Developing low cost feed and transferring the technology to relevant actors for sustainable intensification of Tilapia culture

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WorldFish Bangladesh

Developing low cost feed and transferring the technology to relevant actors for sustainable intensification of Tilapia culture: Final Report

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Disclaimer

These are the views and expressions of the author of this report, and do not necessarily represent the view of the Netherlands Embassy in Dhaka, the Republic Government of Bangladesh or Blue Gold program consultants.

Executive summary

Tilapia is one of the most widely produced and consumed fish in Bangladesh. Since last 10 years the price of Tilapia was stable in the market while input costs – especially the feed cost went up. To ensure producers benefit and still keep the fish price accessible by all group of people including the poor, we need to reduce the production cost. Major step in doing this is to reduce fish feed cost which constitutes more than 60% of total production cost. To achieve this target, WorldFish and Wageningen University with financial support from Blue Gold Program conducted an innovation project from November 2016 to September 2017.

Project Goal was first to increase profitability of tilapia culture and disseminate the knowledge to the users – fish and feed producers. To achieve this, the project had 3 major interlinked working components: 1. **Research** and Innovation; 2. **Extension** to farmers and 3. Cooperation with Fish Feed **Industry**. Major findings of this innovation project are below:

Research

- ~30% fish production cost can be reduced
- Feed manufacturing cost can be lowered ~10% by adopting low protein diet composition
- FCR as low as 1 at grow-out phase
- Only 3% fish meal in the recommended diet
- Water used for each metric ton tilapia production from the best treatment is ~1500 cubic meter
- Environmental impact (soil N - accumulation) can be reduced ~ 35% by using low protein diet
- Pond, smaller than 5 decimal, have lower productivity
- 1 international MSc thesis, 4 national MSc thesis and 2 national BSc research report
- Partnership with WUR, BAU, KU and De Heus

Extension

- 40 research farmers gained knowledge and skill from hands on learning and are playing leading role in dissemination
- Capacity of 50 extension facilitators were developed on facilitation skill, aquaculture planning, feed and pond system tilapia culture management including DOF selected LEAF, private sector LSPs local NGO staffs, WMG and community leaders
- Trained trainers successfully provided training to 500 fish farmers in Batiaghata and Dumuria
- TOT manual, farmer's field guidebook and training festoon prepared and distributed
- Each research farmers received 80kg feed after the trial and each training farmers received 4kg feed during the training as an incentive to get motivated for using feed in their ponds
- Partnership with AIN and IFSL project
- Department of Fisheries (DOF), Bangladesh Water Development Board(BWDB), Global leaders of WorldFish and senior management of Bill and Melinda Gates Foundation visited our research and appreciated the innovative approach of the concept

Industry

- Collaboration between Dutch and Bangladeshi fish feed companies strengthened
- Some companies are interested in collaborative research
- Industry want more evidence to start commercial application
- Commercial application requires amendment in Feed Act
- Opportunities for collaboration between semi-auto feed millers and commercial feed companies identified at field level to reach small scale farmers
- Linkage between feed ingredient sellers and semi-auto feed millers strengthened specially to get ingredients relevant to new formulation

Key challenges for implementing the results are changing farmer's perception and behavior regarding fish feed management; developing trust of the industry on the research findings; and changing feed act to allow commercial production of the new feed composition.

Contents

Introduction

Aquaculture in Bangladesh is mostly extensive to improved-extensive and producing only 2-3 mt/ha except for fewer percentages of commercial producers. Agricultural lands are becoming an important limiting factor to meet the growing food demand of the increasing population. This challenge is equally important for fish and crops and can only be addressed by sustainably intensifying the production. Feed is the most critical input for aquaculture intensification. There are couple of reasons – feed is expensive, feed ingredients are limited and distribution to small scale farmers is difficult.

Tilapia is one of the most widely produced and consumed fish by poor consumers. Since last 10 years the retail price is stable, while production cost is going up due to increased fish feed price. As a result, nowadays producers are getting less interested on tilapia due to minimum profit margin. This can negatively impact animal source protein consumption by the poor. Research also shows that sustaining tilapia culture and ensuring benefit for both producer and consumer depends on increasing efficiency in the production system and reducing fish feed cost.

To address this issue WorldFish conducted a 10 months innovation project with financial support from Blue Gold Program. The specific objectives of the project were:

- To engage farmers in the R&D process of pond productivity improvement so that in future they are capable of solving local level farming problems and able to improve productivity as needed
- To reduce fish production cost by developing low cost feed and efficient feeding techniques
- To scale the research finding at polder 29 and 30 by several extension activities
- To establish linkage between Dutch and local feed companies and semi-automatic feed producers for wider use of the research finding through business development
- Develop partnership with ongoing R&D projects

The project had three interlinked working components (Figure 1) to achieve the goal.

Figure 1: Project components

Project areas

The project was implemented in Batiaghata and Dumuria upazila of Khulna district. On-station research was conducted in Sahos, Dumuria; on-farm research was conducted in different farmers' ponds at Fultola, Batiaghata and Sahos, Dumuria; and pilot demonstration of farmers capacity building was facilitated in Chakrakhali, Hatbati, Debitola, Gangarampur, Gondabari and Sundarmahal villages of Batiaghata, and Jhilerdanga, Baradanga, Sahos, Taltola, Rodakhora, Sahosh modhyopara, Kusharhula, and Sahosh kumar ghata of Dumuria (Figure 2).

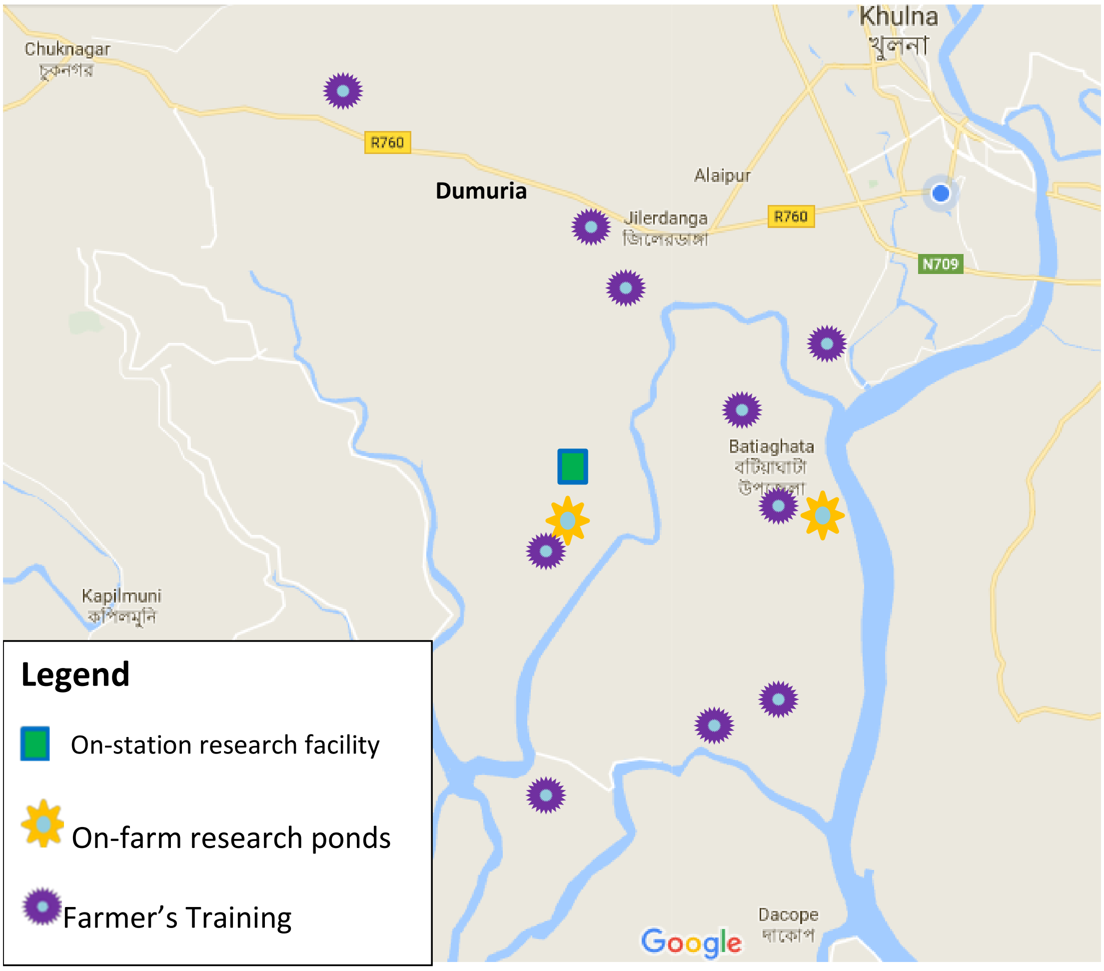

Figure 2: Project area and different interventions

Building Knowledge base through research

The innovative concept required testing at different level to produce authentic result that can make clear impact and can be transferred to application. To achieve this target we designed a protocol where first we conducted this trial in our experimental pond at more controlled environment. Based on the outcome, secondly we have validated this concept at farmers' ponds. While running this trial we have added another variable – stocking density, considering practical application.

Testing the concept at experimental ponds

This research was carried out in 2016 at WorldFish feed research facility in Sahos, Dumuria in 12 compartmentalized ponds with 36 chambers in it. We tested 2 diets – contrast in crude protein (CP) level (table 1) and 3 different feeding levels (i.e. 0%, 0.7% and 1.3% of body weight) with 6 replications of each treatment. This trial was for two months starting with an average individual body weight (BW) of 29g and fish stocked at 4/sqm. The pond compartment had an area of 10sqm and 1.2 meter water depth. Pond compartment structure allowed dissolved nutrients to pass through the water column and the bottom was sealed to prevent passing of complete feed and soil benthos between compartments (Figure 3). Daily aeration was provided to keep the environment optimum for fish growth.

Table 1: Composition of experimental feeds

Composition on Dry matter (DM) basis	Diet 1: (g/kg)	Diet 2: (g/kg)
CP	351	255
CP (91% DM basis)	**323**	**235**
Fat	75	84
Fiber	61	61
Ash	92	81
Starch	266	329
Phosphorus	11.4	11.1
Available Phosphorus	6.2	5.2
Digestible protein(DP): Digestible energy(DE)	20.31	15.43

During the research trial every day we monitored dissolved oxygen(DO), pH, pond surface temperature, transparency, total dissolved soild(TDS), salinity and at every 15 days we monitored NO_2, NO_3 and NH_4. In addition biological parameters i.e. phytoplankton, zooplankton, benthos, water bacteria, soil bacteria and chlorophylla samples were collected, at day 1, 30 and 60, following standard methods and analysed at the Limnology Lab of the Environmental Science Discipline of Khulna University.

Statistics for factorial analysis was done by two way repeated measure ANOVA in R. Multivariate analysis ANOSIM was done in Primer 6 for water quality parameters.

