DEVELOPING SMALLHOLDER AQUACULTURE IN KENYA INTO VIABLE ENTERPRISES: A CASE STUDY OF NYAGUTA FISH PONDS IN KISII, KENYA.

John Okechi, Kenya Marine and Fisheries Research Institute (KMFRI), KENYA, jokechi_1263@yahoo.co.uk
Olivier Mikolasek, CIRAD, FRANCE, Olivier.mikolasek@cirad.fr
Harrison Charo-Karisa, Kenya Marine and Fisheries Research Institute (KMFRI), KENYA, harrison.charo@gmail.com

ABSTRACT

Smallholder fish farming contribute to improved nutrition, incomes and livelihoods of rural communities. Despite the potential, aquaculture in most rural areas is based on extensive production systems characterized by low availability in inputs. In Nyaguta, farmers are involved in agricultural production activities, including fish farming. However, most farmers do not keep records of resources used in their ponds (inputs, and labour) and outputs. This makes it impossible to assess the profitability of the enterprises. A study was carried out with the objectives: To characterize the inputs used by the farmers and determine the rearing parameters, to describe the fish farmers' practices and assess the fish farming cycle and to determine profitability. Monosex tilapia was stocked in 300m^2 ponds at 3 fish/m^2 and fed on pellet feed at 5% body weight. Semi-quantitative and qualitative data was collected from nine ponds over the production cycle (February 2010 to June 2011). An enterprise budget was used to compare profitability. Sale of harvested fish, gave the revenue or total income (TI) from each pond. Variable costs (inputs, labour and other operational inputs) were calculated. Family labour costs, were calculated separately to differentiate from casual labour. Total income (TI) less total variable costs (TVC) gave net income (NI) for each pond. From such a snapshot analysis of costs and returns, farmers would tell if their ventures were profitable or not. It also offered them an opportunity to determine areas to cut down or upscale during the production cycle to maximize on profits. It is only after profit realization, that farmers can be motivated to continue investing in fish farming and related activities.

INTRODUCTION

Globally, aquaculture is the fastest growing food sector and its economic importance is increasing concomitantly. Aquaculture can make an important contribution to poverty alleviation, food security and social well-being [1]. Aquaculture provides food of high nutritional value for households [2], increases household incomes and accelerates rural development and compliments the limited availability from overexploited fisheries [3]. In Kenya, the fisheries sector makes a valuable contribution to the national economy, through employment and an added value multiplier effect from linkages to processing, storage, transport and trade. Its current contribution to the Gross National Product (GDP) is 0.5%. Fish production from capture fisheries has been declining over the years, while demand for fish and fish products has been on the increase.

Since 1970 the global aquaculture production increased 40 times and is expected to quintuple in the coming 50 years [4]. In Kenya, due to a number of constraints, aquaculture is underdeveloped and contributes about 4% of the total fish production.

PROBLEM STATEMENT

In many parts of the country, aquaculture is entirely for subsistence (except for a few farms), with little surplus being sold in the rural market. No record keeping by most farmers on economic evaluation of aquaculture production. Farmers are not able to tell if aquaculture is profitable or not; consequently practicing farmers don't plan their farm operations and many realize poor yields. Fish is in short supply in the country and per capita consumption is declining [1]. The undeveloped and low performance in aquaculture can be partly attributed to poor technology utilization, inefficient production systems and lack of quality inputs among others. Also lack of market information has been cited as a challenge by farmers.
In this study, fish farmers in Nyaguta Kisii, Kenya were shown how to collect data and keep records of resources used in their fish ponds (inputs, and labour) and outputs. This was used to assess the profitability of their enterprises through simple enterprise budgeting.

OBJECTIVES THE STUDY

Overall objective

To assess the profitability of fish pond farming at Nyaguta fish ponds in Kisii,Kenya.

