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Pre-extension Demonstration of Integrated Fish-Poultry-Horticulture-Livestock Feed Production System at Wayu Tuka District, East Wollega Zone, Oromia Region, Ethiopia

Alemayehu Abebe Wake*, Addis Hailu, Daba Tugie, Derribew Hailu, Lema Abera (PhD) and Mathewos Hailu

Oromia Agricultural Research Institute; Batu Fish and Other Aquatic Life Research Center. Ethiopia

Corresponding author: *aleabebe93@gmail.com*

Abstract

Integrated fish farming is a promising and cost effective technology in which waste of one component as an input for other with emphasis on fish culture. The current study was aim to demonstrate Integrated fish-poultry-horticulture-animal feed production system in East Wollega Wallega Zone, Wayu Tuka District. Participatory approach were employed on technology demonstration. Awareness creation was covered for a total of 68 beneficiaries that focus on site identification, pond excavations, poultry house construction constriction, netting, overall farm management, fish harvesting and other processing. For technology demonstration a total of 360m2 ponds size were prepared. Each pond havean area of 120 m^2 was constructed and a total of 245 fish fingerling *were stocked with stocking density of 2.04fish/m^2.The average final weight of fish was 243.7, 892.57 and 679.4 for O.niloticus, C. carpioand C. gariepinus with daily growth rate of 0.64*, 2.42 and 1.82 *respectively*.21015 eggs were collected from 90 *Lohmann brown pullets under integrated farm.* On horticultural production 110kg of *Solanum iycopersicum was produced* per 50$m^2$and *a total of 1450kg* Allium cepa *was produce on 500m^2 of land.* P. pedicellatum and Chloris gayana were used that grown on the dike of fish which produce a dry matter yield of 8,333 and 379 kg ha^{-1}, respectively. Farmers were generating revenue from all components and the highest profit was obtained from egg and fish production which is cover a total ETB of 102,217.5 and 28,808.4 respectively. Overall, 99,090.90 Birr was generated from integrated farm under farmer condition. With this result, the main stakeholder farmers confirmed as integrated farming system is feasible in terms of its contribution to family food, income generation, and employment opportunity. So, Government and other stakeholders have to support extension for wider implementation at aquaculture potential site.

Keywords: Demonstration, fish integration, poultry, production, vegetable, wastes recycle

Introduction

Ethiopia is endowed with several productive freshwater (Lakes and rivers) that is suitable for fishing activities. Aquaculture is 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, 2017). It has been the fastest growing food production sector in the world and now supplies more than half of the world's food fish (FAO, 2010). In Ethiopia, Aquaculture is remained more potential than in actual practice, despite the fact that the country's environmental and socio-economic conditions support for its development. Considerably large area of Ethiopian land is suitable for fish pond culture (Eshete and Zemenu, 2012) which is the priorities and strategy of Ethiopian government to develop the fisheries sub–sector.

It is a potential alternative source of fish supply to fill the increasing demand for fish on the market, if developed in a sustainable way with supported by skilled expertise. 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. 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 multi-commodity farming system with the waste recycling as the key feature and fish culture as the major activity than other integrated commodities. The integration farm increases diversity and the yields of multiple products, waste material of one component used as the main input for other under the system that helps to access the healthy foods and enhances the local economy (Anderson *et al.*, 2017).

There is a best practice in Ethiopia that integrated farming activity has opened new horizons of increasing production per unit area at low inputs cost through an increased interest in utilization of animal manures. Based on last evaluation result; It is a no waste, low cost and low energy production system in which the by-products of one item is recycled into another as input (Lema, 2017).In such integrated system, waste from poultry is used to fertilize fish pond substituting feed supplement for the fish, and nutrient rich water from fish pond is used to irrigate the Vegetable/horticulture crop during the water exchange for fish that substituting fertilizer use in crops (Daba *et al.*, 2017).

The technique recycles waste for food production and saves environment from pollution which saves production cost and is easy to manage at small scale farmer's level in different aquaculture potential site. The system maximizes productivity and economic efficiency of smallholder fish farmers through enhancing the productivity per unit area of land.

