

Reducing Post-Harvest Losses of the Artisanal Dagaa (*Rastrineobola Argentea*) Fishery in Lake Victoria Tanzania: A Cost and Benefit Analysis.

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ABSTRACT

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

INTRODUCTION

The Fisheries resources of Tanzania are of great economic and social significance to the country. The fisheries sector also provides a source of employment and livelihood to a substantial number of people. About 172,000 people are engaged on full-time basis and about 2 million people make their livelihoods through various fisheries-related activities, such as; boat building, net making, fish processing and food marketing. In terms of animal protein availability, fish contribute about 30% of the total protein intake in the country (FAO 2007).

The Tanzania fishing industry is divided into the artisanal (small scale) and commercial/ industrial (large scale) fisheries. The artisanal fishery in Tanzania is the most important fisheries as it lands most of the inland and the marine catches and contributes about 98% of total landings. (FDD 2009). In Africa, over 60% of the fish supply to domestic and regional markets, as well as export-oriented processing units, is of artisanal origin. (NEPAD 2005). In

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

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

The Lake Victoria dagaa constitutes over 38% of total fish landings from Lake Victoria in Tanzania. The fishery supports a major artisanal fishery in the country, ranking second to the Nile perch in Tanzania. The large volume landed, its wide distribution, high nutritional value and low price are characteristics that have made dagaa the most important fishery to the great majority of Tanzanians in supporting food security and sustainable livelihood (LVFO 2004).

However, the dagaa fishery is associated with high level of post-harvest loss, both physical and quality losses (Kabahenda et al 2009). A recent post-harvest study conducted in Lake Victoria estimated losses in the dagaa fishery to be about 32 million USD per annum, which clearly suggests that reduction of losses in this fishery is a potential area for addressing food security and poverty alleviation (Mgawe 2008).

There is a lack of information on the cost and benefit of management interventions that have been recommended for reducing dagaa post-harvest losses. Better understandings of the basic economics (cost and benefit structures) of intervention measures to reduce dagaa post-harvest loss of artisanal fishers in Tanzania, is useful for setting national and regional fisheries strategies and policies for managing fisheries resources.. This would help in managing effective and better synergy in poverty eradication, food security and improved health for the sectors and in realising the Millennium Development Goals.

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

- To analyse the economic impact of post- harvest loss of the small-scale dagaa fishery.
- To suggest strategies for reducing post- harvest loss of the fishery.
- To conduct a cost and benefit study to assess the net economic benefit of the proposed strategy.

Post-harvest loss intervention strategies

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

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

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

Though fishers, processors and traders experience losses, study has been found that people use various coping strategies to control or minimize loss as much as possible (Akande and Diei-Ouadi 2010). The use of drying racks in Uganda has resulted in a reduction of loss to a negligible level as compared with the high level of losses in drying dagaa on bare floors, ground and grasses (Figure 1). It has been realized that dagaa dried on racks are better quality product than the ones dried on the ground, also they fetches a better price as compared to fish dried on the ground (Masette 2005).



Figure 1: Sun drying of dagaa on racks (a proposed design of dagaa drying rack to be used by dagaa fishers in Tanzania)

METHODOLOGY

Data Collection

Quantitative post-harvest loss in dagaa fishery Tanzania data was obtained from a study on Post-Harvest Fish Loss Assessment (PHFLA) of dagaa conducted in Lake Victoria by FAO in (Mgawe 2008). The study designed to generate practical guide for dagaa loss assessment in Tanzania, by providing benchmark data for types of losses (physical, Quality and market losses), percentages of loss in each categories and the dry weight equivalent.

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

Table 1: Estimated price (USDⁱ /T.Shs.) for 1 kg of different products of dagaa in Tanzania

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

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

Construction of drying racks

Drying racks can usually be made either from locally available materials such as bamboo, tree branches, chicken wire, mosquito netting, old fishing nets, (at very little cost) or by using expensive but durable materials like metal wire mesh, tie wire, and square pipe (angle post). The use of the durable drying rack was proposed in this study, Figure 1 shows a picture of the drying racks used in Uganda to dry the same species.

To construct that rack 2m width, 8m lengths and 1.6m height square steel pipe (1.5” diameter) are used. The pipes are welded together to make the structural framework. The top is then covered with wire mesh or chicken wire, depending on preference. The racks of 16 m² can manage 80 kg fresh weight of dagaa.

