Report

on

Solar Energy Associating Shrimp Production in the South West Coast of Bangladesh: An Intervention

Submitted

To

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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Table of Contents

List of Tables & Figures

Executive Summary

Shrimpculture has been the most profitable aquaculture industry in Bangladesh and flourished by the favorable subtropical environment and spatial diversity. The geographic location of the country is also blessed with plenty of natural resources like longest sea beach, 200 nautical mile exclusive economic zone, newly added around 118813 sq km of sea area and numerous coastal rivers and fringes. Moreover, the geographic location of the country facilitates balanced 12 hrs of day and 12 hrs of night time on an average per year. This balanced availability of day time provides another opportunity to ensure optimum use of solar energy.

Currently around 275000 ha of land is engaged in shrimp farming of the country. Considering the aforesaid benefits and the area of land engaged, the following interventions has been designed to evaluate the probability of installing solar panel over the shrimp farm to make better use of land resources. This short-term study was carried out by Shrimp Research Station, Bagerhat by the funding of Sustainable and Renewable Energy Development Authority (SREDA), GFA-group and GIZ for the very first time in Bangladesh to evaluate the impact of the shade (bamboo made structure covered by black polyethylene sheet resemblingsolar panel) on the growth of shrimp, water quality and primary productivity of the pond. To execute the study, 44% area of a 30 decimal pond was covered with the panel resemble structures. Another 30 decimal pond was kept as control pond, however, bamboo poles were installed in the control pond to mimic the periphyton activity of the shaded pond. Pond preparation and feeding management was maintained as per the extensive farming system. The only changes were brought in the stocking density. Shrimp Post Larvae (PL) stocked in each pond at rate of 8PL per m^2.

The research hypothesis was the shade would reduce primary productivity and dissolve oxygen (DO) level of the experimental pond. After 20 weeks of the study period, it was found that the average DO of the experimental pond reduced by 25% just under the shade and 7% in the open area of the shaded pond compared to the control one. But none of the reduced DO exceeded the lethal level, thereby, were not harmful for the shrimp. Interestingly, primary productivity of the shaded pond was comparatively higher than the control pond. The higher abundance of molluscs also indicated better aqua-ecology of the shaded pond. More importantly, the average temperature of the shaded pond was found 3% lower than the control pond. In the long drought, water temperature remains high (28-32) in the shrimp farms due to lower depth. Sudden rainfall therefore, caused massive mortality in the shrimp farms as sudden change in temperature and salinity maximize the virulence of White Spot Syndrome Virus (WSSV) a common, well-known threat in the shrimp industry. Thus installing solar panel could be a way to minimize the virulence of WSSV. However, the growth rate of the shrimp in the experimental pond was found 28% lower compared to the control pond, could be due to higher survival rate in the nursery period.

As stated earlier that it was a short-term intervention, it is difficult to conclude the findings for the following limitations viz., i) no replication of experimental and control pond was maintained due to limited funding; ii) the study was carried out in the late summer; iii) limited manpower

(security guard) is not sufficient for the on farm demonstration of experiment to cope with social issues.

Therefore, a comprehensive experiment is needed to evaluate the probability of installing solar panel over the shrimp farms considering minimum of three years consecutive study in triplicate covering seasonal variation, species diversity and spatial distributions.

1.Introduction

1.1Context of the Study

In Bangladesh, Shrimp sector, however playing a significant role in foreign exchange earnings, employment generation and poverty reduction, since last decades it is suffering with various issues in culture as well as in production site. About 75% of the total shrimp farms are located in Khulna, Bagerhat and Satkhira districts. *Penaeus monodon* and *Machrobrachium rosenbergii* are the two major species cultured in Bangladesh. Of all the exportable agro-based primary commodities, shrimp is, by far, the most important. It alone contributes more than 70% of the total export earnings from all the agro-based products (Karim, 2004); therefore, its contribution to country's economic development is immense. And this contribution can be increased with solution of electricity problem with managing alternative source in the rural region by implementing solar energy in the farms.