Figure 3. On-station research facility

Results and discussion from experimental ponds

Research conducted in experimental ponds shows that total weight gain, individual final weight, specific growth rate (SGR) were higher and food conversion ratio (FCR) was lower in case of diet 2, and the differences were statistically significant (Table 3). In addition FCR had diet and feeding level interaction as well. Survival of the fish was only influenced by feeding level (Table 3). The growth achieved in "0" feeding compartment indicates the contribution of natural food/ecosystem service in the growth of fish. This contribution is more than double in diet 2 compared with diet 1 (Table 3).

Table 3: Performance of fish under different diet and feeding level.

	Diet (%CP)	Feeding Level (%BW)			SEM	p - value		
		N/A	0.7	1.3		Diet	FL	D*FL
FCR ($g.g^{-1}$)	32%	N/A	0.59	1.09	0.028	**0.0068**	**<.0001**	**0.043**
	23%	0.00	0.54	0.91	0.028			
Total weight gain (g/10m2/60days)	32%	**126.66**	1162.50	1665.00	86.216	**0.0377**	**<.0001**	0.3732
	23%	**296.83**	1229.83	2058.00	86.216			
Final individual weight (g)	32%	57.60	80.73	84.41	4.225	**<.0001**	**<.0001**	0.5464
	23%	73.00	89.50	95.76	4.225			
SGR ($\%bwd^{-1}$)	32%	1.13	1.70	1.80	0.09	**0.017**	**<.0001**	0.2752
	23%	1.40	1.80	1.90	0.09			
Survival (%)	32%	56.66	72.50	83.33	5.513	0.5736	**<.0001**	0.7328
	23%	51.66	68.75	85.41	5.513			

- Green field areas are production realized only through natural food web
- Pink filled areas indicates significant difference

The diet and feeding level interaction with FCR shows that at lower feeding level both the diets perform similarly (Figure 4). However, with an increased feeding level FCR of diet 1 goes up (Figure 4). This might be due to limited capacity of the fish to utilize high protein coming through the feed or the influence of the changed water quality on metabolism. This needs further research to make clearer understanding.

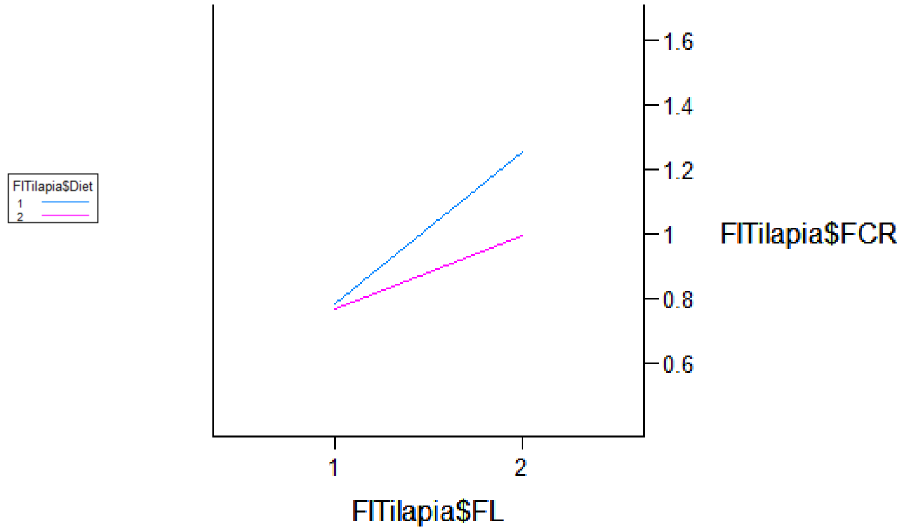

Figure 4. FCR~Diet and feeding level interaction

Water quality parameters during this experiment were optimum and have shown clear shift by phase for salinity and gradual decrease in DO and TDS over time (Figure 5).

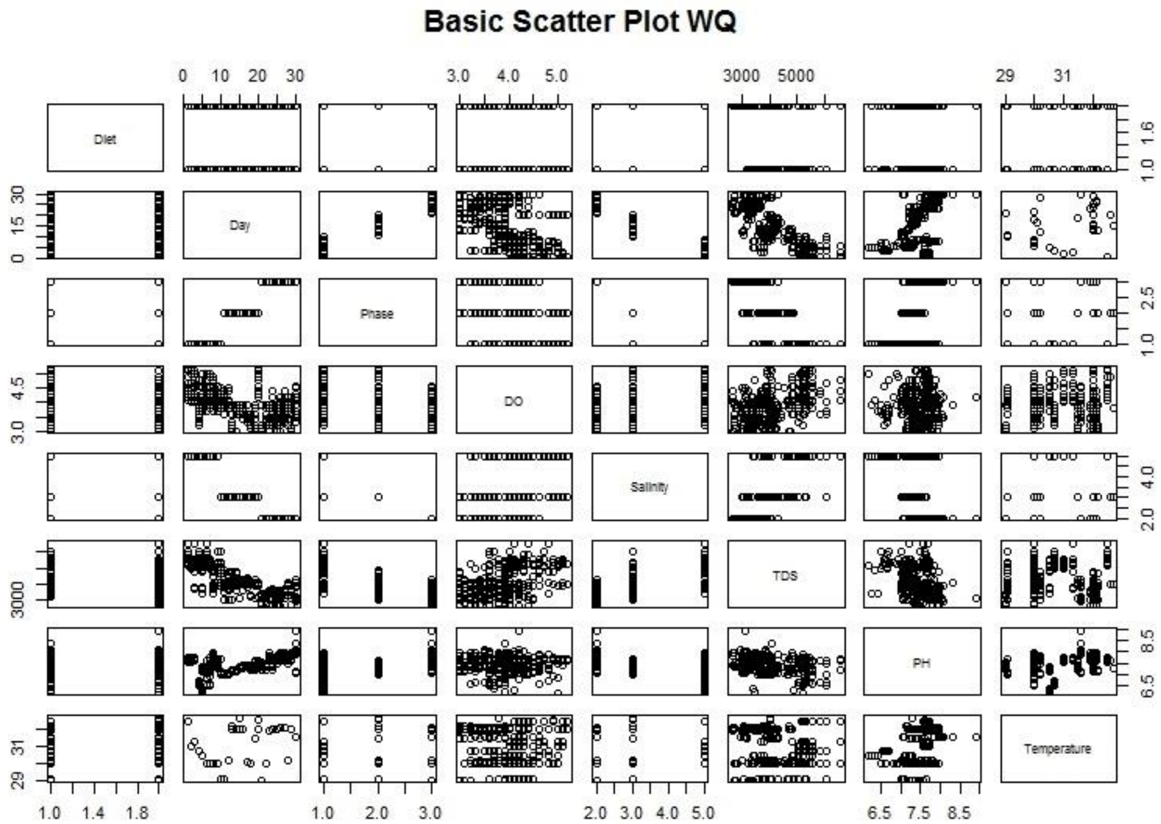

Figure 5. Scatter plot matrix to show relation between DO, salinity, TDS, pH and temperature with diet, days & phases of culture.

Diet didn't make any significant difference in individual water quality parameters. However, when the whole pond water environment was compared by Distance-based redundancy analysis in Primer 6, it showed significant difference by diet (figure 6). This system based difference might have influencing the growth condition differently (Table 3).

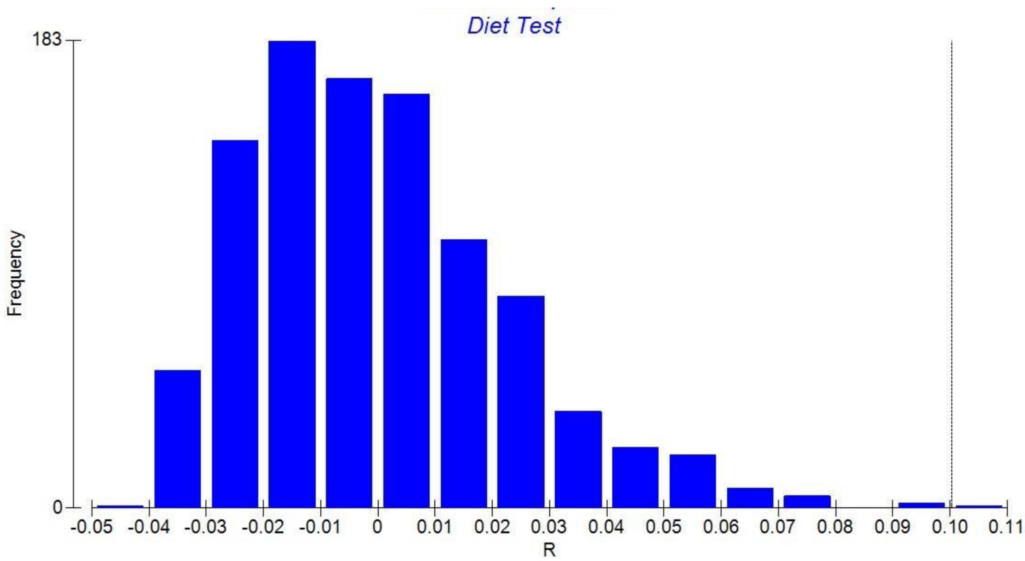

Figure 6 Effect of Diet on Pond Water Quality (ANOSIM -999)

Natural food production in terms of abundance of phytoplankton, zooplankton, benthos, water & soil bacteria and chlorophyll-a level in the ponds indicates no difference and a gradual decline over time (Figure 7). This indicates increased grazing pressure by the growth of the fish. No difference in the abundance of natural food can be also because of higher grazing and a minimum natural food existing in the pond.

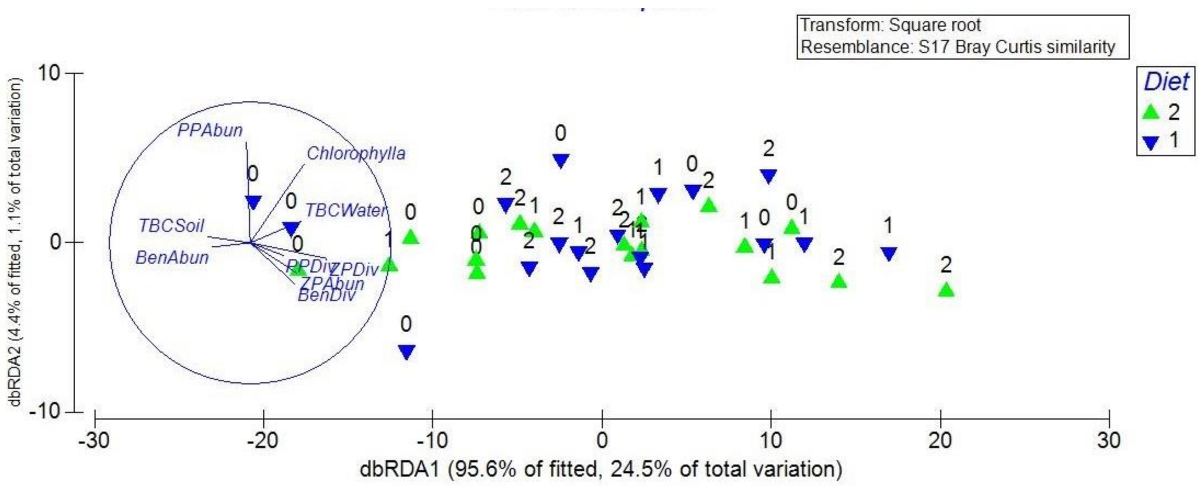

Figure 7. Bray Curtis resemblance test in Primer 6.