The specific objectives of the study were;

- To create awareness on integrated fish-poultry-horticulture-livestock feed production system
- To evaluate integrated fish-poultry-horticulture-livestock feed production system
- To assess feedback information for further technology development/improvement

Materials and Methods

Description of study area

The activity was conducted in East Wollaga Zone Wayu Tuka district which located between 8050'48"- 9011'15"N latitudes and 36033'54" - 36047'51"E Longitudes, extending for about twenty-one minutes (21') north to south and about fourteen minutes (14') east to west. The district is contiguous with Sibu Sire in the East, Leka Dulecha and some part of Guto Gidda in the West, Guto Gidda in the North, and Jimma Arjo, Nunu Kumba, and Wama hagelo in the South direction. This district is divided in to three distinct Agro ecological areas namely; high land (37.55%), midland (49.22%) and lowland (13.23%).

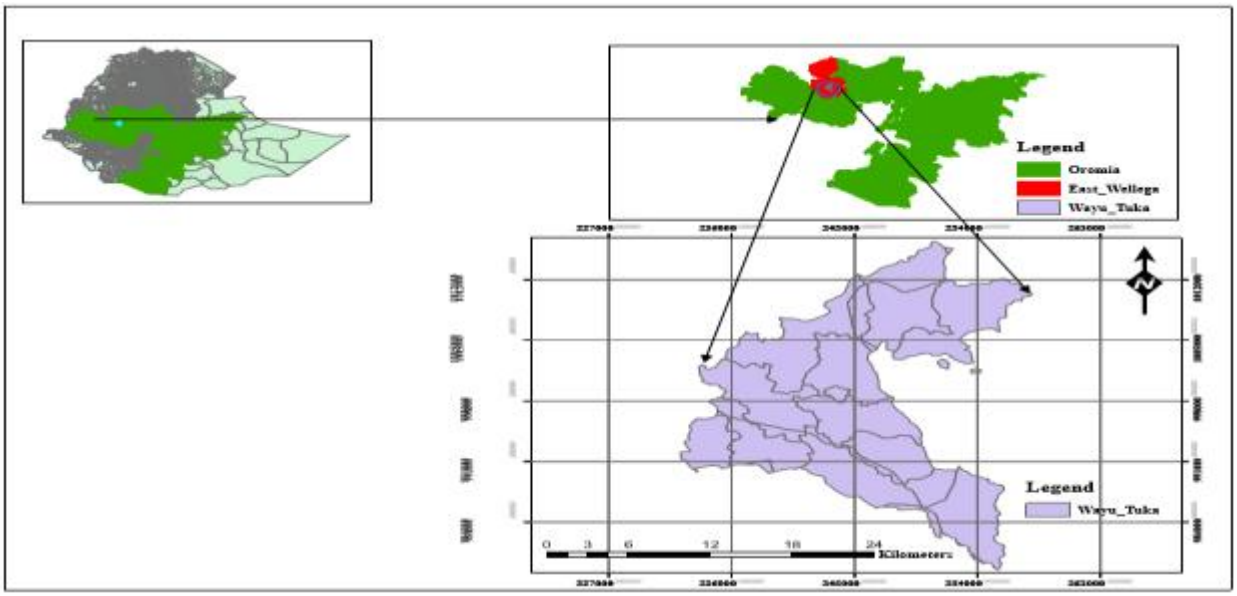

Figure 1: Map of the Study Area

The district has a mean annual temperature of 25^0c to 35^0c, and mean annual rainfall of 1200mm to 2400mm of minimum and maximum respectively. Again, the majority part of the district had good access to water that suitable for irrigation purpose and aquaculture development. Many farmers were participating on producing sugarcane, sweet potato, potato, orange, mango and other vegetable and fruit crop with irrigation. With rain feed system the majority of farmers were participates in producing maize and teff.

Site and farmer selection

Purposive sampling method was employed to select potential site from Wayu Tuka district. Therefore, one Kebele was selected purposively based on accessibility and suitability for aquaculture development, water availability, topography of the land (sloppy land), soil type, weather condition (adaptability of fish species, different horticultural crop and poultry), accessibility to road and other non-FREGs and market outlet were the main criteria to identify site for integration. Targeted farmers were also selected based their willingness to cost-sharing (Land allocation and taking farm management), ability to share information to others farmers and good history with local community.

