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A COST–BENEFIT ANALYSIS OF THE FISH FARMING ENTERPRISE PRODUCTIVITY PROGRAM PROJECT IN KENYA. THE CASE OF IMPLEMENTATION OF THE AQUACULTURE DEVELOPMENT COMPONENT IN MERU COUNTY.

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ABSTRACT

Since 2004 Kenya has experienced a dramatic increase in aquaculture production. Over a 10-year period, aquaculture production increased twenty-fold from 2004 to 2013, from about 1000 tons to more than 23000 tons. The government of Kenya has seen aquaculture as a viable option to stimulate economic growth in the country. Part of that view was the establishment in 2009 of the Fish Farming Enterprise and Productivity Program (FFEPP). The objectives of the program were manifold, not only aiming for economic return but also aiming at unemployment and better quality of food. Much effort was put into building ponds and offering support to farmers. The aim of this study is to provide an economic analysis of the FFEPP project as it was implemented in Meru county in Kenya and make recommendations based on the outcome of the cost-benefit analysis. The cost-benefit analysis was based on calculation of NPV, Benefit-Cost Ratio (BCR), and IRR. At the end a sensitivity analysis was performed to assess the uncertainty around the assumptions in the model. The data was acquired from Meru Fisheries Office and the National Aquaculture Secretariat in Nairobi. The results indicate that the project has and will produce significant economic gains for the Meru communities. The study also finds that the objectives of the FFEPP project have been achieved for Maru county but before the FFEPP is scaled up it is recommended that the government should better examine the costs vs benefits in other areas of Kenya taking into consideration climatic and geographic factors as well and social and cultural factors. The success has attracted the private sector's attention which is an encouraging sign for the future development of aquaculture.

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1 INTRODUCTION

1.1 Background

In the course of half a century, aquaculture has expanded from being almost negligible to fully comparable with capture production of fish in terms of providing the world population with food (FAO, 2012). Aquaculture production continues to grow in the new millennium, albeit at a slower rate than in the 1980s and 1990s.

In 2012, aquaculture set another all-time production high and now provides almost half of all fish for human consumption (FAO, 2014). The total human consumption of fish as food stands at 136.2 million tons. Because of population growth, it is estimated that the world will consume at least another 23 million tonnes of food fish by 2030. This demand needs to be met by aquaculture since many of the world fisheries are at or close to their limits (FAO, 2012).

Aquaculture plays an important role in food security and poverty alleviation worldwide because of its ability to provide freshwater fish, which, although mainly consisting of low-value species in terms of market value, provide food on the table and increases nutritional variety. Aquaculture could play an important role in meeting the needs of people in terms of food now and in the future.

In Kenya, fish farming can be traced back to the 1890s with the introduction of trout for sport fishing. Later, small scale aquaculture was started in the 1940s (Kaliba *et al.*, 2007). It further expanded in the 1960s through the "Eat more fish campaigns" of the Government of Kenya (Rothuis *et al.*, 2011). Subsequently, the growth was slow; aquaculture was mainly a subsistence activity among the rural folk until the Government of Kenya (GOK) started subsidy programs in 2007. These programs were intended to promote aquaculture with the goals of creating employment, improving food security and raising the standards of living in rural areas.

Fish farming is mainly practiced by smallholders with an average production in 2011 of around 3 tons/ha (Rothuis *et al.*, 2011). The number of farmers practising aquaculture on a commercial and intensive scale is expected to rise as the government continues to encourage adoption of aquaculture as an income generating activity.

1.2 Status of aquaculture in Kenya

Aquaculture production in Kenya is insignificant on a global scale and has not seen the same rapid growth the sector has undergone worldwide. However, the demand for fish is constantly growing while supply lags behind because of declining natural fish stocks. This provides an opportunity for further aquaculture development.

Kenya is endowed with good natural resources such as land and water (rivers, lakes and the sea) that can support an increased aquaculture production. Although most parts of Kenya are suitable for aquaculture, by 2011 only about 0.014% of the potential aquaculture sites were being used for aquaculture. Furthermore, about 95% of fish farming was still on a small-scale basis (Otieno, 2011). According to the Kenyan State Department of Fisheries, the area under aquaculture to date is estimated to be about 2% of the potential aquaculture sites.

According to the Ministry of Fisheries Development (2010), Kenya has 9.5 million ha of high potential areas and over 40.5 million ha of medium potential areas suitable for fish farming in the country. If this potential was fully utilized, the production from aquaculture could possibly be increased to 11 million tons per annum. This would increase the production value to over 750 billion shillings creating, in the long run, an industry employing and supporting a substantial percentage of the Kenyan population as fish farmers, fish feed manufactures, fish processors, traders and providers of services to the sector.

Over the last ten years, aquaculture production has increased from 1,035 tons produced in 2004 to 23,501 tons in 2013 (Figure 1). This current aquaculture production is from 69,194 ponds with an area of 2,076 ha, including 161 tanks measuring 2.3 ha and 124 reservoirs with an area of 74.4 ha spread throughout the country (State Department of Fisheries, 2013).

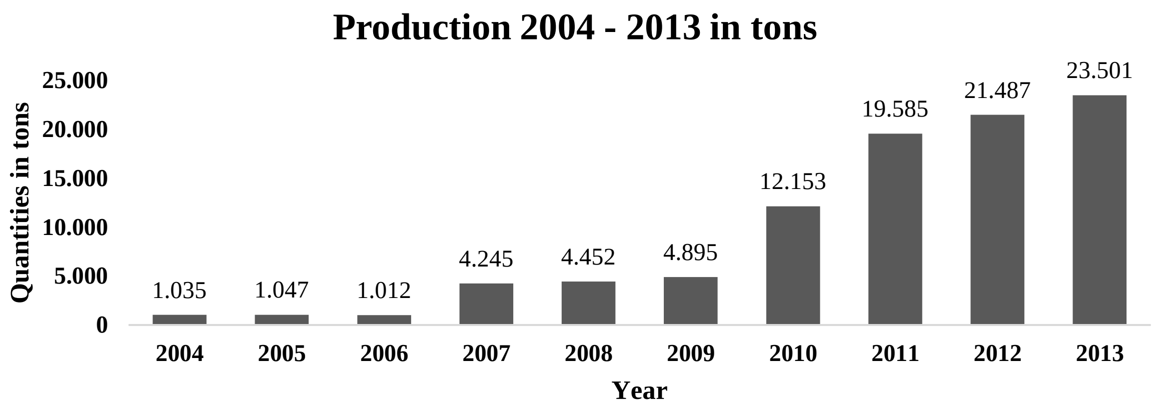

Figure 1: Kenya Aquaculture Production Trends 2004-2013 (State Department of Fisheries, 2013)

The majority of fish farms in Kenya and in particular in the Meru region are small-scale and practise either extensive or semi-intensive fish farming. For most, fish farming is done as a part-time and secondary activity to other farm activities. However, the number of farmers who have taken up fish farming on an intensive scale is growing, although the precise number is unknown since there adequate statistics are not available.

Despite political support, lack of awareness concerning returns on aquaculture investments has significantly slowed growth of the aquaculture sector in Kenya. The farmers see fish farming as a marginal and risky investment (Ngugi & Manyala, 2004).

Since the fisheries sector is driven by many stakeholders, a crucial element of the fisheries policy development has been to provide guidance on the sectoral framework by facilitating coordination and harmonization of the sector's mandate, programmes and implementation of plans of action to achieve sustainable development. The overall objective of the fisheries policy in Kenya is to: facilitate a vibrant industry based on sustainable resource exploitation; provide optimal and sustainable economic benefits, alleviating poverty and create wealth, while also taking into account gender equity (Ngugi & Manyala, 2008).

1.3 Fisheries and Economic Development in Kenya

The Kenya Vision 2030 Development blueprint aims to transform Kenya into a newly industrialised, "middle-income country providing a high-quality life to all its citizens by the year 2030".

The Fisheries Development and Management project has been one of the Vision 2030 flagship projects as from 2012. The overall objective of the project is to increase national fish production by at least 10% per annum from 154,000 tons to 450,000 tons by 2030. The State Department of Fisheries plans to actualize this by focusing on the following components: Increased aquaculture development; capture fisheries development and management; promote fish safety, value addition and marketing (Ministry of Agriculture, Livestock and Fisheries Development, 2014).

Fisheries play an important role in the economic and social development of Kenya. Currently, the industry contributes about 0.5% to the national GDP. This is based on ex-vessel value of fish landings. The contribution could be higher if the estimation is based on the value of final goods and services. At the community level, aquaculture provides a source of subsistence and livelihood to the rural poor within the vicinity of their farming areas. However, the actual socio-economic contribution of the sector has not been accurately quantified (Ngugi & Manyala, 2008).

1.4 Fish Farming Enterprise Productivity Program (FFEPP)

Viewing aquaculture as one viable option for stimulating economy growth, the Kenyan Government initiated Economic Stimulus Programs (ESP) in 2009. One component of that program entailed strengthening fish farming in two thirds of the country and especially in areas with high unemployment rates in the program called Fish Farming Enterprise and Productivity Program (FFEPP).

Although the FFEPP targeted fish farming in the whole country, the main focus was on areas that were the most suitable for aquaculture. The program aimed at enhancing aquaculture development by increasing production of farmed fish from 4,000 tons to over 20,000 tons in the medium term and to more than 100,000 tons by the year 2030 (State Department of Fisheries, 2013).

The FFEPP comprised of six components namely;

i. Strengthening of aquaculture institutions and capacity building
ii. Enhancement of fish production and productivity along the value chain within aquaculture parks
iii. Aquaculture extension services and outreach programs
iv. Aqua-businesses and market development
v. Quality assurance for aquaculture products
vi. Participatory monitoring and evaluation.

In the first year of the project (2008/2009), 200 fish ponds were constructed in 140 constituencies, totalling over 27,000 fish ponds nationally. In the second year, 100 more fish ponds were constructed in the initial 140 constituencies and a further 300 new ponds in 20 new constituencies that were added to the program. In the third and fourth years, a total of 25 fish ponds were constructed in 160 constituencies. In total, over 52,000 fish ponds of over 15,360 ha were constructed across the country. These ponds were located in areas that ranked high on the surveys for aquaculture suitability.

The Ministry of Fisheries Development adopted a common format for the production units in all the benefitting areas. The ponds were each constructed with a surface area of 300 m^2. They were all supplied with an equal amount of the production inputs and were to adopt similar pond management strategies.

1.5 Study Area; Meru County

Meru County lies in the eastern region of Kenya, approximately 225 km northeast of the capital Nairobi. Meru lies to the east of Mt. Kenya whose peak cuts through the southern boundary of the county (Figure 2). The county has a total area of 6,936.2 km^2 out of which 1,776 km^2 is a gazetted forest (Meru County Government, 2013).

The climate in Meru is generally temperate. Temperatures ranges between 16°C during the cold season and 23°C in the warm season. Meru receives an annual rainfall of between 500 mm and 2600 mm each year. The drainage pattern in the county is characterised by rivers and streams originating from catchment areas such as Mt. Kenya and the Nyambene ranges in the north. The rivers cut through the hilly terrain on the upper zones to the lower zones and drain into the Indian Ocean via the Tana and Uaso Nyiro Rivers.

