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Demonstration of Integrated Fish Farming with Vegetables and Herb Production

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Abstract: Integrated fish farming is a successful and ideal approach for increased farm production and productivity of small scale farmers' in developing countries. However, insufficient information is available in this area. More importantly, information on farmers' feedback on these farming systems is scanty. Therefore, it is important to work on this issue so as to inform research target on local challenges and realize demonstrated farming systems to farmers' context. This paper is aimed at assessing farmers' feedback and perception of integrated fish farming taking insights from a model fish-vegetable-herb production system demonstrated at the National Fisheries and Aquatic Life Research Center. For this purpose, a sample of twelve farmers, who already started fish farming in South west Shewa zone of Oromia region were invited. The demonstration was researcher managed showing its operation on the ground. The demonstration includes non-integrated replica of vegetables grown to help participants observe the yield difference between vegetables grown using fish pond water and tap water. Mixed methods research was applied to study the demonstration results. Data collection tools used were mini structured questionnaire followed by a focus group discussion with farmers. Data Analysis was done using MS-Excel and NVivo Version-11. Kirkpatrick's procedure of training evaluation was adapted for this purpose. In addition, thematic analysis was also applied. Simple descriptive statistics was also used. Result of the analysis on farmers' feedback showed that they found the demonstration, effective, motivational and up to their expectations. They also perceived the benefits, challenges and solutions for successful implementation of integrated fish farm site. Finally, diversifying production of horticultural crops in integrated fish farming, sustainable input supply, appropriate design of integrated fish farming site with efficient water resource use were considered by farmers as important ingredients for establishing an integrated model fish farm site.

Keywords: Demonstration, Integrated Fish Farming, Feedback, Perception

1. Introduction

Providing adequate food for a rapidly growing population is one of the greatest challenges in the world. The problem is quite acute in countries like Ethiopia where besides population explosion, natural and manmade calamities have aggravated the problem. Demand for animal products is increasing throughout the world owing to the rise in world population [7, 2]. In addition to increasing food production from agricultural land, it is also necessary to sustainably exploit the aquatic ecosystem [16]. Fish is an important source of animal protein for human consumption, especially in developing countries, where it provides 25% of the total animal protein consumption [11].

In addition to natural sources, fish farming is one option set to increase the fish supply and ultimately the consumption aimed at meeting the rising demand for fish in the whole world in general and developing nations in particular. According to a study on business opportunities for fish farming in Ethiopia, two fish farming business models that work for the country's context were suggested [27]. These are: Large-scale intensive commercial fish production and semi- intensive small-scale commercial fish production. Yet, fish farming has not taken off and still limited to small-scale extensive and semi-intensive fish farming in Ethiopia. This is escorted by a limited number of smallholder producers who own ponds as wide as about 300 m^2 maximum [27].

Fish farming in small-scale and smallholder farmers' context is constrained by several factors one of which is lack or shortage of inputs like fish feed [9, 32]. Integrated fish farming system was suggested as an optimal solution, not only to alleviate the challenges of feed shortage for fish but also bring income, consumption diversification and reduce unit cost of farm produce in the integration compared to individual farm enterprises under mixed farming system. An integrated fish farming system is therefore suggested as an option for small scale fish farming system, where these and other challenges prevail [29].

Integrated fish farming is defined as a concurrent sequential linkage between two or more agricultural activities (one or more of which is aquaculture), directly on-site or through off-site needs and opportunities, or both [26]. Under this system, the output from one of the system components is used as an input for the other, leading to an overall system efficiency and effectiveness. In the concept of integrated fish farming, no byproduct of one production system component is considered as a waste. Yet, wastes are resources out of place [31]. Some research outputs confirmed that farms integrated with fish ponds bring higher overall yield and marginal economic benefits than the non-integrated ones [12, 18, 23, 16].

Integrated fish farming systems which were implemented in different African countries have shown promising results. Some exemplary cases can be mentioned for Ethiopia, Nigeria and Malawi [28]. Among many possible forms of integrated fish farming systems, small scale fish-poultry and vegetable integration are commonly practiced elsewhere [17, 19, 1, 22, 3, 5, 4, 23]. In Ethiopia, earlier studies were conducted by integrating fish farming especially Nile tilapia and African catfish with various types of crops and livestock species in both on station and on farm context. The studies were either inclusive of livestock subcomponent or not [2, 13].