Technology demonstration methods

Participatory approach was followed to enhance technology demonstration efficiency and effectiveness. FREG members and other follower farmers were encouraged to participate on different extension events organized on trial farmers. Training, Mini field day, joint monitoring and evaluation were used as mechanism for technology demonstration and information exchange among farmers.

Roles and responsibilities of participants

Cost-sharing participatory approach was used in this technology promotion in which farmers provide land without compensation. Overall, form trial farmer to area administrative office all of participants had own responsibility during research implementation process

Table 1: Role of farmers and other stakeholders in technology demonstration

Actors	Roles
Trial farmers	Land provision, management, record keeping, field monitoring, providing report the case of emergency and providing feedback
FRG members	Involving in pond and poultry house construction, management, participating on horticultural land preparation, evaluation the output from whole components, and providing feedback
Research Team	Provision of training, Preparing extension materials, delivering all necessary materials, facilitating activities and different stakeholder participation, all data collection and analysis
Extension worker	Facilitating and organizing communities, information transfer, provide technical support as local condition, continuous follow up and monitoring
Other stakeholder	Community facilitation and information dissemination

Fish pond construction

The integrated farms consists fish, poultry, vegetable and animal feed components that conducted on selected site. For establishing the system three rectangular shaped earthen ponds having area of 12m X 10m ($120m^2$) and depth of 1.0m to 1.30m with water inlet, outlet and overflow were excavated on a gentle slope land. Water inlet canal was prepared for pond with one silt boxes for the protection of mud/sand siltation. The water was streamed to the pond through a pipe fixed on ponds and in similar way water out let pipe/canal was fixed to the pond at bottom part that helps to discharge water from pond through gravity.

The excavated ponds were liming before filling with water for the purpose to maintain the extreme change in pH and to kill some harmful microorganisms and parasites. This action also promote the biological productivity through neutralizes sulfides and some acidic substance. Three weeks after liming, the ponds were filled through canal system on inlet side after poultry house construction completed.

Figure 2. Fish pond construction under poultry house

Poultry house construction

Poultry production was one of the main components under integrated farm. For poultry production poultry house were constructed at each site with local available materials. The house was having a total area of $12m^2$ (4m X 3m) that have two partitions/class at each site. The first class was footing on the ground and all sides were covered by strong wood and mud. It had an area of $6m^2$ (4m X 1.50m), which serves for resting, night time stay and has nests for egg laying. The second class (4m X 1.50m) was open to air and light that enclosed by mesh wire around the poles and hanging over the pond. This class was used for the poultry to stay during day time where they eat and drink from hanged feeders and watering containers.

The bottom of this class supporting the chicken was covered by stronger mesh wire protecting chicken against predators and competitors, allows poultry droppings passing down to the pond water. The roof of the house was covered by tin. After the completion of poultry house construction, a total 90 Lohman brown breed of poultry pullets with three months of age were purchased and stocked. Similarly, the recommended commercial feed was provided to the chicken. The feeding system was given based on the age of chicken from 80 to 120 gm. per day with allrequired management and care.

Figure 3. Poultry house construction hovering on fish pond

Method of data collection and analysis

Quantitative and qualitative data were collected through filed observation, FGD, interview and measurement and data sheet/checklist. The qualitative data were carefully collected, recorded and narrated under each topic. The quantitative data were analyzed by using appropriate descriptive statistics like mean and percentages. Data generated from the various sources were presented as tables, figures or graphs. Fish data for the parameters such as fish growth rate and survival rate (%) are calculated from initial number and weight (g) of stocked fishes, and final number and live-weight (g) of fish. The survival rate of the O. niloticus, C. carpio and C. gariepinus was analyzed from the date of stocking to harvesting, during 381 culturing period.

