EVALUATION OF INTEGRATED FISH FARMING WITH CHICKEN AND VEGETABLES IN SILTE DISTRICT OF SOUTHERN ETHIOPIA

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Name of the Author:

Dinku Getu[1*], Fekadu Amare[1], Tekleyohannes Berhanu[2], Hizkiel Kinfo[1], Tsegaye Terefe[1]

[1] *Worabe Agricultural Research Center, Silte zone, Worabe, Ethiopia**

[2] *Southern Agricultural Research Institute, P. O. Box 6, Hawassa, Ethiopia*

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ABSTRACT

The study was conducted in Silte district of Southern Ethiopia with the objective to assess the productivity and profitability of integrated fish with chicken and vegetable farming in the study area. A pond with a surface area of 150 m^2 (10m*15m) and depth of 1.2m was used for the investigation. A poultry house was constructed over the pond with an open garden and a laying room. Twenty five White Leghorn chicken (5 cocks and 20 pullets) of two months old were introduced in to the shelter. Fingerlings of Nile Tilapia (Oreochromis niloticus) 330 fish in number were used to stock the ponds. Three vegetables, viz., onion (Red bombey), cabbage (Vikima) and tomato (ROMA VFN) were grown near by the pond using pond and stream water with or without inorganic fertilizer application.The result indicates that the mean values of pond water physico-chemical characteristics such as conductivity, average temperature, total digestible solute, salinity, resistivity, pH and dissolved oxygen (DO) of the pond water were 113.5µS, 25^0C, 84.5 mg/L, 0.07ppt, 8.3 MΩ, 8.1 and 4.5 mg/L, respectively. A total of 2392 chicken eggs were produced within 161 days. The total fishes produced in number were 3000 and their total weight was 326000 gram (g). The average weight of a fish was 108.7g. Vegetable production varied significantly ($p<0.05$) with pond and stream water and with or without inorganic fertilizer use. The partial budget analysis of the integrated farming indicates that the estimated net profit obtained on 0.25ha of land was 9336.13 Eth Birr (1 Birr = 0.044 USD). However, the net profits from a common crop in the area (maize), fish, chicken and vegetables alone were 2, 9, 18.2 and 72.8 % of the net profit obtained from the integrated system. This indicates that poultry-fish-vegetables integration fetches a higher revenue over the mono crop or mono livestock activities. However, to fetch maximum revenue from the integration, the water physio-chemical characteristics should be kept at constant, with proper species and number of fish introduced, managed and fed with chicken droppings from the optimum chicken number per square meter.

Keywords:

Fish-Chicken-vegetable integration,
productivity,
profitability,
Silte Zone.

I. INTRODUCTION

Integrated fish farming can serve as a model of sustainable food production. The integration of fish and plants results in a poly culture that increases diversity and yields multiple products, Water is re-used through biological filtration and recirculation, local food production provides access to healthy foods and enhances the local economy (Othman 2006). Due to increased population growth and problems such as environmental degradation, land and water scarcity, the integration of aquaculture with agriculture has been advocated in order to increase resource use efficiency (Barg et al. 2000). Integrated fish farming is the blending of various compatible agricultural enterprises into a functional or unified whole farming system for the purpose of sustainability. It is a no waste, low cost and low energy production system in which the by-products of one enterprise is recycled into another as input (Ayinla 2003). Aquaculture contributes to human food fish demands, poverty alleviation and rural development and is often mooted as the fastest growing food production sector in the world (FAO 2010).

Even though, the majority of the systems used in African for aquaculture were introduced through technology development and transfer projects, the current state of most research, development and extension in Africa is poor. Except in few countries of East Africa (Kenya, Uganda and Tanzania), aquaculture is generally under developed. In those mentioned countries, nowadays aquaculture contributes less than 1% of total global fish production (FAO 2000). Integrated livestock-fish culture is still at a rudimentary stage and few successful impacts are documented in Africa (Rasowo et al. 2008). In Ethiopia, availability of favorable agro-ecology, abundant seasonal rainfall and several small water bodies create conducive environment for the sector.