Solar energy has a potential opportunity to boost up the agricultural production as well as the production in aquaculture sector. Solar energy can be utilized to provide power to aeration system and circular water current, which uses the highest amount of power, generally during the summer, preferably the whole season. Solar power is an extremely clean and highly reliable way to generate electricity. It has virtually no environmental impact. There are no air emissions or noise associated with the operation of solar modules or direct application technologies. This results in safer farming environment, less waste products in prawn farms and helps maintain water quality. Solar thermal doesn't require liquid or gaseous fuels to be transported or combusted, thus it is one of the best ways to lower carbon footprint and helps protect the fish or prawn's respiration since it produces no air pollution or hazardous waste.

Aeration and circular water current system powered by solar energy brings better water quality and prawn growth rate comparing to diesel or gaseous fuels aeration and circular water current system. And because its energy source, sunlight, is free and abundant, especially in Bangladesh, a tropical country, these systems can guarantee access to electric power, especially to farms located in remote areas which are too distant to electric supply. Using solar energy can help reduce production cost. It improves energy efficiency on most farms and will probably lead to a reduction in energy costs. Whilst energy costs in aquaculture generally come behind salary, feed and stock costs as a fact happening in Bangladesh, it is nevertheless a significant part of operating cost.

Energy conservation is an important step in reducing costs. Perhaps surprisingly, some of the biggest proponents of energy conservation are the electricity suppliers themselves who are under increasing pressure to meet supply demands and indeed at times have to restrict supply. The reduction of operating costs is the key to increasing competitiveness and long-term profitability.

The initial investment cost is still far above the farmers' income. The farmers thus need some support from the government or from some manufactures as preferential loans or installments payment. The popularity of this high-tech energy use is still very limited. Consumer's confidence is therefore still less. Moreover, more research should be placed on how to operate aeration system using solar energy, especially in commercial large-scale farms in rainy, stormy, gloomy days as aeration systems are used mainly during the summer months when the panels are at their most effective.

However, with the development of renewable energy, including solar energy as an indispensable trend if the country is to meet rising energy demands as a result of socioeconomic growth and the populations bloom, solar energy's application in Bangladesh's aquaculture might see a bright future ahead of it.

1.2 Objective of the Study

- To assess the efficiency and impacts of solar power driven aeration and circular water current system in shrimp farming.

- To assess the efficiency and impacts of shades on the growth rate of shrimp and water quality of traditional farming.

1.3 Methodology Adopted

1.3.1 Assessing the efficiency and impacts of solar power driven aeration & circular water current system in Shrimp/prawn farming

The pilot intervention was based on the recommendations from a recent study conducted by GIZ, focused into "Scope of incorporating Run Existing (RE) technologies in shrimp value chain of the southern Bangladesh". The pilot intervention was introduce active water supply systems for traditionally clustered ponds by the help of PV technology. Additionally, PV based airlift systems was incorporated to break the naturally occurring stratification of 'stagnant' water bodies. These type of equipment was expected (and proven also in other systems) to support a continuous water circulation with the effect that oxygen balance was established in all levels of the water body. This were help to remove zones with low Dissolved Oxygen (DO) and was a positive effect on the feed uptake of the shrimps as they find favorable conditions even at the bottom of the pond, where a low DO environment prevails. In accordance with the nursery pond carrying capacity (biomass and related 24/7 oxygen demand of living animals and biomass in decay) a management model was passed with a Post Larva (PL) stocking density in the range of up to 150 PL/m² (considering mortality up to 50 %) which an improved pond management was bring. A monitoring system for common water parameters was also established (DO, pH, alkalinity) for two ponds under operation and results were recorded. Other good aquaculture practices such as pond depth maintenance, regular cleaning, etc. was incorporated as well.The monitoring work was done during 60 days (April/18-May/18) of nursing period.

