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Economically feasible options for increased women participation in Kenyan aquaculture value chain

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ABSTRACT

This paper used value chain analysis to determine economically viable opportunities for increased female participation in the aquaculture value chains in Kenya. The main opportunities for women are as fish marketers and as fish farmers, especially in the Western Province of Kenya. Fish marketing is economically more viable than fish farming with an overall benefit–cost ratio of over 1.00 while the benefit–cost ratios for fish farmers were less than 0.5. The western region had the strongest fish production sector compared to the Central Province and the Rift Valley and provides relatively better opportunities for women participation in fish production. In the Rift Valley Province, women could work as paid laborers on fish farms as this region showed the largest employment impact on the community from a growth in fish farming activities.

1. Introduction

Various studies have shown a strong link between agricultural development and poverty reduction, especially in developing countries. As agriculture develops in a region so does the local economy leading to a reduction in poverty (Anríquez and Stamoulis, 2007; Christiaensen et al., 2011; Delgado et al., 2003; Muhanji et al., 2011). Aquaculture is the fastest growing agricultural sector in the world and the literature assumes that the increase in demand and income of a community resulting from development initiatives will be greater than the initial investment because the new sector will encourage other sectors through backward and forward linkages. Investments in aquaculture development in Kenya would therefore be expected to yield substantial improvements in rural incomes and improve food security.

Aquaculture development boosts the input sector, including feed and labor, which may be sourced locally. The wages paid to local laborers will constitute an increase in local income (Anríquez and Stamoulis, 2007; Cai et al., 2009). The fish produced may also be distributed or processed locally leading to the establishment of new sectors, such as the *bukas* of Nigeria (Cai et al., 2009; Hishamunda and Ridler, 2006; Miller and Atanda, 2011). The incomes of fish farmers and processors will typically be spent locally leading to increased local economic activity. This in turn boosts local income and the demand for local produce (Anríquez and Stamoulis, 2007; Bezemer and Headey, 2008; Meijerink and Roza, 2007).

Although aquaculture development will benefit a whole community, the benefits may not necessarily be evenly distributed due to different endowments and dissimilar access to resources among members of the community. This is especially true for women and children. Harrison (1995) found that most fish pond owners in Africa are men because they have better access to resources. Harrison reported that women's productive activities were found in fisheries, fish processing, marketing, agriculture and fish culture, participation in the informal and formal labor markets and governmental employment. However, employment opportunities for women have been reduced through a shift from self-employment in primary and postharvest production to wage labor (e.g., as workers in fish processing plants, etc.), which has further increased women's vulnerability (Williams et al., 2005).

Women generally play a major role in the production, processing and marketing of agricultural products in many African countries. However, their participation in the agricultural sector is often considered a traditional responsibility in the household and usually not accorded any economic value. Women are reported to produce half of the total agricultural products, which include fisheries and aquaculture in most countries, yet earn only one tenth of the total income and own only 1% of the total property (Fish et al., 2010; Walingo et al., 2009). Between 80 and 90% of African women live in rural areas and rural women supply about 80% of the labor force (Williams, 2000). Small-scale women farmers represent the majority of rural poor populations in developing countries (Wangila et al., 2007). Women's roles in all continents show patterns of unrecognized, unpaid labor as men own the factors of production and women are often required to work as domestic labor.

Women's role in wage earnings and cash production is therefore secondary (Asinobi et al., 2005; Mullins et al., 1996; Williams, 2000). However, in recent years, increasing male migration to cities in search

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of wage employment is resulting in a greater share of farm activities being managed and conducted by women (Mehra and Hill Rojas, 2008; Williams et al., 2005).

In aquaculture, men dominate fish production but they rely on the full participation of women and the family (Rutaisire et al., 2010). Women have traditionally maintained a central position in harvesting, post-harvest handling of fish, processing and marketing. However, as men enter the fish processing business they appear to be displacing women from those activities and thereby limiting their income sources. The increase in international fish supplies has also reduced the quantity of fish available for small scale processing and marketing by local women (Fish et al., 2010; Lwenya et al., 2006; Williams, 2000). Lwenya et al. (2006) note that women play key roles in the research and development and networking activities of fisheries and aquaculture sectors.

It is clear that there are gender-based differences in agriculture and key issues with regards to development and the role of women. There is therefore a need for an in-depth analysis of the costs and benefits to women (and their households) as participants at any stage in the aquaculture value chain, accounting for unique constraints in aquaculture chains in Kenya. There have been no studies that explicitly identify opportunities and critical success factors for the aquaculture chain and women in Kenya.

A holistic approach is necessary to understand the supply chain actors and determine the points of impact for maximum efficiency that provides opportunities for women. A useful tool is the vale chain map, which provides a basic diagrammatic layout of a food system and forms the basis for subsequent development and analysis (Humphrey, 2005; McCormick and Schmitz, 2001).