However, this situation was further explained by the gut content analysis of fish from different treatments where we see diet 2 has higher contribution in terms of volumetric measurement (figure 8) and in terms of food particle weight basis (figure 9).

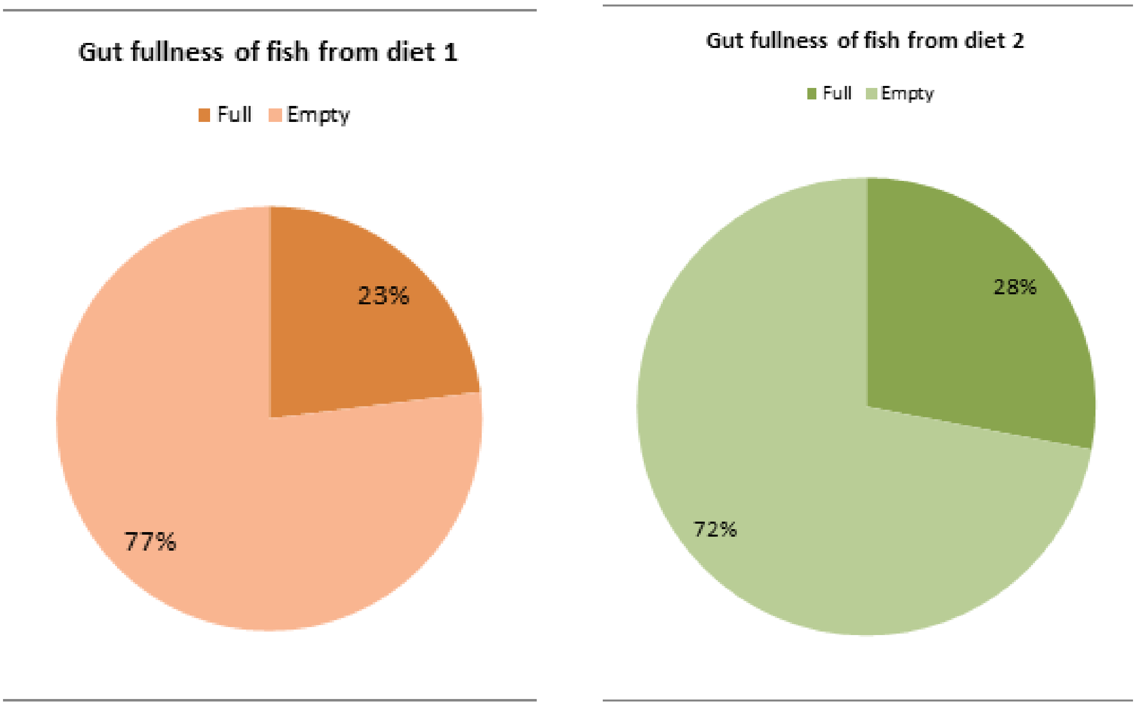

Figure 8. Percentage of gut occupied by natural food by different diets

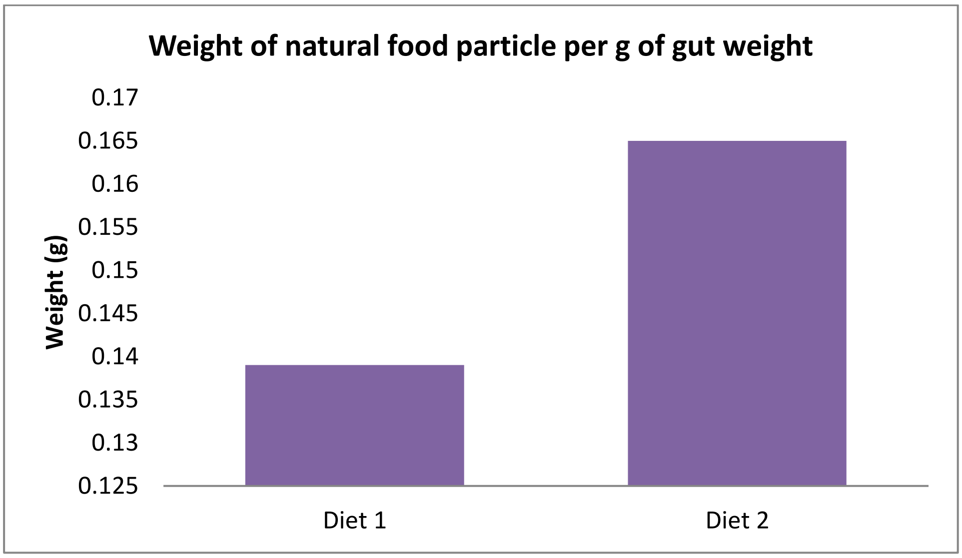

Figure 9. Weight (g) of natural food particle per g of gut weight

Protein content in the flesh of the fish produced in different treatments had no significant difference. However, with the diet1 at "no" and "low" feeding regime the protein content was lower than diet two. This might be due to less contribution coming from the matching natural food. It was only subsidized and came equal at high feeding level (Figure 10)

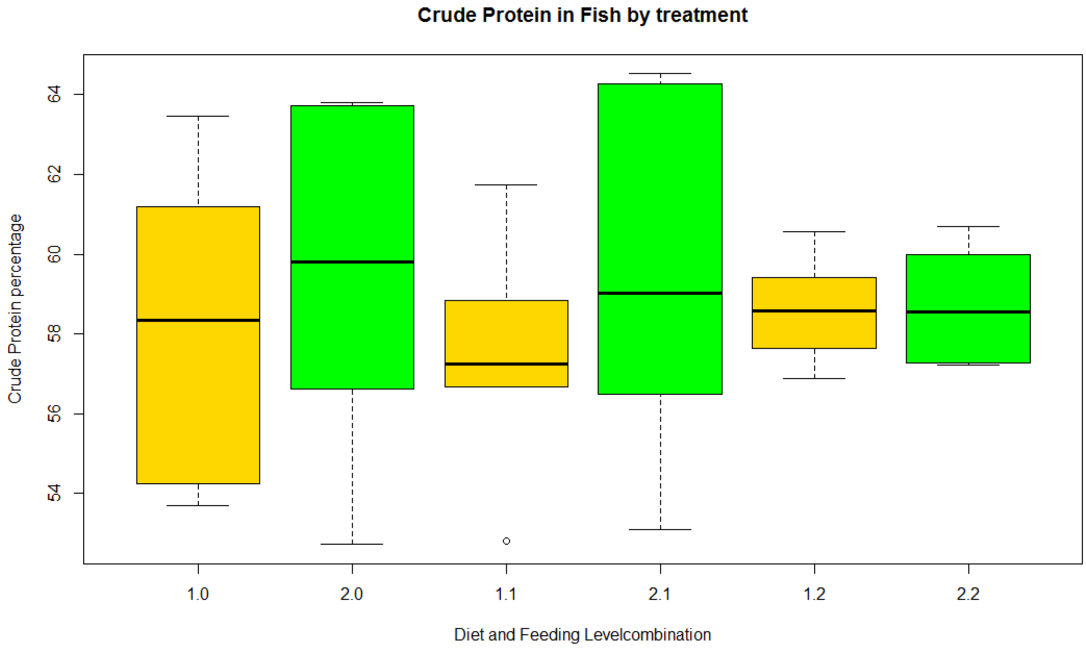

Figure 10. Percentage of crude protein in the fish produced under different treatments

Scatter plot matrix run in "R" to see the relation between the effect of diet and feeding on the dry matter (DM), crude protein (CP), crude fat (CLipid), crude fiber (CFiber) and Ash shows no clear trend or significant relation but a weaker retention in higher feeding level (figure 11). One factor might be at higher feeding level DO and other WQ parameters were not favorable. The limitation of this study was that we measured water quality parameters by pond not by compartment. This indicates that restricted feeding is more efficient to increase production in pond aquaculture without aeration.

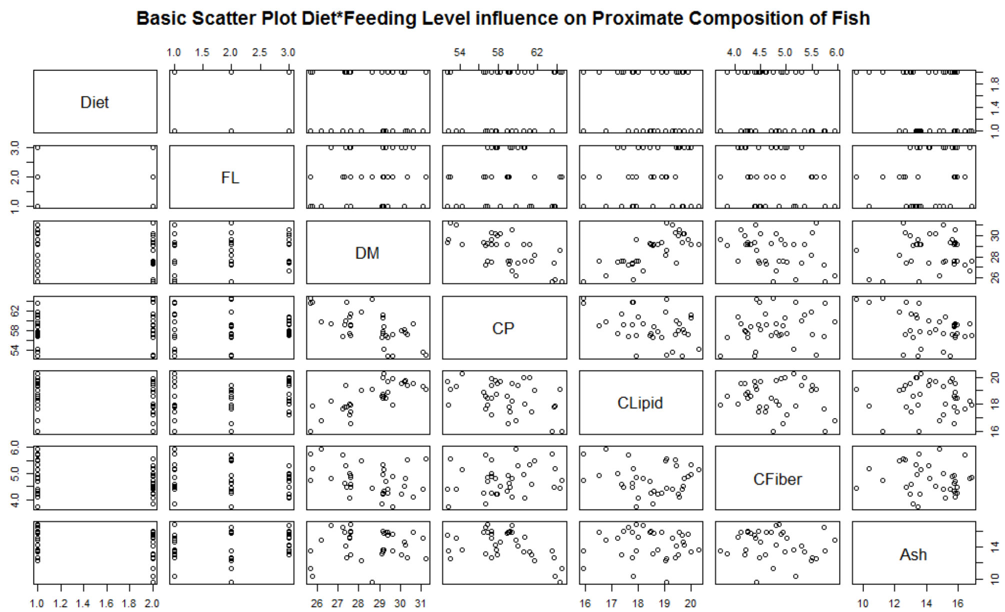

Figure 11. Scatter plot matrix to show relation between DM, CP, CLipid, CFiber and Ash with diet and feeding level (FL).

Validation of the results at farmers ponds

In March 2017 an additional research trial was conducted in 40 farmer's ponds to validate the results obtained from the experimental ponds. The ponds were ranging from 2.5 decimal to 14 decimal in size. We tested eight treatments - two different diets (table 1), two feeding level and two stocking densities (Table 4).

Table 4: Description of the treatments.

Treatment No	**IDs in the figures**	**Diet**	**Feeding level (average % of BW/Day)**	**Stocking density (fish/decimal)**
T1	2.2.2	CP 23%	3	120
T2	2.2.1	CP 23%	3	80
T3	2.1.2	CP 23%	2	120
T4	2.1.1	CP 23%	2	80
T5	1.2.2	CP 32%	3	120
T6	1.2.1	CP 32%	3	80
T7	1.1.2	CP 32%	2	120
T8	1.1.1	CP 32%	2	80

- Feeding schedule were prepared based on 18g/Kg^0.8 and 14g/Kg^0.8 which respectively became 3 and 2.5 % for a culture period of 90 days starting from mean fish BW 22g.