So, daily growth rate and survival rate was calculated using the following formulas;

$$Daily\ growth\ rate\ (DGR, g/day) = \frac{Final\ weight\ (g) - Initial\ weight\ (g)}{Experimental\ days}$$

$$Survival\ rate\% = \frac{(Number\ of stocked\ fish - Number\ of\ dead\ fish)}{Number\ of stocked\ fish} X\ 100$$

Results and Discussion

Training

The first awareness creation was given for farmers, development agents and experts with multidisciplinary research team (Aquaculture, agricultural extension and socio-economic research team)on aquaculture site selection, pond design and construction, poultry house and onion land preparation, fish and pond management and mainly focus on the benefit integrated farming system before its implementation. In addition to this, trainings were given on fish harvesting techniques, processing (gutting and filleting) and on food preparation in the form of soup, fried and boiled fish.

Figure 4: Training given for farmers, development agent and experts at Wayu Tuka a District

Generally, subsequent trainings were given for the beneficiaries at each stage of production starting from the farm preparation up to the harvest and consumption of the products. Moreover, farmers intensively attended and participated in every activity of the farm during pond, poultry house and horticulture land preparations. The training was covered a total of 58 farmers, 8 development agents (DAs) and 4 fishery experts from potential districts of East Wollega zone.

Table 2. Number of participants in the training

Participants	**Gender**		
	Male	**Female**	**Total**
Farmers	49	9	58
DAs	4	-	4
Experts	5	1	6
Total	**58**	**10**	**68**

Mini field day was also other strategy to create demand for different stakeholders. Accordingly field-day was organized in Wayou Tuka District, Wara-baabu menya Kebele to facilitate experience, information sharing and to create better linkage among relevant actors. During field day a total of 76 stakeholders out of them 64 were male and 12 female were participated.

Table 3: Number of participants in mini field day

Trainee	Participants		Total
	Male	Female	
Farmers	49	9	58
DAs	4	0	4
Experts	5	1	6
Researcher	4	0	4
Others	2	2	4
Total	**64**	**12**	**76**

Figure 5: Mini filed day on integrated farm from fish harvesting to consumption

Fish Production

Under fish production three species were used under integrated farm namely Nile Tilipia (*Oreochromis niloticus*), African catfish (*Clarias gariepinus*) and Common carp (*Cyprinus carpio*). One month after poultry stocking, a total of 245 fishes fingerlings of three species (200 *Oreochromis niloticus*, 30 *Cyprinus carpio* and 15 *Claries gariepinus*) were collected from Research Center and stocked for each farmers with stocking density of 2.04 fish/m^2 on February 2020. The sizes of the fish at stocking were 9.4g, 12.8g and 18.7g for *O.niloticus*, *C.carpio* and *C.gariepinus* respectively (table 4). The fishers were managed properly by exchanging water regularly, protecting fish from predators and maintaining inlet and outlet pipes to maintain the water status with pond size.

Throughout culturing period supplementary feed was not provided to the fish under integrated farm. Based on the integrated concept poultry waste is either eaten directly by fish or fertilizes pond water to support the growth of plankton that used by fish as natural organic feed. Then, the nutrient rich water from fish pond is used us organic fertilizer for growing horticultural crop. The average weight of fish was 243.7, 892.57 and 679.4 for *O.niloticus, C. carpio* and *C. gariepinus* respectively (table 4).

Table 4: Summary of fish data in the integration

Parameters	*O.niloticus*	*C. carpio*	*C. gariepinus*	Total
Number stocked	600	90	45	735
Average weight at stocking (g/fish)	9.4	12.8	18.7	-
Culture period	364	364	364	-
Average weight at harvest (g/fish)	243.7	892.57	679.4	-
DGR (g.d-1)	0.64	2.42	1.82	-
Number harvested	585	75	45	705
Survival rate (%)	97.5	83.33	100.00	-
Actual yield/pond/culture period in kg	142.56	66.94	30.57	240.07

At the end of the trial in 364 days, the *O.niloticus* - attained final body weight ranging from 144 to 385g with a mean of 243.7± 89.79g with mean daily growth rate of (DGR) 0.64g/day. This report is almost similar with Daba *et al*. (2017) specified that the mean daily growth rate was 0.65g/day under integrated farm. The fish growth rate in this trial (0.64g.d-1) is close to the previous result of DGR 0.75g.d-1 reported by Endebu, *et al.* (2016) in the integrated ponds.*C. carpio* and *C. gariepinus* attained mean body weight of 892.57±68.54g with DGR of 2.42g/d and 679.4±38.32g with DGR of 1.82g/d in 364 culturing days respectively. The result DGR of 1.82g/d attained by *C. carpio* was relatively on a better level as compared to the 1.7g/d that reported by Endebu *et al*. (2016) under integrated farm.