Specific objectives

1) To characterize the inputs used by the farmers and determine the rearing parameters.
2) To describe the fish farmers' practices and assess the fish farming cycle
3) To determine profitability using enterprise budgeting

STUDY AREA

The study was carried out in Nyaguta **(Fig. 1)** which lies within Kisii Central, Kiogoro division, Kisii. The main activities of farmers include crop and livestock farming with coffee, tea, bananas and agro-forestry as their main cash crops. Several of the community members are also engaged in fish farming of mainly Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*) as a police fish. At the inception of the study, fourteen fish farmers each with an Economic Stimulus Programme (ESP) pond were identified, but only nine signed the agreement and were actively involved in the study. The agreement was signed between researchers and fish farmers defining obligations of each party. The farmers signed the agreement as a group and individually, emphasizing the group and individual commitment to the study.

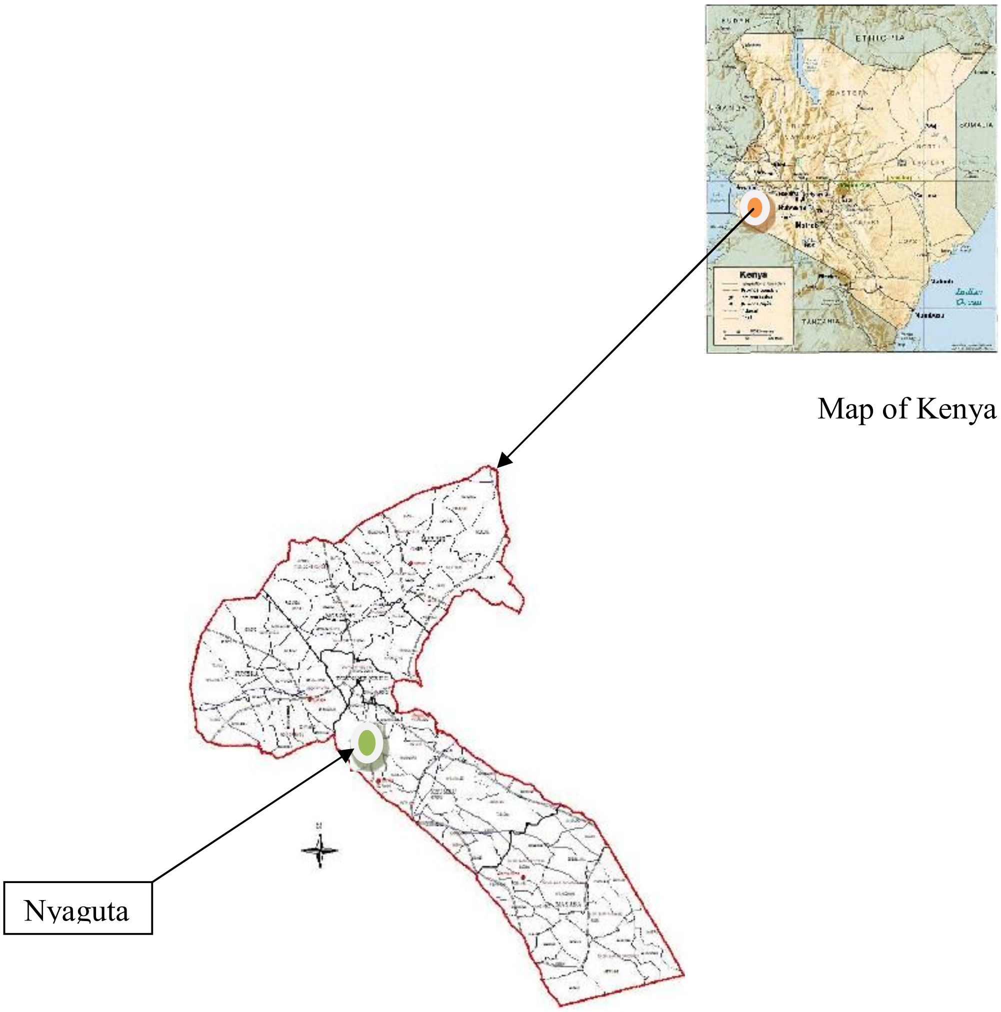

Figure 1. Map of Kisii Central (Nyaguta lies within Kisii Central-Kiogoro Division)

POND PRODUCTION PLANNING

Duration of cycle

Pond production was planned over a horizon of eight months. Each pond, 300m^2 was stocked with 930 mono-sex male tilapia fingerlings of average individual weight of 1 g, giving a stocking density of 3fish/m^2. Assuming a survival rate of 70%, and a final weight (FW) of 300g, a production of 8 tons/ha was projected.