We stocked smaller tilapia fries (0.3g/fish) in pen nurseries for 3 weeks, counted them according to the treatment protocol and released into the ponds. During this phase we fed them commercial nursery feeds. Afterwards we feed them starter feed for two more weeks until they were able to intake our 3mm pellets produced for grow out stage. At that time their BW were measured separately in each pond and accordingly specific feeding schedule was prepared for each pond. Feed was provided twice a day. We monitored DO, pH, temperature, transparency and water depth in all ponds daily. In addition OM, N, P, and K of both soil and water were measured every month after beginning of experimental feed application in all farmer ponds. Fish BW were sampled at every fifteen days and feeding schedule was adjusted accordingly. While feeding survival was gradually lowered to grossly 80% considering the pond condition and little mortality noticed during the culture period. Feeding adjustment according to actual mortality were very difficult as the ponds were located scattered. No fertilization was applied except for pond preparation. Harvesting of fish were done by completely drying six ponds randomly in two location (Figure 12) and based on that a method was developed by counting the number of fish harvested in three attempts of the seine net and multiplied with the factor obtained by complete harvesting of the previous 6 ponds. Statistics for factorial analysis was done by two way repeated measure ANOVA in R and pairwise LSD test was also done in R.


Figure 12. Complete harvesting of fish by pumping out the pond water and then pulling the seine net

Results and discussion from farmers ponds

Fish growth both by individually (figure 13) and by unit area (figure 14) were higher in T3 and diet*stocking-density significantly influenced this performance. Highest individual growth 280g/fish/90days was observed in T3. Similarly highest yield 5.8mt/ha/90 days was also observed in T3.

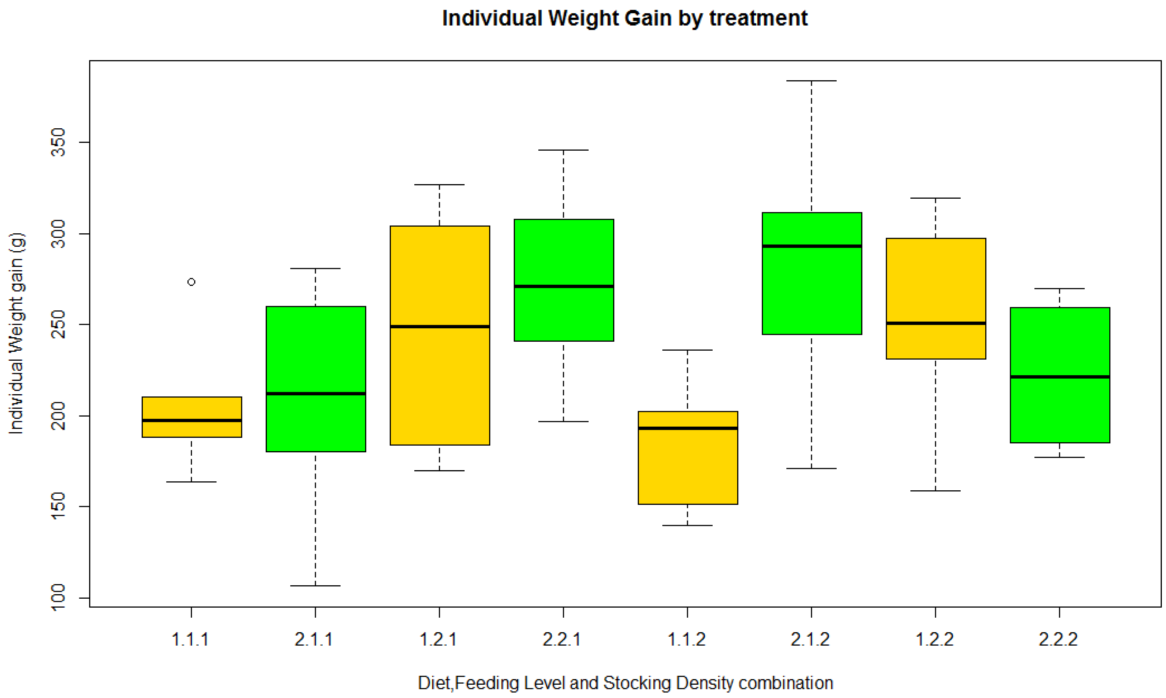

Figure 13. Individual weight gain by treatment

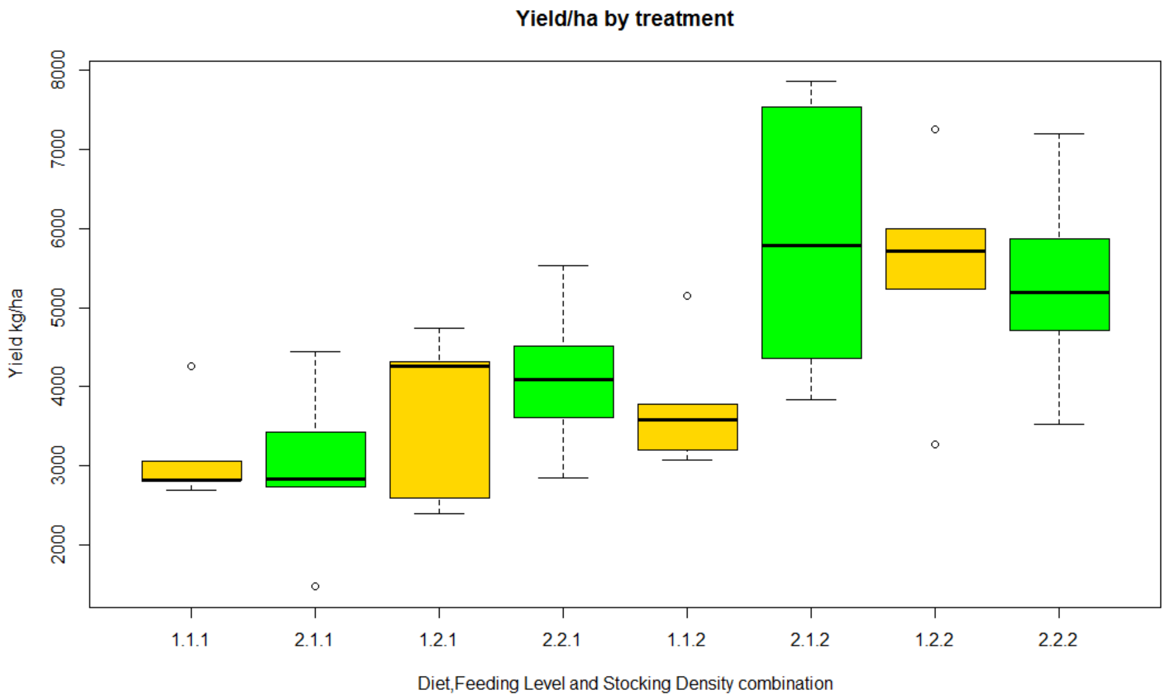

Figure 14. Yield (growth) per ha (unit area) by treatment.

Fish growth from the beginning of the experiment was consistent except T6 and T8. T5 showed higher growth until end of July and then dropped a bit (figure 15). Again this might be due to increase in water level helped in other treatments to allow to grow more natural feed as happened in experimental ponds.

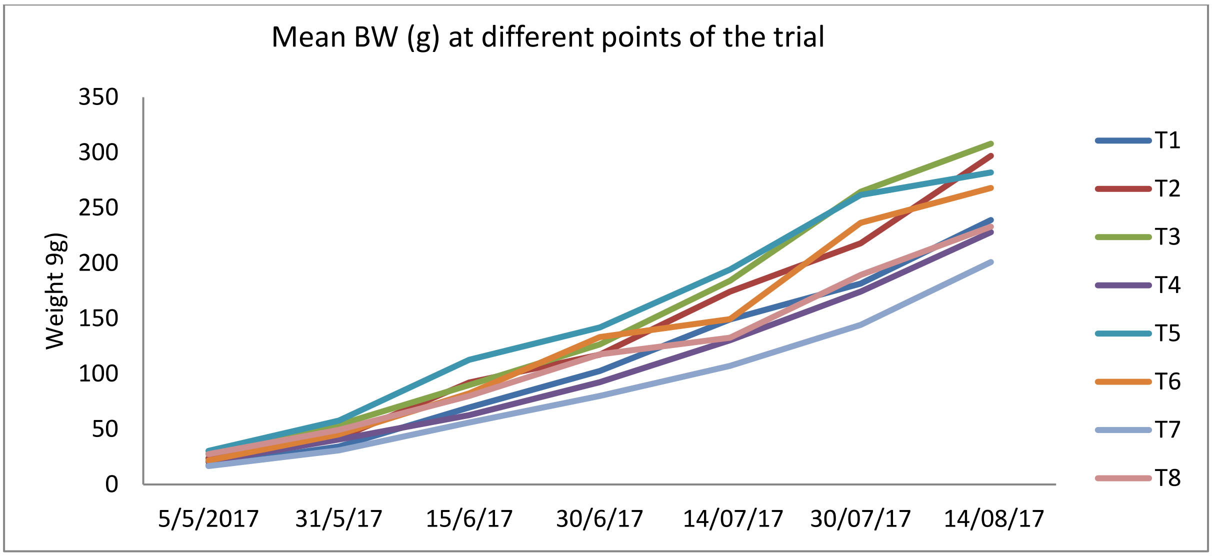

Figure 15. Growth of fish over time based on BW sampling data (except 1st and last point)

When we look at the interaction effect, yield in diet 1 gradually reduced with an increased stocking density (figure 16). Though there was no significant effect of diet on growth performance the better performing trend as in the experimental ponds continued in farmers pond. Pairwise LSD test only shows significant difference between T3 & T7. However, this might be due to variable pond size as the effect of pond size on fish yield was highly significant.