The abundance and fast increment of small water body due to irrigation agriculture intensification can be used for fishery and aquaculture resources and the role aquaculture plays in reducing poverty in rural areas of Ethiopia particularly in southern region where the highest population density figures exist have been described (Hussein 2009). However, despite the availability of huge water resources, salubrious climatic conditions, topography and varied soil conditions conducive to start integrated fish farming with others agricultural activities in Ethiopia, it is almost nonexistent (Mohammed et al. 2016). Therefore, the objective of the current study is to assess the productivity and profitability of integrated fish with chicken and vegetable farming in Silte district of Southern Ethiopia.

II. MATERIAL AND METHODS

2.1. Description of the study area

The study was conducted in Balo Koroso Kebele (village) of Silte district of Southern Nations, Nationalities and People's Regional State (SNNPRS) of Ethiopia. The Kebele is situated 158 km south of Addis Ababa and 12 km from Kibet town of Silte district in south-east direction. Geographically, the area is located 07058.863' North latitude and 38021.914' East longitude. The altitude is 1827m. Based on the 2009 Census conducted by the Central Statistical Authority (CSA), this district has a total human population of 177,249. The population density figures for the district is 289 persons/km2 and most parts of the district is severely degraded (Beyene, 2007).

2.2. Pond preparation and watering

A pond with surface area of 150 m2 (10m*15m) and depth of 1.0m to 1.3m (in the out let side) was used for the investigation. The floor of the pond was lined with fine red clay soil to reduce down ward water percolation. A water inlet canal was prepared for the pond with two silt boxes for the protection of mud/sand siltation. The water was streamed to the pond through a pipe fixed by cement on the rear silt box. Similarly, a water out let pipe/canal was fixed to the pond. Both the inlet and out let canals/pipes were covered with a mesh wire of 0.5cm size in order to protect fish predators. The pond was filled with water directly from the stream in 3 days interval. Lime at a rate of 15kg/100m2 (about 22.5kg) was added to the pond to neutralize the water pH. Manure was added to the pond once a month at the rate of 10.5/100m2 to enhance the development of algae flora. The pond water was refreshed weekly and kept until the required parameters were measured.

2.3. Chicken stocking and management

A poultry house was constructed over the pond with an opening garden and a laying room. It was designed to have an access to the terrestrial and to furnish the chicken droppings directly to the pond. Twenty five White Leghorn chicken (5 cocks and 20 pullets) of two months age were introduced to the shelter. The chicken was kept for 15 days before introduction of fish fingerlings to furnish the pond water with chicken droppings. The chickens were supplied with layers concentrate feed at the rate of 100-120 g/day/chicken and clean water as ad labium. Chicken were vaccinated for Marex, Gumboro and New castle diseases as recommended. Diseased chicken were separated from the healthy ones and treated by appropriate medicine. Laying boxes were prepared and placed in the darkest part of the shelter and daily egg production was collected from the boxes and recorded. Egg data was collected for a total of 161 consecutive days.

2.4. Fish stocking

Fingerlings of Nile Tilapia (Oreochromis niloticus) were used to stock the ponds. The fish was selected due to its fast growth and suitability to the environmental condition of the study area. The stocked fingerlings were two months old, weighing on an average 20g. The fish fingerlings were obtained from Sebeta National Fisheries and Other Aquatic Life Research Center, central Ethiopia. The total fingerlings stocked in the pond were 330 fish in number, assuming 2 fish per meter square and a mortality rate of 10%. The fish fingerlings were supplied with wheat bran and Noug cake in a 3:1 mix. The selected supplement was prepared to float on the surface. The quantity of feeding varied with the age of the fish. During the first to the 3rd months of age, the fish were fed 5% of their body weight (BW) and above 3 months of age fed at a rate of 2% of their BW. Feed was provided twice a day (at 10 AM and 3 PM).