Due to its good climatic attributes, Meru was one of the areas that has been classified as highly suitable for aquaculture production. Consequently, during the FFEPP, Meru received over 2,000 fish ponds. These ponds are distributed across all the county. The major types of fish found in this region are Nile tilapia (*Oreochromis niloticus*), catfish (*Clarias gareipinus*) and the rainbow trout (*Oncorhynchus mykiss).*

1.6 Research Problem

Those with responsibility for spending public money need to know that they are choosing the best option (FAO, 1986). Before massive expansion of the FFEPP project is implemented, various economic assessments should be made in order to answer vital questions. It is important to first identify potential costs and benefits as well as possible challenges met in the initial phases of the project. The project should only continue if its long-term benefits outweigh the costs.

To this end, a Cost Benefit Analysis (CBA) was conducted for this project. It provides a valuation of the project as implemented in Meru County; adds to the existing knowledge on the performance of the FFEPP project, and perhaps points out areas for improvements as the project continues. The Meru case offers a sound basis on which to make inferences on the performance of the FFEPP in the entire country.

1.7 General Research Objectives

The main objective of this study is to provide an economic analysis of the FFEPP project as implemented in Meru County and make recommendations based on the outcomes of the cost benefit analysis.

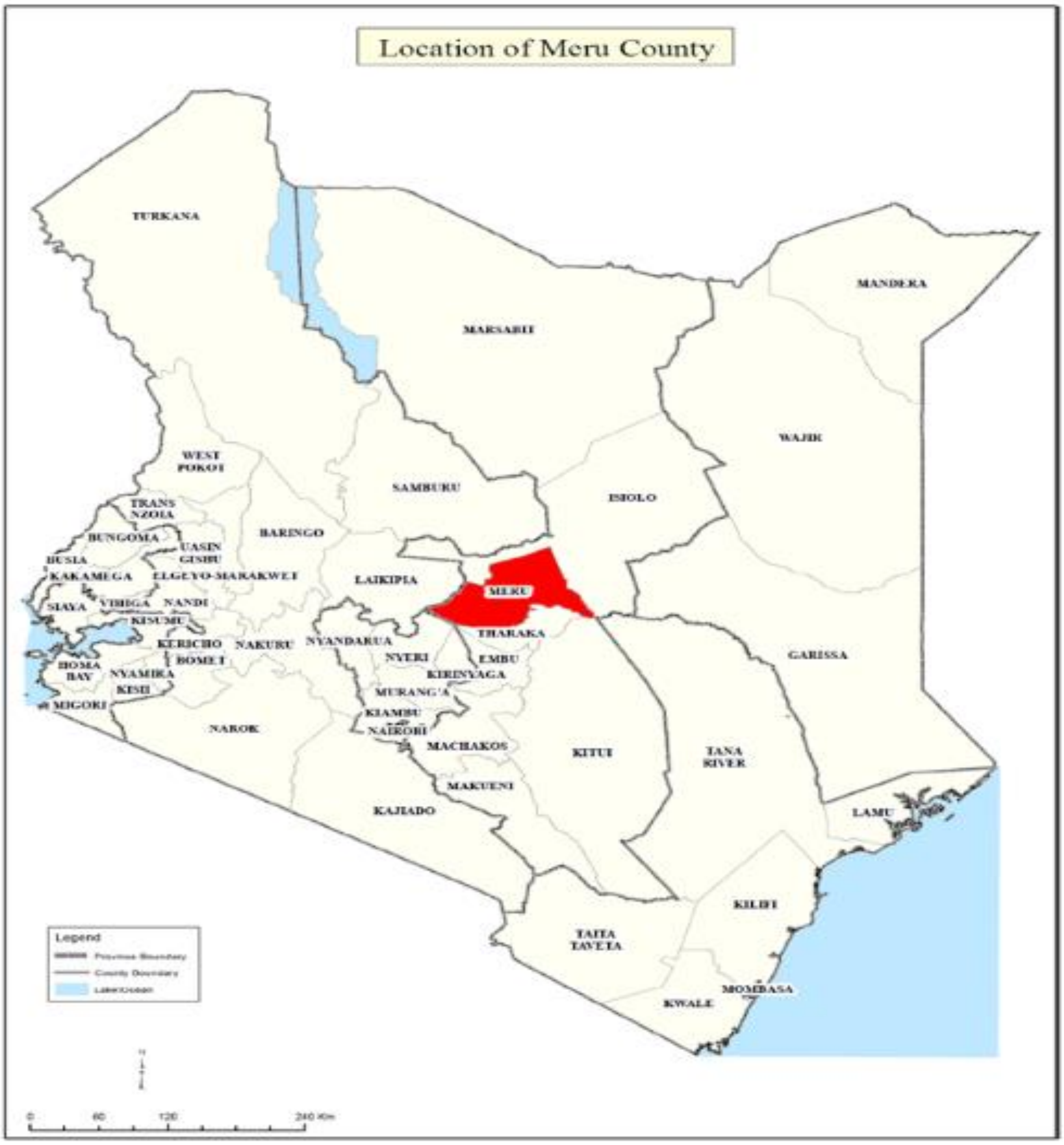

Figure 2: Position of Meru County in Kenya: (Meru County Government, 2013)

2 LITERATURE REVIEW

2.1 World Aquaculture

All over the world, aquaculture production has grown rapidly, which is largely attributable to technological advances in fish production, e.g., hybridization, genetic engineering, formulated diets, and biofloc technology used in ponds, cages, tanks, and recirculation systems (FAO, 2012). However, the rate of growth of global aquaculture differs across the continents. Asia has become the giant in aquaculture production whereas Africa has yet to report any significant quantities of aquaculture on the global scale despite the availability of natural resources in the region (FAO, 2010).

Africa contributes only 2.2% of the global aquaculture production (FAO, 2014), and although impressive strides have been made in African aquaculture, Africa is still far from achieving its full aquaculture potential (AU, 2014). The promotion of aquaculture for rural development has a poor record in Africa where sufficient attention has not been paid to its role in the livelihood or farming system of the intended beneficiaries the result being poor adoption by one of the intended target groups, the rural poor (FAO, 2002).

Most development efforts by the former colonial administrations, and subsequently by independent African governments backed by donor aid, were directed at introducing aquaculture into the small-scale farming sector which constitutes the backbone of Africa's rural economy (Britz & Rouhani, 2004). These efforts, which span half a century, have largely failed. In recent times a number of analysts have tried to explain the reasons for this. They include the following:

- There is a lack of appreciation and awareness for the need to integrate aquaculture development with overall and comprehensive rural development programmes.
- In some instances, aquaculture has been promoted in regions that are unsuitable for aquaculture because of unfavourable climate, infrastructure or market.
- Major technological constraints such as inadequate supply of quality and affordable fish feed ingredients, prohibitive transport costs and a lack of juveniles for stocking ponds.
- Administrative failures that include a lack of coordination between development and research, limited availability of finances, inadequate collaboration within and between administrative departments, a lack of stability of institutional frameworks and inefficient rural extension systems.
- Social constraints that include an absence of a traditional culture of fish farming in sub-Saharan Africa, limited availability of well-trained senior personnel, security issues such as theft of equipment and poaching of stock, and poorly trained extension officers.

In many developing countries nevertheless, aquaculture has had significant positive effects on rural and urban food supply and on income and employment. However, increasing demand for fish in global markets and the complex networks that affect the supply and prices of fish are influencing aquaculture production both at national and local levels. Countries are now faced with challenges to improve efficiency and effectiveness of their production. Therefore, there are both opportunities and challenges which need to be addressed (Mwamunye *et al.*, 2012).

Although an increasing number of developing countries are turning to aquaculture, all its beneficial attributes are often overlooked or ignored. It is vital that both its potential benefits and challenges are identified by agricultural and rural development professionals, policy makers as well as by the local farmers (Mwamunye *et al.*, 2012).

2.2 Cost-benefit considerations in development projects

A Cost Benefit Analysis is a methodology used to measure the economic efficiency of allocating resources to meet certain human needs. The CBA for an aquaculture development project involves comparing the costs, both the initial start-up costs and on-going operational expenses, to the stream of revenues and other benefits that accrues over time.

CBAs help decision makers make investments, assess regulations, and weigh difficult public policy trade-offs. The methodology has been around for over 50 years as an essential economic tool for evaluating projects benefits and is performed in evaluations of policies, programmes and projects, environmental impact assessments and the management of natural resources (US EPA, 2000).

A CBA provides a subjective and systematic way to view policy decisions, which often lack in the world of politics. It forces decision makers to consider who the beneficiaries and losers are, both presently and in the future (Pearce *et al.*, 2006).

There is an implicit assumption in the CBA of any governmental policy: a policy ought to result in an improvement on the overall welfare or well-being of the society. To assess this, we need to measure the total costs and benefits wherever they fall in the society and compare them. Projects or policies for which the total benefits exceed the total costs are considered worth promoting (Denne *et al.*, 2007).

3 RESEARCH METHOD

3.1 Criteria for Evaluation in a Cost Benefit Analysis

Several criteria are used in a CBA to determine whether or not an investment policy, project or programme is economically efficient. The following criteria have been used in this study:

Net Present Value (NPV)

This measures the present value of the net benefits of the development project. The formula for calculating an NPV is:

$$NPV = \sum_{t=t_0}^{T} \frac{(B_t - C_t)}{(1+r)^{t-t_0}}$$
$$= \sum_{t=t_0}^{T} \frac{B_t}{(1+r)^{t-t_0}} - \sum_{t=t_0}^{T} \frac{C_t}{(1+r)^{t-t_0}}$$

Where $\mathbf{B_t}$ is the benefit at time period **t** and $\mathbf{C_t}$ is the cost at period **t.** The project period or terminal year is **T** which can equal infinity, the start time $\mathbf{t_o}$ while the discount rate is **r**.

For a project to be acceptable on economic grounds, the NPV should be positive. This assumes that all costs and all benefits are taken into account and given a monetary value. A positive NPV means that the option produces net economic benefits, assessed in terms of present values. Where there are mutually exclusive options between any two projects, the option with the highest NPV is preferred. Any project that has a negative NPVs is economically undesirable (James & Predo, 2015).

Benefit–Cost Ratio (BCR)

This is the ratio of the present value of benefits to the present value of costs. The ratio determines the return per every unit of investment made. The formula for calculating the BCR is:

$$\mathrm{BCR} = \sum_{\mathrm{t}=\mathrm{t}_0}^{\mathrm{T}} \frac{\mathrm{B_t}/(1+\mathrm{r})^{\mathrm{t}-\mathrm{t}_0}}{\mathrm{C_t}/(1+\mathrm{r})^{\mathrm{t}-\mathrm{t}_0}}$$

If the BCR of a project exceeds 1, the present value of benefits is greater than the present value of costs; thus, the project is acceptable in terms of economic efficiency. If the BCR is less than 1, the project is not economically viable. This is the case if and only if the NPV is positive. Where there are options and choices to be made, the BCR should not be used to rank mutually exclusive options, however, as it can lead to rankings that are inconsistent with those obtained using NPV as the ranking criterion.