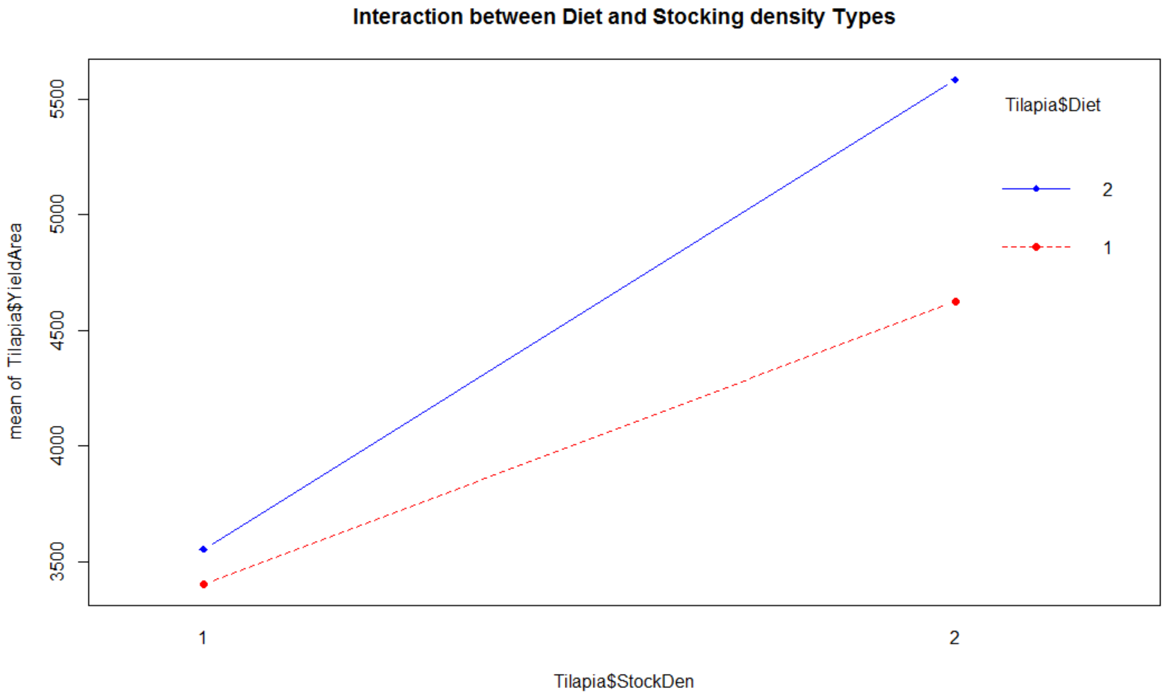

Figure 16. Diet*Stocking density interaction for tilapia yield (kg/ha)

Due to restricted feeding FCR in the best treatment, T3, was as low as 1. Survival was highest in T1 (figure 17), and was significantly influenced by feeding level only which also support the observation of experimental pond research.

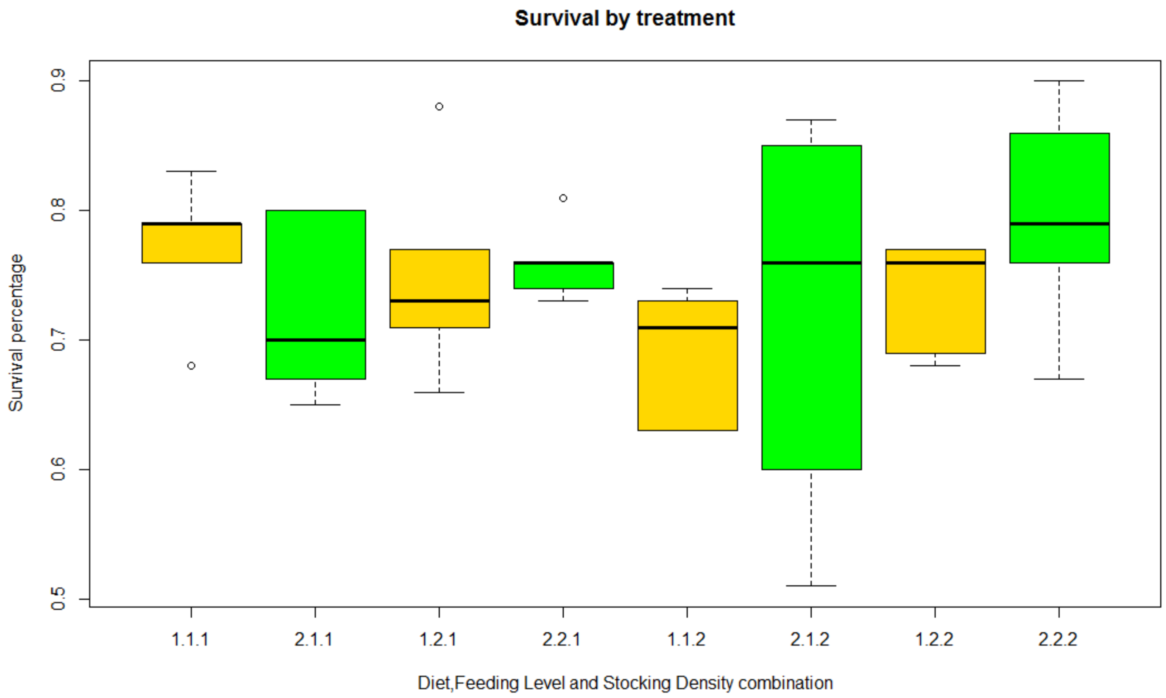

Figure 17. Survival of Tilapia by treatment

Final BW gain was significantly influenced by diet*FL*stocking-density (figure 18). And the best performance was in T3 which is a low protein, low feeding and high stocking density treatment. Thus it indicates that high feeding is not required for a production target between 10-12mt/ha/year.

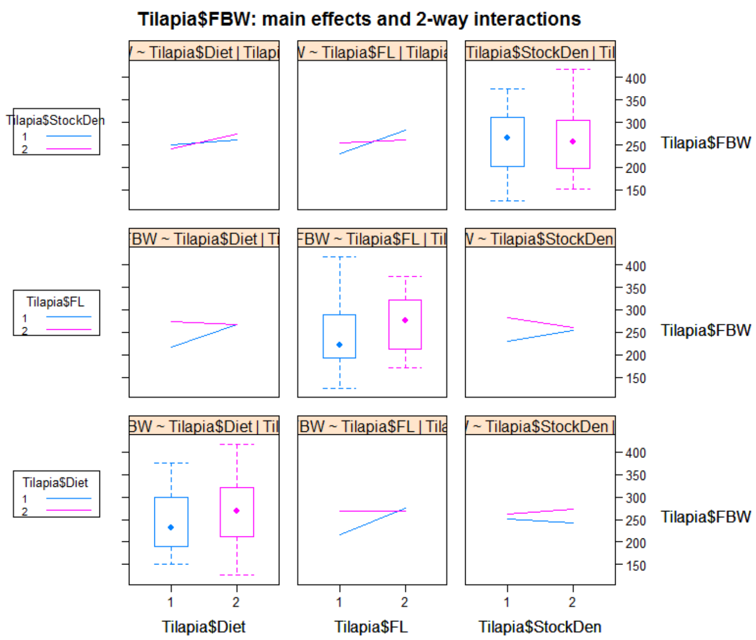

Figure 18. Diet*FL*stocking-density interaction for final BW of Tilapia

Calculating the water used for a crop considering the mean water depth and pond area the most efficient treatment (T3) could produce 1mt fish by using only ~1500 cubic meter water. The effect of diet, feeding level and stocking density on aquatic environment in term of nutrient accumulation is not significant. However, in the high protein diet we noticed higher accumulation of N (figure 19) in the soil which might have impact on lower efficiency and productivity of fish by diet 1.

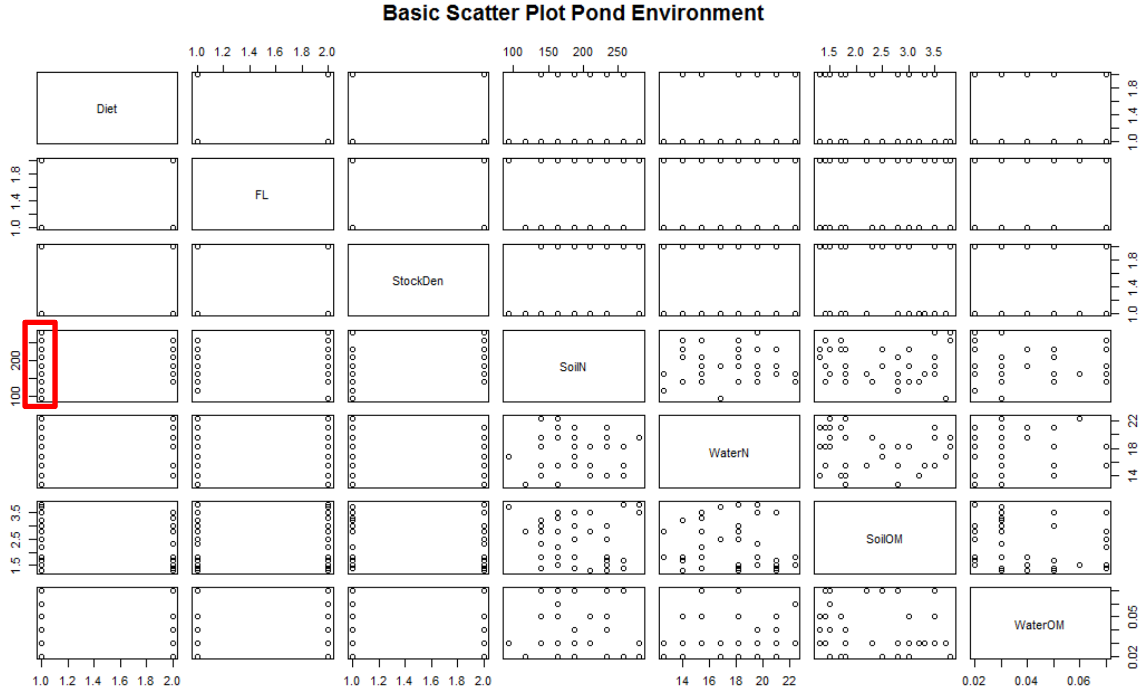

Figure 19. Effect of diet and feeding level on soil and water N and OM

Benefit cost ratio (BCR) is also maximum in T3 (1.62) and the minimum for T4 (0.97). The cost is calculated based on average and local market price. The calculation is based on one decimal area for each treatment. Expected price of low protein feed is 45 BDT/kg and regular protein feed which is compared to available tilapia fish feed in local market is considered 50 BDT/kg. Labor cost, net price, land rent, pond maintenance cost, pond construction cost are estimated for 100 days. Ponds life is estimated for 20 years and net life is for 3 years. Expected time for feeding and others is estimated 40 min/ day and labor cost 200 BDT/ day. Price of tilapia fish is considered 100 BDT/kg. Considering all the factors associated will production cost BCR is negative for T4&T8 (Table 5). Though FCR was only 1.08 and 1.07 respectively in the two treatments, the major responsible factor is low yield.

Table 5: Benefit cost ratio of tilapia fish culture (cost mentioned in BDT)

	T1	T2	T3	T4	T5	T6	T7	T8
Feed	1,116	864	1,048	553	1,625	875	880	680
Labor	258.0	258.0	258.0	258.0	258.0	258.0	258.0	258.0
net	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Rent (land)	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Other input	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Seed	120.0	80.0	120.0	80.0	120.0	80.0	120.0	80.0
Pond maintenance cost	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Pond construction	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Production cost/ decimal	1,884	1,592	1,816	1,281	2,393	1,603	1,648	1,408
Fish sale price	2463	1825	2938	1248	2470	1664	1677	1395
BCR	**1.31**	**1.15**	**1.62**	**0.97**	**1.03**	**1.04**	**1.02**	**0.99**

When BCR is calculated only based on variable cost and excludes labor (often own labor) all the treatments appeared much profitable compared to actual BCR (Table 6).