2. Theoretical framework

The primary focus of this research is female participation in aquaculture value chain in Kenya and how they are affected by channel structure and economic performance. This study uses a two stage approach to examine this issue. The first step is the value chain analysis (VCA), and the second step is the cost benefit analysis (CBA) which involves private and public benefit analysis.

The VCA is often the initial basis of evaluation for the competitiveness of an industry. It is a versatile tool that has been widely used in various sectors to assess progress in reforms, competitiveness of a sector, the performance of supply chain actors, and to identify target areas in a chain needing further attention. It has been applied in aquaculture value chain studies. Ardjosoediro and Goetz (2007) mapped the Indonesian aquaculture value chain and identified three target sub sectors that provided comparative advantages and warranted attention while Jamandre et al. (2010) used VCA to assess transactions and identified performance improvements in the tilapia value chain in the Philippines. Peramune (2010) also assessed the aquaculture value chain in Cambodia for the extent of progress and whether any changes made to the value chain had yielded improvements in competitiveness. The latter study made its assessment from the viewpoint of the micro, small and medium scale businesses in the sector as these were the ones that needed to be strengthened (Peramune, 2010).

In a study of Nile perch value chain in Kenya, Schuurhuizen et al. (2006) found that the traditionally female roles such as fish marketing in the supply chain were disappearing. Schuurhuizen et al. (2006) found that international fish supply chains in Nile perch led to disruptions in information transparencies and there was no investment in local infrastructure. Nile perch found on the local market for domestic use was of a lower quality because the best fish were exported.

A CBA is a widely used systemic economic technique that involves estimating, adding together and comparing the value of benefits and costs of a project to a community against an alternative. The CBA is mostly used as a decision tool. All costs and benefits are measured in financial monetary values at a particular time in a particular place. An important component of the CBA is the benefit–cost ratio (BCR) which measures the individual project's economic profitability. The value of the ratio of the present value of benefits to the present value of costs must be greater than one (Campbell and Brown, 2003; Watkins, 2010). The objective in CBA is to maximize the project's value in present terms, i.e. its Net Present Value (NPV) (Ngazy, 2004). The NPV is a discounted summation of the project's benefits minus its costs in each period. The project will only be viable if its NPV (discounted value) is greater than zero (Campbell and Brown, 2003; Ngazy, 2004; Watkins, 2010).

Rural aquaculture has been characterized as a "low input–low output" production system (Mwanja et al., 2006). Often in fisheries studies, a CBA is applied in the context of an intervention (e.g., Gilmore, 2009; Hishamunda and Ridler, 2006; Johnson, 2008).

3. Methodology

The data and information used in this paper were collected from the literature, in-person survey of industry stakeholders and focus group discussions in Kenya. A list of over 1500 fish farmers in Kenya was obtained from the Kenya Ministry of Fisheries but only three regions were visited because they are the major fish producing areas, i.e., the Central Province, Western Province and the Rift Valley region. Fish farmers from the three regions were randomly selected and were mainly surveyed at their farm location. In-person surveys were conducted for all respondents except the female fish farmers who were interviewed in the form of a focus group. The focus group discussions provided a basis for the analysis of qualitative data (Humphrey, 2005).

The study used a value chain map to identify the major actors in the catfish and tilapia value chain in Kenya. Catfish and tilapia are the two major fish species farmed in Kenya. The major participants were categorized into three groups, i.e., input suppliers; fish farmers; and fish marketers. A total of 6 input suppliers, 301 fish farmers and 98 fish marketers were surveyed. The input suppliers were mainly suppliers of fishing equipment and highly specialized fishing materials such as fish feed, aquatic chemicals, nets and pond liners as well as suppliers of irrigation and greenhouse materials. The fish farmers were practicing aquaculturists and included a few who also supplied fingerlings, brood stock and fry to other fish farmers. The 98 fish marketers interviewed were from the City and Gikomba markets in Nairobi in the Central Province; the open and indoor markets at Kisumu in the Western Province; and the three markets, i.e., Eastleigh, Municipal and Wholesale markets in Eldoret in the Rift Valley region. Fish marketers included small scale wholesalers, market traders and small scale fish processors.

Ideally, a value chain study would assess the financial efficiency and profitability at each stage of the value chain. However, due to data limitations and the unwillingness of input suppliers to share cost and revenue information for proprietary reasons, the economic profitability analysis was only conducted for the fish farmers and fish marketers. A BCR using annual costs and benefits was calculated for the two selected chain actors. The 2011 prices were taken as the base year.