1.3.2 Assessing the efficiency and impacts of shades in Shrimp/prawn farming

Pre-stocking management

Pond preparation: The ponds were prepared by sun drying followed by 6 cm bottom soil removal. Dyke was repaired carefully before stocking the post larvae (PL) in nursery pond.Liming of soil was done using CaO and dolomite (1:1) at 250 kg/ha. Ponds were filled by tidal brackish water up to 100 cm through screening netwhile pumping in. Then the water of the ponds were treated with rotenone as powder forms at 1.5 ppm to kill unwanted fishes and removal of predatoryand unwanted animalspecies.After that **p**onds were treated with dolomite at 20ppm to increase the buffer capacity of the ponds.

Fertilization: Fermented molasses were applied to the pond water to develop color of water to prevent penetration of sunlight and then fertilized with urea and TSP at 25 and 30 kg/ha respectively for quick development of color of water and production of plankton.

Stocking Management

Fry Collection, Conditioning & Releasing:PCR tested PL was collected from Coxsbazar from the PL suppliers. Conditioning of PL was done for30 min in the mixture of pond water and water used intransportation.Releasing method of PL in the nursery was simple. Thepolythene bag containing PL was immersed in the pondwater and after 20 minutes, bag was opened to release the PL.

Post-stocking Management

Pond Monitoring: Growth, plankton production,were checked at weekly interval. Physico-chemical parameters of water viz., temperature, salinity, transparency, pH, dissolved oxygen (DO) and alkalinity were determined following standard methods at seven days interval.Chlorophyll-*a* of two ponds were measure at 4 weeks interval.

Feeding: In the nursery the stocked PL were fed with CP nursery feed. After 3rd week of nursery rearing, the juveniles were released to the pond by removing the nylon net of the nursery enclosure.In the grow-out ponds, the shrimp were fed with boiled rice, rice polish, rice bran, wheat bran, mastered oil cake, soybean cake and occasional commercial feed in a way extensive shrimp farmers fed in their farm.After 17weeks of culture all shrimp were harvested by pond drying.

Plankton Biomass Measure:

Tomeasure plankton biomass,50 liter water of each pond were screen through plankton net and collect the filtered water. One drop filtered water were place in S-R cell then count the phytoplankton & zooplankton in 20 squares in the S-R cell. After count this phytoplankton & zooplankton was calculated by following equation.

Plankton Count Equation: $N = \frac{A \times 1000 \times C}{L}$

Where, $A = \text{Area} = \frac{\text{Total Plankton Count} * 10}{\text{Grid study}}$

C=Final Count

L=Liter water filter

Chlorophyll-*a* Measure:

Tomeasure Chlorophyll-*a* 50ml sample water was collected from study pond. Shake the sample water vigorously. Depending on the concentration of plankton, a known vol. (10 to 30ml) of sample water was filtered throughassembly use GF/C filter paper. About 1ml of magnesium carbonate suspension was added during sample filtered. After filtered,the filter paper was completely disintegrated in a tissue grinder with a few ml of 90% acetone.The pestle of the grinder was rinsed to make 10 ml liquid extract. The tube with extract was placed in a refrigerator in completely dark for 24h to allow the pigments to be extracted. After

24 hours, the tube were allowed to reach in room temperature in the dark and made the vol. of the extracts up to 10 ml with 90% acetone. Then centrifuged for 5min. After that the supernatants (without delay) of the extractantwas measure at 630, 645, 665 and 750 nm. After measure this Chlorophyll-*a*was calculated by following equation.

Calculation:

$$\text{Chlorophyll-}a\ (\text{ug/l}) = v/(Vxd)\ x\ [11.60(E_{665}-E_{750})\ -1.31(E_{645}-E_{750})\ -\ 0.14(E_{630}-E_{750})]$$

Where, v = vol. of extract (ml)

V = vol. of water sample (1)

d = Path length of the cuvette (cm)

1.3.3 Statistical analysis:

The data were analyzed using Microsoft excel to evaluate the impact of shade on growth of shrimp, primary production and physic-chemical properties of the two ponds.