The most common type of integration found in the literature and the Ethiopian context as well is that of fish-with vegetables and poultry-fish-vegetable type [22, 4]. There are also cases where fish farming is integrated with small ruminant fattening in Ethiopia [19]. Some of the candidates of vegetables reported to be integrated with fish farms include: Onion (Baro and Red Bombay), cabbage (Chinese and round cabbage), tomato, potato and the like. Studies were also conducted by integrating small scale fish farming with poultry and vegetable production altogether. The results of implementing integrated fish farming trials at farmers' level in Ethiopia show that major factors affecting farmers' application of these practices were: lack of training and demonstration efforts, absence of focus on enhancement of farmers' indigenous knowledge and lack or shortage of inputs for integrated fish farming such as improved vegetable seeds (varieties), fish fingerlings and the like [22].

Before commencement of the current demonstration activity, an on station integrated fish farming experimental trial was once conducted at the National Fisheries and Aquatic Life Research Center on. The integration trial was conducted by incorporating a potato variety called "*Belete*" and a local variety of tomato as components. Consequently, experimental trials irrigated with fish pond water have shown positive yield increment over using pure spring and ground water but the rate of increase was not as much as that of using chemical fertilizer. Result of this experiment finally ended up with a conclusion that fish pond water can partially replace chemical fertilizer [6]. Other trials conducted by the research center, but on-farm, were in North Shewa zone of Amhara region.

This included Kebeles like: *Yimlo, Mulo, Washa Wonz, Anguamesk, Bakelo, Kewet, Keyet and Washa*. However, all of them were neither demonstrated to farmers nor lack information on farmers' feedback and perception of the demonstration. Hence, the current study fills this information gap.

2. Methodology

2.1. General Procedure of the Demonstration

For the purpose of demonstrating integrated fish farming with vegetable and herb production at NFALRC, both result and method demonstration procedures were followed using the procedures cited by Suvedi and Kaplowitz [30]. The procedures followed were:

a) Setting up the demonstration site (Field preparation, planting, agronomic management).
b) Rehearsing the new idea to be demonstrated with possible set of questions to be asked.
c) Preparing extension materials and audio-visual aids).
d) Arranging demonstration site and facilities ready for the event.
e) Selecting farmers for the demonstration.
f) Scheduling and communicating the date and venue of the demonstration.
g) Rechecking status of the demonstration site and make amendments to fit the its objective.
h) Conduct the demonstration.

2.2. Sampling and Sample Size Determination

In the process of selecting participants one of the three active pilot project areas of NFALRC nearest to the center and with long years of intervention history was purposively drawn. The number of farmers actively participating in aquaculture is in the selected pilot project area is 24. Quota sampling technique was thus applied due to budget shortage. Hence, 12 participants were invited to the study out of which, 11 were farmers and 1 participant from the district office of agriculture and rural development. For the purpose of data collection and analysis, the group size is a bit higher than the one recommended as an ideal size of 6-8 members per group for demonstration [15]. However, since all participants had almost the same level of experience in fish farming (homogenous groups) and the modulator was able to manage the discussion flow well; all participants coming to the center were involved.

2.3. Method of Data Collection and Analysis

The demonstration was undertaken in the form of researcher led practical visit and experience sharing to the site. Both qualitative and quantitative methods of data collection were used. As part of a qualitative method, focus group discussion was applied to capture data on farmers' perception of the demonstrated model farm site and integrated fish farming in general. Focus group discussion was selected because it is a method of enquiry that provides a rare insight into human behavior and belief [10]. Quantitative data was generated using a mini structured questionnaire to evaluate their feedback on how the demonstration is organized. Field notes were also taken to collect data on crop yield and communicated during the demonstration.

In this study, two grand methods of data analysis were used: qualitative and quantitative. Quantitatively, data on yield performance of vegetables and herbs integrated with fish farming or not were analyzed using MS Excel. To analyze farmers' feedback on the demonstrated site, Kirkpatrick's method of evaluation was followed [14], as the demonstration was provided in the form of a researcher facilitated practical training using the principle of learning by doing. Among the four procedures of training evaluation suggested by Donald Kirkpatrick, only the reaction level was evaluated by virtue of limited span of observation needed at the current level. Hence, the participants' level of satisfaction on the demonstration outcome and the state of objective attainment was gauged using a scale of satisfaction measure ranging from very high to very low levels for an agreement scale using positive statements only (Table 1).

