Profitability of improved fish processing technologies in Malawi

Draft Report

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1 Introduction

Scaling out improved fish processing technologies (IFPTs) such as improved smoking kilns and solar tent dryers in Malawi have been constrained by financing challenges. This may not be unique to Malawi but other low income countries as well. This happens irrespective of the economic viability studies that have shown that IFPTs are economically viable investments (Chiwaula et al., 2019) and there being adequate willingness to pay (Chiwaula et al., 2018). In view of this, there is need to develop financing mechanisms that are flexible and considers the characteristics of the fishing and fish processing industry. The financing mechanism need to attract a willing financier and willing borrower at the given conditions. One of the ways to generate such a situation is to show the profitability of using IFPTs and the marketability of the fish that is processed through the IFPTs. Profitability analysis would help to show the level of profits as well as the ability of the borrowers to service loans. The objectives of this report are thus to:

1. Assess the level of profitability of using improved smoking kilns and solar tent dryers in processing fish;
2. Assess marketability of fish processed from improved fish processing technologies; and
3. Develop investment profiles associated with the adoption of the two technologies.

2 Description of fish processing

2.1 Fish processing requirements

The quality of fresh fish declines quickly if not well processed soon after catch (Cheng *et al*., 2013). This eventually affects the consumer's preference as they demand for quality healthy products (Sen, 2005). It is worth noting that in terms of processed fish products, sensory characteristics tend to be a significantly influencing factor among consumers (Ojutiku *et al*., 2009; Alasalvar *et al*., 2011). Therefore, maintaining product quality from the landing site where the fresh fish is processed to consumer is very vital (Hylding and Nielsen, 2000). The subsequent post-harvest processing methods are applied to reduce the degree at which quality loss in fish products proceeds (Abolagba and Nunfah, 2011). Furthermore, processing also intends to diversify fish products to suit different taste preferences of consumers (Mussa *et al*., 2010). However, different processing methods produce different physical and chemical properties that in turn could be liked or disliked by consumers because of its quality (Pieniak *et al*, 2008; Turan, 2006).

2.2 Post-harvest processing methods

In Malawi, a small proportion of small fish species like *Engraulicypris sardella* (Usipa), *Copadichromis* species and *Diplotaxodon* species (Ndunduma) caught are sold fresh, a greater portion is processed by various methods. Common processing methods include open sun-drying, paraboling, deep frying and smoking (FAO, 2011).

2.2.1 Open sun drying method

Open sun drying refers to a post-harvest processing method that involves drying fish on racks above the ground on an open environment. This allow the loss of moisture from fish in form of vapour (Eyo, 2001). The method is common for processing pelagic fish species like *Copadichromis, Barbus paludinosus*, *Diplotaxodon* species and *Engraulicypris sardella* (Kawarazuka, 2010). Open sun drying is labour and time intensive, as fish products have to be covered at night. There is also a chance of insect infestation and growth of microorganism due to nonuniform drying. Apart from exposing the products to fecal contamination, the products are prone to case hardening. Case-hardening or surface hardening is the process of hardening the surface of a fish products while allowing the fish deeper underneath to remain soft, thus forming a thin layer of harder at the surface (FAO, 2010; Jumbe *et al*., 2008). This results to multiplication of microorganisms such as spoilage and pathogenic microorganisms.

Figure 1.0 Open sun drying of small fish products at Nsaka, Lake Malawi

2.2.2 Paraboiling method

Paraboiling is common for *Engraulicypris sardella* (Usipa*)* a pelagic cyprinid endemic to Lake Malawi, which supports a substantial fishery using open water and beach seines. The process involves partial boiling of the Usipa in hot water and subject it to open sun drying (Fig 2.0). The method results to re-contamination of the products during final drying resulting to high level of microbes that pose a health threat to consumers.