Internal Rate of Return (IRR)

The IRR is the rate of discount that equates the present value of benefits with the present value of costs. IRR appears as the 'unknown' ***i*** in the following equation:

$$\sum_{\mathrm{t}=\mathrm{t}_0}^{\mathrm{T}} \frac{(\mathrm{B}_\mathrm{t} - \mathrm{C}_\mathrm{t})}{(1+i)^\mathrm{t}} = 0$$

This equation has no closed-form solution for the value of ***i*** and can only be solved using numerical methods.

The IRR is typically used to compare the internal financial productivity of a project with the official interest rate or cost of funds, to see whether the project is desirable as a financial investment. The IRR should not be used to rank mutually exclusive options, as it can also result in a ranking that is inconsistent with a ranking based on NPV.

A distinction is sometimes drawn between an economic IRR and financial IRR. The difference is that for an economic IRR, all values for benefits and costs comprise economic rather than financial values (James & Predo, 2015).

Sensitivity Analysis

The economic desirability of any particular project depends on particular choice of values, which are often estimated for the various categories of benefits and costs, as well as the discount rate that is adopted. In reality, most of these values are subject to uncertainty. Risk and uncertainty are features of most business and government activities and need to be understood to ensure rational investment decisions (Pickering & Johnston, 2003).

A sensitivity analysis is applied to assess the uncertainty that surrounds these assumptions relating to prediction of variables and their values in the future.

3.2 Data Collection

This study was done based on data and information on aquaculture management and production from the Meru Fisheries Office and the National Aquaculture Secretariat in Nairobi. These data sources include; implementation guidelines for the FFEPP, monthly and annual productions of the project ponds from 2009 to end of 2015, government expenditure records on the project in Meru region, results from on-farm pond surveys and experiments, recurrent farm expenditure estimates for Meru farmers, guidelines for aquaculture practises in Kenya and aquaculture production characteristics in Meru region, and other relevant data available from these offices. Additional information was obtained from reports and records in the Meru County agricultural offices.

3.2.1 Components of the FFEPP

During the implementation of the project, extension officers identified farmers that were in areas that met the requirements for suitable aquaculture siting. This selection depended on the suitability of the farm sites and the willingness of the beneficiaries to adopt the new enterprise and demonstrate commitment to run it as a small-scale business after the government withdraws its support. The government paid all the costs for pond construction, the provision of tilapia fingerlings, fish feeds for one production cycle and the cost of training on the aspects of fish farming, fish marketing and basic business practises. The project was implemented in four phases, each lasting one financial year. During the third phase, the government provided high-density polyethylene (HDPE) and polyvinyl chloride (PVC) pond liners for areas that had pervious soils. These FFEPP support to farmers are listed in Table 1 below.

Table 1: FFEPP Support to Benefitting Farmers

PHASE ONE 2008/2009			
Support	**Unit Cost**	**Units**	**Total (KSh)**
Casual Labour	250	100	25,000.00
Fingerlings	10	1,000	10,000.00
Feeds (kg)		200	24,000.00
Total			**59,000.00**
PHASE TWO 2009/2010			
Support	**Unit Cost**	**Units**	**Total (KSh)**
Casual Labour	250	100	25,000.00
Fingerlings	7	1,000	7,000.00
Feeds (kg)		200	24,000.00
Total			**56,000.00**
PHASE THREE 2010/2011			
Support	**Unit Cost**	**Units**	**Total (KSh)**
Pond Liner	1	105,000	105,000.00
Casual Labour	250	100	25,000.00
Fingerlings	7	1,000	7,000.00
Feeds (kg)		200	27,958.00
Total			**164,958.00**
PHASE FOUR 2011/2012			
Support	**Unit Cost**	**Units**	**Total (KSh)**
Casual Labour	250	100	25,000.00
Fingerlings	7	1,000	7,000.00
Feeds (kg)		200	27,958.00
Total			**59,958.00**

Source: FFEPP Implementation guidelines

Table 2 shows the distribution of costs for the pond construction, stocking and training expenses in the different phases of the project. These are the cost that this CBA assumes were incurred by the Government of Kenya.

Table 2: Government of Kenya FFEPP Expenditure

Year	Cost Item	Cost/ Pond (KSh)	Ponds/ Constituency	Cost/ Constituency (KSh)	Ponds/Region	Region Sub-Total (KSh)	Year Total (KSh)
2008/2009	Ponds Construction and Supplies	59,000	200	1,800,000	1,400	**82,600,000**	
	Farmer Training			150,000		**1,050,000**	**83,650,000**
2009/2010	Pond Construction and Supplies	56,000	100	5,600,000	700	**39,200,000**	
	Farmer Training			150,000		**1,050,000**	**40,250,000**
2010/2011	Pond Construction and Supplies	164,958	20	3,299,160	140	**23,094,120**	
	Farmer Training			55,620		**389,340**	**23,483,460**
2011/2012	Pond Construction and Supplies	59,958	5	299,790	35	**2,098,530**	
	Farmer Training			55,620		**389,340**	**2,487,870**
						TOTAL	**149,871,330**
					FFEPP Ponds		**146,992,650**
					Training		**2,878,680**

Source: FFEPP Implementation guidelines for each corresponding year

Total government expenditure on the project in the four years is KSh 149.8 million: KSh 146.9 million as the cost of pond construction and supplies for production while KSh 2.8 million the cost of farmer training.

All the FFEPP ponds were constructed to a standard size of 300 m^2. They were supplied with equal amounts of production supplies as indicated in Table 1. The benefiting farmers organized into cluster groups near their localities. Each cluster comprised of 15-100 farmers. The clusters are used for capacity building, sharing experiences on fish farming, sharing of equipment like nets, making on-farm fish feeds and in some cases marketing of the harvest.

The fisheries office, through its extension staff, offers support to ensure that all the farmers follow similar if not better aquaculture production practises throughout the region.

3.2.2 Production Characteristics of FFEPP Ponds and Basic Assumptions

Table 3 below summarises the production characteristics of the FFEPP ponds.

Table 3: Production characteristics of the FFEPP ponds

Parameter	**Characteristic**
Stocking size of tilapia	2g-3g
Stocking rate of tilapia	3/m^2
Stocking rate of catfish	10% of tilapia
FCR	1.5 - 2.0
Minimum feeds required per cycle	200 kg
Crude protein content in feeds	26%-28%
Fertilization/ manure rate	50 g/m^2/ week
Liming rate	20 kg/100 m^2/cycle
Survival rate per production cycle	~80%
Minimum average production	0.6 kg/m^2
Harvest weight tilapia	350 g
Harvest weight catfish	500 g
Market prices/ kg	KSh 350
Consumption per capita household	24 kg/annum
Dropout rate from program	1.16%
Length of production cycle	9 months
Lead time to market	1 months
Pond treatment period (between cycles)	1 month
Fallow period (refill and restock)	1 month

The stocking rate of tilapia applied in Meru is 3/m^2, each pond is stocked with 1000 fingerlings. The extra 100 are usually expected to compensate for mortality during handling, transport and stocking. The sizes of tilapia fry supplied by hatcheries is 2g-3g. Experiences from Meru fisheries office are that farmers prefer stocking ponds with mono-sex tilapia. In the FFEPP project, catfish are recommended for polyculture; where farmers have stocked mixed sex tilapia. The recommended stocking rate of catfish to tilapia is 1/100 respectively. There is no FFEPP farmer practicing catfish monoculture.

The survival rate is assumed to be approximately equal to 80% based on Opiyo *et al.* (2014) who argue that Nile tilapia has a survival rate of up to 83% when fed daily.

The length of production cycle for most of the FFEPP ponds in Meru is 9 months. Besides that, farmers set apart at most one month prior to the next production cycle to repair the pond dykes, leaks and treat the ponds with lime. The liming rate used by farmers is 20 kg/100 m^2/cycle. Most fish farmers let their ponds lie idle (fallow) for some time during which period they refill their ponds with water and source fingerlings for the next stocking. Fingerlings are often not readily available since demand for fingerlings is higher than the hatcheries can supply. From the author's experience, it can take up to 1 month to refill ponds with water and restock them. Farmers use naturally produced in-pond feeding and supplemental feeds. According to results from on-farm pond experiments and farm surveys in Meru, 200 kg of formulated fish pellets are required as supplemental feeds for every production cycle. This study assumed that 200 kg is the required amount of supplemental feeds per production cycle.

An FCR of 1.5-2.0 is assumed based on the work of Githukia *et al.* (2015) who argue that Nile tilapia (*Oreochromis niloticus*) grown in earthen ponds in Kenya can achieve FCRs of 1.5 for mono-sex and 2.0 for mixed sex when fed on 28% crude protein supplemental feeds. Locally available fish pellets are required to have a crude protein content of 26%-28% (Munguti *et al.*, 2014). Majority of the farmers use compost manure for natural pond fertilization since it is readily available. The applicable fertilization rate with farm compost manure is 50 g/m^2/week or 15 kg per week for each pond.

The average production of the FFEPP ponds in Meru based on the annual production data for 2013 up to 2015 is 188.2 kg. This is a pond production of 0.63 kg/m^2. According to the Meru fisheries office annual periodic reports, the common harvest weights for fish from the FFEPP ponds is 350 g and 500 g for tilapia and catfish respectively. The market prices of whole tilapia fish in Meru region averages KSh 350/kg. The prices of catfish are however varied across the region and often depend on haggling between buyers and sellers. These prices range between KSh 300/kg to Ksh 400/kg. This study assumes the same price of KSh 350 for catfish and tilapia.

The demand for fish in Meru is great but there are no developed marketing chains. In order to sell their fish, farmers must either rely on brokers and middlemen or source markets for themselves. The duration between having a ready harvest to finally delivering it to a prospective buyer often takes 1 month.

According to the surveys on fish farmers by the Meru fisheries office, the per capita consumption of fish for households in Meru is 24 kg/year.

The dropout rate of farmers in Meru is currently 1.16% of the existing farmers. This is based on the actual drop out trends from 2014 to 2015 as presented in annual fisheries reports from Meru. This study assumes that 2015 being the 7^{th} year of implementation of the program, farmers have had opportunity to gain sufficient information about the program and are able to make sound decisions on whether to continue or not. This study adopts the same dropout rate of 1.16% for future periods. A sensitivity analysis is nevertheless conducted to investigate the effects of changes in the dropout rate of fish farmers on the NPV.

The costs of all labour needed by the farmer in one production cycle according to this study is valued as KSh 6,000. Table 7 in the Appendix shows the estimation of these costs of labour for pond treatment, routine maintenance, harvest of fish and the entire pond management. Actual wage rates are used to calculate this cost.

Table 4 below summarizes the supplies for production required by a Meru fish farmer in the course of one production cycle. These are based on the standard extension recommendations given to farmers in Meru. Actual market prices of these items have been used in Table 4.

Table 8 in the Appendix shows the estimates of the FFEPP farmer operation costs and expected returns per production cycle.