Most of the farmed fish is marketed locally, which allowed the use of CBA to assess the impact of aquaculture on the local community. The study used the current 2011 input costs and forecasted input costs for the next period to allow for harvests from the farmers who were yet to harvest. The forecasted prices for the next period were average prices per region from farmers who have harvested in the previous period. The forecasted prices and costs were discounted at four different rates to allow for a sensitivity analysis. A regional multiplier was applied to the average regional BCR to assess the impact of aquaculture on local food availability and local employment opportunities for the three provinces (Gilmore, 2009; Maredia and Raitzer, 2010).

The costs were divided into capital costs and operating costs. The capital costs are investment costs such as money set aside to buy the fish to sell and pond construction costs. The initial capital costs in fish farming are considerable and access to capital often acts as a barrier to

entry into this venture. These costs are irrespective of whether the farmer is producing fish for food or fingerling production (Campbell and Brown, 2003; Okechi, 2004). There are significantly lower investment costs in fish marketing as the trader needs to have enough capital to ensure they can always afford to purchase a consignment of fish. The sales revenue is often reinvested into the next consignment.

Although operating costs often include fixed and variable costs, this study refers to variable costs as operating costs for fish farmers. This is because of the poor quality of data which made measuring depreciation difficult. Also, many of the farmers were new farmers without any fixed costs such as machinery. Rural households also had no knowledge of issues such as formal land tax or access to resources such as insurance or formal credit markets. These costs varied according to the magnitude of the operation (Campbell and Brown, 2003; Okechi, 2004).

The metrics for benefits in the case of the private CBA include the increases in income from the sale of the product and the increase in food availability. The amounts taken for household consumption were multiplied by the sale price and taken as a proxy for the increase in food availability. In the case of community CBA, the metrics for benefits include labor costs (wages paid) which was used as a proxy for the increase in local employment opportunities and local sales was used as the proxy for increase in food availability. The multiplier was applied to the household income to estimate the increase in local income and therefore the increase in society's standard of living (economic development).

Multiplier effects are the disproportionate increase in consumption and income brought about by a change in spending. In this case the multiplier would measure the increase in local demand and income brought about by the establishment of aquaculture farms in the region (Meijerink and Roza, 2007). Agricultural income has been noted to generate a higher growth multiplier than non-agricultural sectors because the increased demand and linkages are more locally oriented (Block and Timmer, 1994; Christiaensen et al., 2011; UNECA, 2009).

Various factors, such as the product (e.g. perishability and elasticity) and the area (e.g. infrastructure) affect the size of the multiplier (Delgado et al., 1994b, 2003; Hishamunda and Ridler, 2006). Block and Timmer (1994) report an agricultural growth multiplier of 1.63. However, aquaculture is not as developed as general agriculture in Kenya and the average multiplier for agriculture for sub-Saharan Africa is about 2.0.

Based on personal observation from the three provinces visited, this study used three different multipliers. In the Central Province, which is the capital region of Nairobi, a growth multiplier of 1.2 was used because there are many other opportunities in this region. In the Rift Valley Province, which includes Eldoret, there is no strong fish culture and most inputs are acquired from other provinces. The fish market is also limited. A growth multiplier of 1.0 was therefore used. In the Western Province, which includes Kisumu, a growth multiplier of 1.5 was used because they have a flourishing fish culture in the region, and it's close to Lake Victoria.

The Central Bank of Kenya controls the interest rate (Wehliye, 2011). The interest rate used is the rate the Central Bank charges to banks when it provides liquidity in extreme situations. During 2011, the interest rate was increased to reduce liquidity (Wehliye, 2011). In August 2011, Kenya's interest rate experienced substantial volatility as the central bank shifted to a system in which its interest rate was based on a moving average of interbank rates. The interest rate went from 13.87% on August 16 to 15.68% on August 17, 17.89% on August 18, 31.4% on August 27 and finally to 19.83% on August 29 (Miriri, 2011; Richardson and McGregor, 2011). The weighted average interbank lending rate also experienced the same volatility from 30% to 28.44% on August 27 (when the interest rate was 31.4%) then down to 27.73% on August 29. The fluctuations also caused an increase in the inflation rate from 15.53% in July to 16.67% at the end of August 2011 (Obulutsa and Miriri, 2011).

Gilmore (2009) suggests using a discount rate of 0% to illustrate the costs and benefits when inflation does not occur and the future gains and costs are equal to those in the current period. This is adopted in the study although this is not a feasible rate, given that the study area is Kenya where a 0% rate is unlikely and the growth period for fish is at least 9 months. This study used five discount rates in accordance with the fluctuations in the interest rate and interbank lending rates experienced in 2011. The discount rates used were therefore 0.0, 5.0, 15.0, 30.0 and 50.0% for both the revenue and the labor (proxy for decrease in unemployment). The discount rates allowed for a sensitivity analysis.