Cost and Benefit Analysis

The analysis of management intervention was narrowed to sun drying by using drying racks. Two categories for each analysis were set i.e. private (individual fisher) and public (Government) for a pilot district (500 fishers), the analyses were divided into five parts:

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

Assessment of all possible dagaa post-harvest losses

Post Harvest Fish Loss Assessment standards (Indicative quantitative PHFL) of Lake Victoria dagaa fishery from previous study by FAO, information on the weight of total dagaa catch per year for individual fisher (private) and for a pilot district to 500 fishers (Government) and price of fish were used to calculate the monetary loss.

Assessment of the cost of reducing the losses.

Construction costs for drying racks and implementation cost are the most direct costs to individual fisher and the government for a public project respectively. Estimated price of construction materials i.e. wire mesh, square pipe, tie wire, along with labour cost and transport cost were used to calculate the cost of construction, The monetary cost of reducing loss was calculated as.

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

Where;

C = cost of different items i.e. construction materials, implementation, transport etc.

t = time of year when cost was assessed,

∑= summation of all cost,

w= the price of one unit of input j at time t,

x= quantity of input j at time t. (Boardman *et al.* 2006)

Assessment of the benefits associated with reducing the losses

Direct benefits accrued from drying dagaa on racks are income generation (Economic gain) through acquiring best price of the improved product and government increase of revenue collection from local, national and regional trade.

The analysis of benefit of using racks was done by deducting the total loss weight for drying on ground from average catch per fisher (private) for one year to obtain the total weight left for selling. The total weights left for selling were then calculated by 35% (to obtain output after drying) which was later multiplied by price (better price 2.7 USD/kg) for one kg to attain the monetary gain.

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

Where;

B = Benefit of drying dagaa on racks and salt sun-drying processing,

∑ = Summation of all monetary gain,

p = price of output *i* at time *t*.

q = quantity of output *i* at time *t*,

t = time when the benefit was evaluated (Boardman *et al.* 2006)

Evaluation of Costs and Benefits to determine net benefit and NPV

The cost and benefit analysis was done by subtracting all identified costs of management intervention for reducing post-harvest loss from the expected benefits gained after reducing the losses, so as to determine whether the benefit outweigh the cost. To compare the changes in benefits and costs, the value were discounted back to the present period given present values. The discount rate of 0.172 was used in this study; it is the rate central bank of Tanzania charges in determining the present value of future cash flows.

Net-benefits = NPV (benefits – costs), the following formula was used;

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

Where;

NPV is the net present value of the items of subtracting benefits to costs.

r = the discount rate

B (t) = benefit at time *t*, as described above

C (t) = cost of items at time *t*, as described above

T = number of years of implementation (Boardman *et al.* 2006)

Sensitivity Analysis

The analysis was categorised into two parts, private and public (Government) drying racks project, to check the robustness of the calculated Net Present Value for drying racks projects. The analysis was done by working out percentage change from -50% to 50% in NPV, different scenarios of assumptions were set to investigate how changes in values of implementation cost, investment cost, quantity of fresh dagaa and sales price of dagaa would impact the Net Present Value. It was done by varying a single assumption while holding others constant.

ANALYSIS AND RESULTS

The study assessed the feasibility of drying dagaa on racks as intervention strategy to reduce post-harvest loss.

Evaluation of loss when drying dagaa on ground (before using racks) and after drying on racks.

Private (individual) post-harvest loss for drying racks

The average catch per year for one fisher was estimated to be 5 tons/year/fisher (Kolding *et al* 2008). The FAO PHLA data identified 59 % of dagaa post-harvest loss (physical and quality loss) per year. Based on an average catch of 5 metric tonnes per year, fishers will incur financial losses of approximately 1,139 USD per annum when dagaa is dried on the ground (Table 2). According to Mwambazi (1992) using racks can reduce post-harvest loss by half. Therefore dagaa post-harvest loss (physical and quality loss) will be reduced to 30% after using drying racks per fisher/year, this loss will be equivalent to 662 USD. The price of dried dagaa is expected to increase from 1.7 USD / (kg) to 2.7 USD/ (kg) as the product of dagaa dried on racks will be of better quality.