Table 4: Requirements of FFEPP Ponds per Production Cycle

Item	Unit	Requirement	Cost	Value (KSh)
Tilapia fingerlings	number	900	10	9,000.00
Catfish fingerlings	number	100	10	1,000.00
Fish feeds	kg	200	120	24,000.00
Manure	kg	180	2	900.00
Lime	kg	60	50	300.00
Water	KSh/month	12	100	1,200.00
Labour/ Maintenance	KSh	24	250	6,000.00
			TOTAL	**42,400.00**

3.3 Framework for Analysis

This study examines the scenario of implementing the FFEPP project against the usual scenario where the local communities of Meru region continue to use their land for alternative farm activities. This CBA is premised on the following:

- The lifespan of the project is assumed to be 15 years. This presumes that the 15-year period is long enough to highlight all of the consequences of changes in land use that promote aquaculture, including evidence that the project may yield significant benefits to local communities, improve their livelihoods and increase food security. During this time, local stakeholders and communities living in Meru County should have an opportunity to gain a clearer understanding of the aquaculture project. The 15-year period is also the estimated lifespan of the HDPE and PVC liner material used for the FFEPP ponds that require liners.
- This study does also develop an alternate model with an infinite lifespan in which the project is assumed to continue after the initial 15 years but with periodic maintenance costs.
- Kenya Shillings (KSh) have been used to monetize all values in the calculations. Adjustments are made for inflation and all amounts expressed in their latest value (2016).
- The estimated total amount of funding that was invested in the project is KSh 149 million.
- A social discount rate averaged at 7% after adjustment for inflation is used to calculate the NPV of this project. This discount rate is equivalent to the real interest rate on Kenya's sovereign debt. The rationale for applying this approach in discounting is that it would significantly correspond to the borrowing cost of the government that would, in most cases, be responsible for funding the project (Warusawitharana, 2014). By using the sovereign borrowing rate as the social discount rate enables one to match the projected cash inflows from the project to the cash outflows for the government responsible for financing it.

4 RESULTS

4.1 The referent groups

The two main referent groups are (1) the local farmers in Meru County and (2) the Government of Kenya. These two groups were the main ones involved in implementing the project.

4.2 The portfolio of project options

There are two scenarios for this project. The base-scenario is where there is no intervention by the Government other than the normal condition. In this case the assumption is that the locals would put their land in to use by practising the most preferred and profitable agricultural activity in the region which is cereals (maize) production. The value of this production is given in Table 9 in Appendix as KSh 5,115/annum for a land size equivalent to that taken up by a fish pond which in this case is 400 m^2 comprising of the pond area and the approximate area of the dykes. This is the assumed opportunity cost of agricultural land for the second scenario.

The second is the FFEPP scenario in which the aquaculture project is implemented. Data is available on the number of farmers recruited into the FFEPP project as well as the monthly and annual harvest data from these farmers. The revenues from the project are assumed to be generated by direct sales of the harvested fish at market prices.

4.3 Costs and benefits expected without the FFEPP

The assumption of this study is that locals would continue to enjoy the benefits that they derive from agricultural activities such as cereal production, livestock production and other forms of agricultural activities practised in the region. Based on this assumption, the value of their production would remain lower if compared to the alternative returns from other enterprises like fish farming. Further, throughout the next 15 years there would be no significant improvement in the food security, poverty, employment and the status of the regional economy.

4.4 The costs and benefits of the FFEPP over its expected life

The project is anticipated to provide direct economic benefits to beneficiaries by improving their livelihoods through creating a new source of income from revenues of harvests sold. It is also expected to improve food security among the locals and in the region from the alternative source of food offered by the fish from the ponds. Table 10 in the Appendix shows production of fish from FFEPP.

Indirect economic benefits to the locals are expected through creation of new job opportunities in the aquaculture enterprises, hatchery production, and trade of fish as well as value addition activities along the value chain.

Furthermore, the FFEPP scenario is expected to enhance social cohesion among the Meru region beneficiaries, encouraging farmers to work together. This is supposed to happen through the clusters formed for training and ease of extension service delivery during the FFEPP implementation and through the Aquaculture Association of Farmers in Kenya (AAK) that links fish farmers together and offers them a platform to share their experiences.

Indirect benefits are also expected through integrating the aquaculture enterprises with other on-farm practises. These benefits include improved drainage of once swampy areas, opportunity for cultivation of crops on the outer walls of the pond dykes, use of the pond water as a reservoir for irrigation of crops, and such other benefits that would increase the farms production.

Benefits to the Government are expected as the project spurs the Meru region’s economy through the revenues and trade of the harvested fish. This production of fish in large scale is expected to create and attract new enterprises handling processing of fish for onwards marketing. Support enterprises such as aqua-shops and businesses supplying aquaculture production inputs such as fish feeds, nets, cooler boxes and various water quality equipment are expected to start and thrive as well.

Some of these benefits are already evident by the increase in harvest and activities of the FFEPP. The government has financed the construction of a fish processing factory in Kanyakine area of Meru. This cold chain fish processing factory is capable of handling 15 tonnes of fish weekly and is expected to start operations in 2016. The factory is managed by the Meru County Development Corporation. As part of support to the aquaculture enterprises, the Meru County Government in 2015 launched a new program to promote fish farming in the region. This was implemented through the ongoing establishment of two hatcheries, the establishment of a model trout farm for the region, the acquisition of a cold storage truck to serve the fish processing factory and acquisition of cooler boxes and deep freezers to aid in transport, handling and storage of harvested fish. Furthermore, the County has also purchased fish feed mills and pelletizers for farmer cluster groups.

The increase in fish farming has attracted private investors to the region. There is an increase in the number of fish feed processors operating in the region. New private hatcheries have been established. A large scale private fish processing factory; the Mt. Kenya Fish Factory was established in 2015 in the adjacent Tharaka County. This factory targets to process the fish being harvested from Tharaka County, Meru County and the greater Mount Kenya Region. These developments are ultimately expected to elevate the quality of life of the local community and spur regional economic growth.

The private sector has followed the initiative of the government and now there are examples where the whole value chain is produced by the private sector, from the private hatcheries to private fish farms down to private processors and end users, such as hotels and residents. This confidence from the private sector is a great sign that the benefits of this projects can be greater than the cost and that aquaculture can potentially provide a viable path for future prosperity.
The beneficiaries are expected to incur the opportunity cost of agricultural land required to construct the ponds on their farms and the new costs to operate and manage the fish enterprises. These include all operational costs after the first production cycle and any other costs needed to revamp the ponds in the long run.

The government met all the initial costs of establishing the fish farms and is not expected to incur any additional costs on the project.

4.5 Monetization of the outputs and impacts of the project

In this study, real market prices are used to derive the monetary values used in the calculations.

Increase in income for the region and the beneficiaries have been monetized from the values of the streams of revenues that arise from the sales of harvested fish. Improvement of livelihoods of the fish farmers is monetized from the value of the annual average consumption of households in Meru.

The costs of government expenditure and farmer operations are based on their actual market values.

The cost of farm labour is calculated using the actual costs of labour in Meru. The opportunity cost of using the agricultural land is taken to be equivalent to the net income of cereal production in Meru region. Maize production is the most preferred alternative land use in the region.

Due to lack of available data, this study has not valued the indirect costs and benefits of the entire program such as new businesses related to the fish farming boom. It also does not evaluate the entire value chain of the fish from the project.

4.6 The NPV, BCR and IRR of the project

The projects' NPV, BCR and IRR are calculated using the standard formulas. The present value of the net benefits (NPV) of the FFEPP project expected in its 15-year lifespan is KSh 59 million, the Benefits to Cost Ratio (BCR) is 1.05 while the Internal Rate of Return is 10%. Table 5 summarizes the results. The payback period of the project is 11 years, occurring in 2019 as shown in Table 11 in the Appendix.

If the project is left to continue to infinity, assuming that all factors remain constant and that there would be periodic costs every 15 years to revamp the remaining ponds, the project would reach a terminal NPV of KSh 197.9 million with a terminal IRR of 13.2%. Table 12, 13 and Figure 11 in the Appendix show the predicted values of the FFEPP benefits past the initial 15 years.

Figure 9 and Table 11 in the Appendix show the flow of accumulated costs and accumulated benefits for the 15-year period.

Table 5: NPV of the FFEPP Project

YEAR	NPV	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Time		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
HARVEST (kg)			205,155	326,587	358,291	373,932	385,511	391,613	388,574	379,223	374,894	370,566	366,237	361,909	357,768	353,628	349,487
CONSUMPTION (kg)			32,496	48,384	50,784	50,952	50,208	49,512	48,936	48,360	47,808	47,256	46,704	46,152	45,624	45,096	44,568
SALES INCOME (kg)			172,659	278,203	307,507	322,980	335,303	342,101	339,638	330,863	327,086	323,310	319,533	315,757	312,144	308,532	304,919
BENEFITS																	
CONSUMPTION (KSh)			19,476,654	27,894,344	25,677,944	23,554,524	21,953,672	20,258,806	17,127,600	16,926,000	16,732,800	16,539,600	16,346,400	16,153,200	15,968,400	15,783,600	15,598,800
SALES REVENUE (KSh)			103,484,111	160,389,594	155,484,946	149,309,943	146,612,731	139,977,337	118,873,300	115,802,050	114,480,240	113,158,430	111,836,620	110,514,810	109,250,470	107,986,130	106,721,790
COSTS																	
GOK COST (KSh)		156,470,906	68,925,876	38,681,955	3,594,123												
FARMER COSTS (KSh)			110,170,623	157,785,683	145,248,513	133,237,287	124,181,989	114,594,903	96,883,085	95,742,725	94,649,880	93,557,035	92,464,190	91,371,345	90,326,015	89,280,685	88,235,355
TOTAL BENEFITS (KSh)			122,960,766	188,283,937	181,162,890	172,864,467	168,566,403	160,236,144	136,000,900	132,728,050	131,213,040	129,698,030	128,183,020	126,668,010	125,218,870	123,769,730	122,339,590
TOTAL COST (KSh)		156,470,906	179,096,499	196,467,639	148,842,636	133,237,287	124,181,989	114,594,903	96,883,085	95,742,725	94,649,880	93,557,035	92,464,190	91,371,345	90,326,015	89,280,685	88,235,355
NET BENEFITS (KSh)		- 156,470,906	- 56,135,733	- 8,183,701	32,320,254	39,627,180	44,384,413	45,641,241	39,117,815	36,985,325	36,563,160	36,140,995	35,718,830	35,296,665	34,892,855	34,489,045	34,104,235
PV TOTAL BENEFITS (KSh)	1,346,779,480		114,916,604	164,454,483	147,882,883	131,877,474	120,185,515	106,772,108	84,694,525	77,248,934	71,371,200	65,931,902	60,898,829	56,242,111	51,961,379	48,000,035	44,341,497
PV TOTAL COSTS (KSh)	1,287,184,975	156,470,906	167,379,906	171,602,444	121,499,928	101,646,089	88,540,042	76,359,423	60,333,916	55,723,138	51,483,263	47,559,653	43,929,071	40,569,970	37,482,085	34,624,589	31,980,553
PV NET BENEFITS (KSH)		- 156,470,906	- 52,463,302	- 7,147,962	26,382,955	30,231,386	31,645,473	30,412,686	24,360,609	21,525,796	19,887,936	18,372,249	16,969,759	15,672,141	14,479,294	13,375,446	12,360,944
NPV (KSH)	**59,594,505**																
BCR	**1.05**																
IRR	**10%**																

4.7 Sensitivity Analysis

A sensitivity analysis is carried out in relation to the discount rate, cost of fish feeds, market price of fish, average pond production, cost of fingerlings and annual drop-out rate of farmer. In all the cases, the allowable margin of error or fluctuation, that is, changes in parameter's value beyond which the NPV becomes negative, were examined.

