform on which future interventions to promote the use of solar tent dryers can be built on. Presently, 188 individuals are using solar tent dryers out of which 123 are female. These users include 52 fish processors (23 male and 29 female), 20 permanent workers (6 male and 14 female), 78 temporary workers (25 male and 53 female), and 38 unpaid workers (11 male and 27 female). This implies that solar tent dryers are creating employment and that most of those benefiting are females. More employment benefits of solar tent dryers are observed on solar tent dryers that are owned by individuals. As such, it should be stated that benefits of solar tent dryers that are owned by individuals trickle down to other members of the community through employment generation.

It is noted that more women (78) than men (45) are now involved in using the four solar tent dryers that are owned by four men. More women (29) than men (19) are also involved in using solar tent dryers that are owned by groups.

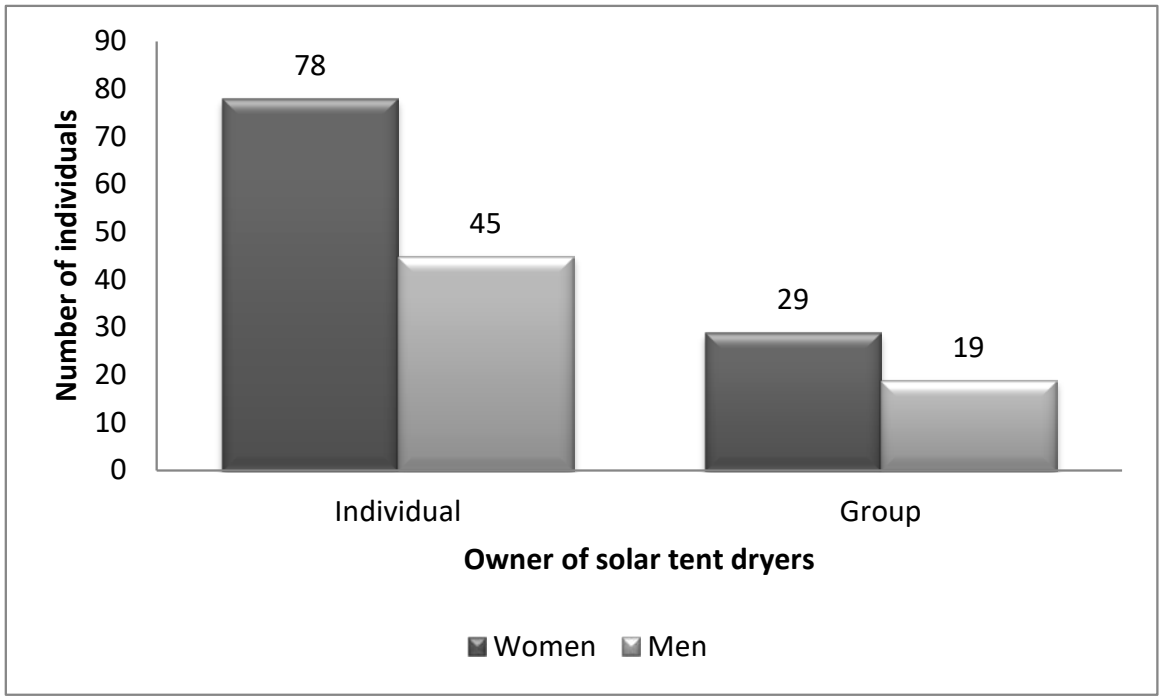

Figure 5: Number of men and women that have adopted solar tent dryers

Additionally, benefits of adoption of solar tent dryers are through improvements in the supply of quality fish to the community. Most solar tent dryers started operating in January 2017 except for one that started operating in May 2016. For this period, the total quantity of dry fish produced is estimated at 86,685.50kg. With an estimated annual per capita fish consumption of 5.05kg, the fish output from the solar dryers have supplied fish to over 17,000 individuals. Basing on the supermarket price of MK4500 per kg, the value of solar tent dried fish in the past year is US$ 543,734.38. This value is from eight solar dryers from four sites.