Feeding schedule

The fish were fed with pellet feeds which were adjusted with the growth of fish according to Ngugi et al. 2007, as a guide (**Table I**).

Table I: Daily Feed Rations

Time since stocking (months)	Assumed size of fish (grams)	Amount to feed (grams) per day* per fish	
		Wheat bran	Pelleted diet
1-2	5-20	1	1
2-3	20-50	1-3	1-2
3-5	50-100	3	2
5-8	100-200	4	3
8 or more	over 200	5	3-5
*using supplementary feed at Sagana, e.g., bran and a diet of 26% protein			

From, Ngugi et al. (2007)

Characterizing the inputs with the farmers

All the farmers were shown how to weigh and record the daily ration of feed to give per feeding and on how to fertilize the ponds (both organic and inorganic fertilizers). The feeds supplied by the ESP programme could not last for the entire production cycle targeted at eight months. Some farmers supplemented the feeding by making their own feeds. Other farmers bought other types of feeds (maize flour wastes, chicken feeds and fish wastes among others) from local markets to supplement in feeding. In fertilizing the ponds organic manure available within the homesteads (chicken droppings and cow dung) was used. Farmers also used inorganic fertilizers (DAP/CAN) supplied under ESP. The information collected was used in the assessment of the fish production cycle.

Monitoring pond physicochemical parameters

The following physicochemical parameters: temperature (ambient and pond water temperature), pH, conductivity, dissolved oxygen and Total Dissolved Solids (TDS), were monitored in the ponds using portable meters. Turbidity was measured using Secchi disk. Farmers were shown how to monitor these parameters and explained their essence.

Sampling the ponds for fish growth

The ponds were seined once a month to determine the size of the fish. Length, weight and sex of sampled fish were recorded. The information obtained was used to determine weight gain and feed adjustment.

Record keeping and data collection

Farmers were explained the importance of data collection and record keeping of the activities in their farms/ponds. They were trained on what kind of data to collect and how to record the same. Each farmer was supplied with a hard cover notebook, ruler and pen. Data on physicochemical parameters (dissolved oxygen, conductivity, pH, TDS, temperature and turbidity), daily feeding and types of feeds, pond fertilization, and growth and labour inputs were collected. Other happenings observed in the farm/pond were also recorded. They included but not limited to predators (birds and frogs), fish deaths, ectoparasites like leeches, pond seepage, algal mats and level of water in the pond.

RESULTS AND DISCUSSION

Sampling for growth

Regular sampling (once a month) was done to determine the growth of the fish and feeding adjusted accordingly during the entire growout period. Also during sampling, the healthiness of the fish was ascertained. In some incidents, fish were found to be infested with ectoparasites (like leeches).

Harvesting fish

Though the production cycle was planned for a period of eight months, harvesting from most ponds was done way beyond this period. Farmers gave varied reasons for the delayed harvests, ranging from small size of fish (of less 250 grams), lack of market, unfavorable prices among others. Most of the fish harvested had an average individual weight of 250g (after eight months). A few harvested fish weighed more than 300g (most being those held in ponds for more than ten months). Almost all the fish farmers employed partial harvesting as a marketing strategy, just harvesting what they could sale. Most farmers harvested more than twice (**Table II**). However, harvesting more than twice was not advisable as it prolonged the production cycle and increased operational costs in addition to delaying the next production cycle. Farmers were encouraged to practice complete harvesting as it is economical.