Profit is calculated by subtracting all the costs from the benefits. Gross returns do not take the costs into consideration and are not reported in this study. Net returns and profit are synonymous and are measured as an important decision tool for both the BCR and the community CBA (Campbell and Brown, 2003; Maredia and Raitzer, 2010; Okechi, 2004).

4. Results & discussion

The gender distribution of fish farmers and fish marketers by demographic factors are presented in Tables 1 and 2 respectively. These chain actors provided financial information and had the most substantive

Table 1
Gender distribution of fish farmers by demographic factors (%).

	Male (N = 172)	Female (N = 129)	Total
Age			
18–30 years	5.30	6.25	5.41
31–40 years	23.48	18.75	22.97
41–50 years	29.92	18.75	28.72
51–60 years	21.21	28.13	21.96
over 60 years	20.08	28.13	20.95
Household head			
Father	98.11	6.25	88.18
Mother	0.00	90.63	9.80
Other	1.89	3.13	2.03
Marital status			
Single	2.28	16.13	3.74
Married	96.58	12.90	87.76
Divorced/separated/widowed	1.14	70.97	8.50
Education level			
None	0.00	3.13	0.34
Primary	24.05	15.63	23.13
Secondary	51.15	55.07	51.02
Tertiary	22.52	18.75	22.11
Adult education	2.29	7.13	3.06
Other	0.00	0.34	0.34
Primary activity			
Full time farmer	49.41	43.75	48.78
Part time farmer	50.59	56.25	51.22
Farm income (Ksh)			
0–5000	28.63	35.48	29.35
5001–10,000	38.55	38.71	38.57
10,001–15,000	19.47	12.90	18.77
15,001–20,000	6.11	6.45	6.14
20,001–25,000	1.91	3.23	2.05
25,001–30,000	3.44	0.00	3.07
Over 40,000	1.91	3.23	2.05
Non-farm income (Ksh)			
0	3.16	5.26	3.39
1–5000	38.61	42.11	38.98
5001–10,000	28.48	26.32	28.25
10,001–15,000	8.23	15.79	9.04
15,001–20,000	8.23	10.53	8.47
20,001–25,000	5.70	0.00	5.08
25,001–30,000	3.80	0.00	3.39
over 40,000	3.80	0.00	3.39
Type of fish farmed			
Tilapia	72.52	66.67	71.92
Catfish	3.44	3.33	3.42
Both	24.05	30.00	24.66

Table 2
Gender distribution of fish marketers by demographic factors (%).

	Male (N = 44)	Female (N = 54)	Total
Market			
City Market	92.31	7.69	28.28
Gikomba Market	30	70	30.30
Kisumu Market	11.54	88.46	26.26
Eldoret Market	46.67	53.33	15.15
Age			
Less than 18	9.30	0.00	4.12
18–25	44.19	22.22	31.96
26–35	32.56	29.63	30.93
36–45	4.65	25.93	16.49
Older than 45	9.30	22.22	16.49
Marital status			
Single	27.91	5.66	15.63
Married	69.77	71.70	70.83
Divorced/separated	2.33	1.89	2.08
Widowed	0.00	20.75	11.46
Education level			
Primary	23.26	50.00	38.14
Secondary	60.47	38.89	48.45
Diploma/certificate	13.95	3.70	8.25
Bachelor's degree	2.33	1.85	2.06
Graduate degree	0.00	5.56	3.09
Type of fish sold			
Farmed fish only	0.00	0.00	0.00
Wild caught only	93.02	96.23	94.79
Both	6.98	3.77	5.21
Business function			
Wholesale	37.21	66.67	53.61
Retail	88.37	81.48	84.54
Processing	46.51	25.93	35.05

survey numbers of female participants. From Tables 1 and 2, there are regional differences in the gender distribution of fish marketers and farmers. The gender disparities in educational level for both fish farmers and fish marketers suggest constraints to access to education for women in Kenya. This could also be a contributing factor to their marginalization in decision making.

The gender differences in fish marketing are pronounced in the different markets, as well as the type of business functions performed. Women form the majority of fish marketers in most markets except the City Market in Nairobi. However, based on personal observation, though many women did not operate stands at the City Market, they were observed to be involved in the cleaning and processing of fish as laborers in the market. Women dominated the fish wholesaling sector. In terms of fish farming, women had higher participation in the Western Province. Women also were involved more in polyculture production than males.

Profitability analysis for the 98 fish marketers and 301 fish farmers examined are reported in Tables 3 and 4 respectively. All results are given in Kenyan shillings and year 2 values have not been discounted to 2011 Kenyan shillings as they are for the CBA.

The major cost was the cost of fish stock, either as fingerlings for fish farmers, or as food fish for traders. Feeds were also a major cost to fish farmers. Transportation costs were high depending on the distance and logistics involved in acquiring inputs or delivering products. The costs varied according to the magnitude of the operation. This is similar to findings by Campbell and Brown (2003) and Okechi (2004). The high capital costs are a major factor in the decision to practice fish farming as compared to fish marketing which has no real capital costs.

