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Enabling environment for fish farming as an alternative livelihood in Makueni, Kenya

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Abstract
The objective of this paper was to determine the costs and returns for fish farming and tomato production in Makueni County, Kenya. The comparison parameters were gross margin, net income, profit cost ratio and benefit cost ratio for three enterprises namely Nile tilapia (*Oreochromis niloticus*), African catfish (*Clarias gariepinus*) and tomatoes (*Lycopersicon esulentum*). The Profit cost ratio of catfish was 0.561 and 0.518 for tomatoes during the second season. The results of benefit cost ratio for catfish and tomatoes enterprises were 1.51 and 1.54 respectively. These ratios are within the recommended profitability parameters. The study provides relevant information on profitability measures that can be used to promote aquaculture as an alternative livelihood in the Arid and Semi- Arid Lands (ASALs).

Keywords: ASALS, catfish, comparison, tilapia, tomatoes, Kenya

1. Introduction
Makueni has diverse farming activities that include agricultural crops, livestock and fishery [1]. In the agricultural sector we have cereal crops are maize, sorghum and finger millet, and horticultural crops are tomatoes, Egg plant, Kale, pepper okra, lettuce, watermelons cowpeas, soy beans, Root crop crops include cassava while fruit crops include eater melons, mangoes, oranges and lemons. The key livestock animals kept are cattle, goats, sheep and chicken are the primary poultry birds raised. Tilapia and catfish are the two types of fish farmed [2]. Tomato accounts for 6.72% of the total Kenyan horticultural crops [3]. Makueni annual tomato production was 17,552 Metric tons in 2012 mostly grown using open field production system [4]. In determining an enabling environment for fish farming a costs and returns' comparison of fish farming with tomato farming was done. According to the Government of Kenya [5], the national average tomato production per hectare is 30.7 Metric tons. Average tomato production per hectares assumes two cycles of planting and a farmer maximizes on the utilization of recommended inputs. Makunike[6] found out that one plant in a greenhouse has the potential of yielding 15 Kilograms (Kgs) at first harvest with a maximum potential of 60 Kgs at the end of one year. Six tomato varieties commonly grown in Kenya are Romana V F, Cal J, Onyx, Beauty, Money Maker and Anna F1 [7]. In Makueni county Onyx, Cal J and Money Maker dominate the tomato produced due to their adaptability to the warmer climate [8]. Onyx is preferred by farmers due to its added advantages of being a high yielder, longer shelf life and resistant to diseases/pests [9]. Based on Ricks' studies [10], best conditions for tomato production are as follow: low to medium rainfall or irrigation. Tomatoes are sensitive to frost and are easily killed by freezing temperatures. Wet conditions increases disease attack chances to tomatoes. Tomato grows well in a wide variety of soils with high organic matters, well drained and with a PH range of 5-7.5. Tomatoes require optima pollination temperatures of 20-24 degrees centigrade (night); and 15-35 degrees centigrade during the day. These ideal tomato growing climatic conditions is supported by a study lead by Musyoki [11]. Tomatoes provide vitamins C and A, can be eaten fresh or processed [12]. Three major techniques used to determine comparative farm enterprise profitability are gross margin, budget analysis and return per unit input. These techniques are common partial measures selected although they do not follow the law of diminishing returns to scale [13]. In this study, gross margin (GM) was used due to its simplicity and flexibility in determining enterprise profitability. Whittaker *et al*, [14], further stipulate that gross margin relies on a number of assumption that farmers used different production and technology; the sale price used were those current during the production period for each of the farm enterprise for each operator.

2. Materials and Methods

Makueni County is located in the Eastern region of Kenya and its coordinates are 1° 48' 0" South, 37° 37' 0" East [15]. The County borders Kitui to the East, Machakos to the North, Kajiado to the West and Taita Taveta to the south.

This study used a sample size of 146 respondents from the target population of 1300 enrolled fish farmers in Makueni County [16].

2.1 Data Collection

Cost and return data for fish and tomatoes was collected between June, 2015 and May, 2016, variable expenses were entered by a Research Assistant on operating sheets over that period. Fixed costs were record on semi-structure questionnaire that was administered by the Researcher. The collected primary data included the cost of production and income generated from the sale of the fish and tomatoes.