Table II: Fish Harvested From Farmers' Ponds in Nyaguta, Kisii (Culture Period February 2010 to June 2011)

Initials of farmers' name	Date of first harvest	Date of final harvest	Number of partial harvests	No of tilapia harvested & sold (pieces)	No of Catfish harvested & sold (pieces)	Total sale (Kshs)
YB	10/01/11	15/05/11	10	410		22,200
OW	03/02/11	24/05/11	8	107	3	6,950
LI	12/03/11	05/06/11	2	500		16,500
OS	05/10/10	08/05/11	6	986	21	37,110
OC	24/12/10	10/03/11	9	445	32	27,050
NJ	06/10/10	08/06/11	5	463	12	34,200
SO	07/01/11	24/03/11	5	457		30,300

Assessing the fish production cycle

After harvest, an assessment of the first cycle operations for each farmer was carried out using simple enterprise budget. This was to have a quick view of the general profitability of pond fish farming in the area. The revenue for each farmer was obtained from the total fish harvested multiplied by the unit price. This gave the total income (TI) from each pond. Fish consumed by the family and those given in kind, were included in the total fish harvested. In the case of SO' pond, the total income (TI) obtained was Kshs 30,300 (**Table III**).

All other inputs recorded during the culture cycle were cost as variable costs and this included costs of fingerlings, feeds, fertilizers (organic and inorganic) and casual labour all amounting to Kshs 19,270 (**Table III**). Total Family Labour Costs (TFLC), was calculated as the number of hours spent by a family member in stocking, feeding, fertilizing, maintaining ponds (dyke and levee repairs, after draining) and also harvesting. The sum of the hours was converted to money totaling to Kshs 6,406. Total Variable Costs (TVC) and Total Family Labour Costs (TFLC) were added together and subtracted from Total Income (TI) to give a Net Income (NI) of Kshs 4, 624 (**Table III**) . However, farmers did not pay for the fingerlings and feeds (extruded pellets), which were subsidies from ESP. If these costs were not subtracted, then in this case the Net Income (NI) for SO pond amounted to Kshs 12,124.

Table III: An Enterprise Budget of The First Cycle of Fish Production From SO' 300m^2 Pond at Nyaguta, Kisii

	Unit	**Quantity**	**Unit price (Kshs)**	**Total value (Kshs)**
Tilapia sales				18,000
Tilapia consumed				6,300
Tilapia given in kind (workers)				6,000
Total Income (TI)				**30,300**
Fingerlings	piece	900	3	2,700
Extruded pellet	20 kg	4	1200	4,800
Chicken Manure	kg	50	10	500
Cow Manure	kg	399	10	3,990
DAP	kg	7.5	100	750
CAN	kg	5.3	100	530
Casual labour	man/hrs			6,000
Total Variable Costs (TVC)				**19,270**
Field and maintenance labour:	Hour	205	31.25	6,406
Total Family Labour Costs (TFLC)				**6,406**
Net Income (TI-TVC), *without family labour cost*				**11,030**
Net Income (TI-TVC-TFLC), *total cost*				**4,624**

The same assessment was done for each farmer's pond and the results are summarized in **Table IV**. It should be noted that although the farmers stocked the same amount of fish in same size of ponds, the amount of fish harvested and revenue collected from fish sales varied. This could be attributed to the general pond management practices by each farmer, their feeding strategies, prevailing price at time of harvest, among other reasons. Other factors like predation may have affected the fish survivorship hence varied harvests from the ponds.

Such an analysis (simple enterprise budget) is important as it enables farmers to quickly tell if their ventures are profitable or not. It also offers them the opportunity to determine which areas to cut down or upscale during the production cycle.

Table IV: Total Income (TI) and Net Income (NI) For Each Farmers' 300m^2 Ponds at Nyaguta, Kisii.

Initials of farmers' pond	Revenue (Kshs)	Net Income (NI) with subsidies (Kshs)	Net Income (NI) without subsidies (Kshs)
	Kshs (1USD = Kshs 78)		
SO	30,300	12,124	4,624
CO	27,050	13,229	5,729
JN	34,200	25,800	18,300
LN	16,500	8,519	1,019
WO	6,950	4,841	-2,659
YM	22,200	18,882	11,382

Pond physicochemical parameters

Pond physicochemical parameters were monitored during the culture cycle and the results are summarized in (**Table V**). Most of the parameters were within acceptable limits therefore not a limiting factor to fish growth.