Figure 2.0 Paraboiling process of *E. sardella* at Nsaka beach, Lake Malawi

2.2.3 Smoking method

Except for fish drying, which is the simplest and traditional fish processing method, smoking is using smoking kiln whose principle is based on closed circuit air conditioning is the second oldest fish processing method used by artisanal fisheries (Fig 3.0). The importance of fish smoking is two-fold; preservation and value addition through improved taste and product diversification. Smoking, uses a combination of drying with the addition of chemicals from the smoke to flavour the fish, thereby preserving and adding flavour to the final product (Raji, 2009). However, smoking is dominated by use of traditional open fire using firewood that renders the product with high levels of smoke deposits, polycyclic aromatic hydrocarbons and unhygienic handling by the processors and smoking facilities and usually use too much wood for small amount of product thereby increasing deforestation a draw back in the fight against climate change. It is apparent that firewood fuel demand in fisheries sector is increasing with the rise in population. This situation is worsening as more consumer also prefer smoked fish products. However, firewood fuel is unsustainable as shown by the deficit and degradation of available forest in Malawi especially in the lake shore.

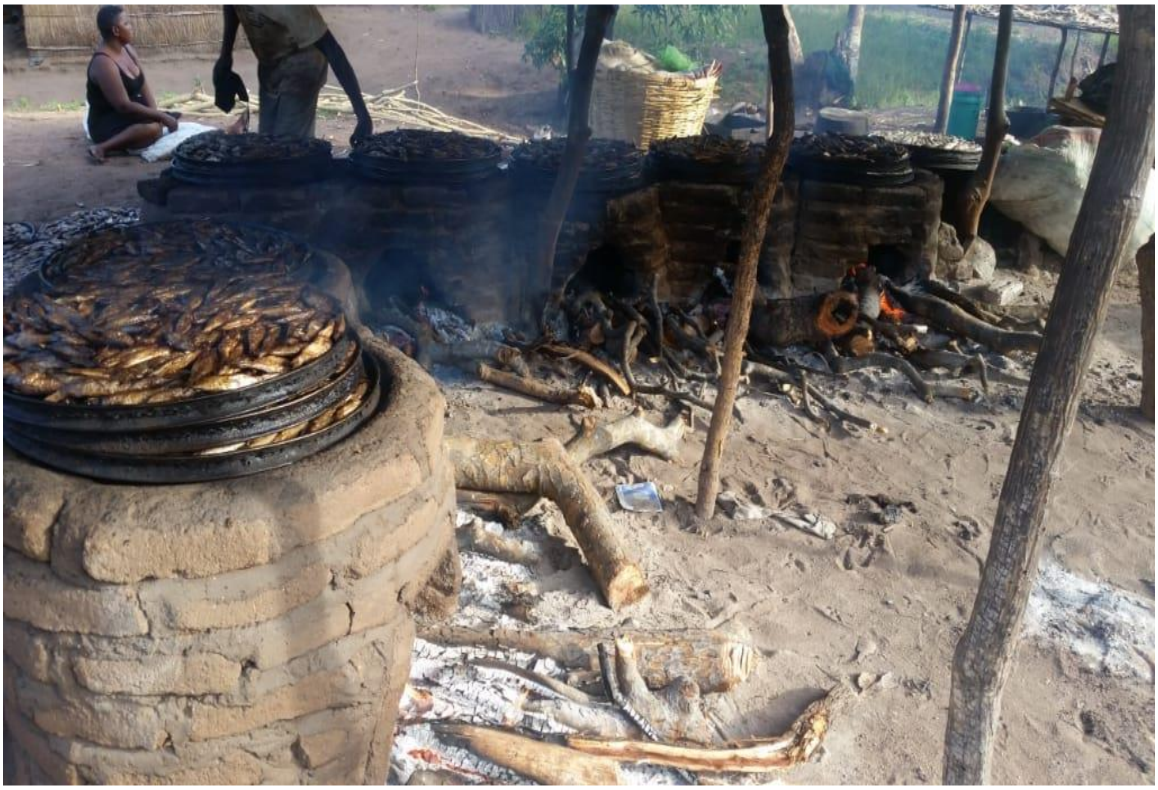

Figure 3.0 Smoking process at Malembo beach, Lake Malawi

2.2.4 Deep frying method

Deep frying target Ndunduma, Usipa and Utaka fish species. The process involves subject the fish products in a pan of with hot oil (Larrañaga *et al*., 2012). This in turn allows the fish to be fried followed by air drying on open rack. One clear caution and risk is the possibility of degrading nutrients due to hot oil.