2. Baseline Information of Pilot Project

2.1 Generic Information of the pilot place

Assessing the efficiency and impacts of solar power driven aeration & circular water current system in Shrimp/prawn farming study was conducted on two nursery pond having on 0.13ha/33 decimal/1336m^{2}each inM/S Rafid Aquaculture Ltd located at Mongla, Bagherhat and owned by Mr. Salim.

On the other hand, Assessing the efficiency and impacts of shades in Shrimp/prawn farming study was conducted in two farmer's pond around 30 decimal each situated in Village- Boitpur (Chitali), Bemarta Union, Bagerhat near to the Shrimp Research Station, Bagerhat.

2.2 Baseline Information on Water and other parameters as per ToR

Ambient air, which is drawn down the tube, enters the water column through the diffuser as fine bubbles where it is mixed by the impeller (Boyd 1998; Tucker 2005).Typically, the paddles are 2 to 10 inches wide and are attached to a drum in an alternating or spiral pattern. Drum speeds range between 70 and 120 rpm, and the spinning paddles are typically submerged in 3 to 6 inches of pond water (Boyd 1998; Tucker 2005). At extreme stocking rates, routine nightly aeration will usually produce more catfish at a better feed conversion than utilizing emergency aeration procedures (Lai-fa and Boyd, 1989). Using micro controller based control system will help in the reduction of power required for aeration process in addition to the low cost (Kaur, 2010). This means that the control system may help to operate different types of aerators in an economic way. The purpose of aeration or oxygenation is either to remove gases such as nitrogen (N) and carbondioxide (CO2) from the water, or to increased of gas concentration such as oxygen (O2) in the water (Lekang, 2007). In 2011, Vinateasaid that calculation of the number of aerator for extensive, semi-intensive, intensive adapted to the size of the shrimp, stocking density, temperature and salinity.

On the other hand, general water quality parameters of the pilot site selected for the shading study was also suitable for shrimp and prawn farming. However, the salinity was little bit low (2 ppt) for being rainy season. Overall physic-chemical parameters were as per the standard requirement of the shrimp farming.

2.3 Energy Consumption Behavior of the existing system

2.4 CO_2 emission due to diesel pump

3. Feasibility of Aeration Technology

3.1 Basic concept and Description of the intervention

The pilot intervention is based on the recommendations from a recent scoping study conducted by GIZ, focused into "Scope of incorporating RE technologies in shrimp value chain of the southern Bangladesh". The pilot intervention will introduce active water supply systems for traditionally clustered ponds by the help of PV technology. Additionally, PV based airlift systems will be incorporated to break the naturally occurring stratification of 'stagnant' water bodies. These type of equipment is expected (and proven also in other systems) to support a continuous water circulation with the effect that oxygen balance will be established in all levels of the water body. This will help to remove zones with low Dissolved oxygen (DO) and will have a positive effect on the feed uptake of the shrimps as they find favorable conditions even at the bottom of the pond, where a low DO environment prevails. In accordance with the pond carrying capacity (biomass and related 24/7 oxygen demand of living animals and biomass in decay) a management model has to be passed with a (Post Larva) PL stocking density in the range of up to 10 PL/m² (mortality up to 50 %) which an improved pond management will bring. A monitoring system for common water parameters will also be established (DO, pH, alkalinity) for any pond under operation and results will be recorded. This task will be given to the women in the family as the reading should be done twice daily. Other good aquaculture practices such as pond depth maintenance, regular cleaning, etc will be incorporated too.