Table V: Summary of Physicochemical Parameters at Nyaguta Ponds

N0.	Parameter	Range	Remarks
1	Ambient temperature ^{0}C	20^{0}C-30^{0}C	Temperatures low in months of November and December because of rain and cold weather in general.
2	Pond water temperature ^{0}C	22^{0}C-24^{0}C	Was lower than ambient temperature.
3	Dissolved oxygen (mg/l)	3-9mg/l	Low values recorded in the months of November and December corresponding with a drop in temperature.
4	Conductivity (µs/cm)	30-90µs/cm	Reflected low acidity in area
5	pH	5-7	The variations reflected the pond management by each farmer.

6	Turbidity (cm)	10-25cm	High turbidity corresponded with poorly fertilized ponds
7	Total Dissolved Solids (TDS) (mg/l)	10-37mg/l	The low values indicate that not much material was suspended in the water column, hence not limiting photosynthetic activities.

CONCLUSION

Pond fish production is influenced by both abiotic and biotic factors, and it involves more than just the biological processes. It includes paying close attention to economic and financial measures of the business. Efficient management of a fish farm can make the difference between profits and losses, even in years with unfavorable prices and costs. A number of economic and financial indicators can be employed to better understand the performance of the fish farm business. This will assist farm owners and managers to make more informed decisions on fish farms.

In Nyaguta farmers should move away from subsistence fish farming and run their fish ponds as a business with the intention of making profits. They should plan their production cycle over a horizon of time and make harvests as planned. It is important for a fish farmer to look at whether or not fish farming is profitable during the planned production cycle or in a representative year. For such analysis enterprise budget is used, whereby profits are determined by finding whether or not revenues generated from the sale of fish are greater than the sum of all costs involved in fish production.

The fish pond farmers involved in this study realized the importance of keeping records of their operations. The records once analyzed gave an insight into the status of their ponds. Each farmer was able to understand the results of his/her practices and to determine profits or losses during the production cycle. From the results, the first cycle was apparently profitable for most farmers but not viable. However, motivated by the enterprise being potentially profitable, the Nyaguta smallholder fish ponds can be transformed by way of up-scaling to commercial entities and consequently become a sustainable local fish farming model.

It is important for farmers to plan over a horizon of time, say broader than a year so as to know how profitable their capital investment is over time. Further, farmers can use other indicators like “internal rate of return” (IRR), which shows the returns to the capital investment over the life of the investment. Fish farmers should also carry out the “risk analysis” of their ventures.

ACKNOWLEDGEMENTS

The Authors wish to thank the French Embassy in Kenya for the financial support (FSD grant) through Commercial Aquaculture Producers of Africa (CAPA). We also wish to express our gratitude to the Director of KMFRI and the Director CIRAD/IFREMER for supporting the collaboration between the Institutions. Our sincere thanks go to the District Fisheries Officer, Kisii Central District and his field officer whom we closely worked with. Finally but not least, we wish to thank the Nyaguta Star Self Help Group fish farmers for their valuable contribution in making this study a success.

REFERENCES

FAO, 2009. The State of World Fisheries and Aquaculture 2008. Rome, FAO. Gál, D., Pekár, F., Kerepeczki, E., Váradi, L., 2007. Experiments on the operation of a combined aquaculture-algae system. Aquaculture International 15, 173–180

Wijkstrom, U.N., 2003. Short and long-term prospects for consumption of fish. Veterinary Research Communications 27, 461–468.

Cullis-Suzuki, S., Pauly, D., 2010. Failing the high seas: a global evaluation of regional fisheries management organizations. Marine Policy 34 (5), 1036–1042. doi:10.1016/j.marpol.2010.03.002.

Avnimelech, Y., Verdegem, M.C.J., Kurup, M., Keshavanath, P., 2008.Sustainable land-based aquaculture: rational utilization of water, land and feed resources. Mediteranean Aquaculture Journal 1, 45–55.