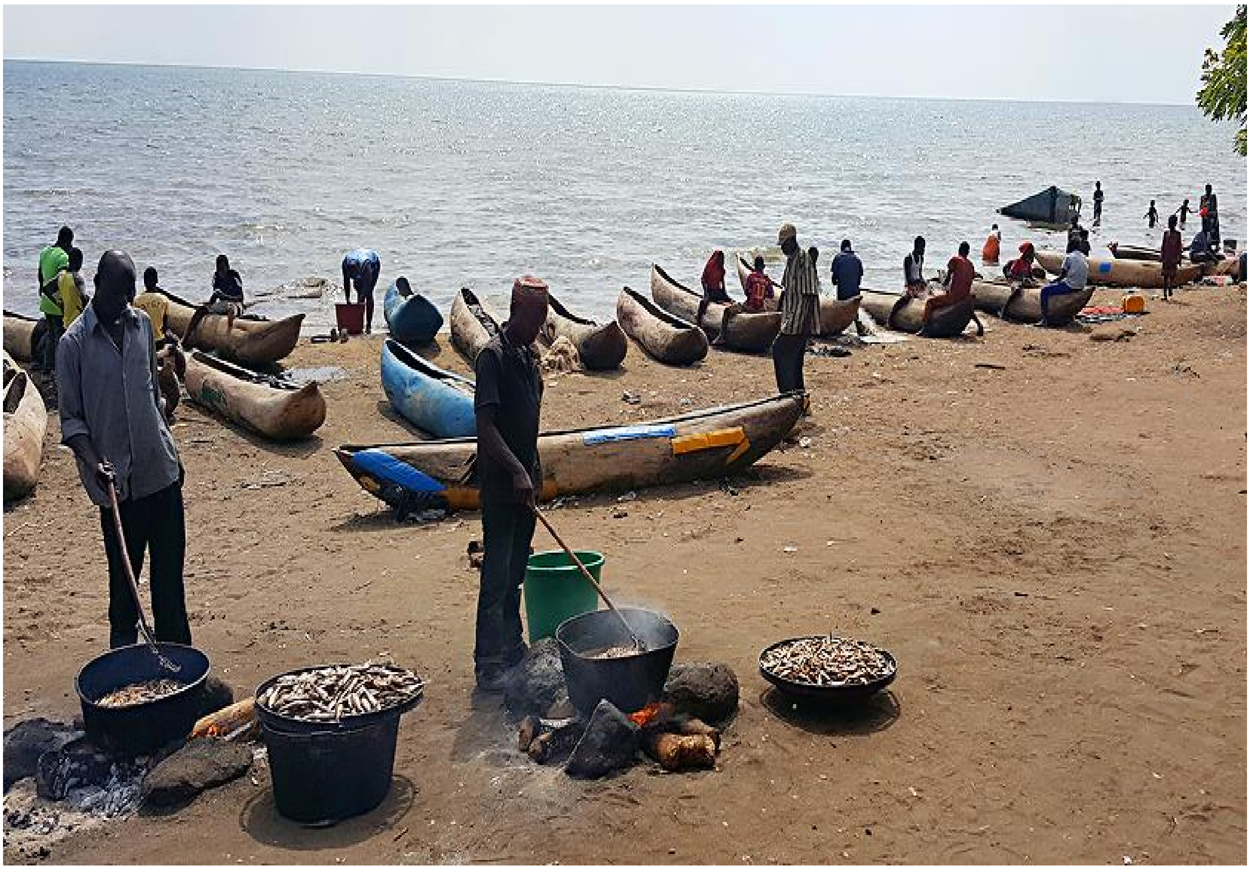

Figure 4.0 Deep frying process at Malembo beach, Lake Malawi

2.2.5 Solar tent drying method

Solar tent drying methods was first introduced and implemented under Nsomba Nchuma Project to process small fish species of Lake Malawi (IDRC, 2014) (Fig 5.0). The use of solar tent dryer for processing fish is not a new technology in Africa, but it is relatively new in Malawi. The solar tent dyer is a greenhouse structure that was first discovered in Southern Asia in Bangladesh (Doe et al., 1977; Chiwaula et al., 2018). The technology was successfully adapted and modified in Nigeria for processing fish products during seasons associated with higher relative humidity (Olokor, 2009). Studies in Lake Chilwa on *Barbus paludinosus* have demonstrated that the solar tent dryer is more effective in removing the moisture in the fish which speeds up fresh fish spoilage as well as retaining more nutrients than sun-drying and parboiling processing methods. The drying of fish in an enclosed environment protects the products from dust, dirt, attack by birds, rodents and insect infestation, hence yield products of better quality (Olokor et al., 2009). The technology is capable to provide enough amount of heat that is more than ambient heat under certain relative humidity. This increases the vapor pressure of the moisture kept and confined within the fresh fish products on racks and eventually decreases the relative humidity of the drying air so that the moisture carrying capacity of the air is increased (Leo and Kumar, 2008; Banda et al., 2018). This allows the fish products on the racks to dry freely following the three phases of drying which are initial, free falling and constant falling rate (Akinola et al., 2006; Chiwaula et al., 2018). This enhances prevention of reverse osmosis of the product during and after the drying process (Turan et al., 2007).

Figure 5.0 Solar tent drying of *E. sardella* at Nsaka beach, Lake Malawi

3 Methodology

3.1 Profitability of fish processing