2.2 Data analysis

Data was entered into Excel and SPSS 22 spreadsheets. The quantitative analysis used gross margins, net fish income, benefit-cost ratio and profit analysis. Data on the Profit and Loss statement section of the questionnaire was entered and analyzed using Excel 2007 to get total revenue, gross margins. Total variable costs, total fixed cost, total cost and net fish income. Gross margin (GM) for fish farming was the difference between the total revenue (TR) and the total variable cost (TVC) of fish farming (GM = TR – TVC) while the gross margin ratio (GMR) is equals to (TR-TVC)/TR. A ratio of 0.35 or higher is more desirable [17]. In profit analysis, Profit was the positive difference between total revenue and total cost of the fish enterprise (Profit = TR – TC), if negative then it was considered a loss. Profit-cost ratio (PCR) was equals total cost divided by total revenue (PCR= TC/TR), a ratio of 0.65or less is preferable [17]. Net Fish Income (NFI) was profit less non–cash adjustments to income plus gains/loss on capital assets sale. Benefit-cost ratio (ROR) was equal to total revenue divided by total cost (ROR=TR/TC)

3. Results and Discussion

The costs and returns of fish and tomatoes was done and the results are shown in Tables 1 to 4

Table 1: Gross margin and net income for tomatoes planted on 0.05ha in KES*

VARIABLE		KES.
Total revenue	25cases @120Kg@KES50	150,000.00
Land preparation		7,000.00
Seedlings		10,000.00
Pesticides		7,500.00
Labor	72mdys@200mdy	14,400.00
Fertilizer(manure+ Dap)		3,550.00
Harvesting	25cases @KES100	2,500.00
Transport	25cases @KES200	5,000.00
Total variable cost		49,950.00
Gross margin	M^2= 100,050/500=KES200.10	100,050.00
Land lease		5,000.00
Equipment		20,000.00
Commissions		15,000.00
Fuel	78litres@100	7,800.00
Total fixed costs		47,800.00
Total costs		97,750.00
Net cash income		52,250.00
Depreciation		-
Loss on machinery		10,000.00
Net income	M^2= 42,250/500=KES84.50	42,250.00

Source: (Authors, 2015) * 100 KES=1 U.S $

The total sold tomato output (Q_f) was 3,000Kgs per 0.05 hectares (FPA). The computed per hectare (H=1) production (Q_h) is 60 Metric tons using the formula:

Q_h=H/FPA x Q_f/1000

Where

Q_h is the computed average production per one hectare.

H is a hectare equals 10,000M^2

FPA is fish pond area equals to 500M^2

Q_f is the total tomato output per fish pond area (FPA)

The per hectare computed tomato output collaborates with other global studies [18], but is inconsistent with the Kenya small scale farmer national average yield of 12 Metric tons [19] and 30.7 Metric tons for a progressive farmer [20]. The results of tomato production in Table 1 found gross margin of KES.200.10/M^2 and net profit of KES.84.50/M^2 in returns. These returns are comparable higher than in Wachira *et al*, 2014 study [21] that found a gross margin of KES.14.92/M2 and a net profit of KES.12.99/M^2 in open field production system in Nakuru County, Kenya. This differential might be attributed to the fact that in Makueni, a progressive farmer was used as opposed to small- scale farmers in Nakuru who were sampled.

The details of the income statement for the two fish culture are shown in Table 2 and Table 3.

Table 2: Gross margin and net income for catfish on 0.03ha earth pond in KES*

Variable		Kes.
Total revenue	1800Kg+@KES360	648,000.00
Fingerlings	3000@KES15	45,000.00
Feeds	2635Kg@KES54	142,290.00
Labor	896mhrs@KES60	54,760.00
Fertilizer(manure)	300Kg@KES7	2,100.00
Transport		.13,600.00
Total variable cost		336,650.00
Gross margin Pond preparation	1 @ KES 60,000.00	311,350.00 60,000.00
Land lease Equipment		5,000.00 19,460.00
Commissions		64,800.00
Fuel	90litres@100	9,000.00
Total fixed costs		98,260.00
Total costs		434,760.00
Net cash income		213,240.00
Depreciation		-
Loss on machinery		-
Net catfish income		213,240.00

Source: (Author, 2015) * 100 KES=1 U.S $; + fish production = 6Kgs/M^2

The average weight of harvested tilapia and catfish was 290grams and 550grams respectively after six months. The local wholesale price for both fish was KES360.00 per kilogram from a price perspective it is advantageous to rear catfish.

Table 3: Gross margin and net income for tilapia on 0.03ha earth pond in KES*

VARIABLE		KES.
Total revenue (TR)	416Kg@360	148,760.00
Fingerlings	2,000 @ KES 10	20,000.00
Feeds	1035Kg@KES54	55,890.00
Labor	400mhrs@KES60	24000.00
Fertilizer(manure)		550.00
Transport		2,000.00
Total variable cost		142,440
Gross margin		5,560.00
Pond preparations Land Lease	1 @ KES 60,000.00	60,000.00 5,000.00
Equipment		19,460.00
Commissions		14,800.00
Fuel	62litres@KES100	6,200.00.
Total fixed costs		45,460.00
Total Costs		187,900.00
Net cash income		(39,900.00)
Depreciation		
Loss on equipment		
Net income		(39,900.00)

Source: (Authors, 2015) * 100 KES=1 U.S $

This is because of good site selection where ponds were built within 300 metres of a permanent source of water (River Kiboko). Secondly, the black clay soils does not allow water sill page which help in pond water retention. Fish farmers used pumped water thus close proximity to the water source minimizes the cost outlay in pipes and fuel.