To analyze farmers' perception of integrated fish farming, themes were extracted from the focus group discussion. In this case, a procedure for thematic analysis was followed [28]. The procedure was applied to map their perception on the demonstrated integrated fish-herb/vegetable production system in particular and integrated fish farming in general. The procedure boldly includes: defining the research question, which in this case is participants' perception by identifying and extracting qualitative data from the source, which is focus group discussion. To do so, a transcription of verbal data is done from the speeches, extraction of the data and coding, synthesizing codes into themes using a theme piling method, and illustrating the overall perception using a model map.

To support the process of data analysis, NVivo software V-11 was used. Detailed procedure of data analysis includes the following: First, data collected from the focus group discussion using an audio recorder was translated into English by putting it in a written form. In the process, no idea was left untranslated. Next, the translated information was analyzed using a procedure of thematic analysis by first defining the research theme, which is "perception". Then, data points which include words and phrases of perception are extracted from the text. These are called codes or data extracts. The data extracts, with similar ideas are grouped together under one dimension of perception. Each dimension of perception is regrouped based on the similarities to one another to form a subcategory of the main theme. Similar subcategories are then brought together to form a main category under the theme "perception". The main categories are then used to explain farmers' perception of integrated fish farming. The relationships among these and other concepts of perception were then used to draw a perception map (figures 2 and 3).

3. Results and Discussion

Farmers who participated in the study were 11 and all of them were men. The current study is both a result and a method demonstration and the role of farmers was as learners supported by a facilitator of the demonstration. In this activity, how components of the farming system are integrated were clearly shown. The result demonstration is inclusive of showing the yield difference between vegetable and herbs irrigated with fish pond water and non-irrigated plots, both by observing the biomass physically on the ground and measuring the harvest in front of the participants. During the demonstration, yield obtained both from the pond water irrigated and non-irrigated plots were measured with a hand-held balance and comparatively evaluated on the site. For tomato (local variety) planted alone, a comparison is made against selected varieties based on the national average yield records cited in the horticulture production technology manual of Ministry of Agriculture [21]. Since, the core idea of demonstrating this model farm is to show the crop yield advantage of including pond fish farming into their horticulture cropping system, data on fish harvest was not collected.

Table 1. *Yield of vegetables and herb for integrated and non-integrated plot.*

S/No	Name of the herb/vegetable crop	Area (m^2)	Yield/plot/year	Loss/plot/year	Yield/ha/year
1	Tomato (*Local Variety*) Irrigated	7.83	26.56kg	5.16kg	339.2 qt
2	Sweet Basil (*V-02-WOL WGSB II*) Irrigated	3.80	15.86kg	-	41.74 tons
3	Baro Onion Irrigated	2.99	20.02kg	-	669.57 qt
4	Baro Onion Non-Irrigated	3.40	8.06kg	-	237.06 qt
5	Beet Root Non-Irrigated	3.42	5.36kg	-	156.73 qt
6	Beet Root irrigated	3.86	4.82kg	-	126.84 qt

In the above table, the fresh biomass yield of sweet basil from Wondogenet Agricultural Research Center known by the variety name "*V-02-WOL WGSB II*" was evaluated for a fresh above ground biomass of 15.86kg in 3.8 m^2, which is equivalent to 41.74t per ha/year. Regarding the yield result of the tomato (local variety), on an experimental on station pilot demonstration plot the output was found to be better than that of the national average yield registered for varieties: *Woyno, Mersa* and *Leku* (21). A yield of 3.392 kg per square meters or 339.2 qt per hectare per annum per year was obtained. This result was obtained with a loss of about 66 kg of tomato per ha per year. The loss was attributed to predation by birds and spoilage after over ripening. Yield obtained from tomato is within the range of a previous integrated fish farming trial conducted at NFALRC, which is 110.3-496.23 qt/ha [6].

Baro onion of un unknown variety was also evaluated for its bulb yield during the demonstration. The bulb yield difference between pond water irrigated and non-irrigated onion was expected by the participants when they observe the above ground biomass difference. The difference in yield was weighed and found to be 20.02kg against 8.06kg for the pond water irrigated and non-irrigated plots respectively. Hence, it was jointly observed that the broadening and intensity of above ground onion leaves irrigated with fish pond water as well as its bulb weight (consumable part) was found to be higher for pond water irrigated than that of the non-irrigated onion. The difference is the same as 669.57 and 237.06 quintals per hectare per annum for the pond water irrigated and non-irrigated onion respectively.