4.1. Fish marketers

Table 3 reports monthly averages for 3 periods; an 8-month average for "normal" months, 2-month average for fish "crisis" months, and 2-month average for "festive" months. The normal months are months during which demand and supply are normal for the year (January through May and August through October). The fish crisis months are June and July when supply is low and fish costs more, which results in reduction in operating costs such as packaging, electricity and cooling costs because there are fewer leftovers requiring refrigeration. The festive months are November and December when both supply and demand increase. Consumers have more money during this period due to bonuses, and demand goes up leading to an increase in revenue; variable operating costs also rise because of the increase in supply and the need to always maintain some fish stock.

The fish stock, wages, municipality tax and rent are fixed operating costs. Packaging, electricity, cooling, transport costs and other miscellaneous costs are variable operating costs. There are no capital costs for traders as they often rent the space in which they trade and it comes equipped with tables. The limited equipment they use is often from their households. The net revenues reported in Table 3 are those supplied by the respondents as their "take-home" profits after costs and wages have been paid.

The overall averages of BCRs are also reported for the various marketers (Table 3). Overall, it appears that most fish marketing activities are very profitable as the marketer showed a BCR of over 1.00. Marketers in Nairobi had the highest averages for BCRs. Fig. 1 presents the distribution of BCRs for the whole sample of marketers. Fig. 1 shows that 53% of the marketers had a ratio of 1.0 or below while 47% had a ratio of above 1.0. Of this 47%, 51% were females and 49% males; 60% were from Nairobi (44% from City Market and 56% from Gikomba Market), 23% from Kisumu, and 17% from Eldoret. All 47% marketers with a BCR above 1.0 traded in tilapia, 71% traded in Nile perch, 36% traded in catfish, 49% performed only one business function, 53% were involved in wholesaling, 78% were involved in retailing and 24% were processors.

The estimated benefit–cost ratios presented is based on the financial variables. Other intangible benefits such as the increase in food security and flexible and convenient work conditions were not taken into consideration. Consequently, a further regression analysis was performed to investigate whether selected structural and demographic characteristics affected the ratios in fish marketing. The following regression was performed.

$$(1)\quad \mathrm{BCR} = f\,(\mathrm{Con}, \mathrm{Gender}, \mathrm{Nairobi}, \mathrm{Kisumu}, \mathrm{Experience}, \mathrm{Multibus}, \mathrm{Wholsalep}, \mathrm{Retailp}, \mathrm{Oinc}, \mathrm{Catfish}, \mathrm{Nileperch}, \mathrm{Farmed})$$

where '*con*' is the intercept term; '*gender*' equals 1 for female; '*nairobi*' equals 1 for a marketer in Nairobi; '*kisumu*' equals 1 for a marketer in Kisumu; '*experience*' is the number of years in fish business; '*multibus*' equals 1 if respondent performs multiple marketing functions; '*wholesalep*' is the percentage of total business that is wholesaling; '*retailp*' is percentage of total business that is retailing; '*oinc*' equals 1 if respondent has other income sources besides fish marketing; '*catfish*' equals 1 if respondent markets catfish; '*nileperch*' equals 1 if respondent markets Nile perch; and '*farmed*' equals 1 if respondent markets farmed fish. There are no a priori expectations on the effect of these structural and demographic variables on the BCRs.

Table 4 presents the results of the OLS regression analysis. Of the selected variables the location of the market, whether a respondent performed multiple business functions, the percentage of business that is retailing and wholesaling, and experience were statistically significant. Having a higher percentage of marketing business being wholesaling and retailing and experience had a positive effect on BCRs, and consequently financial viability. A higher percentage of wholesaling and retailing suggests specialization in the marketing functions and that appears to pay off for marketers compared to those performing multiple business functions (diversification) that had a statistically significant negative effect on BCRs. Marketers with experience probably have gained experience managing their business. It was observed that fish marketing in Kenya was largely based on customer–seller relationships and informal contracts. Fish marketers who had been there longer

Table 3
Summary of fish marketers' household benefit:cost ratio per month.

	City Market, Nairobi	Gikomba Market, Nairobi	Kisumu Market, Kisumu	Eldoret Market, Eldoret	Sample total
Average months					
Total costs (Ksh)	205,572.86	270,483.09	125,476.03	130,489.71	193,466.99
Net revenue (Ksh)	421,000.00	740,793.10	218,266.67	225,454.55	437,174.39
Fish crisis months					
Total costs (Ksh)	237,994.21	309,945.55	144,083.92	143,668.76	221,630.09
Net revenue (Ksh)	378,900.00	666,713.79	196,440.00	202,909.09	393,456.95
Festive season months					
Total costs (Ksh)	206,656.50	273,431.32	126,959.79	133,652.19	195,524.56
Net revenue (Ksh)	463,100.00	814,872.41	240,093.33	248,000.00	480,891.83
Total annual costs (Ksh)	211,157.02	277,551.54	128,824.64	133,213.30	198,503.77
Total annual net revenue (Ksh)	421,000.00	740,793.10	218,266.67	225,454.55	437,174.39
Benefit–cost ratio	1.993	2.669	1.694	1.692	2.202

had developed a strong customer base and stronger ties with their suppliers.