The intervention will be taken in consultation with the Ministry of Fisheries and Bangladesh Fish Research Institute (BFRI). At first, 1 pilot project (if possible 2) will be installed in Bagerhat or Satkhira region with a solar panel capacity of 10 kwp , covering medium/large shrimp farmers. M/S Rafid Aquaculture Ltd. has been chosen as one of the potential implementing partner. This firm located at Mongla, Bagherhat and owned by Mr. Salim. He is one of the established aqua culturists in Khulna region. He has around 125 acers of pond. It was found that Mr. Salim's farm is suitable for piloting in terms of pond size and knowledge of shrimp farming of the owner. He is one of few farmers who could avoid recent EMS outbreak with caution. He is interested to participate in pilot project with his establishment.

In this pilot project one medium surface pump will be installed to create artificial current inside the pond and increase DO. It is expected that artificial current and increased DO will help to increase the productivity of shrimp firm.

Another objective of the pilot is to monitor effect of shadow from Solar panels installed on shrimp pond with support from BFRI. If there are no negative effect or minimum effect found for shadow on pond, those area can be used not only for shrimp firming but also for solar power generation.

3.2 Observation of the Pilot Intervention

It was interesting to observe the impact of shading on aquaculture pond. It was hypothesized that primary productivity and dissolve oxygen level would be fluctuated from the control pond, but interestingly the primary production in terms of phytoplankton and zooplankton was higher in the experimental pond. Throughout the culture period, water of the shaded pond looked greenish than the control pond. Noticeable abundance of molluscs also indicated the better aquatic ecology in the shaded pond. Apparently the survival rate of the PL in the shaded pond was higher than the non-shaded pond could be a reason of lower growth of the shrimp in the shaded pond. Further experiment in triplicate would be needed to conclude the issues arose from the current study.

4. Results of the Pilot Intervention

4.1 Analysis of Data

For the aeration study using solar energy driven mump, dissolve oxygen (DO) were measured at different depth of the pond ranging (Distance from pond bottom) 3'', 6'', 12'' / 1 foot, 24'' / 2 feet, 36'' / 3 feet, 48'' / 4 feet and 2'' under surf. At the initial stage of the study, pumps were directly connected with the solar panel instead of battery backup resulted no pumping facility at night. Pumps were operated during the day and hence no significant difference were observed among the DO level (Fig a~e) of the two pond (One pond operated with solar driven pump and other pond with diesel generator powered paddle wheel).