2.5. Vegetable production and management

The vegetables selected for the evaluation were onion (Red bombey), cabbage (Vikima) and tomato (ROMA VFN). The vegetable were planted randomly in four treatment designs (Table 1), on a plot of 3m x 2m using randomized complete block design (RCBD) with 4 replications, between plots and between replications sizes were 0.5m and 1m, respectively. The vegetables were planted 6 months and 5.5 months after the chicken and fish introductions, respectively. Vegetable plots were managed for seasonal and off time weed. The inorganic fertilizers DAP and urea (Table 1) was applied at sowing and after 40days of vegetable sowing, respectively. Anti fungal and insecticidal chemicals were applied as necessary.

Table 1. Treatment design for vegetable production

Code	Treatments
T1	Vegetable production with stream water only (control)
T2	Vegetable production with pond water only
T3	Vegetable production with river water + Inorganic Fertilizer (DAP and UREA) each at a rate of 100 kg/ha
T4	Vegetable production with pond water + Inorganic Fertilizer (DAP and UREA) each at a rate of 100 kg/ha

T1=treatment 1; T2 = Treatment 2; T3= Treatment 3; T4= Treatment 4; kg= kilo gram; ha= hectare; DAP= Diammonium sulphate.

3.3 Partial budget analysis

The total investment budget analysis was conducted using the cost and revenue values of using the investment land size. Costs and revenue analysis were made using the estimated cost-revenue of the local area at that season. Partial budget analysis was conducted for measuring profit margin of integrated poultry-fish-vegetable production. Using the method Upton (1979), net income (NI) was calculated as a difference between total return (TR) and total variable cost; change in net income (ΔNI) was calculated as a difference between changes in total return (ΔTR) and change in total variable cost (ΔTVC). Marginal rate of return (MRR) measures the increase in net income (ΔNI) associated with each additional unit of expenditure (ΔTVC) and was calculated as MRR= (ΔNI/ΔTVC) x 100.

2.7. Data collection and statistical analysis

Fish total weight and total length was measured at every two months interval. This was done 5 times before the total fish harvest. Costs of pond preparation, supplemental feed, plot preparation and management, chicken production and management and costs of vegetable production were recorded. Other data collected include number of chicken eggs, weight of eggs, yield of vegetables and physico-chemical parameters of pond water such as, conductivity, average temperature, total digestible solute, salinity, resistivity, pH and dissolved oxygen (DO) were adjusted and collected continually. The condition factors (K) was calculated for individual fish species for each month using the conventional formulae described by Worthington & Richardo (1930) as:

$$K = \frac{W \times 100}{L^3}$$

Where K = the condition factor

W = weight of fish in grams

L = Total length of fish in cm.

Vegetable yields using different treatments were subjected to ANOVA using General Linear Model (GLM) procedure of SPSS Version 22 (SPSS 2014). Means were separated using Duncan's Multiple range test at $P<0.05$.

The model used for analysis of the three vegetable yields in four treatments was

$$Yi = \mu + \alpha i + ei$$

Where: Yi = Vegetable yield in kg (i= tomato, onion and cabbage);

μ = over all mean;

αi = effect of three treatments and

ei = random error.

III. RESULT AND DISCUSSIONS

3.1 Pond water physico-chemical characteristics

The mean values of the physico-chemical parameters such as conductivity, average temperature, total digestible solute, salinity, resistivity, pH and dissolved oxygen (DO) of the pond water were 113.5µS, 25^0C, 84.5 mg/L, 0.07ppt, 8.3 MΩ, 8.1 and 4.5 mg/L, respectively. The mean pH value of this experiment (8.1) was lied within the recommended range of FAOs' (2011) and Charles et al (2007) who have reported pH values of 6.7-8.6 and 6.5-9.0, respectively. The average temperature in the current experiment was 25^0C which corresponds to the values report by Gangwara et al. (2013) (20-30ºC) and Abdel-Tawwab (2000) (24.2^0C -27.7^0C).