Performing multiple business functions, which depicts diversification and being in Nairobi and Kisumu appeared to have negatively affected BCRs. Relative to Eldoret, marketers in Nairobi and Kisumu were more likely to have lower margins possibly due to the competitive nature of the fish markets in those metropolitan cities. Kisumu is by Lake Victoria and handles a lot of wild-capture fish while Nairobi is the national capital and central point where almost all fishers target for markets.

4.2. Fish farmers

Table 5 provides a summary of the BCRs and net benefits for fish farmers. For year 2, a factor per species farmed was created based on land allocation (i.e., pond size) and with reference to the region's average pond size for the species. This factor is used to determine the scale of fingerling costs and production. Average prices and quantities were used for calculation of these fingerling costs and revenue from production. Labor costs from year one are used in year 2 because the labor costs reported were wages to hired labor. It is therefore difficult to forecast whether the farmer will hire more labor as production expands or if more members of the household will be used for the farm work. Transport costs and other costs relating to marketing were also not forecasted because the farmer could choose not to take his fish to the market and continue to rely on informal farm gate sales.

From Table 5, the benefit–cost ratios are below 1.0 and net benefits are negative in both years 1 and 2 however, there is noticeable improvement in net benefits in year 2. A forecast for the 3rd year and future years combined with improvements in the scale of production and efficiency may show better ratios. However, that would require more data beyond the scope of this study.

The payback periods for the Central and Rift Valley provinces could not be accurately calculated due to the low current sales and lack of information on production specifics and potential sales if the scale of production and efficiency improve. However, the Western Province payback period was calculated to be about 4 years without subsidies from government and 2.5 years with subsidies. The government has implemented an economic stimulus program (ESP) that funded aquaculture through pond construction and supplies of inputs for fish production from 2009 to 2011. The 4 year payback period without ESP funds is similar to the 5 year payback found by Okechi (2004) for catfish farming in the Lake Victoria Basin of Kenya. The sample average for all provinces was 5 years with ESP funds and almost 9 years without the ESP funds.

The major barrier to entry into the fish farming sector was identified as high initial capital outlay. This is especially true for women as they often lack collateral required to borrow money. While married women may have their husbands sign as surety, single, divorced and widowed women do not have this option. Although the ESP significantly reduces one of the major barriers to entry to aquaculture adoption, the government of Kenya has acknowledged that the Ksh40,000 subsidy is not sufficient (Anon., 2010). The study calculated that even with the ESP funding, on the average, fish farmers may not recoup their investment until after two years of fish farming.

Levinson (2011) suggests that new agricultural initiatives, such as aquaculture should be combined with other traditional farming practices. Feed and composting costs were not a substantial cost in this study because the farmers were only just starting production. However, as production expands, these costs will increase. Intercropping and integrated agriculture have been shown to significantly improve the success rate and increase food security. Moehl (1999) and Mullins et al. (1996) state that prosperity of aquaculture depends on merging farm and non-farm activities and that the farm activities must be complimentary so as to reduce production costs from each venture. This would be especially advantageous for women as they could then merge their household duties with aquaculture.

A complimentary viable option would be for the fish farmers to also venture into fish processing. The perishable nature of fish necessitates prompt sales. However, this is not always possible in remote locations. Fish processing, even just salting or drying creates a more stable food supply and may create jobs and generate income. Levinson (2011) and Leroy and Frongillo (2007) found that development initiatives that included women and involving processing led to improved household income and food security. Leroy and Frongillo (2007) stated that these initiatives helped women gain more control of household income although their workload was increased. Jagger and Pender (2001) support the need to venture into post-harvest practices as they assert that it allows for fish to reach a larger market when it is no longer so

Table 4
Results of regression to determine effects of selected factors on BCRs for marketers.

	Coefficient	Std. error	t-Statistic
Intercept	1.56	0.818	1.90
Female	0.07	0.427	0.16
Nairobi	−1.81[a]	0.554	−3.27
Kisumu	−2.50[a]	0.660	−3.78
Experience	0.032[b]	0.019	1.69
Multi-business	−1.42[a]	0.363	−3.91
% wholesaling	0.029[a]	0.008	3.71
% retailing	0.017[a]	0.007	2.22
Other income sources	−0.13	0.464	−0.28
Catfish	0.68	0.455	1.49
Nile perch	0.64	0.407	1.57
Farmed fish	−0.02	0.795	−0.02
N			98
R-squared			0.387
Adj R-squared			0.308

[a] Indicates statistical significance at 5%.
[b] Indicates statistical significance at 10%.