On the demonstration session, it was also noted that the beetroot irrigated with fish pond water has shown significantly higher above ground leaf biomass than the non-irrigated one. However, the fish pond water irrigated beet root has shown lower bulb yield than the irrigated one, which is similar to 126.84 against 156.73 quintals per ha per year for the irrigated and non-irrigated beet roots respectively. This finding contradicts with the common scientific assumption that fish pond water contributes for an overall yield increment of consumable and vegetative part of crops, due to added fertilization with pond water effluent. Hence, this subcomponent of the integrated fish farming system has to be re-implemented and evaluated before on farm evaluation and further dissemination.

3.1. Analysis of Farmers' Feedback

Participants' feedback was measured with a structured questionnaire. Feedback was collected as an element of the demonstration on tools used, content, method of delivery, time vested on it, learning, expectations and overall evaluation of its settings. Kirkpatrick's method of training evaluation was adapted to this context and applied to analyze farmers' reaction to the demonstration as shown below (Table 1).

Table 2. *Farmers' feedback to the demonstration.*

Feedback Statements	Level of Agreement					
	Very High	High	Medium	Low	Very Low	Rank
Content of the demo was suitable for your needs	5	5	1	-	-	4
Tools used for the demonstration were appropriate	5	5	1	-	-	4
Methods used to demonstrate were appropriate	5	2	4	-	-	6
The demonstrator was effective	6	5	-	-	-	3
Facilitator of the demonstration was effective	5	3	3	-	-	5
Contents of the demonstration were motivational	7	4	-	-	-	2
Demonstration results meet your expectation	9	1	1	-	-	1
You have clearly understood the demonstration	3	6	2	-	-	7
Duration of the demonstration was adequate	3	2	2	2	2	9
Overall the demonstration was successful	3	4	3	1	-	8

From the above feedback information given from the farmers, it is understood that overall status of the demonstration is quite good and up to the level of participants' expectation. However, more work has to be done on the duration of the demonstration session with an improvement in the facilitation process while the subject matter expert demonstrates.

3.2. Farmers' Perception of the Demonstration

Farmers' perception of integrated fish farming in general and the model farm in particular was also captured from the focus group discussion. A procedure of thematic analysis recommended by Sivakumar, 2017 [28] was used with the result shown below:

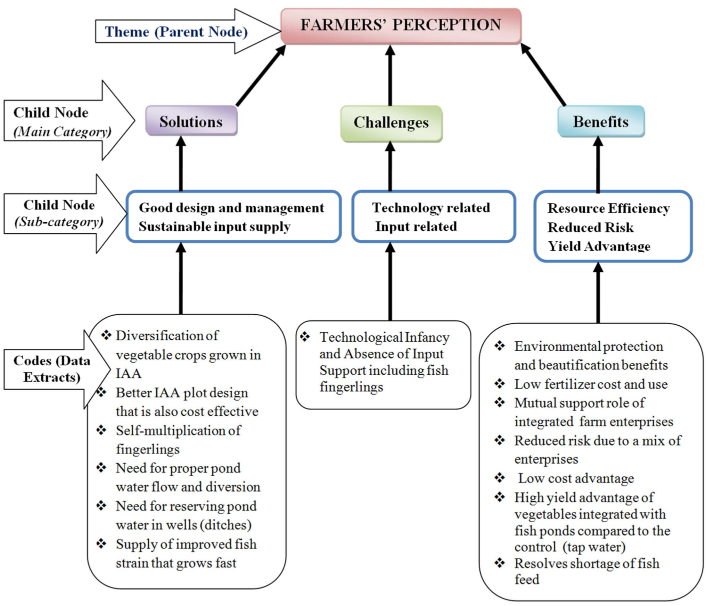

Figure 1. *Illustration of farmers' perception.*

From the result on the analysis of farmers' perception on integrated fish farming system in general and with the one demonstrated in particular, eight key categories of perception were identified. These categories reflect a thorough list of farmers' perception on integrated fish farming system including the one demonstrated. The findings in relation to their perception generally reflect the importance of careful planning, good design and local innovations to start up and continue implementing integrated fish farming practice successfully. Additional points of concern were more of management related as integrated fish farming demands ways of understanding complexity and systems thinking.

Generally, the participants perceived the benefits, challenges and solutions for the challenges observed in integrated fish farming system. From the benefit side, they noted better crop yield performance of integrated fish farming than when it is not integrated. Reduced unit farm enterprise or product cost advantage of applying the system in their local context was also understood. This finding is similar with that of other researchers', who worked on the same topic [25, 23, 24]. They also perceived the importance of integrated fish farming as it reduces the use of herbicides and chemical fertilizers along with efficient utilization of pond water and reduction of waste through effective and efficient recycling.