Table 6: Benefit cost ratio of tilapia fish culture (cost mentioned in BDT) excluding permanent cost, rent value and labor (often own) cost

	T1	T2	T3	T4	T5	T6	T7	T8
Feed	1,116	864	1,049	554	1,625	875	880	680
Labor								
net	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Rent (land)								
Other input	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Seed	120.0	80.0	120.0	80.0	120.0	80.0	120.0	80.0
Pond maintenance cost								
Pond construction								
Production cost/ dec	1,436	1,144	1,369	834	1,945	1,155	1,200	960
Fish sale price	2,463	1,825	2,938	1,248	2,470	1,664	1,678	1,395
BCR	**1.72**	**1.60**	**2.15**	**1.50**	**1.27**	**1.44**	**1.40**	**1.45**

Based on the above production performance it is concluded that the low protein diet does not reduce fish productivity and the feed manufacturing cost estimated in consultation with couple of commercial company indicates a reduction of manufacturing cost upto 10%. Moreover, using best performing treatment the production cost can be reduced upto 30% compared to the other treatments.

Dissemination of knowledge through sharing and extension

Inception workshop

Figure 20. Inception workshop in Dumuria

Two inception workshops were organized in Batiaghata and Dumuria to share the innovation concept with local stakeholders and involve them in the process of our research and development interventions. Couple of recommendations was made by the participants. Among them the relevant points were considered in planning next activities.

Nine learning sessions were conducted at both the locations targeting only the research farmers to build their capacity on the contents (Annex 2). These were hands on learning and couples with cross visits among other treatments of the same village. Reflections of field trial in addition to the content were discussed. The sessions were arranged for learning and building research farmers capacity to share their knowledge to other farmers. These series of learning sessions brought positive changes in farmers knowledge and skill in major areas of aquaculture management (figure 21).

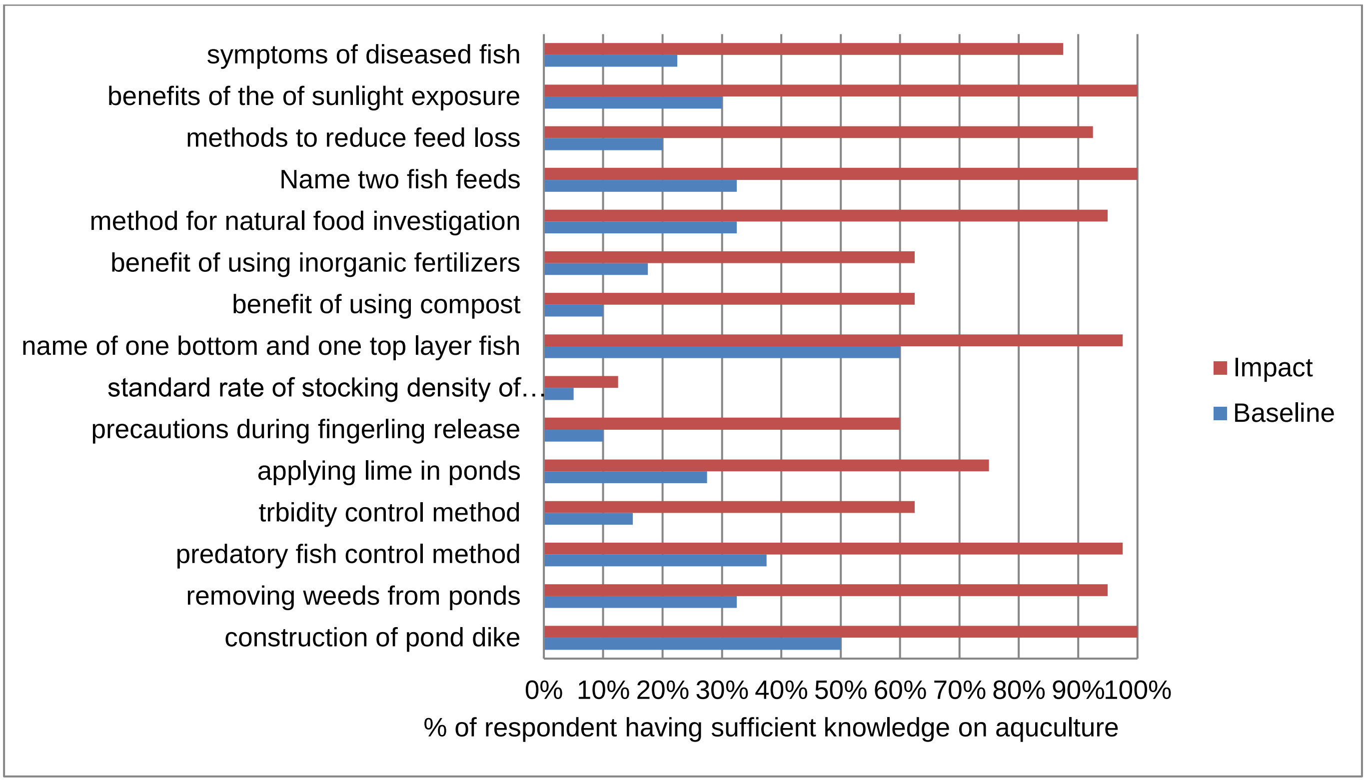

Figure 21. Knowledge of respondents on aquaculture before and after the learning sessions.

The learning sessions developed interest, improved technological aspect and gathered more market information (figure 22). However, this made no impact on the input supply and their perception of investment requirement for intensification of aquaculture became clearer and more people realized that they are lacking investment capital

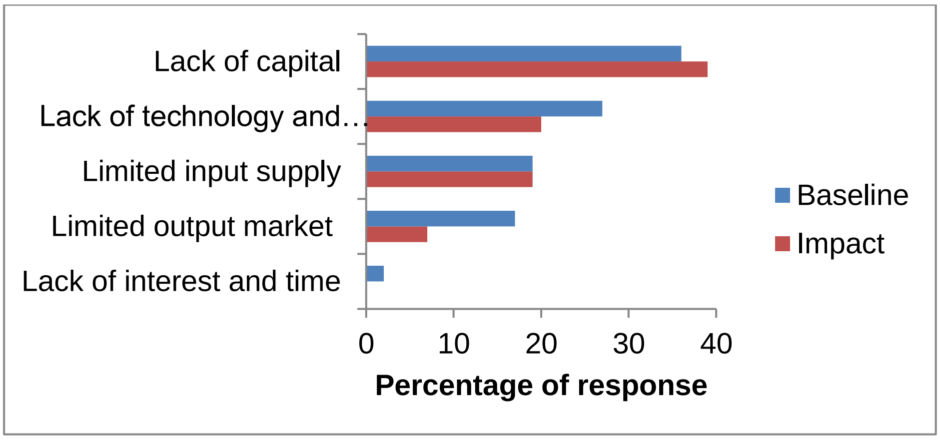

Figure 22. Response of farmers on challenges of aquaculture intensification.

Each month farmers after the learning session were engaged in cross visit to observe the difference between different treatments in their village. This was designed to make farmers understanding of different outcomes from different feed and feed management practices. After each cross visit in the learning session there were comprehensive discussion to explain individual outcome by treatment and variations within the treatment. At end this created a sense among the farmers of what sort of pond they have, how suitable they are for aquaculture and which approach and management practice is more beneficial for them.

Figure 23. learning session and on site explanation of the cross visit outcomes

Improving linkage between Local service providers (LSPs) and fish farmers

The main purpose of the meeting was to establish professional relationship between the groups. Of them one was service providers and the other were fish farmers as service receivers. Fish farmers need many interventions like fish fry, lime, fertilizer, net, feed, medicines, technical services, fishermen and others. Some other interventions are required like selection of harvesting time, where to sale, and how to keep quality for best price. All these issues are equally important for intensive aquaculture.

The service providers (LSP) informed about the services they can provide and the farmers shared the services they usually require. To introduce their services a LSP said

'If fish farmer calls me for any problems related to fish culture, I will be available anywhere and anytime within the quickest time. I had supplied huge amount of virus free fingerlings to these areas last year and got income. We also can support you by testing different parameters of water and soil as we have kits.'

From the meeting it is found that LSP usually supports at every stages of fish culture. They usually offer their members in

- Pond/ gher preparation
- Fingerlings, feed and medicine supply
- Water quality check i.e., pH, Salinity, etc.
- Expert opinion on a problematic condition i.e., low dissolved oxygen, turbidity
- Manage emergency situation if pond water becomes contaminated by some ways
- Contact to the upazila office (agriculture, fisheries, and livestock) for expert opinion at critical situation
- Harvesting and selling fish (when to harvest, where to sale to get higher price)

After hearing from LSP, farmers shared their necessities and wanted to know how they can be supported and how much is to pay to get services. The farmers asked different questions to LSPs and they responded mentioning different possible reasons and mentioned some ways to solve the problem.

Farmers participatory evaluation

All the 40 Tilapia fish farmers participated to the evaluation process. The fish farmers who adopted same culture seated and discussed together. At the beginning, the purpose and programs were described in detail.

The farmers introduced each other and discussed their experience on pond preparation, feed use, survival, average weight, yield etc. They were equipped with different sized papers, types of pens and markers and requested to write their experience separately and finally accumulate forming consensus among them. Special character or issues were requested to write separately. One of the group members were requested to present their experience and other farmers discussed on their results. Field trial results including FCR and BCR were also discussed and explained by treatment.

Most of the farmers who adopted T1, T3, T5 and T8 were satisfied with the survival rate and growth. The production was better than the previous year. The difference of size and yield were similar to each other within the groups. T8 group members were very much satisfied with the fish culture technology. Most of them within the groups had similar experience and no one complain regarding fish size, total yield, feeding level and others. T1 farmers have complained that the amount of feed was lower than the necessity.

Figure 24. One farmer presenting their group observations

Those who adopted T2 had different opinion. Some of them said that the survival rate was nearly 80% and average body weight of fish rages from 300 to 500 grams. They were satisfied with both growth and total yield but the other farmers said that the average weight of their fish was from 200 gram to 250 gram. They were satisfied with survival rate but not with size of the fish. They informed that sunlight was not easy to be exposed to their ponds and that may be a reason for less growth. All the farmers were satisfied with the learning process of fish culture.

The farmers with T4, T6 and T7 complained that the survival rate was not satisfactory to them compared to other groups. Growth was not also less than their neighbors participated in this research. Few of the ponds were shaded and the amount of feed was lower than the necessity according to their perception. The difference was higher among the group members and the reasons were water low water depth, high water temperature and shade in few cases. Earlier they were not used to provide feed at a fixed place of pond and also not providing supplementary feed in most of the cases. After the project they become accustomed in using feeding ring and know the benefit of using commercial feed. Farmers from these groups have realized shade and water depth are critical limiting factor for fish growth and hence yield.

Training of trainers on feed formulation and feed management

Four, day-long training of trainers (ToT) were arranged. Total 48 professionals dividing into 4 groups were participated to the programs. First day the LSPs and Local Extension Agent for Fisheries (LEAF) by DOF, 2nd day WMG members from Batiaghata and NGO staffs, 3rd day CFC (community feed center) owners and finally on day 4th the WMG members from Dumuria participated to the training. The purpose of ToT programs was to share the knowledge gained through trial so that they can support the farmers to their community. They were also taught different issues like session management, how to deliver, what to do to arrange and maintain training program, etc.

Figure 25. Training of Trainers on better feed management in tilapia culture

During ToT, they were shown the comparative results of different treatment of the trial in farmers' pond with FCR and BCR. During discussion, causes of difference in yield and growth among treatment were also discussed. Purpose of such discussion was to help them to understand cost and benefit related issues so that they can support farmers of their locality to select appropriate technique of intensive tilapia fish culture.