Table 2: Summary of estimated post-harvest loss of dagaa dried on ground and dagaa dried on racks private (individual) weight (kg) and price in USD

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

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

To determine the loss for a pilot district (500 fishers), 10 villages / communities in a pilot district were selected for introducing drying racks. It was assumed that 50 dagaa fishers in each village will be sensitized and trained on using drying racks. It is known that one fisher can catch a total weight of 5 tonnes per year, therefore 500 fishers are expected to catch 2,520 tonnes of dagaa per year. The analysis indicated that, for a pilot district (500 fishers) dagaa post-harvest loss (physical and quality loss) is about 57 thousand USD for dagaa dried on ground (Table 3) and 33 thousand USD after using drying racks.

Table 3: Summary of estimated post-harvest loss of dagaa dried on ground and dagaa dried on racks for a pilot district (500 fishers) weight (kg) and price in USD

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

Estimated Cost of reducing the post-harvest losses in Tanzania

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

Implementation Costs

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

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

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

Table 4 indicate the investment cost of constructing 1 rack (pipes, mesh wire and tie wire) along with operation cost (labour and transportation cost). It was estimated that construction and operation of one rack will cost 98 USD for one year.

Table 4: Estimated investment cost for constructing one rack per year (USD).

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

It is estimated that one fisher is capable of catching at least 50 kg of dagaa for one day during good harvest period; therefore one rack was used to compute the total investment cost per year for one fisher. And for a pilot district (500 fishers) project there were 500 drying racks for 500 fishers (Table 5).

Table 5: Estimated investment cost for private (individual) and public dagaa drying racks project (USD)

Investment cost	Price /USD		Construction Materials	Price USD	
	Year 1	Year 2-5		Year 1	Year 2-5
Construction Materials			Pipes	24	
Pipes	24		Mesh wire	26	26
Mesh wire	26	26	Tie wire	5	5
Tie wire	5	5	Labor	34	34
Labor	34	34	Transport	9	9
Transport	9	9	Total investment for 1 rack	98	74
Sub -Total	98	74	Capital cost for 1 racks	17	13
Capital cost for 1 rack	17	13	Investment 500 racks	49,000	37,000
Material cost for 1 racks	98	74	Capital 500 racks	8,428	6,364
Capital cost for racks	17	38	Total investment for 500 racks/500 fishers	57,428	43,364
Total investment cost	115	112	Initial implementation cost to the Govt.	636,225	
			Subsequent implementation cost to the Govt.		12,000
			Total implementation cost to the Govt.	636,225	12,000

Materials for construction of racks can last for one year with exception of pipes, so there is recurrent cost for rehabilitation of racks in subsequent years. It was estimated that, for the first year of the private project a fisher will incur a total cost of 115 USD and the total cost in the subsequent 4 years will be 112 USD per year. Likewise for the pilot district (500 fishers) the initial cost will be 57 USD thousands for racks construction and 636 USD thousands to the government as implementation cost, while in subsequent years it will cost 43 thousands USD for the pilot district (500 fishers) and 12 thousands USD to the government as implementation cost for the public project in a pilot district.

Expected benefit after reducing post-harvest losses

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

Benefit for the private (individual fisher), and to the government in a pilot district (500 fishers)

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

Monetary gain from weights left for selling for private/public drying on ground and drying on racks projects were deducted from the monetary loss (3.1 assessment of loss) for drying on ground and drying on racks both for public and private respectively, this was also done for the public project. (Table 6 and Table 7).

Table 6: Anticipated private benefit after using racks, weight in kg and price in USD

Category/catch/loss/benefit	Wt/Kg	Quantity in USD
Total catch available/fisher/year	5,040	
Physical loss/wt/kg	388	
Quality loss wt/kg	2,596	
Total loss/wt/kg	2,984	
Left for selling in wt/kg	2,056	
Revenue from Quality loss product /USD		908
Revenue from left wt for selling/USD		1,224
Total benefit/USD		2,132
Loss occurred when drying on ground		1,139
Loss occurred after using drying racks		662
Benefit drying on racks		1,470
Benefit drying on ground		993
Total benefit after using racks		477

Table 7: Anticipated total benefit for the pilot district (500 fishers) after using racks, weight (ton.) and price in 000' USD.