4.7.1 Effects of changes in the pond production on the NPV

Figure 3 below shows the effects of changes in the pond production on the NPV. The NPV increases with increase in the average pond production and decreases with the same. NPV is directly proportional to the average pond production. NPV becomes zero at an average pond production of 164.6 kg and subsequently becomes negative with further reduction. The point marker on the graph indicates the current pond production and NPV.

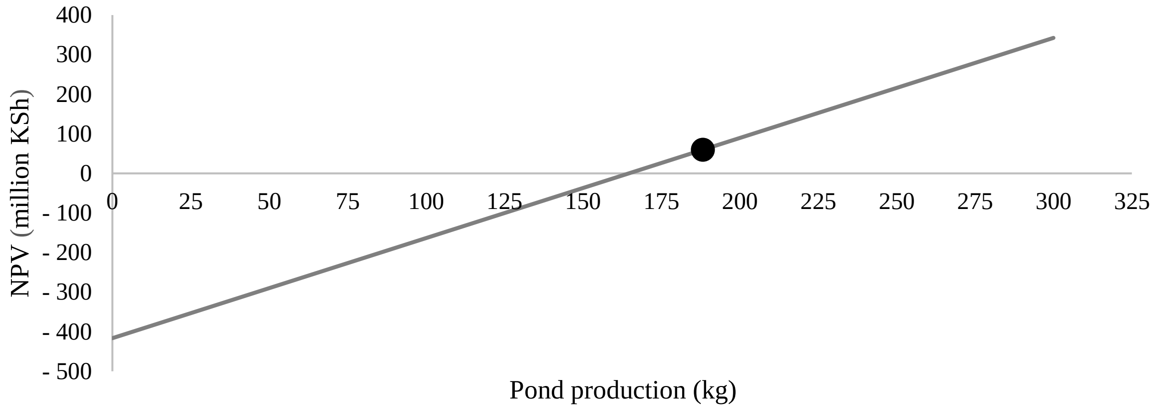

Figure 3: Effects of changes in the pond productivity on the NPV

4.7.2 Effects of changes in the dropout rate on the NPV

The NPV is inversely proportional to the dropout rate of the fish farmers (Figure 4). If the dropout rate of farmers is increased to 46.2% NPV becomes zero and becomes negative if the dropout rate is higher than that. The point marker on the graph indicates the current dropout rate of 1.16%.

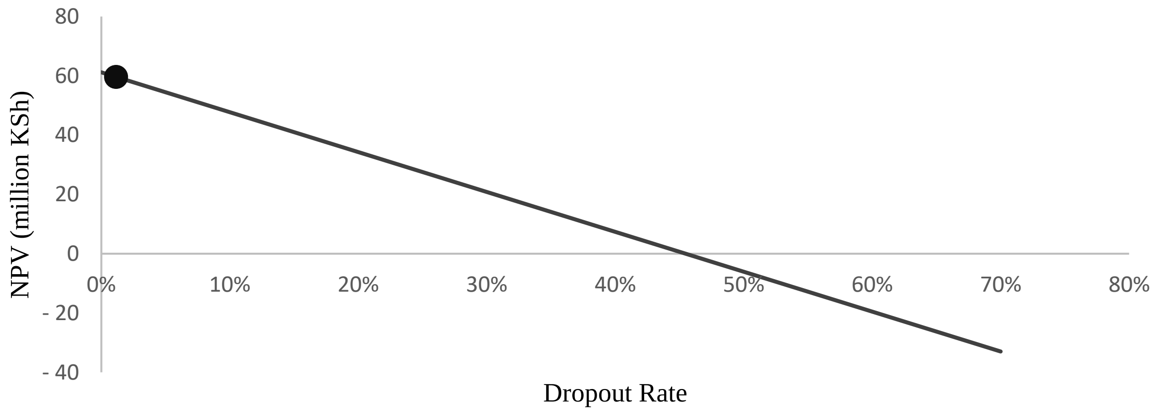

Figure 4: Effects of changes in the dropout rate on the NPV

4.7.3 Effects of changes in the fingerling prices on the NPV

The NPV is inversely proportional to the fingerlings prices (Figure 5). A fingerling price of KSh 13 produces a zero NPV. Subsequent increase of price produces a negative NPV. Point on the graph indicates the current fingerling price of KSh 10.

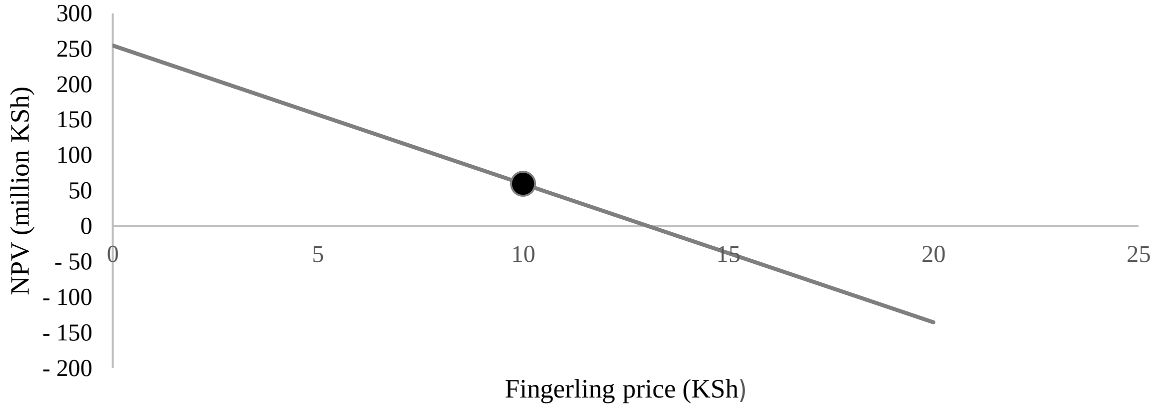

Figure 5: Effects of changes in fingerlings prices on the NPV

4.7.4 Effects of changes in the market price of fish on the NPV

The NPV is directly proportional to the market prices of fish. If the market price falls to KSh 334, the NPV becomes zero. Below that, the NPV becomes negative. Figure 6 below shows the results of the effects of change in market prices of fish on the NPV. Point marker indicates current price.

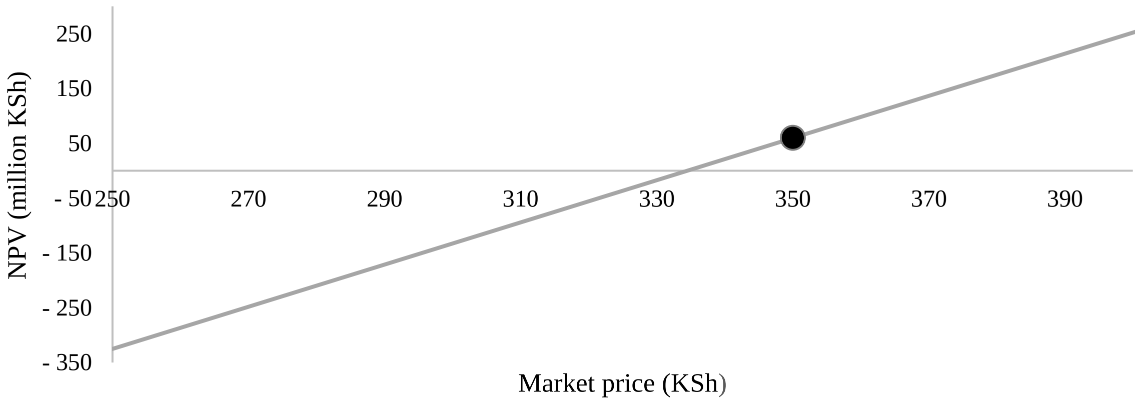

Figure 6: Effects of changes in market price on the NPV

4.7.5 Effects of changes in the discount rate on the NPV

The NPV is inversely proportional to the discount rate (Figure 7). If the discount rate increases to 11%, the NPV becomes zero beyond that, any further increase in the discount rate produces a negative NPV. The applied discount rate of 7% is indicated by the point marker.

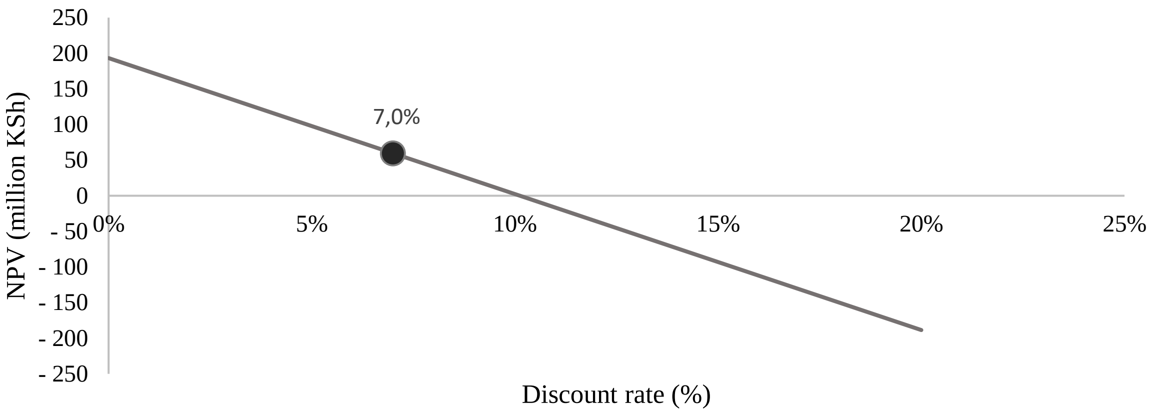

Figure 7: Effects of changes in discount rate on the NPV

4.7.6 Effects of changes in the cost of feed on the NPV

Figure 8 below shows the effects of change in the cost of feed on the NPV. The NPV is inversely proportional to the cost of feeds. If the cost of feeds increases to KSh 134 /kg the NPV becomes zero and subsequently becomes negative with any further increase. The point marker indicates the current price of 1 kg fish food.