Solar tent dryers have also opened opportunities for the fish processors to sell dried fish at lucrative formal markets which before the project were not being accessed. It is estimated that 39 fish processors (23 women and 16 men) have had access to formal lucrative markets. The Malawi Bureau of Standards has certified fish from solar tent dryers to be healthy for consumption. It is just expected of other fish processors to go through the formalities of certification of their solar tents. From 2015, over 10 formal lucrative markets have been accessed by fish processors. These include Peoples Trading Center (PTC), Chipiku Plus, Spendrite, Stella Maris Secondary School and Malindi Secondary Schools. Figure 5shows the number of men and women that have been selling fish to PTC supermarkets. At most of the project sites, more women than men sold solar tent dried fish at PTC supermarkets. However, more fish was sold through formal markets by men (38,549.50 kilograms of dry fish) than women and these are the ones who were operating individual solar tent dryers. The women that accessed formal markets were members of groups that were comprised of both men and women and these supplied 24,480.00 kilograms of dry fish.

They supply *Usipa* and the freshwater *Ndunduma* in 100g and 500g packets. *Usipa* is sold for about MK 2,300 (about US$3) per kg at local markets, whereas at the supermarket the fish is sold for roughly MK 4,500 (about US$6) per kg. This shows the role the project has made in promoting access to formal lucrative markets by men and women and that more women have access to these markets.

Fish processors have also been supplying fish to special functions like weddings and religious functions which was not the case before they started using solar tent dryers. One of the fish processors has received an order to supply solar dried fish to constituents of Monkey Bay Constituency for about 18 months. Solar tent dried fish is also sold in the local markets in central and southern regions of Malawi and even in Chipata, Zambia.

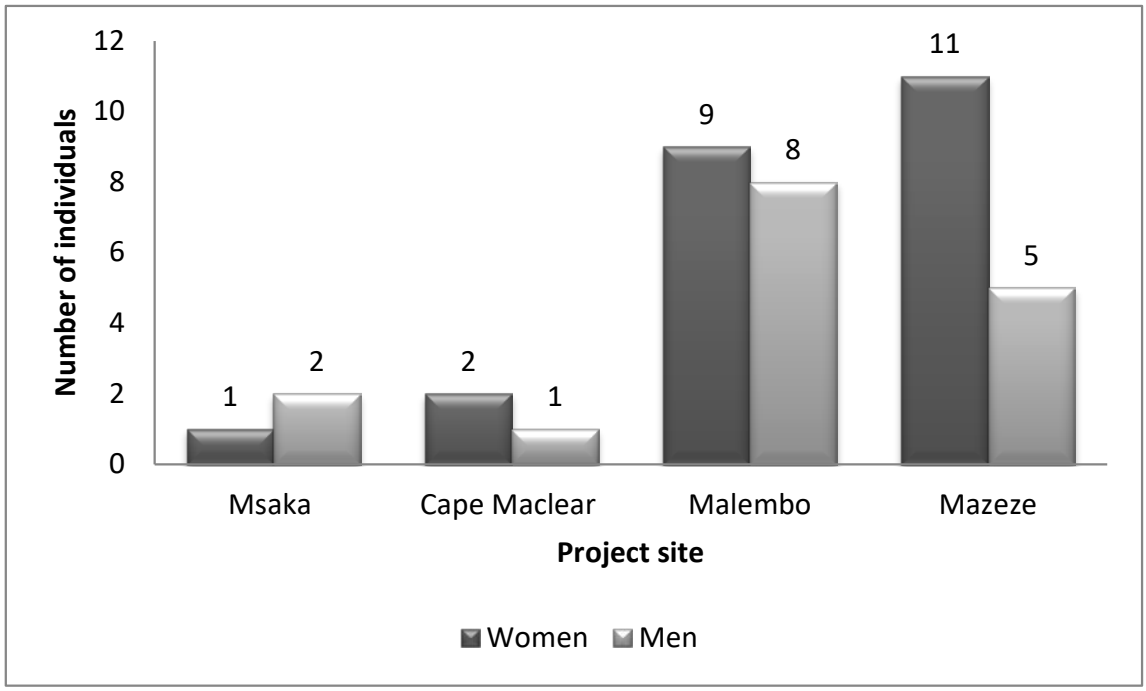

Figure 6: Number of male and female fish processors accessing PTC markets per project site