Table 41: Costs and returns comparison for catfish; tomato and tilapia)

Measure	Catfish	Tomatoes		Tilapia		Catfish
	1st Crop	1st Crop	2nd Crop	1st Crop	2nd Crop	2nd Crop
Total revenue in KES*	648.000.00	150,000.00	150,000.00	148,760.00	148,760.00	907,200.00
Gross Margin (GM) in KES	371,350.00	100,050.00	100,050	65,560.00	65,560.00	585852
Gross margin Ratio(GMR)	0.573	0.667	0.667	0.441	0.441	0.656
Profit or (Loss)	218,240.00	52,250	77,750.00	(39,140.00)	45,320.00	398,472.00
Profit cost Ratio (PCR)	0.663	0.652	0.518	1.263	0.695	0.561
Benefit cost ratio (BCR)	1.508	1.535	2.076	0.791	1.438	1.783

Source: (Authors, 2015); 100 KES=1 U.S $

Calculated rate of return in Table 4 indicated that for one Kenyan shilling invested in catfish and tilapia production returned KES 1.51 and KES0.79 respectively. The comparable returns for tomato enterprises were KES 1.54 for the first season.

The Profit cost ratio of catfish was 0.561 and 0.518 for tomatoes during the second season. The results of benefit cost ratio for all three enterprises were greater than 1 except for tilapia during the first crop as indicated in Table 4. A farmer with a BCR of greater than 1 implies that farmers met their costs and was left with net cash income to invest [22]. These profit indicators are within the recommended profitability parameter that can sustain an enterprise [23, 24]. In studies done in Nigeria by Olaoye[25] and in Egypt by El-Naggar *et al*.,[26] found that BCR must be greater than 1 and PCR must be less or equal to 0.65 for an enterprise to be sustainable.

Based on the results of the consumer survey, consumers in Makueni preferred catfish that was above one kilogram in weight. The implication is that a catfish farmer has to rear catfish for a period of between nine months and one year when the average weight of catfish is 1.3kgs. Main reason for the preference was that a catfish of that weight tasted similar (fillet texture was firm and sweet) to the one hatched in the wild. It is important that more research on fish taste been done to validate this consumer perception

Undeveloped fish market infrastructure, poor management, institutional and policy bottlenecks impede the development and sustainable management of fish markets. For example the ESP built ponds and subsidized feeds without investing in postharvest storage cooling and refrigeration facilities. To have a viable fish markets farmers have to have easy access to good postharvest storage to preserve the surplus. Thus good postharvest cold surplus was a facility that would have encouraged fish farming.

On the management side, no stocking rotation among the farmers was organized such that the fish matured at the same time causing logistic problems in harvesting and fish oversupply in the local market. The problem was noted by county fishery officials in pre-survey interviews [27]. An enabling solution would be for farmers to organize as groups and stagger their production over the year

Local input infrastructures and long commuters to input markets present a major constrain in securing key inputs (Fingerling and Feeds). Fingerlings and feeds, the main inputs of fish production were sourced from distant input markets. Fingerling was mainly from Sagana and Western Kenya, this increased procurement costs for local farmers. Only a minority of farmers could afford to secure feeds from Nairobi while the rest were not able thus their fish were not fed adequately. The added cost on the two items negatively impacted fish farming profitability.

The enablers of reducing input costs is establishment of one feed plant and upgrading the four hour hatcheries such that fingerling produced can be high quality. The excess fingerling supply could be marketed out of county.

Focus group discussion results indicated that there was no political will to support fish farming. Reasons advanced were it uses a lot of the available scarce water and a majority of politicians thought it benefited only a small part of the county that has permanent rivers.

4. Conclusion

It was found that catfish was the most profitable of the culture fish. Catfish farming had comparable rates of returns to those of tomato production. It was also determined that proximity to water sources and black clay soil sites were the best enablers of fish farming. Other key enabling factors included the establishment of a single feed plant that could attain economics of scale, Upgrade of current hatcheries to produce quality fingerings and the installation of a postharvest cold storage facility. Further research is needed using a larger sample of small-scale farmers to establish whether the high returns could be sustainable on a mass scale.

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