Figure 6: Fish production *(a- O.niloticus, b- C. carpio and d- C. gariepinus)*

However, this result is different with Daba *et al.* (2017) who specified that the DGR of *C. carpio* was reach 4.01g/d. This difference was attributed due to higher initial weight and longer culturing period in the current study as compare with previous work. Under this integrated farm the fish had no any supplementary feed throughout culturing period. In integrated poultry-fish farming, the protein-rich chicken dropping was made available to the fish either directly or indirectly. The survival rates of the fishes, *O. niloticus, C. carpio* and *C. gariepinus* was 97.5%, 83.33% and 100.00% respectively (table 4). Generally, a total of 240.07 kg fish was produced from integrated farm during the culture period.

Egg Production

The Lohmann brown pullets in the integrated farm started laying eggs two months after stocking in March 2020, at age of 20 weeks. The maximum production of egg was recorded on the month of January 2021. As the recorded result indicated that the production was fluctuated from at different month in the year.

The research team was not deliver poultry feed as expected due to covid-19 emerged in our country and security problem of the site. Especially, from moth of May to July the production was declining due to luck of commercial feed for stocked poultry. But, starting from the month September commercial feed was delivered by the research team that significantly shows the increment of egg production. As Daba et. al. (2017) indicated that some irregularities and decline in egg production observed when the chickens were fed with locally made cracked grains during shortage of commercial feed supply.

Later, poultry start to decline its production from the age of 17 month and is not economically feasible (figure 6). Similar study result show that, the production of egg decreases in later ages and becomes uneconomical after chickens reach the age of 18 months due to change in their physiology (Daba et al., 2017). The same report also specified by Hirpho (2017) in which the egg production decline in later age of chickens. Generally, *21,015*eggs were collected from the 90 layers in 12 months. The collected eggs were sold by the beneficiary farmers to the local people at price rate of 4.5 Ethiopian Birr (ETB) per egg. The contribution of eggs as a protein source for the local people and the income from the selling to the beneficiary farmers are also valued

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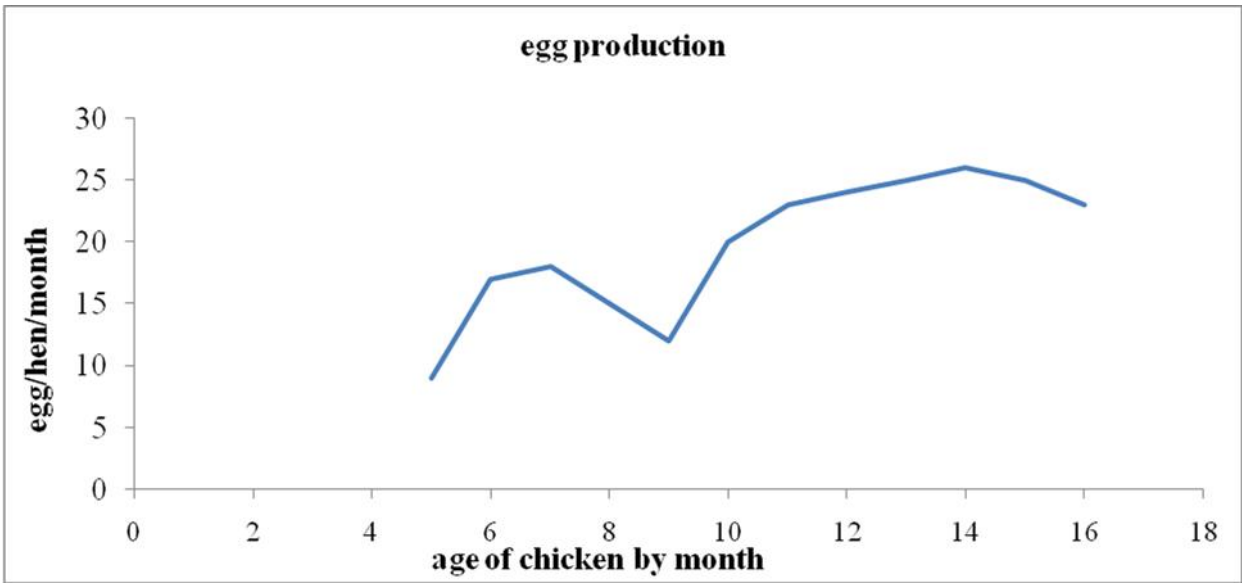