There were technical sessions on aquaculture planning, defining stocking density, understanding on feed quality and feed management for tilapia culture in ponds. Some areas of culture management specially nursing and feeding approach at this stage were also discussed broadly. At the end of sessions, they were taught in planning farmers training at the field level and session planning for the training. Finally they were equipped with farmers' training materials and ToT manual (annex 3).

During the TOT the knowledge about the technical aspects increased positively (figure 26). However, it is also evident from the evaluation that clearer understanding on these issues are not completely achieved and requires longer term intervention.

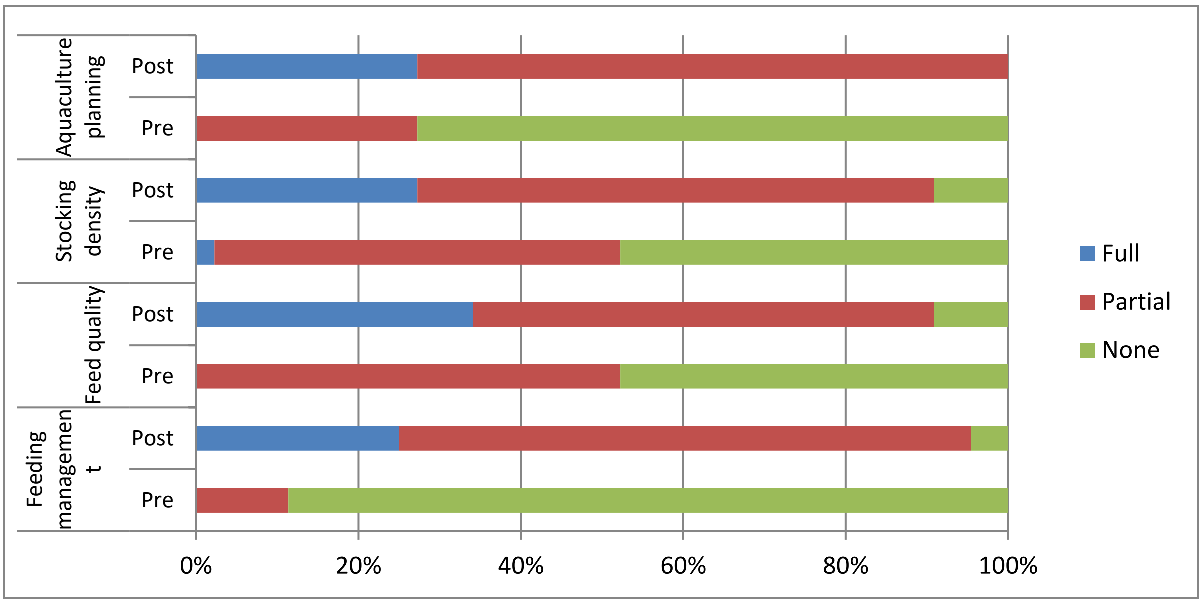

Figure 26. Changes of knowledge in the technical aspects discussed during the TOT

Training of farmers

Around 500 farmers were trained on feed management in tilapia culture. Technical contents of the training were aquaculture planning , knowing the right stocking density, understanding on balanced feed and efficient feed management at nursery and grow-out ponds. Research results were also shared with the participants. Around half of the farmers were from Taltola, Rodakhora, Borodanga, Sahosh modhyopara, Kusharhula, Jhilerdanga, Sahosh kumar ghata, and nearby villages under polder 29 (Dumuria). The other half were from polder 30. The farmers were from Boyarvanga, Chorkhali, Hatbati, Sundormohol, Gojamari, Jolma, Gonggarampur, Debitola, Gandhamari, Barariya, Hogolbunia, Hatbati dokkshin para villages under polder 30. More than half of the participants were female.

Figure 27. farmers' training and feed distribution

At the end of training each participant was given 4 kg feed aiming to create interest among them to use feed and start planning to intensify aquaculture in their ponds.

Developing and printing of extension materials

Feed management guide book was designed as part of extension materials. 1000 copies are in the process of printing and will be distributed among the farmers of Batiaghata and Dumuria. The book

“Bokuler Golpo (story of Bokul)”contains the messages of planning intensive tilapia aquaculture, feed management, fertilization and its necessity, fingerlings release, and other related issues (Annex 4). In addition Training of trainers manual on better feed management for tilapia culture in ponds (Annex 3) has also been developed.

External visits

Project activities were visited by the Project coordinating director(PCD) and Deputy Chief Fisheries (DCF) and Sustainable Value Chain Advisor (SVCA) of Blue Gold; Director, Aquaculture and Fisheries of WorldFish; Director, Agriculture of Bill & Melinda Gates Foundation and Program Oversight team of this project. Other important visitors were Program leader of Nutrition and Value Chains and Business development Consultant of WorldFish HQ. Also representatives from DoF visited the low cost Tilapia feed project areas to oversee the research activities. The results and experiences gained through the project were shared with the team and they appreciated the concept and its potential impact on tilapia culture.

Figure 28: WorldFish and Bill and Melinda Gates Foundation representatives visits our activities in Dumuria

Figure 29: PCD, DCF and SVCA visits our activities in Dumuria

Sustaining technology transfer through private sector linkage

Making feed more accessible by the small scale producers

Fish feed distribution to remote parts of the project areas are often challenging. Aquaculture yet didn’t emerge as an industry in this areas rather improving slowly from subsistence practice. To many farmers using feed is only an ambitious plan as they don’t have enough money and right technology to apply. Restricted but regular feeding (T3) can be a good option for this type of farmers to start gradually intensification of their system. Community feed centers(CFCs) can play important role in bridging the gap of fish feed distribution in those locations either by producing quality feed or by supplying commercial fish feed at an affordable price to the farmers. In the tri-party (CFC, feed ingredient seller and division level representatives of commercial feed companies) linkage event in the first half ingredient suppliers and community feed center owners interactive at very participatory manner to find their way of working more effectively, collected product lists from the suppliers and set a negotiation for discounted price (figure 30). This will help the community feed centers to produce the new feed at an affordable rate. Besides in the second half of the day CFC owners together with regional representatives of the commercial feed companies worked out on couple of pathways to collaborate including CFCs acting as small scale dealer at the community and proposed to access bulk ingredients from the commercial feed companies which policy level negotiation. A commitment by all the parties were made to disseminate the research output and working together to make feed accessible in their own community. A list of potential local ingredients were also prepared of which 2-3 were non-conventional and requires intensive testing before start to use those at commercial level. One of the major challenge identified by the CFC owners is not getting the quality ingredients and wholesale price. This makes them less competitive.

Figure 30. Linkage event between fish feed ingredients sellers, CFCs and commercial feed company agents at Khulna level.

Increasing national and international interaction for quality improvement

De Heus, a well reputed international fish feed producer, had limited interest and collaboration in Bangladesh. We identified this company as potential international collaborator to support our national companies by technical cooperation and also as a good vehicle to create competition in the fish feed market for quality products. This collaboration started with couple of meetings at their HQ in Ede, Netherlands and in WUR. This was followed by two separate meeting with their team in Bangladesh who are more involved in market development and business expansion. Finally they agreed to collaborate with us regarding on-station trial at the experimental ponds. They also realized the market potential in BD and are keen to start a joint venture fish feed factory in Bangladesh.

Figure 31. De Heus representatives visited Bangladesh.

Support national industry to increase profitability by sharing the research

Result sharing workshop was organized in Dhaka on 20 September 2017 with key industry representative, and senior management of DOF, BFRI, FAO and national media (The Daily Samakal) aiming at presenting results of new fish feed formulation and invite discussions from relevant expert personnel.

Figure 32. Group photo during the result sharing workshop

After the formal inauguration and introduction the technical findings were presented. Some of the key findings were very controversial with the conventional thinking of feed formulation and management. Thus the later part of the workshop raised more question than answer and emphasized on gathering more evidence by doing new research based on the findings of this innovation project. DOF and FAO were interested to take it forward in their coming interventions.

These created further room for discussion on better feed management, low FCR, feeding practices, lowering operating cost and tweaking the protein usage guidelines of the fish feed act. FAO recently launched "Resilient Tilapia Aquaculture Project" where they agreed to adopt our restricted feeding schedule.

One of the ways to build further evidence and create trust among the researcher and industry is working jointly.

Major Challenges and potential mitigation measures

Major challenges faced during implementation of this innovation grants and possible mitigation measures are illustrated in table 7.

Table 7. Major challenges and possible mitigation measures

Challenges	Mitigation measures
Short project life	Flexibility in duration while awarding the grant based on nature and extent of activities
Making trial feed	Feed factories in Bangladesh can't make smaller quantity of feed. Our collaboration with De Heus through Wageningen University was very effective in solving this. They have an R&D unit in Vietnam and they produces all sort of animal feed. Price including shipping is also acceptable for research. In future any project dealing with animal feed experimentation might contact De Heus.
Prolonged and dry summer	Flexibility in the project life might be helpful in accommodating the effect of adverse condition by shifting or extending the culture cycle Area selection for project implementation can take it into consideration. So, areas with alternative water source and easy access to water exchange might be also useful.
Convincing farmers on the new innovation	In the process of testing an innovation, it requires highest effort to make farmers understand and accept the concept. For our case we took help from our colleagues working in the same field with other WorldFish projects. So, institutional capacity can be a big consideration while approving an ambitious project
Failure to make the Video documentary	Planning well ahead could help achieving all targets
Interaction and coordination between different government departments	Multilayer – central and local level – communication.
Involving industry in research process	In Bangladesh industries are often reluctant in participating in research. Changing the practice requires their active involvement. A small grant might be awarded to organize a platform of industries who will be actively collaborate with innovation approaches. It can consider future Blue Gold innovation investment areas.

Conclusion and key messages

Component 1: Building knowledge base through research trial

- Fishmeal used in the recommended diet was only 3%.
- Feed manufacturing cost can be reduced upto 10% by adopting low protein diet.
- Tilapia production cost can be reduced upto 30% by using the management practice followed in treatment three. This can motivate farmers to go for sustainable intensification of their production system.
- Practicing restricted feeding can keep the FCR as low as 1 at grow out phase (mean FCR for all treatments was 1.16) and maintain water quality in the pond suitable for fish growth.
- High stocking density (120/decimal) resulted in better yield. Based on this further research can be carried out to optimize stocking density with and without aeration for more intensive production and increase water use efficiency
- For producing 1mt. fish ~1500 cubic meter water was used which is less compared to extensive and many semi-intensive systems in Bangladesh.
- Production potential can be reached upto 11mt/ha /year by growing two cycle of tilapia which is 3 times higher than national average fish production per ha.
- Application of low protein diet will reduce N accumulation in pond bottom thus helps lowering environmental impacts from aquaculture.