The value of dissolved oxygen of this experiment was 4.5mg/L. According to Charles et al.(2007) this value is more than the required amount for tilapia because it can survive below 2.3mg/L as long as the temperature and the pH value remained constant. Olapade et al (2015) reported that there was observed variability of DO from season to season. According to their report mean DO was 6.7+0.2mg/L-7.09 +0 .18mg/L and the highest was recorded in July but least was in September. The authors added that body oxygen demand (BOD) values were obtained throughout the sampling period in the range of 3.07 ± 0.12 mg/L –3.93 ± 0.06 mg/L and asserted the absence of significant difference with locations and months of sampling. Therefore, according to Olapade et al (2015), 4mg/L for fish culture in the tropics is sufficient.

The conductivity value of the pond water was 113.5µS. From measured observation, low conductivity value resulted from the water source. Water from the eroded land and from bicarbonate reach sources has low conductivity. Total digestible solute was 84.5 mg/L. This value was assumed to be enough for fish. Among the main digestible solutes, $Caco_3$, NH_3 and NH_4 are the primary ones on which the fish consume directly and also used as source of input for Eukaryotes. The salinity value of the pond water in this experiment was 0.07ppt. This value was more than the salinity of the FAO's (2011) report (0.004ppt). Even though the salinity of the pond site of the current study was neutral, the area from where the stream water comes may have caused the variation.

3.2 Chicken and Fish productivity

The chicken (5%) started laying eggs after 5 months and all the chicken laid eggs after 6 months old. A total of 2392 eggs were produced within 161 days. This shows that 0.743 egg/day/chicken was produced (on an average 272 eggs/year) which was within the range of maximum egg production in an intensive poultry farm. In addition to egg production, droppings from the chicken were used as a feed source for the fish.

The study showed that in the last fish harvesting day, 300 fish weighed 300g, 1000 fish weighed 100g and 1700 fish weighed 80g. There were also fingerlings less than 80g and taken as insignificant. The total fish harvest in number was 3000 and their total weight was 326000g. The average weight was found as 108.7g. In the last day of sample collection, using manually made net with the size of 6cm, 7cm, 8cm, 9cm and 10cm, the maximum weight was 303g. This maximum weight was found only on limited samples. Among captured samples in 10cm size net, majority of fish samples weighed in the range of 205-230g. From the experiment, the average fish production in 306 experimental periods was 326kg (2.17kg/ m2), excluding fingerlings which weighed less than 80g.The yield in this experiment was better than the one reported by Gangward et al (2013). However, the lower weight in the current study (80g) was much lower than the report of Lally (2000) in which the fish were within the weight range of 180 - 250g and most of them were indigenous tilapias (Oreochromis andersonni, Oreochromis mossambicus, O. niloticus, C. gariepinus and Cyprinus carpio). The upper limit of their experiment (500g) was also higher than the current study (303g). The deviate size of this experiment may be due to over breeding of the fish since there were enormous fingerlings on the day of total harvest.

3.3. Condition factor

The mean length, weight and condition factor (k) of tilapia was presented in Table 2. The k value of for female tilapia was 1.872 + 0.002, for male tilapia was 1.927 + 0.002 and for both sexed was 1.911+ 0.001. From the result male tilapia had higher k value followed by both sexed tilapia but females' had the lowest. This was due to the variation in body weight and length of the fish.

The condition factors (k) of the fish species in the current study was greater than what was obtained in other tropical water bodies like in Nigeria, where a k-value of 0.49 - 1.48 have been recorded (Nwadiaro & Okorie, 1985). The k-value in the current study for male and female fishes, however, was less than the earlier report of Bernard et al. (2010) but lied between the range studied by Kumolu-Johnson & Ndimele (2011) & Ahmed et al (2011). Bagenal & Tesch (1978) reported that k value greater than 1 was an indication that the fish species were doing well in the reservoir. According to them, heavier fish of a particular length were in a better physiological condition.