Category/catch/loss/benefit	Weight/Tonnes	Quantity/000' USD
Total catch available/500 fisher/year	2,520	
Physical loss/wt/Tons.	194	
Quality wt./Tons.	1,298	
Total loss/wt./Tons	1,492	
Left for selling in wt/Tons.	1,028	
Revenue from Quality loss goes to the market/USD		454
Revenue from left wt for selling/USD		612
Total benefit/USD		1,066
Loss occurred when drying on ground		570
Loss occurred after using drying racks		331
Benefit using drying on racks/USD		735
Benefit drying on ground/USD		496
Total benefit after using racks		238

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

Evaluation of Private/Public Costs and Benefits for drying racks to determine net benefit and NPV

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

It was found that, the net benefit for drying racks project is 142 USD per fisher (private) for the first year, the benefit will then increase to 145 USD for the subsequent years. The present value for each year was calculated and summed up to get the NPV 460 USD (Table 8). For the public project the first year of implementation, the project will be in loss approximated at -607 thousand USD, then it will make profit for the rest of implementation period, the NPV will be 9,049 USD.

Table 8: Drying racks (individual) private project cost and benefit analysis for five years

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

Sensitivity Analysis results

Percentages change under a given set of assumption of implementation cost, investment cost, quantity of dagaa and sales price of dagaa was done to examine their impact in NPV. Analysis of the drying racks project both private and public revealed that, NPV is most sensitive to changes in sales price (Fig. 2 and 3). However the results showed that NPV is not sensitive to quantity of catches and investment cost.

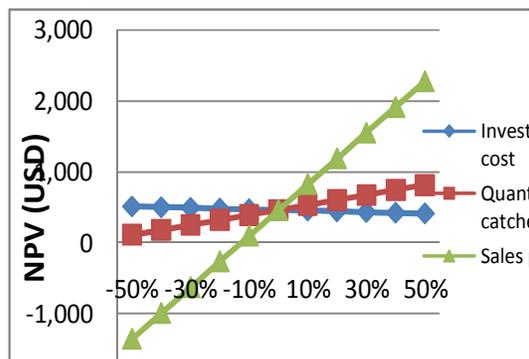


Figure 2: Sensitivity analysis chart on different % changes of cost, price (USD) and quantity of dagaa (kg) private project

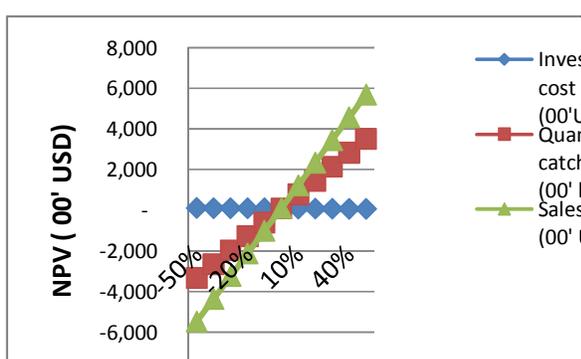


Figure 3: Sensitivity analysis chart on different % changes of cost, price (USD) and quantity of dagaa (kg) public project

Discussion

Reducing Post-harvest loss of Dagaa fisheries in Tanzania

The current rate of dagaa post-harvest loss was estimated to be 59% by FAO study, and the use of drying racks could reduce this loss by half (FAO 2008). Based on average catch per fisher for year (5 tonnes) for the individual fisher and 2,520 tonnes for a pilot district (500 fishers) in aggregate, the use of drying racks will reduce the post-harvest loss from 1139 USD (drying on ground) to 662 USD when drying on racks for the individual fisher and 57 thousands USD to 33 thousands USD for the pilot district (500 fishers). Drying racks are beneficial because they can reduce losses, decrease drying time and process a cleaner product of higher quality.

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

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

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

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

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

Limitations of this analysis

In the reduction of post-harvest loss some of the benefits are indirectly gained by a third part. There were several intangible benefits in the analysis that were difficult to quantify in monetary terms, including improvement of food security, nutrition status to the society and contribution to employment.

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

CONCLUSIONS

Reducing post-harvest losses in artisanal fisheries will increase productivity, profitability and secure access of dagaa fishery to rewarding local and regional markets. From the analysis it was found that, drying racks project have positive NPV hence they are worthwhile to be implemented in Tanzania to reduce dagaa post-harvest loss. Also sensitivity analysis indicated that NPV is sensitive and is likely to be affected by changes sales price while investment and implementation cost changes were found to have no impact in NPV.

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

RECOMMENDATION

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

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

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

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

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ⁱ USD is set equivalent to 1480 Tanzanians shillings (2009)