Figure 7: Average egg production per hen per month in the integration farm

Horticulture production

Horticultural production under integrated farm is mainly contributing in developing organic agriculture that primarily use in home consumption and local market. It is one of the alternative ways of vegetable production as a source of income, help to minimize input cost and protect environment from pollution. On this technology demonstration *onion (Allium cepa)* and tomato *(Solanum iycopersicum)* was used without applying any chemical fertilizer that minimizes the cost of production in the system. It also minimize environmental pollution duet to waste from poultry farm and fish pond. The yield obtained from *S. ijcopersicum* and *A. cepa* that integrated with fish were separately analyzed and changed in terms yield per hectare (table 5).The production of *S. ijcopersicum* was 130kg per $50m^2$ and estimated to produce 26000kg/ha which is slightly higher than the average production of tomato $2.5kg/m^2$.

Figure 8. Horticultural production status under integrated farm

Regarding on production of onion (Allium cepa),a total of 1450kg was produce on 500m^2 of land that estimated to 29,000kg when extrapolated to hectare base. The obtained yield was significant and almost similar with previous work on integration farming system that conducted at different site of Oromia region. As the study conducted by Daba et al., (2017) at Wayu Tuka District, a total of 21,600kg/ha was produced from 520m^2 of land under integrated system.

Table 5. Yield of Allium cepa and solanum iycopersicum

Type of Vegetable	Area coverage (m^2)	Total Yield (kg)	Yield (kg ha^{-1})	Sale (Eth. Birr)
Onion (Allium cepa)	500	1450	29,000	23,200
Tomato (Solanum iycopersicum)	50	130	26,000	2,600

Forage production

Under forage production Desho grass (*P. pedicellatum)* and Rhodes grass *(Chloris gayana)* were used that grown on the dike of fish pond with the water source of integrated system. The dry matter yield of each grass was separately calculated and estimated in terms of hector. *P. pedicellatum* and *Chloris gayana* were produced a total of 8,333 and 379 kg ha^{-1}, respectively (table 6).*Choris gayana* is primarily useful forage of moderate to high quality with leafy grassand harvest a total of 200-300kg/ha on less fertile soil (FAO, 2017). By nature this type of grass is a spring and summer-growing grass that found in open woodlands, river banks and pond dike which is very tolerant to either cutting or grazing. *Choris gayana* is used as year round fodder that begins to produce valuable forage within 6 months after sowing and provides regular harvests, even monthly cuts under sufficient moisture or during rainy season.

Table 6. Forage yield under integrated system

Type of forage	Area (m^2)	Total Yield in kg	Yield (kg ha^{-1})
Pennisetum pedicellatum	132	110	8,333
Choris gayana	132	5	379

On the other hand, *Pennisetum pedicellatum* is grows in its native geographic location, naturally spreading across the escarpment of the Ethiopian highlands (Smith, 2010). It is an ideal for livestock feed and can be sustainably cultivated on small plots of land. In addition to animal forage, *P. pedicellatum* is becoming increasingly utilized along with various soil and water conservation techniques, as local methods of improving grazing land management and combating a growing productivity problem of the Region.

Both grass type is an important fodder that grown in the dike of pond in integrated system. Additionally, planting such grass on the dike of pond helps to protect soil from erase during heavy rainfall

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Figure 9: Forage production under integrated farm

Partial budget analysis

Simple calculation was made to know the economic feasibility of the integrated farm comparing input costs against outputs in money value. Labor cost was considered in all activities performed on integrated farm and all necessary materials were considered in partial budget analysis process interims of Money. On establishment of integrated farm, the poultry house and fish pond construction was estimated in terms of money and considered as depreciation values in production costs. All products from the integrated farm were used for local consumption after they were estimated in terms of money.