4 Synthesis of results towards AFS themes

4.1 Increased agricultural productivity

Agricultural productivity in this project has been enhanced through the reduction in post-harvest fish losses and improvements in the quality and safety of dried fish. The project has come up with a design of fish solar tent dryer that is able to dry fish from Lake Malawi. Due to lack of refrigeration facilities, fresh fish from most African fisheries are dried to reduce moisture content and increase shelf life. Traditionally, fish is dried on open sun on drying racks. When using open sun drying racks, fish is susceptible to infestation with insects, microorganisms, dust, and theft by animals and thieves. Solar tent dryers that have been promoted by the project enable fish processors to reduce quality, physical losses, and economic losses in fish. The findings have shown that solar tent dryer reduces physical and economic losses by 10%. Apart from the reduction in losses, productivity gains are also due to quality gains that increase the prices by about 50% although we know that the profit margin will not necessarily go up by 50% because of additional marketing costs. Additionally, open sun drying is almost impossible during rainy seasons but solar tent dryers makes fish drying possible in all weather conditions. For quality losses, the project has shown that solar tent drying does not lead to degeneration of important nutrients (crude protein and fats) while lowering moisture and ash content. There are also significant reductions in microbial load by over three times when a solar tent dryer is used. Solar tent dried fish also elongates shelf life to about 7

to 16 weeks compared to 3 to 7 weeks for open sun dried fish. The reduction in quantitative and qualitative losses ensures that we increase fish supply without increasing fishing effort.
One of the elements that have been addressed by the project which contributes to this AFS theme is the reduction in drudgery. It has been estimated that using a solar tent dryers requires an average of two and half hours per day to work on the fish. This has substantially reduced time spent when fish is dried on open sun drying because they are supposed to be around for almost the whole day because they are expected to do a number of things like turning the fish, guarding from thieves, chasing predators, covering and uncovering the fish during rainy season and at night they are forced to sleep under the fish drying rack. Since guarding roles are mostly given to children, reduction of this need reduces child labor.

The project has also addressed the AFS theme on increased agricultural productivity by addressing gender issues. Since fish processing is predominantly done by women, the quality fish products that are produced from solar tent dryers results in high economic gains to women, which is improving their incomes and wellbeing. The project has been implementing Gender Transformative Activities (GTA) which aims at empowering women and improving their access to technology and markets. The implementation of these activities has seen more women than men adopting and using solar tent dryers. For example 123 women are involved in using solar tent dryers on various capacities and this is greater than the number of men which is estimated at 65. The only challenge is that the project did not manage to attract any woman to own a solar dryer privately and this has resulted in lower levels of production of dried fish for women (11, 555 kg) than men (56, 830 kg). GTA have also made women to be engaged in active fishing in some parts of the project area; lead in beach village committees (BVCs) as chairpersons, secretaries or treasures; and get involved in activities that are normally considered as men's activities.

4.2 Improving access to resources, markets and incomes

The project has been improving access to solar tent dryers, formal lucrative markets, and incomes. At inception point, there was no solar tent dryer in the project sites and open sun drying was the only method that was used to dry fish. Presently, the project has assisted in the construction of 11 solar tent dryers in the five project sites and there are about188 individuals. In constructing the solar dryers, the project has been using local artisans with technical support from the project. This has ensured the building of local expertise which means that the community can still have access to the technology beyond the project life.

Due to quality improvements in solar tent dried fish in terms of food safety and sensory characteristics, it has become easy for fish processors to access formal lucrative markets. At the time when the project was being conceptualised, there was no local fish processor who sold fish in formal markets. Presently, about 10 formal lucrative fish markets have been accessed by fish processors. The project facilitated access to one formal lucrative market (PTC) but fish processors have managed to identify other markets on their own because of the number of capacity building sessions that were organised for the community. The additional markets include supermarkets,

secondary schools, religious functions and wedding ceremonies. Up to 26 fish processors are now accessing the formal markets which ensures stable prices and certainty in demand.