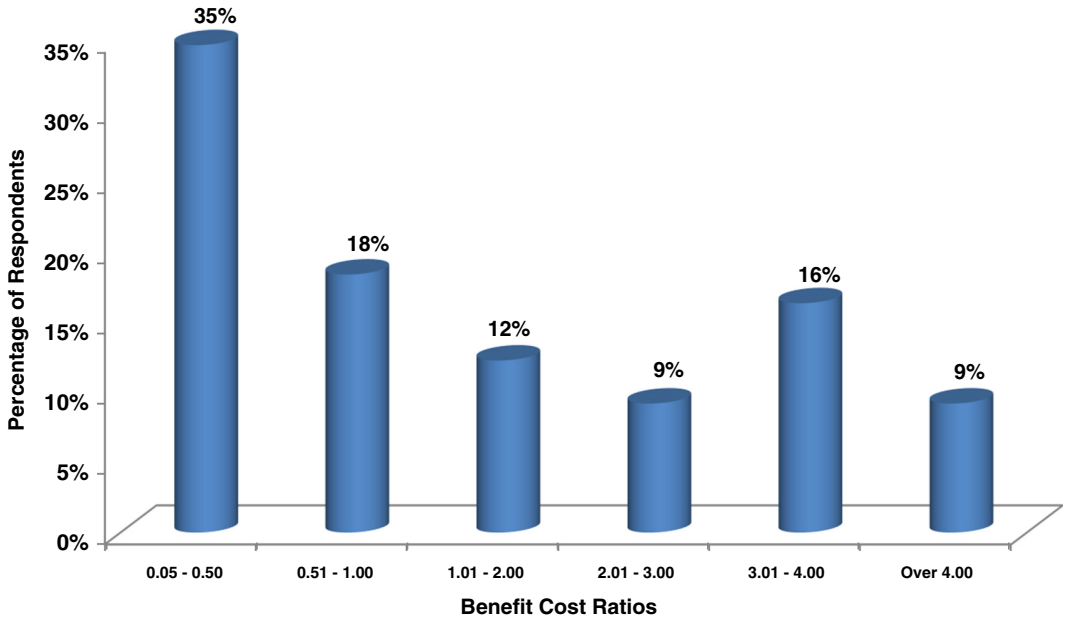

Fig. 1. Distribution of calculated benefit–cost ratios.

Table 5
Summary of fish farmers' household benefit–cost ratio & net benefits.

	Western Province	Central Province	Rift Valley Province
Year one			
Average total annual capital costs: pond construction (Ksh)	86,819.67	79,555.39	32,499.69
Average total annual fixed operating costs: fingerling/seed (Ksh)	69.01	30.49	41.09
Average total annual variable operating costs (Ksh)			
Feed	6042.51	3693.10	5153.33
Labor	13,561.28	12,665.91	21,493.33
Transport	2044.46	2021.75	6032.13
Cellphone	895.57	1407.53	666.67
Average harvest (kg)			
Tilapia	2.504	0.184	0.109
Catfish	4.975	0.182	1.423
Average prices (Ksh)			
Tilapia	180/kg	245/kg	130/kg
Catfish	185/kg	70/kg	200/kg
Average number of harvests in 2011	1.5625	2.392	1.408
Total average year 1 costs (Ksh)	109,432.49	99,374.18	65,886.25
Total average year 1 revenue	4971.53	1021.65	663.13
Average benefit–cost ratio	0.328	0.009	0.018
Average net benefits (Ksh)	−104,460.96	−98,352.53	−65,223.11
Year two			
Average total annual fixed operating costs (Ksh): fingerling/seed	67.57	48.93	36.14
Average total annual variable operating costs (Ksh)			
Feed	6099.83	3693.10	5153.33
Labor	13,561.28	12,677.85	21,493.33
Transport	2044.46	2022.34	6032.13
Cellphone	895.57	1407.53	666.67
Total average year 2 costs (Ksh)	22,668.70	19,849.74	33,381.61
% change from previous year	−382.75	−400.63	−97.37
Total average year 2 revenue	21,931.61	1518.41	720.88
% change from previous year	77.33	32.72	8.01
Average benefit–cost ratio	1.751	0.107	0.024
% change from previous year	81.28	92.01	23.67
Average net benefits (Ksh)	−737.09	−18,331.33	−32,660.74
% change from previous year	−14,072	−436.53	−99.70

perishable. This study found fish marketing to be a highly profitable business venture with no evident barriers to entry. Fish marketing has also been shown to be ideal for women due to the flexible hours reported and the relationship contracts that allow for a higher level of financial flexibility. Fish trading has been noted to be a traditionally female occupation, especially when it is at a small scale. Therefore, it seems that fish marketing may be combined with fish farming to improve income sources, especially during the first years in fish farming. Women can be involved at the production level and/or the processing, and as fish marketers.