These findings generally lead to the fact that integrated fish farming helps to optimize the use of all available resources [8], which is also the same as the one found by an author in Ethiopian context [20]. Thus, adopting an integrated fish farming system generally contributes for land and water resource utilization efficiency, reduction of input cost for the vegetables grown, waste recycling from agricultural by-products and diversification of agricultural outputs both from crop and livestock enterprises.

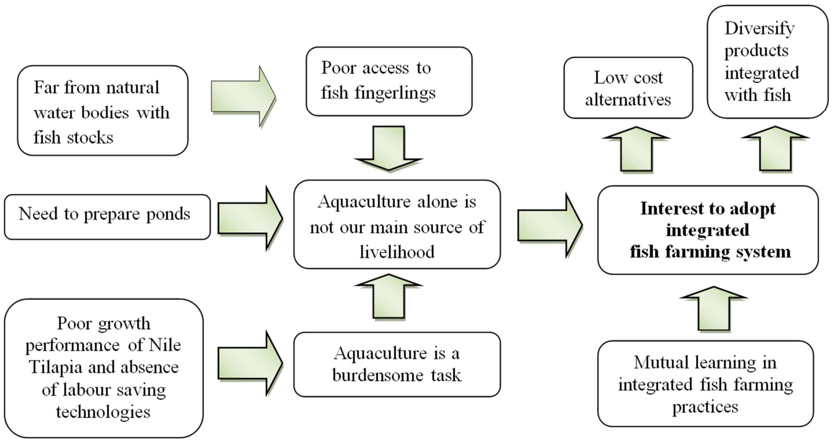

Figure 2. *Factors triggering interest to apply integrated fish farming.*

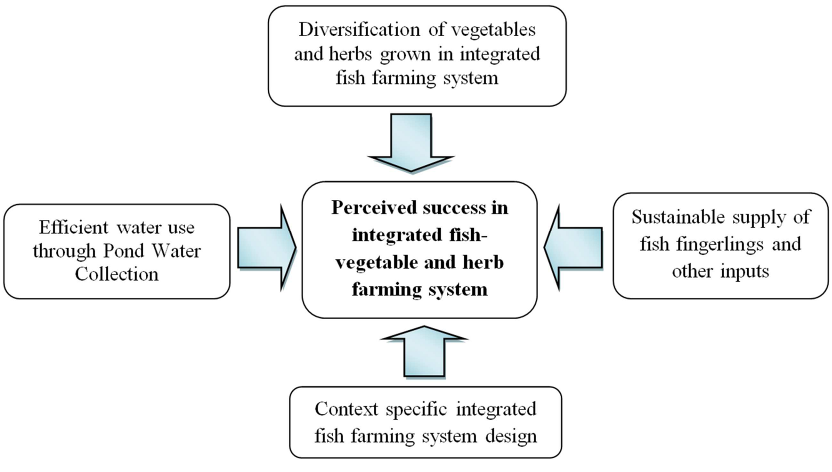

Figure 3. *Conceptual map of factors for the success of integrated fish farming.*

4. Conclusion

So far, this demonstration trial confirmed us that integrated fish farming is a viable approach to small-scale fish farming experience, where there is a reduction of cost and increment in the yield of vegetables and herbs grown along with it. Key drivers of success in piloting integrated fish farming activity among selected farmers are: Diversification of vegetables and herbs grown along with fish farming, sustainable input and technology supply, including the management option of components in the integrated fish farm; context specific and efficient integrated fish farm site design and pond water use efficiency. Cost effectiveness of integrated fish farming was one of the lessons learned from the participants' reflection. Sustainable fish fingerling supply was also taken as a key ingredient of success for integrated fish farming. Similar to the recommendations made based on previous assessments of small scale pond fish farming in Ethiopia, it is advisable for farmers' who manage small scale fish farms to produce their own fingerlings [27]. Specific type of integrated fish farming system depends on an assessment of environmental suitability in successfully applying its package components.

5. Recommendation

Generally, feedback collected from the demonstration participants shows that involving farmers' and a multidisciplinary team of technical experts is highly recommended for establishing successful integrated fish farms. Since context specific fish farming system design is one of the factors contributing for a successful establishment of integrated fish farming system, local innovations had to be exhaustively used which are not necessarily expected from research institutions. Some of these innovations could emerge from farmers' indigenous knowledge of natural resource management and others from experiences shared from other countries and institutions. To enhance, farmers' skills in natural resource management options, behavioral change tools such as games could help. However, these should be supported by the provision and multiplication of locally adaptable agricultural technologies within the reach of farmers or by the farmers themselves.

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