Component 2: Dissemination of knowledge through sharing and extension

- Couple of knowledge dissemination and extension activities were organized including learning sessions and cross visits for research farmers, TOT for community leaders and extension agents, presentation of the concept at the local fish week events and press briefing, training of interested farmers and package of fish feed as an incentive for the participants; which brought positive changes in their knowledge. However, to translate this into practice needs longer term intervention to bring them out of their deep rooted believe on high protein diet, over feeding and over stocking at their ponds. Interventions like awareness creation on sustainable intensification of aquaculture and behavior change activities towards better feed and system management based on the research findings might be useful.
- One of the effective drivers for change can be making credit easily accessible for the small and medium scale farmers. This can be done either by negotiating with credit providing NGOs/Banks, contract farming or increasing the extent of credit facility to small and medium scale farmers by the feed companies which are currently restricted only to the large scale commercial producers.
- Two extension materials – farmers field guide book and training of trainer's manual for better feed management in tilapia aquaculture is produced. This can be distributed widely through on going aquaculture development projects.
- We explained and demonstrated the concept and its success to national (i.e. DOF and BWDB) and major international (i.e. Bill & Melinda Gates Foundation, WorldFish Global Leaders and CSRIO) institutes. To bring the success of this concept in application and create larger and global impact collaborative future planning is essential.

Component 3: Sustaining technology transfer through private sector linkage

- Collaboration between Dutch and Bangladeshi fish feed industry has been strengthened than before and joint investment for industrial set up is more likely to take place.
- Bangladesh feed industry is interested about the concept but still remains cautious in terms of application of this finding. They don't want to take risk in their production line. They want to build more evidence of success of the new feed formulation. One of the major ways of building trust might be conducting similar research jointly with the industry. Also for industrial application National Feed Act needs to be amended to accommodate the lower level of protein
- This formulation was more useful for small scale feed producers who can't compete with the commercial company due to higher production cost. Now with the new formulation they can lower the production cost and can expand their local market. However, to produce quality fish feed by this semi-auto feed millers at competitive price; they need easier access with the ingredient suppliers. A linkage event strengthened this collaboration which the users need to take forward for their own benefit.
- Several collaborative working opportunities were identified at field level commercial feed company representatives and semi-auto feed millers. However, implementation of those activities needs more dialogue with the policymakers if the commercial feed companies.

Next steps . . .

- Scaling better feed management practice through ongoing and new aquaculture development projects.
- Generating more evidence and building trust with industry by working together.
- Creating synergy among all actors of fish feed industry to influence the farmers on using feed for sustainable intensification
- Policy level communication with government to convince them to change the Feed Act to allow the practical application of the innovative concept for longer term sustainability of the sector and to increase benefit for feed industry, fish producer and fish consumer.

Annex

Annex 1: Farmer and Pond selection criteria

Farmer selection criteria:

- Interested in Tilapia monoculture at semi intensive level
- Have capacity and strong interest to adopt and practice small scale semi-intensive aquaculture
- At last 50% women
- Poor farmers – preferable according to HIES criteria upto marginal category
- Strong interest and track record in innovation, learning, leadership at community level and knowledge sharing within and beyond community
- Have capacity and interest to collaborate with private sector and LSPs
- Agreed with the ToR from WorldFish for participation in the research activities.
- Farmers will be interested investing their time and intelligence and living.
- Agreed to join meeting, workshop and visits.
- Member of WMG

Pond selection criteria:

- Average size 5 decimals, maximum 10 decimal – total 36 ponds
- Sunny pond preferred
- Near the road side
- Perennial ponds
- Farmer agreed to kill relevant fish to increase efficiently of the research

Annex 2: Structure of the learning session

Session 1: Basics of pond based aquaculture (before the trial begins)

Session 2: What is sustainable intensification and why we need this? What farmers can do and how?

Session 3: How fish grow? What they eat? Why we need to give nutrient (or food for fish) in ponds?

Session 4: How much we can intensify our production system –

Session 5: sampling and monitoring of your pond – any contrast between the groups (treatments)

Session 6: What type and how much feed we should? How we can maximize feed input efficiency? Managing water quality and planktonic bloom at aquaculture ponds

Session 7: Water exchange, bottom soil use and environmental concerns

Session 8: Maximize benefits from your resource – increase profitability by reducing production cost towards sustainable intensification

Session 9: Compare the outcomes of your research trial and try to reflect on your learning

Annex 3: TOT Manual on feed management in Tilapia Aquaculture

তেলাপিয়া চাষের খাদ্য ব্যবস্থাপনা

প্রশিক্ষক প্রশিক্ষণ সহায়িকা

Tilapia Feed Research Project

WorldFish Bangladesh Office

URL: https://www.dropbox.com/sh/j0s0aw3cqyj72sj/AABlV9ZQeYGkajB1s77TNqyAa?dl=0

Annex 4: Farmer's guidebook on feed management in Tilapia Aquaculture

URL: https://www.dropbox.com/s/9lg0d2czia3jrhp/FInal%20   %2008.10.2017.pdf?dl=0

Annex 5: Two different feeding schedules for sustainable intensification tilapia culture.

Day	Regular Feeding (% of body weight)	Expected BW (g)	Reduced Feeding (% of body weight)	Expected BW (g)	Expected survival
1	4.3	10.41	3.4	10.35	100
2	4.3	10.84	3.4	10.70	100
3	4.3	11.27	3.4	11.07	100
4	4.2	11.73	3.3	11.45	100
5	4.2	12.19	3.3	11.83	99
6	4.2	12.67	3.3	12.23	99
7	4.1	13.17	3.3	12.64	99
8	4.1	13.68	3.3	13.06	99
9	4.1	14.21	3.2	13.49	98
10	4.1	14.76	3.2	13.93	98
11	4.0	15.32	3.2	14.38	98
12	4.0	15.90	3.2	14.84	98
13	4.0	16.49	3.2	15.32	97
14	3.9	17.10	3.2	15.81	97
15	3.9	17.74	3.1	16.31	97
16	3.9	18.39	3.1	16.82	97
17	3.9	19.06	3.1	17.35	96
18	3.8	19.74	3.1	17.89	96
19	3.8	20.45	3.1	18.44	96
20	3.8	21.18	3.1	19.01	96
21	3.8	21.93	3.0	19.59	95
22	3.7	22.70	3.0	20.18	95
23	3.7	23.49	3.0	20.79	95
24	3.7	24.31	3.0	21.41	95
25	3.7	25.14	3.0	22.05	94
26	3.6	26.00	3.0	22.71	94
27	3.6	26.89	2.9	23.37	94
28	3.6	27.79	2.9	24.06	94
29	3.6	28.72	2.9	24.76	93
30	3.5	29.68	2.9	25.48	93
31	3.5	30.66	2.9	26.21	93
32	3.5	31.67	2.9	26.96	93
33	3.5	32.70	2.8	27.73	92
34	3.5	33.76	2.8	28.51	92
35	3.4	34.85	2.8	29.32	92
36	3.4	35.97	2.8	30.14	92
37	3.4	37.11	2.8	30.97	91
38	3.4	38.28	2.8	31.83	91
39	3.4	39.49	2.8	32.71	91
40	3.3	40.72	2.8	33.60	91

Day	Regular Feeding (% of body weight)	Expected BW (g)	Reduced Feeding (% of body weight)	Expected BW (g)	Expected survival
41	3.3	41.98	2.7	34.52	90
42	3.3	43.28	2.7	35.45	90
43	3.3	44.61	2.7	36.41	90
44	3.3	45.97	2.7	37.39	90
45	3.2	47.36	2.7	38.38	89
46	3.2	48.79	2.7	39.40	89
47	3.2	50.25	2.7	40.44	89
48	3.2	51.74	2.6	41.50	89
49	3.2	53.27	2.6	42.59	88
50	3.1	54.84	2.6	43.69	88
51	3.1	56.44	2.6	44.82	88
52	3.1	58.08	2.6	45.97	88
53	3.1	59.76	2.6	47.15	87
54	3.1	61.48	2.6	48.35	87
55	3.1	63.24	2.6	49.57	87
56	3.0	65.04	2.5	50.82	87
57	3.0	66.87	2.5	52.10	86
58	3.0	68.75	2.5	53.40	86
59	3.0	70.68	2.5	54.72	86
60	3.0	72.64	2.5	56.08	86
61	3.0	74.65	2.5	57.45	85
62	2.9	76.70	2.5	58.86	85
63	2.9	78.80	2.5	60.29	85
64	2.9	80.94	2.5	61.75	85
65	2.9	83.13	2.4	63.24	84
66	2.9	85.37	2.4	64.76	84
67	2.9	87.66	2.4	66.31	84
68	2.9	89.99	2.4	67.89	84
69	2.8	92.37	2.4	69.49	83
70	2.8	94.81	2.4	71.13	83
71	2.8	97.29	2.4	72.80	83
72	2.8	99.83	2.4	74.50	83
73	2.8	102.42	2.4	76.23	82
74	2.8	105.06	2.4	77.99	82
75	2.8	107.76	2.3	79.78	82
76	2.7	110.51	2.3	81.61	82
77	2.7	113.32	2.3	83.47	81
78	2.7	116.19	2.3	85.37	81
79	2.7	119.11	2.3	87.30	81
80	2.7	122.10	2.3	89.26	81
81	2.7	125.14	2.3	91.26	80
82	2.7	128.24	2.3	93.30	80

Day	Regular Feeding (% of body weight)	Expected BW (g)	Reduced Feeding (% of body weight)	Expected BW (g)	Expected survival
83	2.6	131.41	2.3	95.37	80
84	2.6	134.63	2.3	97.48	80
85	2.6	137.92	2.2	99.62	80
86	2.6	141.28	2.2	101.81	80
87	2.6	144.70	2.2	104.03	80
88	2.6	148.18	2.2	106.29	80
89	2.6	151.73	2.2	108.59	80
90	2.6	155.36	2.2	110.93	80
91	2.6	159.04	2.2	113.31	75
92	2.5	162.80	2.2	115.73	75
93	2.5	166.63	2.2	118.19	75
94	2.5	170.54	2.2	120.69	75
95	2.5	174.51	2.2	123.24	75
96	2.5	178.56	2.2	125.83	75
97	2.5	182.68	2.1	128.46	75
98	2.5	186.88	2.1	131.13	75
99	2.5	191.16	2.1	133.85	75
100	2.5	195.52	2.1	136.62	75
101	2.4	199.95	2.1	139.43	75
102	2.4	204.46	2.1	142.29	75
103	2.4	209.06	2.1	145.19	75
104	2.4	213.74	2.1	148.14	75
105	2.4	218.50	2.1	151.14	75
106	2.4	223.35	2.1	154.19	75
107	2.4	228.28	2.1	157.29	75
108	2.4	233.30	2.1	160.43	75
109	2.4	238.41	2.0	163.63	75
110	2.3	243.60	2.0	166.88	75
111	2.3	248.89	2.0	170.18	75
112	2.3	254.27	2.0	173.53	75
113	2.3	259.74	2.0	176.93	75
114	2.3	265.31	2.0	180.39	75
115	2.3	270.97	2.0	183.90	75
116	2.3	276.72	2.0	187.46	75
117	2.3	282.58	2.0	191.09	75
118	2.3	288.53	2.0	194.76	75
119	2.3	294.59	2.0	198.49	75
120	2.3	300.74	2.0	202.28	75

This feeding schedule is to start with fish at 10g BW