We take the gross margin approach to measurement of profitability of fish processing enterprises. Gross margin of fish processing is calculated by subtracting total variable cost (TVC) of processing and selling fish from the total revenue (TR) obtained from processed fish. This approach assists to check if the fish processors are able to cover the operating cost and remain with resources to service a loan. The gross margin (GM) is calculated as presented by equation 1 below.

$$GM = TR - TVC \qquad 1$$

Total revenue is calculated by multiplying the quantity of processed fish by its selling price as given by the following equation.

$$Total\ Revenue = Quantity\ of\ dried\ fish * Selling\ price \qquad 2$$

Total variable cost is calculated by summing all the variable costs that are incurred when processing fish. The cost components included in the analysis are cost of fresh fish, cost of firewood, labour cost, cost of packaging materials, transportation cost, cost of implements and tools, and maintenance cost.

3.2 Marketability of processed fish

For marketability, we assess how fish processed by using IFTP fairs on the market. The analysis looks at the speed of sales and the other aspects including marketing challenges reported by fish processors.

3.3 Investment Profile

In developing the investment profile, we assess the possibility for the fish processors to service a loan. This analysis assumes that the initial cost of owning and operating an improved fish processing technology is serviced by a loan and is thus added to the total cost. The initial investment costs include construction cost and certification cost.

3.4 Data

Data on solar dried fish were collected from fish processors that are using solar dryers in Mangochi while data on improved smoking kilns were obtained from fish processors who used improved smoking kilns at Lake Chilwa. Data for fish processors that were using solar dryers were collected in February and March 2018 and February 2019. The data has different levels of completeness and we will thus use the different datasets to show different aspects of profitability and further develop a standard gross margin analysis for fish processing.

Marketing data were collected from PTC when we implemented a marketing survey in the first phase of the project. Additional marketing information were obtained from informal discussions with fish processors. The data were analysed in MS Excel.