To improve access to financing by the youth, the project trained 5 youth groups in business management and entrepreneurship as a way of empowering them to look for financing for their business ideas. All the youth groups applied for business grants and one of them was awarded a grant. There is also a young man who applied on his own and was awarded the business grants.

4.3 Improving utilisation

The project supports the AFS theme on improved utilisation by increasing the availability of an animal protein product (dried fish) to families. Not only is the supply of dried fish improved but the project is also improving the supply of healthy fish products through improved processing technology that reduces microbial contamination in the dried fish. It is estimated that the project has made available health fish to more than 17000 individuals. Among these are secondary school pupils (about 900 pupils) that are now having fish diets twice a week.

4.4 Informing policy

The project has been engaging policymakers and decision-makers at national level and local level since its inception. The formulation of the project team also included a government department that is responsible for fisheries research (Fisheries Research Unit). This has ensured uptake of research results by policy makers since the outputs from the research are being included in their normal reporting systems. As such, the Ministry of Agriculture under which the Department Fisheries falls choose the presentation on solar tent dryers as one of the few presentations that were made during the launch of the National Agriculture Policy. The ministry has thus chosen solar tent dryers as one of climate smart technologies that will be promoted. To show that the Department of Fisheries have adopted the technology, they have given the technology a local name "*Samva Nyengo*", a name which emphasizes the fact that solar tent dryers can dry fish in all weather conditions.

Policy makers have also been engaged through participation in a number of forums which includes National Agricultural Fairs, the launch of the Ecosystem based Adaptation for food security in Africa Assembly (EBAFOSA) Malawi Chapter, and the 2016 African Green Revolution Forum (AGRF 2016).

Presently, there are no certification standards for dried fish in Malawi and the certification and placement of the MBS seal on the packets of fish produced by one of the fish processors reflects acceptance of the standards by the national quality regulatory body. This will go a long way in informing certification processes of dried fish in Malawi.

5 Project outputs

The following are the main projects that have been completed;

Published papers

1. Banda et al., (2017). Nutrition, microbial and sensory quality of solar tent dried (*Samva Nyengo*) and open sun dried C. virginalis (Pisces; cichlidae). *International Journal of Marine Sciences*, 7 (11): 96-101

Submitted Manuscripts

2. Banda, et al., (Under review). Nutrition and safety of solar tent dried and open sun dried *Diplotaxodon limnothrissa*. African Journal of Food, Agriculture, Nutrition and Development

3. Chiwaula, et al. (Under Review). Gender Differences in Willingness to Pay for Capital Intensive Agricultural Technologies: the case of Fish Solar Tent Dryers in Malawi. *Journal of Agricultural and Food Economics*

4. Banda et al., (Under Review). Shelf life of solar tent dried and open sun dried *Diplotaxodon limnothrissa*. *Journal of Food Processing and Preservation*

MSc Theses

5. Nadzanja, T. (2016). Willingness to pay for fish solar tent drying by Lake Malawi Fish Processors. Unpublished MA thesis, Department of Economics, University of Malawi.

6. Kawiya, C. (2016). Economic assessment of fish solar tent dryers in Malawi. Unpublished MA thesis, Department of Economics, University of Malawi.

7. Banda, J. (Forthcoming). Quality and shelf life of solar tent dried and open sun dried *Diplotaxodon limnothrissa* (local name Ndunduma. Unsubmitted MSc thesis, Mzuzu University (MZUNI).

8. Mwanza, P. (Forthcoming). Assessing options for out scaling solar tent fish dryers for fishing communities along Lake Malawi. Unsubmitted MSc thesis, Lilongwe University of Agrculture and Natural Resources (LUANAR).