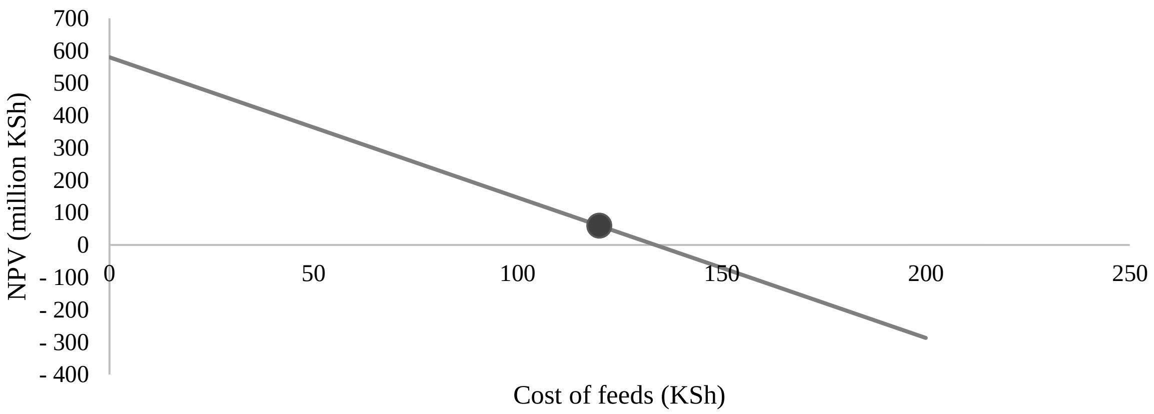

Figure 8: Effects of change in the cost of feed on the NPV

4.7.7 Summary of the sensitivity analysis

The values of the respective attributes were varied in all the cases by either decreasing them up to -20% of their presumed value or increasing them by 20% of their value. The net change in the value of the NPV were observed. The results are summarized in Table 6.

The NPV is by far most sensitive to the market price of fish, followed by the cost of feeds and the average pond production. The NPV is less sensitive to fingerling and the discount rate. The last in line is the dropout rate of farmers which has little effect on the NPV unless the changes are very high.

Table 6: Summary of sensitivity analysis

Change in variable	Corresponding Change in NPV					
	Market price	Cost of feeds	Pond production	Fingerlings price	Discount rate	Dropout rate
-20%	-452%	175%	-160%	65%	50%	0.57%
-10%	-226%	87%	-80%	33%	24%	0.34%
0%	0%	0%	0%	0%	0%	0.00%
10%	226%	-87%	80%	-33%	-22%	-0.23%
20%	452%	-175%	160%	-65%	-43%	-0.46%

5 DISCUSSION

According to these findings, the FFEPP has a positive NPV. This indicates that the project is a viable venture compared to the base case and will eventually produce net economic benefits to the locals of Meru. This is similar to the findings of Oyieng *et al.* (2013), there seems to be great potential for smallholder aquaculture in Meru, fish farming seems capable of creating employment, improving food security and lifting the standards of the local community.

The BCR of 1.05 indicates that the project is economically efficient and beneficial; the stream of benefits exceeds the costs incurred over the project life. The IRR of 10% for the 15-year period and 13.2% for an infinite period indicates a good return on the investment into the project compared with the cost of the funds that the government has invested in to the project. The pay-back period of the project is 11 years.[1] This is acceptable as it occurs within the project period. Optimally, in order to determine the extent of success of the FFEPP in Meru, we would need to compare the current outcomes of the projects with the intended project outcomes. Furthermore, the success of the FFEPP in Meru is not guaranteed to be extendable to the entire project in the whole of Kenya. Diverse climatic and geographical factors in the country as well as the cultural preferences of the various communities need to be considered; these have a significant impact on the implementation and performance of the project.

As the sensitivity analysis revealed, the NPV is highly dependent on the market price of fish; a mere price drop of KSh 15.5 or 4.5% decrease, would eliminate the net benefits altogether, and further drop would make the project uneconomical. This is similar to the findings of Mbugua (2007) that the NPV of aquaculture enterprises in Kenya is highly sensitive to produce prices. The prices of the fish vary across the region, data on the same is not readily available. Although most farmers sell their fish based on weight at about KSh 350 /kg, there are a few farmers who opt to sell their fish based on sizes. In such cases, table sized fish of about 200 gm or more are traded as large while fish below that are traded as small. This is common with catfish sales. Certainly, large fish attract better prices whatever the method of sale. There is a need to emphasize to fish farmers the importance of proper pond management practises and their effect on the sizes and weights of fish harvested.

Fish marketing in Meru is not fully developed, the linkage between buyers and suppliers of fish is in most cases poor. This is similar to the findings of Amadiva and Ngugi (2010) that there are poor marketing mechanisms for fish in Kenya. The demand for fish is nevertheless good, but the poor communication between the farmers and intended buyers, compounded by

[1] This takes into account the discount factor for both costs and benefits.

marketing structure problems, have not worked to the benefit of farmers. Farmers still have to rely on brokers and middle men to sell their fish. Excessive time and effort that farmers put into search for buyers reduces productivity. This search can in many cases take up to a month if a farmer is to get a good buyer offering competitive prices. When farmers take long periods to sell their produce in the market, the production cycle becomes longer than desirable resulting in higher costs (Maina *et al.*, 2014). The establishment of fish markets and aqua-shops in the region would be a solution to this problem.

Nile tilapia is the main species of the FFEPP. The productivity of this fish has however not been optimized given that the average production cycle of most farmers in Meru is 11 months. The processes of treatment of ponds, sourcing of fingerlings and pond stocking take in most cases two months as mentioned in the production characteristics of the FFEPP ponds. It is the author's view that this could be reduced to less than one month in order to shorten the production cycle and improve on efficiency. Actual farming of the fish takes an average 9 months. This production cycle can be reduced to a shorter and more profitable six months as recommended in the FFEPP guidelines through proper on-farm management practises. Shorter production cycles produce more returns per year (Ngugi *et al.*, 2007).

Tilapia growth rates increase with increasing temperature and reach an optimum at 30^0C (Santos *et al.*, 2013). Meru being a highland area in Kenya has temperatures that tend to be cooler compared to other low-lying areas of the country. It is important that more research is put into the possible impact of the region's temperatures on the productivity of fish. Better harvests and shorter production cycles can be realized if only better strains of tilapia fish more resilient to the low water temperatures can be propagated for the region. Given the diversity of climatic factors across Kenya, it would be prudent to investigate the performance of various strains of Nile tilapia across the country. Although tilapia and catfish are the most preferred fish in the region, considerations should be made to include common carp (*Cyprinus carpio*) and rainbow trout (*Onchorhynchus mykiss*) in future programs. These species could do well in the low water temperatures and climatic circumstances present in Meru.

The average pond productivity since 2013 when the government withdrew support is 188 kg/pond/cycle. In the FFEPP recommendations, fish ponds in the program are expected to produce a minimum average production of 270 kg/pond/cycle. According to the sensitivity analysis, increasing the production in line with this expectation would increase the NPV by 347%, assuming other parameters remain intact. This would also bring the IRR up to 17.1% and the BCR to 1.2 and greatly boost the returns of the project.

There are fish farms that have been able to produce the anticipated amounts of harvest per pond, but many have not. The reason for low productivity of ponds could be attributed to several factors namely: poor quality of feeds and on-farm feed management; poor manuring and fertilization of ponds; low water temperatures; poor farm records of harvests and sales; poor pond management practises and low quality of seeds. All these reasons are inherently present in the fish farms in Meru.

In this study, the cost of fish feeds is the second parameter to which the NPV is highly sensitive. The results also indicate that feeds take up 51% of the cost of production of farmers. Fish feeds are often not available in the region, the demand for quality fish feeds is high with very low supply. In previous studies on fish farming, most Kenyan farmer's note that fish feeds and feed management is their greatest challenge. The large demand of quality fish feeds created by the program gave rise to occasions where low quality feeds are sold to farmers. Unscrupulous dealers have sometimes taken advantage to compromise the quality of fish feeds (Munguti *et al.*, 2014). Stakeholders in the feed industry need to ensure strict compliance to the laid-out fish feeds standards. Farmers in the program need further training on the best on-farm feed management practises which would also involve training on how to improve the quality of their farm-made feeds. More research and incentives need to be put in place by the key sector players to ensure that low-cost but quality feeds are made available to farmers. High quality low-cost feeds could increase the returns for project farmers and raise the net benefits for the entire project.

Fish farms started in the project were semi-intensive. Productivity of semi-intensive aquaculture is very limited especially where availability of quality feeds for these systems is a problem. Increase in the productivity of the FFEPP ponds could however be realised if the model of farming system is changed from semi-intensive to intensive. This could be done in future phases of the program given that developments in agriculture and other land-based enterprises is already causing a rising competition for land and water resources in Kenya (Munguti *et al.,* 2014). Certainly, the opportunity cost of agricultural land is bound to increase with time therefore reducing the potential returns from semi-intensive fish farming.

The role of farmer clusters and organisation in Meru has been beneficial to the program and contributes to its success. Well-functioning fish farmer associations contribute to aquaculture development (Sarnissa, 2010). In Meru, they have been resourceful in the dissemination of information, farmer to farmer training, farmer mobilization and in the production of farm-made feeds. The formation of the Meru chapter of the Aquaculture Association of Kenya strongly relied on the social network and foundation of the clusters formed under the project. While most of the clusters are vibrant and very active in sharing experiences, there are clusters that have become dormant and lack clear focus and enthusiasm in their operations. Further studies could be put in understanding the roles of clusters in Kenyan aquaculture and possibly in how to reorganise them to take up more roles in the future of the program.

Information on production characteristics of fish farmers is usually obtained from farmer records. Proper record keeping among farmers remains a big challenge in accessing the outcomes of this program. This study agrees with the finding of Okechi *et al*. (2012) that most fish farmers in Kenya lack diligent record keeping on the economic performance of their fish farms and therefore lack properly planned farm operations which often leads to poor yields.

Lack of availability of appropriate data hindered the valuation of secondary costs and benefits as well as intangible costs and benefits to the farmers and the region. Nevertheless, they have been mentioned in the results. Increase in agricultural productivity of farms, job creation, infrastructural developments in the region and such benefits are some of the positive externalities of the FFEPP. Although externalities are typically overlooked in traditional cost benefit analysis, positive externalities, if considered appropriately, have the potential to amplify the returns from public projects.

6 CONCLUSIONS AND RECOMMENDATIONS

According to the results of this CBA, the project will produce significant economic gains to the community in Meru compared with a continuation of their usual agricultural practises. There is however a need for a much more comprehensive CBA that would identify all the stakeholders and the implications of the project upon the agricultural sector, the corporate sector, the social sector and the general environment. As the discussion entails, the factors omitted in this study are more likely to add to the net benefit than to lessen them.

This study finds that the objectives of the FFEPP have been achieved in the Meru region. Similar studies that focus on the performance of the project indicate that considerable success has been achieved in other areas of the country. Nevertheless, before a justification to upscale the project in the Meru region and the whole country at large is arrived at, it is important for the government to re-examine the model of the project in terms of intended costs and benefits as well as the mode of support and expected outcomes. More effort and assistance should be directed towards intensive commercial farming as opposed to semi-intensive.

Future aquaculture development strategies should begin by addressing the challenges experienced by the pioneer FFEPP beneficiaries. The number and reasons for dropping out, the decline in the harvest of tilapia, the low productivity of ponds, the number or value of fish that reaches the market and any other emerging issues need to be investigated and properly addressed.