4 Results

4.1 Profitability of solar dried fish

We estimated profits in 2018 and 2019. For 2018, data was collected in February and March, while data for 2019 was collected in February. The analysis is standardised to a month to make sure that the results are comparable. The results for profit analysis in 2018 are presented in Table 1 below.

Table 1: Results of profitability analysis for solar tent dried fish in 2018

	Unit	Quantity	Price (Cost) (MK/Unit)	Amount (MK)
Revenue				
Dried fish	80g Packets	6,500.00	260	1,690,000.00
Total Revenue				**1,690,000.00**
Cost				
Fresh fish	Basin	33	24,846.15	807,500.00
PHL at 6% of fresh fish				92,950.00
Labour	Drying cycle	13.00	4,000.00	52,000.00
Transport	Trip	1.00	60,000.00	60,000.00
Firewood	Drying cycle	6.50	4,923.08	32,000.00
Packaging bags	Packet	6,500.00	7.00	45,500.00
Lodging and accommodation	Trip	1.00	20,000.00	20,000.00
Total cost				**1,109,950.00**
Profit Margin				**580,050.00**

From the findings presented in Table 1, we find that a fish processor processed 33 basins of fresh fish which produced 6, 500 packets weighing 80 grams each. These packets were sold at MK260 per packet and this translated to revenue was equal to MK1, 690, 000. Cost incurred to generate this revenue was largely due to purchase of fresh fish which costed MK807, 500. The fish processor also bore cost of labour, transport, firewood, and lodging. The total cost of production was thus MK1, 109, 950 leaving the fish processors with a monthly profit of MK580, 050 (about USD794).

The results of the profitability analysis of solar dried fish in 2019 are presented in Table 2 below.

Table 2: Profitability analysis for solar tent dried fish in 2019

	Unit	Quantity	Price (Cost) (MK/Unit)	Amount (MK)
Revenue				
Dried fish	80g Packets	10,000.00	260	2,600,000.00
Total Revenue				**2,600,000.00**
Cost				
Fresh fish	Basin	50.00	32,000.00	1,600,000.00
PHL (6%)				143,000.00
Labour	Drying cycle	10.00	4,000.00	40,000.00
Transport	Trip	2.00	130,000.00	260,000.00
Firewood	Heaps	4.00	5,000.00	20,000.00
Packaging bags	Packet	10,000.00	7.00	70,000.00
Lodging and accommodation	Trip	2.00	30,000.00	60,000.00
Food supplies	Lumpsum	2.00	30,650.00	61,300.00
Total cost				**2,254,300.00**
Profit Margin				**345,700.00**

The results in Table 2 show that the level of profit in 2019 has declined from about MK580, 0505 per month to MK345,700 per month. The reduction is largely attributed to the increase in cost of fresh fish. In 2018 during the same period, fresh fish was costing MK25,000 per basin and in 2019, the same amount is costing MK32,000 per basin reflecting a 28% increase in fresh fish prices. There were also increases in other costs such as transport and lodging and accommodation. Despite these increases in cost, the selling price for solar dried fish remained at MK260 per 80g packet. The reduction in profitability of fish was therefore largely attributed to increase in the cost of production.

4.2 Standardised profit analysis

The information in Tables 1 and 2 is combined to generate a standard profit analysis for solar dried fish. In the standardised analysis, we included all the cost elements presented in Table 2 and the monthly quantity is raised to 5500 packets from 30 basins of fish. We also used 2019 pricing for the inputs and fish. The results are presented in Table 3.