Completed manuscripts

9. Banda et. al. (2017) A comparative analysis of the quality of solar tent dried (*Samva Nyengo*) and Open Sun dried Usipa fish (*Engraulicypris sardella*) Pisces; Cyprinidae

10. Simbeye et al., (2017). Assessing the effectiveness of an adapted solar tent dryer in drying Lake Malawi's Engraulicypris

11. Kawiya (2017). An economic appraisal of fish solar tent dryers used on small fish species on Lake Malawi sardella (*Usipa*)

Uncompleted outputs

12. Chiwaula et al. Application of choice experiments to willingness to pay for solar tent fish dryers in Malawi. Draft manuscript

13. Katundu, et al. A comparative analysis of the sensory quality of Engraulicypris sardella fish species (*Usipa*) and fresh *Copadichromis virginalis* (*ndunduma*) dried using solar tent and open sun methods

Conference Presentations

14. Banda, J., et al., (2016). Quality analysis of Diplotaxodon fish species processed in Solar Tent Dryer and Open Sun drying. An oral presentation made at the 18th International Conference on Food Manufacturing and Safety 25-26th July 2016, Paris, France.

15. Chiwaula, L. (2016). Better processing and marketing of healthy fish products in Malawi. An oral presentation made at the 2016 African Green Revolution Forum (AGRF), Nairobi, Kenya.

16. Nagoli, J and Chiwaula, L. (2017). Reducing Post-Harvest Losses of Great Lakes Pelagics through Solar-tent drying. A poster presentation made at the 2017 African Great Lakes Conference, 2-5, May 2017, Entebbe, Uganda.

17. Organised an end of project dissemination workshop in Mangochi, Malawi on 7 June 2017 where 52 stakeholders attended;

18. Nagoli, J. (2017).Fish Solar Tent Dryer (*Samva Nyengo*). An oral presentation at The 1st All Africa Post-Harvest Congress, 28th to 31st March 2017 Safari Park Hotel, Nairobi, Kenya.

19. Department of Fisheries (2016). Solar Tent Fish Dryer (Samva Nyengo): A SMART Innovation Reducing Reliance on Fuel Wood Fighting Global Climate Change in Fisheries Sector. A poster presentation made at the 2017 Malawi Forum on Extension for Climate Smart Agriculture (CSA), Blantyre, Malawi.

20. Banda, J. (2017). Solar tent fish dryer for fish safety in Malawi. An oral presentation made at the Food Safety in the value chain Conference, 3 -6 July, 2017, Harare, Zimbabwe.

6 Problems and challenges

Below is a highlight of some of the major problems and how they were addressed;

One of the major challenges our project has faced is the lack of financial capital among fish processors that show interest to own solar dryers. To ease the constraint, the project is introducing a loan facility in which solar fish dryers will be constructed for them so that they can be using the structures in processing fish and repay from the returns. We are presently discussing with potential partners to manage the loan facility and these include the One Village One Product (OVOP) programme, the Local Development Fund (LDF). We are also talking with microfinancing institution, Opportunity International to see if they can extend microcredit facilities to these fishing communities.

The second problem related to the misconception on group ownership of solar tent dryers. When solar tent dryers were constructed for some of the groups on loan basis, the groups continue to consider these as belonging to the project such that they were not using them as they were expecting the project to give them operating capital although they were still drying fish on open drying racks and they were not repairing the dryers when there is need.

There were also problems related to certification of solar tent dried fish during the marketing study. When solar dried fish from the project was placed in the PTC shops the Malawi Bureau of Standards (MBS) demanded that the fish should be removed from the shops after three weeks of the study because there is no certification for the project but individuals in the project. This affected data collection. The project decided to analyse the data that was collected.

7 Overall assessment and recommendations

From our experiences during the implementation of the project, two major recommendations are made to IDRC;

Firstly, the duration of the project was not long enough to observe tangible changes on some of the project outcomes. Considering that the project needed to design a solar tent dryer and promote the design among fish processors, it was necessary that the project be given adequate time to promote the adoption and measure the impact of adoption.

The second element relate to capacity building on different elements of the project. We recommend that IDRC should conduct capacity building trainings on gender and communication in the first three months of the project. Some of the elements on communication and gender came way into the project and this made us to change elements of the project after the plans and projects had already been approved.