Market development should be made a priority. The government should put in place initiatives for the farmers to be able to effectively market their fish in local, urban, regional, and global markets. The whole value chain from seed production to fish end-users need to be developed.
Fish feeds are one of the major production factors in this program. The low productivity per ponds may be an indication that there is either poor feed management practises or low quality of fish feeds among other problems. Future research should investigate the causes of low productivity of the ponds and the quality of fish feeds. Farmers ought to be taught how to source, make and store their own nutritionally complete and balanced quality feeds. It would also be important to offer incentives to feed producers and quality seed producers as this could increase the productivity of the initial fish ponds.

Farmer clusters should be strengthened and networked to form bigger clusters, cottage industries and fish farmer’s cooperatives that can create synergy in the procurement of aquaculture inputs, value addition and in marketing of their harvests.

The entire aquaculture sector can be spurred further by involving public private partnerships in its ventures. The government needs to identify strategic partners that can invest in the sector. These partnerships can in feed manufacturing, quality fingerlings production, fish processing and in marketing. Growth of this sector could be very fast if the private sector is encouraged to play key roles in the aquaculture sector.

Assuming that this success in Meru was indeed replicated in other parts of the country, then it would be possible with time to ease the pressure on the natural fish stocks; however, the government needs to fully quantify the benefits of the entire project and come up with strategies by which it can tap from the stream of incomes and channel them back for the development of fishery.

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LIST OF REFERENCES

Amadiva, J., & Ngugi, C. (2010). *Marketing of Farmed Fish in Kenya.* Louisiana: AQUAFISH.

AU (2014). The Round Table of African Ministers of Fisheries and Aquaculture. *Introduction Remarks by H.E. Tumusiime Rhoda Peace*. Addis Ababa, Ethiopia: Nepad.

Britz, P. J., & Rouhani, Q. A. (2004). *Contribution of Aquaaculture to Rural Livelihoods in South Africa: A Baseline Study.* Water Research Commission. Grahamstown: Water Research Commission.

Curtis, M. J., & Howard, A. C. (1993). *Economics of aquaculture.* New York: Food Product Press.

Denne, T., Irvine, R., Atreya, N., & Robinson, M. (2007). Recycling: Cost Benefit Analysis. New Zealand: Ministry for the Environment.

FAO (1986). *Report of the Expert Consultation on Small-Scale Rural Aquaculture.* Fisheries and Aquaculture Department. Rome: Food and Agricultural Organization of the United Nations.

FAO (2002). Aquaculture development and management: status, issues and prospects. *COFI:AQ/1/2002/2.* Rome: Food and Agricultural Organization of the United Nations.

FAO (2010). Securing Sustainable Small-Scale Fisheries: Bringing Together Responsible Fisheries and Social Development. *APFIC/ FAO Regional Consultative Workshop, 2010/19*, 1-56. Bangkok, Thailand: RAP Publication. Rome: Food and Agricultural Organization of the United Nations.

FAO (2012). *The State of World Fisheries and Aquaculture.* Rome: Food and Agricultural Organization of the United Nations.

FAO (2014). *The State of World Fisheries and Aquaculture; Opportunities and Challenges.* Rome: Food and Agriculture Organization of The United Nations.

Githukia , C. M., Ogello, E. O., Kembenya, E. M., Achieng, A. O., Obiero, K. O., & Munguti, J. M. (2015). Comparitive growth performance of male monosex and mixed sex Nile tilapia (Oreochromis niloticus L.) reared in earthen ponds. *Croatian Journal of Fisheries*, 73(1): 20-25.

Hecht, T. (2000). Considerations on African Aquaculture. *World Aquaculture.* 31: 12-19. World Aquaculture.

James , D., & Predo, C. (2015). Principles and Practise of Cost-Benefit Analysis. *Cost-Benefit Studies of Natural Resource management in Southeast Asia*. Springer. pp 11-46.

Kaliba, A. R., Ngugi, C. C., Mackambo, J., & Quagraini, K. K. (2007). Economic profitability of Nile Tilapia (Oreochromis niloticus L) production in Kenya. *Aquaculture Research* 38(11): 1129-1136.

Maina , J. G., Mbuthia , P. G., Ngugi , J., Omolo, B., Orina, P., Wangia, S. M., . . . Owiti, G. O. (2014). Influence of Social-economic Factors, Gender and the Fish Farming Enterprise and Productivity Project on Fish Farming Practises in Kenya. *Livestock Research for Rural Development*.

Manyala, J. O. (2011, September 1). Fisheries Value Chain Analysis; Background Report Kenya. Kisumu, Kenya.

Mbugua, H. M. (2007). *A Comparative Economic Evaluation of Farming of Three Important Aquaculture Species in Kenya.* Reykjavik: United Nations Fisheries Training Programme, Final Project.

Meru County Government (2013). *Meru County Intergrated Development Plan*. Meru, Kenya: Meru County Government.

Ministry of Agriculture, Livestock and Fisheries Development (2014). *Fisheries Development and Management Flagship Project.* Nairobi: State Department of Fisheries.

Ministry of Fisheries Development (2010). Fish Farming Enterprise Productivity Program Phase 2. *FFEPP 2 Project Document*. Kenya: Government of Kenya.

Ministry of Planning and National Development (2007). Kenya Vision 2030. *Kenya Vision 2030*. Nairobi: Government of the Republic of Kenya.

Munguti, J. M., Musa, S., Orina, P. S., Kyule, D. N., Opiyo, M. A., Charo-Karisa, H., & Ogello, E. O. (2014). An overview of current status of Kenyan fish feed industry and feed management practises, challenges and opportunities. *International Journal of Fisheries and Aquatic Studies*. 1(6): 128-137.

Mwamunye, M. K., Cherutich, B. K., & Nyamu, H. M. (2012). Performance of Commercial Aquaculture under the Economic Stimulus Program in Kenya. *International Journal of Business and Commerce* 2(3).

Ngugi, C. C., & Manyala, J. O. (2004). Aquaculture extension services in Kenya. *Fisheries Department Circular, C1002*, 35-42. Rome: Food and Agricultural Organization of the United Nations.

Ngugi, C. C., & Manyala, J. O. (2008). *Assessment of National Aquaculture Policies and Programmes in Kenya.* SARNISSA. Eldoret: SARNISSA.

Ngugi, C. C., Bowman, J. R., & Omolo, B. O. (2007). *A new guide to fish farming in kenya.* Kenya: Aquaculture Collaborative Research Support Program.

Ngugi, C. C., Engle, C., & Neira, I. (2014). Economic and Risk Analysis of Tilapia Production in Kenya. *Journal of Applied Aquaculture* 21(2): 73-95.

Okechi, J., Mikolasek, O., & Charo-Karisa, H. (2012, July). Developing smallholder aquaculture in Kenya into viable enterprises: A case study of Nyaguta fish ponds in Kisii, Kenya. *16th IIEFT Conference* . Dar es Salaam.

Opiyo, M. A., Munguti, J. M., Ogello, E. O., & Charo-Karisa, H. (2014). Growth Response, Survival and Profitability of Nile Tilapia (Oreochromis niloticus) Fed at Different Feeding Frequencies in Fertilized Earthen Ponds. *International Journal of Science and Research*, 3(9): 893-898.

Otieno, M. J. (2011). Fishery Value Chain Analysis; Background Report Kenya. 2-10. Rome: Food and Agricultural Organization of the United Nations.

Oyieng, E. P., Charo, H. K., Kahi, A. K., & Ojango, J. M. (2013). Characterization of fish production and marketing practises under small-holder fish farming systems of Eastern Kenya. *Livestock Research for Rural Development*.

Pearce, D., Atkinson, G., & Mourato, S. (2006). *Cost-Benefit Analysis and the Environment, Recent Development.* France: OECD Publishing.

Rothuis, A., van Duijn, A. P., van Rijsingen, J., van del Pijl, W., & Rurangwa, E. (2011). Business opportunities for aquaculture in Kenya; With special reference to food security. The Hague: Wagenigen UR.

Santos, B. V., Mareco, E. A., & Silva, M. D. (2013). Growth curves of Nile Tilapia (Oreochromis niloticus) strains cultivated at different temperatures. *Acta Scientiarum*. Brazil.

Sarnissa. (2010). *Assesment of national aquaculture programmes and policies in Sub-Saharan Africa.* Leusden: SARNISSA.

State Department of Fisheries (2013). *Fisheries Annual Statistical Bulletin.* Nairobi: Ministry of Agriculture, Livestock and Fisheries Development.

The Economist (2014). Frontier markets: Wedges beyond the edge. *The Economist*.

US EPA (2000). *Guidelines for preparing economic analyses.* Washington, DC: US Environmental Protection Agency.

Warusawitharana, M. (2014). The Social Discount Rate in Developing Countries . *Economic Research & Data*. Washington, D.C., USA: Board of Governors of the Federal Reserve System.

APPENDICES

Table 7: Labour Estimates for FFEPP Fish Farmer

Pond operation	Man hours	Man days	Cost/day (KSh)	Total cost (KSh)
Treatment	8	1	250	250
Maintenance	32	4	250	1,000
Harvest	32	4	250	1,000
Routine management	120	15	250	3,750
			TOTAL	**6,000**
Renovation (After 15 years)	400	50	250	12,500

Table 8: FFEPP Farmer Costs and Income Estimates

ITEM	UNITS	AMOUNT	UNIT PRICE (KSh)	TOTAL (KSh)
Gross Output				
Tilapia	kg	188	350	51,800
Catfish	kg	40	350	14,000
Sub Total				**65,800**
Variable Costs				
Tilapia seed	number	10	900	9,000
Catfish seed	number	10	100	1,000
Feeds	kg	120	200	24,000
Manure	kg	10	90	900
Lime	kg	5	60	300
Value of labour	man day	250	24	6,000
Water	monthly	100	12	1,200
Opportunity cost	value	1	5,115	5,115
Sub Total				**47,515**
Gross Income				**18,285**

Note: Opportunity cost is of the agricultural productivity.