Table 2. Mean length (cm), weight (g) and condition factor (k) of tilapia tested in the experiment

Parameter	Fish sex	N	Mean total length (cm)	STD	SE
Mean length(cm)	F	41	18.25	4.55	0.661
	M	41	18.43	4.30	0.661
	Both sex	46	19.27	4.22	0.624
Mean weight(gm)	F	41	134.59	93.98	14.551
	M	41	140.40	94.49	14.551
	Both sex	46	153.32	91.24	13.737
Condition factor(k)	F	41	1.872	0.01	0.002
	M	41	1.927	0.01	0.002
	Both sex	46	1.911	0.00	0.001

Where: N= Population number; F= female tilapia; M= Male tilapia; cm = centimeter; STD= Standard deviation; SE= standard error

3.4. Vegetable production

The vegetable production values were presented on Table 3. Vegetable production among the treatments varied significantly ($P < 0.05$). Highest onion was produced in T3 and T4 but lowest in T1. However, onion yield in T3 was equivalent with T2. Similar yield variation among the treatments was observed in tomato and cabbage. Vegetable production with pond water (T2) had equivalent effect as stream water + inorganic fertilizer (T3) except for cabbage for which T3 has more yield than T2. For onion, pond water (T2) produced 75% more yield than the control (stream water, T1). For tomato, T2 was more productive over T1 (by 67%) and T3 was more productive over T1 and T2 by 96% and 14%, respectively, while T4 was more productive over T1, T2 and T3 by 100.3%, 18% and 3% respectively. For cabbage, T2 was more productive over T1 (by 27%) and T3 was more productive over T1 and T2 by 51% and 10% respectively, while T4 was more productive over T1, T2 and T3 (by 61%, 15% and 4%), respectively. Among the three treatments (T2, T3 and T4), the highest yield difference was observed in cabbage production than onion and tomato. This shows that T2 with T3 and T3 with T4 were comparable in onion and tomato yield but greatly vary in cabbage yield. The variation in vegetable yields was attributed to the variation in availability of valuable minerals in the pond water since poultry litter was rich in valuable nutrient for plant growth (FAO, 2011).

Table 3. Vegetable production (kg/plot)(Mean ± SE)

Vegetable ypes	Treatments				SE	P-value
	T1	T2	T3	T4		
Onion	7.80^{a*}	13.70^{b}	15.02^{bc}	15.35^{c}	0.473	P<0.05
Tomato	54.50^{a}	94.02^{b}	107.10^{bc}	110.60^{c}	5.046	P<0.05
Cabbage	164.67^{a}	373.90^{b}	412.87^{c}	429.25^{c}	7.559	P<0.05

*Row values bearing different superscripts vary significantly (p<0.05). T1= vegetable production with stream water; T2= with pond water; T3= with stream water + inorganic fertilizer; T4= with pond water + inorganic fertilizer; kg = kilo gram; SE= standard error; P= probability.

3.5. Investment Economic analysis

The partial budget analysis of the integrated fish farming is depicted in Table 4. The estimated net profit of the integrated farm obtained on 0.25ha of land was 9336.13 Eth Birr. This profit was obtained within 306 working days. The profit was inclusive of the farmers' daily wage cost during the experimental period.

When the net profit obtained in this study compared with a single crop production (in this case maize, with a current price of 450 Birr/quintal), the highest estimated yield of maize was nearly 12 quintals/ 0.25 ha, which was equivalent to 48 q/ha and the least estimate was 8 q/0.25 ha, the average maize yield being 10 quintals/ 0.25 ha. If it was sold by 450 Eth Birr, it would be 4500 Birr. The estimated cost was 60% which equated 2700 Eth Birr. Therefore, the net profit from maize would be 1800 Eth Birr which was less than 2% of the net profit from the integrated farming. Similarly, the net profit from fish was 9%, from poultry was 18.2% and from vegetable was 72.8% of the integrated farming. This indicates that integrated fish-poultry-vegetable farming is more profitable than the unitary systems of agriculture as it ensures the spread of financial risk (Ogello et al. 2013). AIFP (2005) and Pullin (1994) also stated that farmers practicing pig-fish farming reported 28% - 30% economic advantage over normal pig farming.