Table 3: Standardised profitability analysis for solar tent dried fish in 2019

Standard monthly profit analysis

	Unit	Quantity	Price (Cost) (MK/Unit)	Amount (MK)
Revenue				
Dried fish	80g Packets	5,500.00	340	1,870,000.00
Total Revenue				**1,870,000.00**
Cost				
Fresh fish	Basin	30.00	32,000.00	960,000.00
PHL (estimated at 6%)				102,850.00
Labour	Drying cycle	5.00	4,000.00	20,000.00
Transport	Trip	1.00	130,000.00	130,000.00
Firewood	Drying cycle	5.00	5,000.00	25,000.00
Packaging bags	Packet	5,500.00	7.00	38,500.00
Lodging	Trip	1.00	30,000.00	30,000.00
Food supplies	Lumpsum	1.00	30,650.00	30,650.00
Total cost				**1,337,000.00**
Profit Margin				**533,000.00**

The findings show that presently, a fish processor that is drying fish in solar dryers would be obtaining about MK533,000 (USD 729) per month in gross margin. This is an amount from which the fish processor would derive resources to service a loan as well as carter for livelihood needs. From this level of profit, we consider that a fish process would manage to repay MK300,000 per month which will leave them with about MK233,000 to reinvest in the fishing business or consumption. This information is used in developing the investment plan.

4.3 Investment analysis

Basing on the profitability analysis, we developed an investment plan for the adoption of the IFPT. Our estimations show that a fish processor will need MK2, 500, 000 to construct a standard solar tent dryer. We therefore assume that banks will provide loans to the tune of MK2, 500, 000 per fish processor. We further assumed that interest rates will be charged at 18% and that the fish processors will be repaying MK300,000 per month. The results of the analysis are presented in Table show that fish processors will be able to repay the loan with interest by the ninth month.

Table 4: Investment plan for IFPT

	Starting balance (MK '000)	Loan Repayment (MK '000)	Interest paid (MK '000)	Principal Paid (MK '000)	New Loan Balance (MK '000)
Month 0	2,500	-	-	-	2,500
Month 1	2,500	300	38	263	2,238
Month 2	2,238	300	34	266	1,971
Month 3	1,971	300	30	270	1,701
Month 4	1,701	300	26	274	1,426
Month 5	1,426	300	21	279	1,148
Month 6	1,148	300	17	283	865
Month 7	865	300	13	287	578
Month 8	578	300	9	291	286
Month 9	286	300	4	296	-9
Month10	-9	300	-0	300	-309
Month11	-309	300	-5	305	-614

5 Implications for financing mechanism

The analysis shows that fish processors can manage to take a bank loan and service it. In using the analysis in this report to develop a financing mechanism, some factors need to be considered. Firstly, the analysis is for solar tent dryers only and not improved smoking kilns. The reason for this is that Lake Chilwa dried up and we did not have good data source to conduct the analysis. We however know that fish from improved smoking kilns also fetch prices higher than traditionally processed fish and that the investment cost for improved smoking kilns are lower than that for solar tent dryers. This means that loans for improved smoking kilns will be smaller and these may have shorter repayment period or same repayment period with lower amounts. Proper profitability analysis for using improved smoking kilns will be conducted after they are introduced at Lake Malawi.

The second thing is that the investment analysis assumes that there is constant flow of fish and that the fish processors will be able to process fish continuously. This does not hold with fishing industry as there are significant seasonal changes. This will not be a big issue because we expect them to make more than MK600,000 in some months thereby enabling them to repay more than MK300,000 per month. To facilitate this, the financing mechanism should be designed in a way that fishers will pay the profit, and this should be deducted at the bank. Fish processors who have taken loans will be required to open accounts with FDH Bank and PTC and other supermarkets will also be required to make direct transfers to the fish processors' bank accounts at FDH Bank to facilitate loan repayment.

The investment analysis also assumes that fish processors will have money to process fish as they are waiting for their fish to be bought at the supermarket. In the case when they run out of the operating capital, fish processors could not process fish. The introduction of a fish bulker will assist in resolving cash flow challenges as the fish bulker will pay immediately for the fish supplied to him/her. The financier should therefore provide part of the loan to the bulker who will also be paying the fish processors direct to their FDH Bank accounts.