Table 9: Cereals (Maize) Profits for one acre in Meru

ITEM	UNIT	AMOUNT	UNIT PRICE (KSh)	VALUE (KSh)
Gross Out Put (G.O)	90 kg Bag	25	2,200	**55,000**
Variable costs (VC)				
Land preparation	acre	1	2,000	2,000
Seeds	kg	10	250	2,500
Planting	md	10	250	2,500
Fertilizer				
a) Basal	kg	1	3,000	3,000
b) Top dressing	kg	1	2,000	2,000
Weeding				
a) 1^{st}	md	10	250	2,500
b) 2^{nd}	md	10	250	2,500
Fertilizer application	md	2	250	500
Stock borer control	md	1	250	250
Bull dock insecticide	250 g	1	500	500
Harvesting	md	10	250	2,500
Shelling	90 kg Bag	25	200	5,000
Actellic super dust	kg	1.25	500	625
Dusting	md	2	250	500
Gunny bags (synthetics)	no	25	50	1,250
Transport		1	1,000	1,000
Total Variable Cost (TVC)				**29,125**
Net Profit (1 Season)				**25,875**
Total for 2 seasons/acre (KSh)				**51,750**
Gross Margin for 400 m^2 (KSh)				**5,115**

Legend
md- man days
no - number

Table 10: Annual FFEPP Production from Meru County (kg)

YEAR	SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NIOV	DEC	SUB-TOTALS	ANNUAL TOTAL
2009	**Catfish**														**205,155**
	Tilapia	6,539	12,436	12,985	10,639	11,256	14,327	14,528	17,624	11,412	36,542	24,189	32,678	**205,155**	
2010	**Catfish**				78	124	179	168	89	142	247	362	614	**2,003**	**326,587**
	Tilapia	14,281	12,684	24,583	23,458	33,869	28,921	18,694	16,128	38,569	26,536	28,630	58,231	**324,584**	
2011	**Catfish**	214	142	54	212	142	256	394	214	284	342	785	1,423	**4,462**	**358,291**
	Tilapia	39,689	26,584	31,649	29,568	27,569	28,669	27,789	32,429	16,478	18,200	31,623	43,582	**353,829**	
2012	**Catfish**	548	697	479	592	645	849	742	842	1,224	1,473	2,414	2,319	**12,824**	**373,932**
	Tilapia	36,580	25,650	36,598	31,247	28,860	24,003	22,142	23,450	24,512	25,692	34,620	47,754	**361,108**	
2013	**Catfish**	8,353	3,241	1,728	689	978	1,002	1,975	1,849	2,417	3,845	7,622	9,469	**43,168**	**385,511**
	Tilapia	38,125	23,487	28,260	31,263	26,780	24,530	19,869	19,687	22,465	19,879	38,462	49,536	**342,343**	
2014	**Catfish**	7,284	8,429	4,627	4,297	2,505	4,786	3,578	5,324	6,541	9,246	6,588	9,258	**72,463**	**391,613**
	Tilapia	37,864	32,360	29,567	28,475	14,256	19,766	23,415	24,784	18,452	21,468	23,120	45,623	**319,150**	
2015	**Catfish**	9,222	7,614	5,412	6,321	8,942	5,576	2,635	4,509	7,562	8,727	7,420	11,273	**85,213**	**388,574**
	Tilapia	28,463	25,648	19,685	23,697	23,569	21,824	18,573	24,351	19,844	22,104	33,247	42,356	**303,361**	

Source: Meru County Fisheries Office

Table 11: Accumulated Costs and Benefits of the FFEPP Program

YEAR	Period	Accumulated Benefits (PV) (KSh)	Accumulated Costs (PV) (KSh)	Accumulated NPV (KSh)
2008	**0**		-156,470,906	-156,470,906
2009	**1**	114,916,604	-323,850,812	-208,934,209
2010	**2**	279,371,086	-495,453,256	-216,082,170
2011	**3**	427,253,969	-616,953,184	-189,699,215
2012	**4**	559,131,443	-718,599,273	-159,467,830
2013	**5**	679,316,958	-807,139,315	-127,822,357
2014	**6**	786,089,067	-883,498,738	-97,409,671
2015	**7**	870,783,592	-943,832,654	-73,049,062
2016	**8**	948,032,526	-999,555,792	-51,523,266
2017	**9**	1,019,403,726	-1,051,039,055	-31,635,329
2018	**10**	1,085,335,627	-1,098,598,708	-13,263,080
2019	**11**	1,146,234,457 **Pay Back Year**	-1,142,527,778	3,706,679
2020	**12**	1,202,476,568	-1,183,097,748	19,378,820
2021	**13**	1,254,437,947	-1,220,579,833	33,858,114
2022	**14**	1,302,437,982	-1,255,204,422	47,233,561
2023	**15**	1,346,779,480	-1,287,184,975	59,594,505

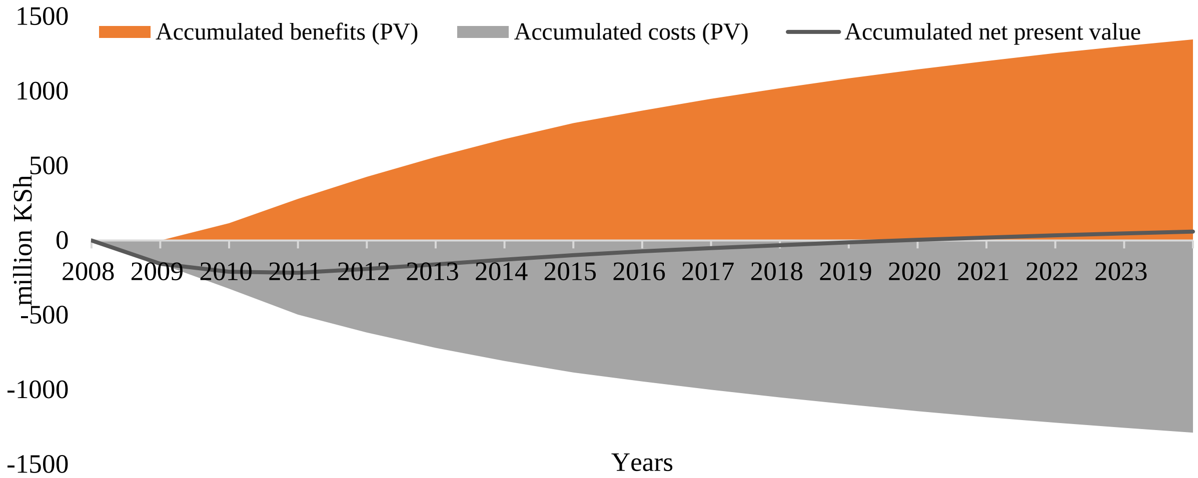

Figure 9: Accumulated Costs, Benefits and NPV over Project Period

Table 12: Predicted NPV Values for Recurring 15 Year Periods

Year	Period	Regular NET Benefits	Overhaul Costs	Total Net Benefits	NPV
2024	0	33,689,846	23,212,500	10,477,346	10,477,346
2025	1	33,299,044		33,299,044	31,120,602
2026	2	32,912,775		32,912,775	28,747,292
2027	3	32,530,987		32,530,987	26,554,976
2028	4	32,153,628		32,153,628	24,529,848
2029	5	31,780,645		31,780,645	22,659,161
2030	6	31,411,990		31,411,990	20,931,135
2031	7	31,047,611		31,047,611	19,334,892
2032	8	30,687,459		30,687,459	17,860,380
2033	9	30,331,484		30,331,484	16,498,318
2034	10	29,979,639		29,979,639	15,240,128
2035	11	29,631,875		29,631,875	14,077,890
2036	12	29,288,145		29,288,145	13,004,287
2037	13	28,948,403		28,948,403	12,012,558
2038	14	28,612,601		28,612,601	11,096,460
			NPV 2024 to 2038 (KSh)		**284,145,274**

Table 13: Prediction of NPV to Infinity

YEAR	Total benefits for each 15 years period	NPV (Discounted to 2008)
2024	284,145,274	96,249,835
2039	238,523,673	29,284,268
2054	200,226,953	8,909,817
2069	168,079,052	2,710,835
2084	141,092,731	824,779
2099	118,439,262	250,941
2114	99,422,972	76,350
2129	83,459,887	23,230
2144	70,059,792	7,068
2159	58,811,180	2,150
2174	49,368,615	654
2189	41,442,123	199
2204	34,788,287	61
2219	29,202,773	18
2234	24,514,055	6
2249	20,578,144	2
2264	17,274,172	1
2279	14,500,678	0
2294	12,172,488	0
2309	10,218,106	0
NPV 2024 to 2264 (KSh)		138,340,213
NPV 2008 to 2023 (KSh)		59,594,505
NPV 2008 to 2264 (KSh)		**197,934,718**

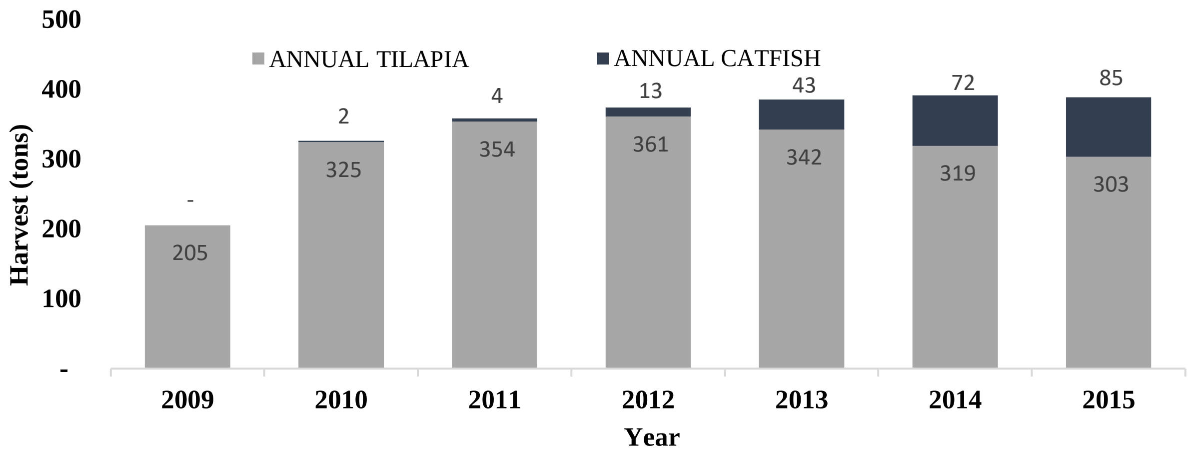

Figure 10: Annual FFEPP Fish Production from Meru County

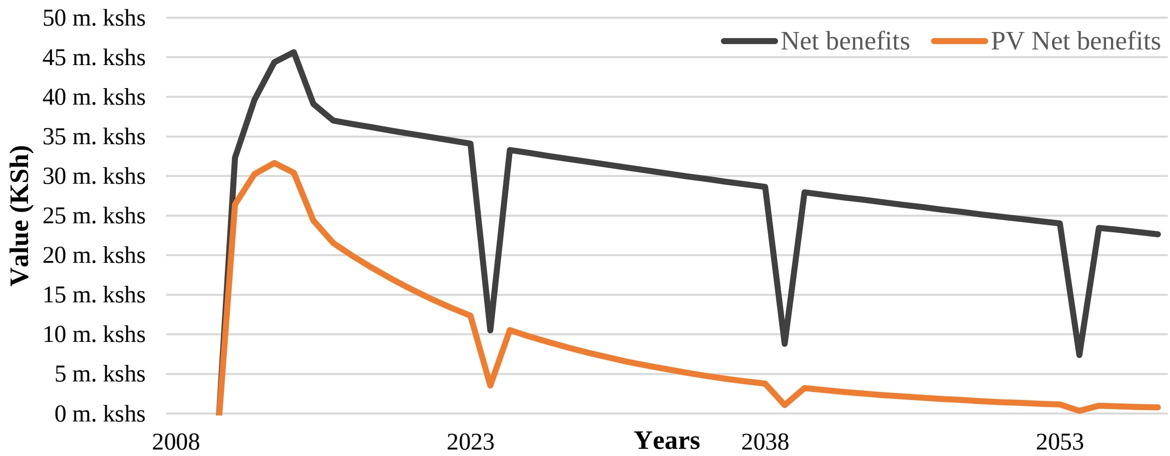

Figure 11: Progression of FFEPP Net Benefits into Infinity