Table 4. Investment economic analysis obtained on 0.25ha of land for 306 days

Cost title	Cost lists	Estimated value (Birr*)
a. Fixed cost	Chicken house construction	4500
	Pond construction	1830
b. Operating cost	Land rent	2000
	Vegetable seed	1000
	Chicken	1125
	Chemicals and inputs	1010.08
	Labor	18360
	Feed	3600
c. Others	Transportation	1000
Summary cost	Fixed capital	6330
	Operating expenses	28845.08
	15%bankloan	5276.26
Cost sum		40451.34
a. Revenue	Fish sale	4500
	Egg sale	6578
	Poultry sale	2500
	Vegetable sale	36400
Total revenue		49978
Gross profit		9526.66
2% income tax		190.53
Net profit		9336.13
*Birr= basic monetary unit of Ethiopia (1Birr= 0.044 USD)		

3.6. Treatments economic analysis

Treatments economic analysis is depicted in Table 5. As shown in the table, there was profit difference between the treatments. The net maximum profit was obtained in T2 and T4. But when it was calculated as the change in net income, T3 was more profitable than the other treatments. Marginal rate of revenue was higher in T3 followed by T4. Based on the treatments' yield variability, T2 was 7.6 times more profitable than T1. T3 was profitable over T1 and T2 by 21.77 and 2.53 times, respectively. Similarly, T4 was profitable over T1 and T2 by 21.87 and 2.55 times, respectively. T3 was similar with T4 in profitability. Treatment 3 and 4 earned better revenue over T1 and T2.

Table 5.Treatment economic analysis obtained from 0.25ha of land for 306 days

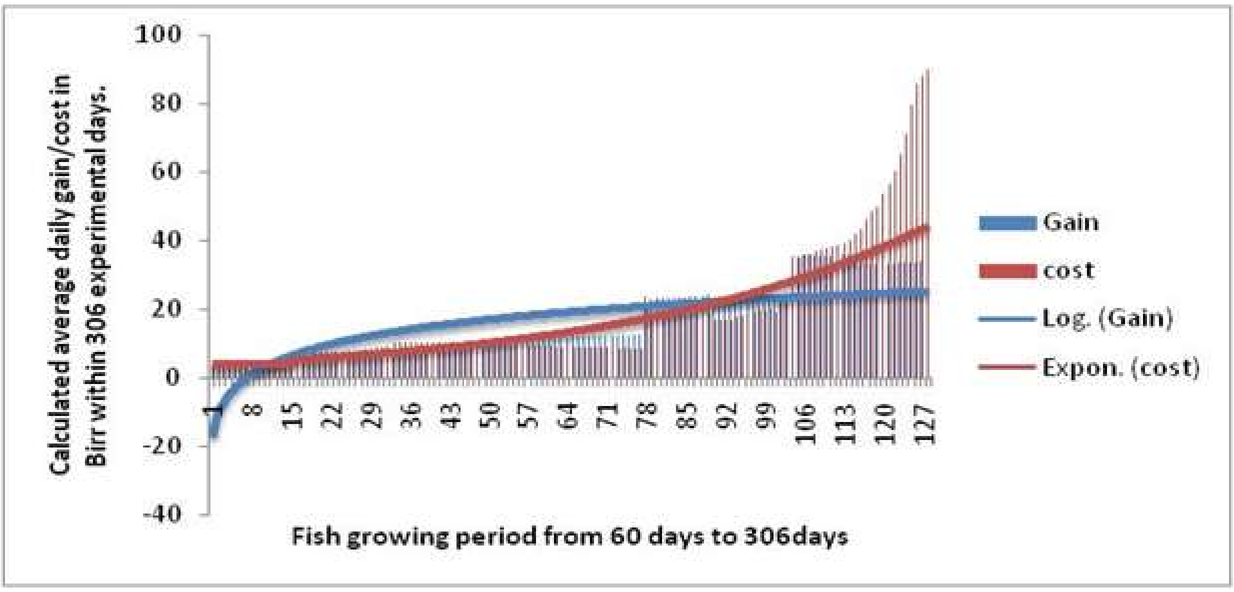
Justification	Treatments			
a. Major costs	T1	T2	T3	T4
Land rent	500	500	500	500
Wage	4590	4590	4590	4590
Seed	250	250	250	250
Insecticide	250	250	250	250
Loading and unloading	250	250	250	250
Bank loans(15%)	876	1753.875	876	1753.875
Investment cost sum	6716	7593.87	6716	7593.87
Income tax(2%)(a)	4.16	155.02	90.29	214.32
Major cost sum	13436.16	15342.77	13522.29	15402.07
b. Variable cost				
Fish management		375		375
Poultry house construction		2250		2250
Chicken purchase		512.5		512.5
Feed		1800		1800
Fertilizer cost			**5.04**	5.04
Mesh wire		45		45
Water inlet and outlet tubes (PVC)		120		120
Fish net		750		750
c. Variable cost sum(b)		5852.5	**5.04**	5857.54
d. Revenue				
Vegetable sale	**6924.08**	8455.72	**11230.76**	11420.95
Egg sale		3389		3389
Fish sale		2250		2250
Chicken sale		1250		1250
Estimated gross income	**6924.08**	15344.72	**11230.76**	18309.95
Estimated total return(c)	**208.08**	7750.85	**4514.76**	10716.08
Estimated net income(c-(a+b))	**203.92**	1743.33	**4419.43**	4440.3
Δ NI	-	1540	**4215.51**	3148.82
ΔTVC	-	5852.5	**5.04**	5857.54
MRR	-	26.31	**83641.07**	53.76