Revenue generated from the selling of eggs, fish, onion, tomato and animal feed were used. The chicken and all purchased equipment's were also estimated for their current value in terms of money. All products from integrated farm was used for home consumption and sold to the local market with negotiable price. The revenue generated and production costs were presented and analyzed trough partial budget analysis. From budget analysis the total cost of fish, poultry, horticulture and forage production were 6285, 47900, 5950 and 300 Ethiopian Birr (ETB) respectively (table 7).

On the other hand, 28808.4, 102,217.5, 19400 and 3000 Ethiopian Birr (ETB) were the revenue generated from fish, poultry, horticulture, and forage production. The highest profit was obtained from egg and fish production as comparing with other components. Overall, the total cost incurred in integrated farm and the final revenue generated were 60,735 and 153,425.9Birr respectively. From this the total profit of the system was 92,690.9 Birr.

Table 7: Partial budget analysis

Components	Items	Production cost (in birr)	Revenue (in birr)	Amount (in birr)
Fish production	Fingerling purchase	735	Fish selling (120 birr/kg x 240.07 Kg)	28,808.4
	Pond depreciation cost	3500		
	Fishing net depreciation	350		
	Estimated labor cost	2000		
	Total cost in fish	**6585**	**Total revenue**	**28,808.4**
Poultry production	Pullets purchasing	9900	Revenue from egg production(21,015 Egg*4.50)	94,567.5
	Poultry feed purchase	35300	Estimated value of poultry at the end of the trial(Cull out hen) (45 *150)	6750
	Poultry feeders & equipment	1200	Estimated value of equipment	900
	Estimated labor cost	1500		
	Poultry house depreciation	1200		
	Total cost in poultry	**47900**	**Total revenue**	**102,217.5**
Horticulture production	Estimated cost for land preparation, weeding, etc	3000	Selling of onion	23,200
	Purchase of seedling	2500	Selling of tomato	2600
	Purchase of pesticide	450		
	Total cost in horticulture	**5950**	**Total revenue**	**19400**
Forage production	*Pennisetum pedicellatum*	150	Estimated revenue	1500
	Choris gayana	150	Estimated revenue	1500
	Total cost in forage	**300**	**Total revenue**	**3000**
Net benefit from the system			**99,090.90 ETB Birr**	

Stakeholder's feedback

Pre-extension Demonstration of Integrated Fish-Poultry-Horticulture-Livestock Feed Production System was fully completed according to research plan on selected site. Farmers, other local community, Development Agent and experts from districts and Zonal level were participating from training to providing feedback on technology demonstration and result. All stakeholders confirmed and understood that, the integrated farming system is feasible in terms of its contribution to family food, income generation, and employment opportunity. Specially, FREG farmers specified that, integration of fish, poultry, horticulture and animal feed production system is a promising technology to generate income for household on a small plot of land having access to water source.

Challenge encountered in technology demonstration

- Lack of commercial feed for poultry
- Security problem

Conclusion and Recommendation

Integrated fish-poultry-horticulture-animal feed farming system was implemented in East Showa Zone, Wayu Tuka District. Site and trial farmers were purposively selected based on its potentiality of site for fishing activities and other criteria's. Under this technology, one component is used as input for the other component and relatively small plot of land as compared to the traditional farming system with lower costs of inputs. From the system farmers were generate about 99,090.90 ETB Birr within one year which is highly contribute on the status of famer's income level. The result also confirmed that, the system is cost effective and efficient enough to generate more many from small plot of land as compare with customary traditional method of farming.

Moreover, it helps to produce different king of item which helps to diversify the farmers in production and is good resilience approach to produce sustainable food for rural farmers. The technology is promising in agriculture sector in all potential sites and economically efficient under farmer's condition. Overall, Integrated farming of fish, poultry, horticulture and animal feed production system has been effective approach for sustainable production, income generation and employment opportunity for resource poor rural households. So, government and NGO should be make an emphasis on its wider population (scaling-out) as one of aquaculture strategy that can be adopted by smallholder farmers of the country to increase farm returns from per unit area of land.

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