4.3. Cost benefit analysis and society welfare

Table 6 gives a summary of the estimated values of the effects of aquaculture on society's welfare in 2011 Kenyan shillings. The average BCR per region was calculated from the household profitability analysis for fish farmers in each region. It was then discounted at the four rates (5.0, 15.0, 30.0, and 50.0%) and a region specific multiplier, i.e., 1.2 for Central Province, 1.5 for the Western Province, and 1.0 for the Rift Valley, were applied to the proxies. From Table 6, the impact of aquaculture on local employment appears significantly higher compared to local food availability in the early stages of production. Though the Rift Valley employs the most labor for production, it appears to be producing inefficiently and creates the smallest growth impact on the local economy. The higher rates of aquaculture adoption in the Central and Western provinces lead to higher increases in the value of food availability for the local community. In all cases, fish farms result in a positive increase in society's welfare in terms of food availability, increased employment opportunities and economic growth creation (Table 6).

The literature suggests that animal protein agricultural ventures, such as fish farming tend to have significantly higher impacts on food availability and rural income than those reported in this study. Bouis (2000) argues that it is almost impossible to measure the impact of such initiatives in the short run due to institutional constraints. Jagger and Pender (2001) also suggested that small-scale fish farming in remote areas, such as the Rift Valley and the Western Province, may

Table 6
Summary of the estimated values of the effects of aquaculture on community welfare in Ksh & US$ equivalent.[1]

	Year 1	Year 2 Discount rates				
		0%	5%	15%	30%	50%
Value of increase in local employment per farm						
Central Province	13,572.08	12,677.85	12,074.14	10,499.25	8076.35	5384.23
USD	(152.50)	(142.45)	(135.670)	(117.970)	(90.75)	(60.50)
Western Province	2540.06	13,561.28	12,915.50	11,230.87	8639.13	5759.42
USD	(28.54)	(152.38)	(145.12)	(126.19)	(97.07)	(64.71)
Rift Valley	21,493.33	21,493.33	20,470.00	17,800.00	13,692.00	9128.10
USD	(241.50)	(241.50)	(230.01)	(200.00)	(153.85)	(102.57)
Value of increase in local food availability per farm						
Central Province	1760.18	7975.29	7595.51	6604.79	5080.61	3387.07
USD	(19.78)	(89.61)	(85.34)	(74.21)	(57.09)	(38.06)
Western Province	357.17	1520.23	1447.84	1258.99	968.45	645.64
USD	(4.01)	(17.08)	(16.27)	(14.15)	(10.88)	(7.25)
Rift Valley	31.4	58.91	56.11	48.79	37.53	25.02
USD	(0.35)	(0.66)	(0.63)	(0.55)	(0.42)	(0.28)
Value of generated growth in local economy						
Central Province	1021.65	1822.10	1735.33	1508.98	1160.76	773.84
USD	(11.48)	(20.47)	(19.50)	(16.96)	(13.04)	(8.70)
Western Province	4971.53	27,364.14	26,061.09	22,661.82	17,432.17	11,621.44
USD	(55.86)	(307.47)	(292.83)	(254.63)	(195.87)	(130.58)
Rift Valley	663.13	720.88	686.55	597	459.23	306.15
USD	(7.45)	(8.10)	(7.71)	(6.71)	(5.16)	(3.44)

[1] This is according to Oanda (2011b) exchange rate for June 30, 2011.

be limited to subsistence farming with localized sales because of lack of access to formal chains and transport constraints.

5. Conclusions

The findings suggest that in the short term, fish marketing is economically more viable than fish farming with an overall benefit–cost ratio of over 1.00. Marketers in Nairobi had the highest averages for BCRs. About 53% of all marketers had a benefit–cost ratio of 1.0 or below while 47% had a ratio of above 1.0. The benefit–cost ratios for fish farmers were less than 0.5.

The high initial costs of fish farming in terms of land, training and pond construction are major constraints to increased female participation in the aquaculture production sector. The western region had the strongest fish production sector compared to the Central Province and the Rift Valley and provides relatively better opportunities for women participation in fish production. In the Rift Valley Province, women could work as paid laborers on fish farms as this region shows the largest employment impact on the community from a growth in fish farming activities.

In the short run, fish marketing has fewer barriers to entry and if combined with fish farming, the benefits can be significantly higher in the long run for women despite the high initial cost outlay. Fish farming also benefits the local community and enhances rural economic growth.

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