Where: T1= stream water; T2= pond water; T3= stream water + inorganic fertilizer; T4= pond water + inorganic fertilizer; Δ NI= change in net income; ΔTVC= change in total variable cost; MRR= marginal rate of revenue.

3.7. Fish revenue maximization period

Within the treatment period, the cost verses profit margin value trend for fishing is depicted in Figure 1. Based on the data, cost for the investment was high at initial. Starting from the 4th month when the fish reached a lower weight for table size, the cost was comparable with revenue. Following the 4th month, the revenue slightly increased above the cost but not increased continually.

Figure 1. Cost verses profit determination margin within treatment period for fish culture



The estimated cost curve showed a rapid increasing logarithmic trend followed by a steady trend while the gain estimated curve had a steady logarithmic trend followed by a rapid increasing trend at initial. Starting from 119 to 187 days of fish fingerlings introduction, profit from fishing part evolved as a profit business. Within this period the profit trend showed a steady increment but the cost curve showed slight increment. Starting from day 187 to day 238 of fish introduction, the profit and cost margins were increased rapidly. Starting from day 238 to day 260 the profit margin was increased similarly but the cost margin started to shoot up. Following day 260 till end period, the cost margin increased rapidly and started to be asymptotic to the perpendicular line but the gain was in similar fashion as the previous one. The gain from fishery was dependent on the amount and weight of captured fish. From the result, revenue from fish was maximized between days 238 to 260 of fish introduction.

IV. CONCLUSION

Integration of poultry with fish production (poultry house being erected above the periphery of the pond) doesn't affect the potential productivity of the chicken as long as the management and feed quality and quantity for the chicken kept properly. Semi-intensive integration of fish and poultry farming resulted higher fish production per square of pond size which was attributed to the suitability of the pond water physio-chemical characteristics and management condition which was proved by the condition factor(k). The net integration profit was much higher than the unitary system of agricultural activity. For vegetables (onion and tomato) pond water has equivalent productivity effect as application of inorganic fertilizer. Maximum revenue from fish depends on the fish size, captured number and harvest time. The longer the fetch time the higher fish number that inversely affect the fish size. Fish yield and revenue was maximum on a given square meter of pond size within 238 to 260 days of fingerlings introduction. Generally, chicken integrated with fish and horticultural crops resulted better benefit on a given plot of land than single agricultural activity. However, to fetch better revenue from the integration, the water physio-chemical characteristics should be kept at constant, with proper species and number of fish introduced, managed and fed from the optimum chicken number per square meter. Moreover, farmers who have suitable land with continuous water supply should be selected and a regular technical support from research or extension side is required for the farmers to realize the benefits from the integration system.

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Corresponding author : Dinku Getu
Worabe Agricultural Research Center, Silte zone, Worabe, Ethiopia
Email : fretse93[at]gmail[dot]com