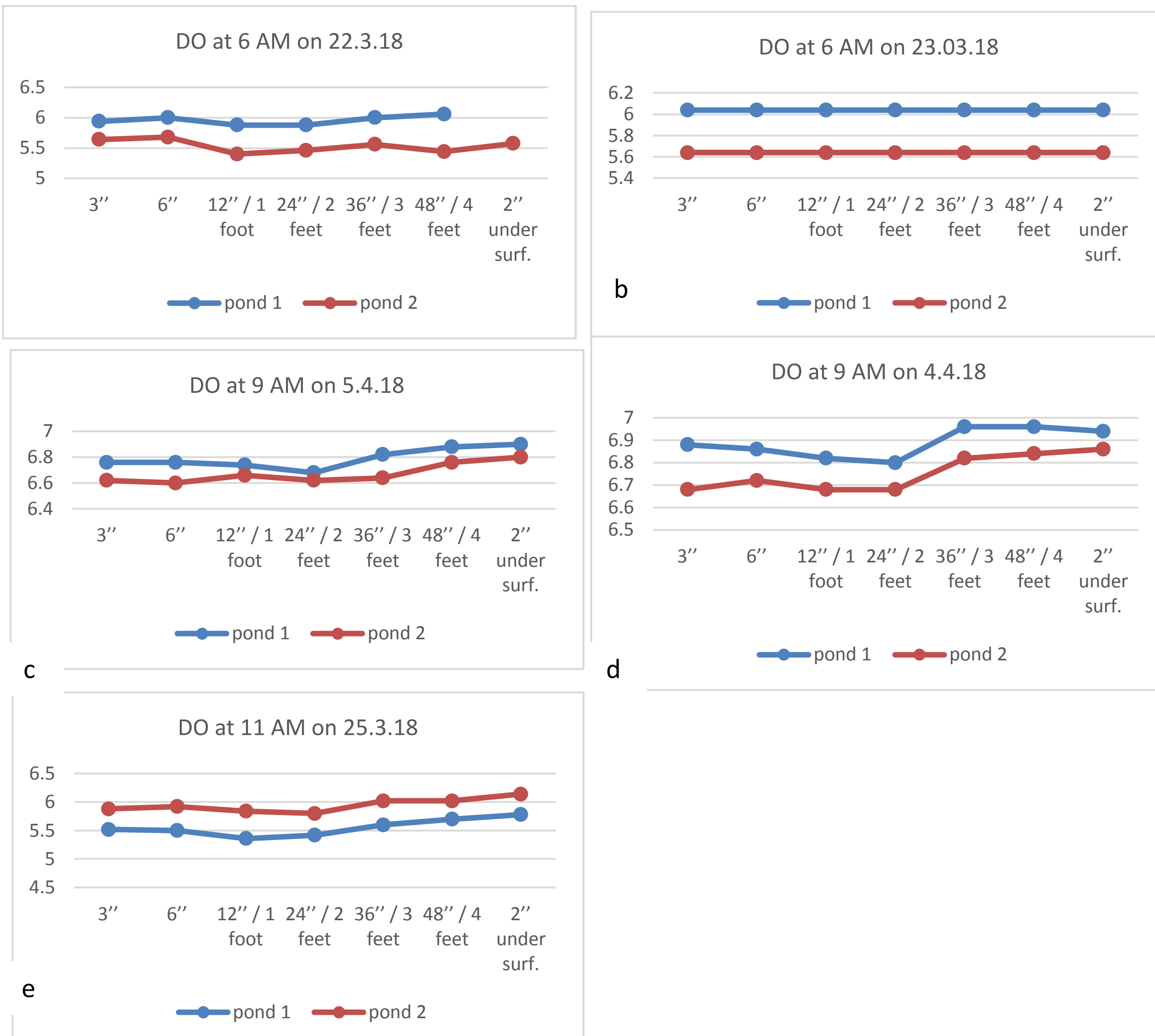

Fig.a~e. Level of DO at different depth and date on different time of the day

In the experimental ponds, ammonia, pH, salinity, iron, alkalinity, etc., were also monitored but found no significant differences.

For the shading impact study, general water quality parameters viz., temperature, dissolve oxygen (DO), salinity, pH, ammonia and iron were measured under the study. Throughout the study, a few fluctuations among the parameters were notices within the treatments, i.e., the experimental pond further will be termed as experimental pond and the control pond as control pond.

DO is the most important parameter in shrimp aquaculture. Usually DO is dependent on the primary productivity of the water and air water interaction. In the experimental pond, it was hypothesized that lower penetration on sunlight will hamper primary productivity. Moreover, the panel was supposed to cut off usual air flow over the pond water thus would reduce the DO compared to the control pond. But average DO in the experimental pond at day time found minimum fluctuation from the control pond. In the both ponds DO found within the range, i.e., 5 to 8 mg/L, however, in the control pond avg. DO was 5.8% higher than the experimental pond (Fig. 1). But diurnal change of DO showed noticeable variation within the ponds. Diurnal change of the DO in the control pond ranged from 4 to 10 mg/L whereas, in the experimental pond, DO ranged from 4 to 8 mg/L. Diurnal variation of DO were also observed right under the shade and outside the shade in the experimental pond. Under the shade, diurnal variation (from 6 am to 6 pm) of DO ranged from 3 to 6 mg/L while it was 4 to 8 mg/L in case of outer area of the shade. In the normal shiny days, open area of the experimental pond showed 6.8% less DO than the control pond while it was 25% less right below the shade compared to the control pond (Fig. 3). In the cloudy days, under the shade, DO found to be 27% less than the control pond (Fig. 3). However, the lower level of the DO never recoded as low as the critical level of DO in the either area of the experimental pond.

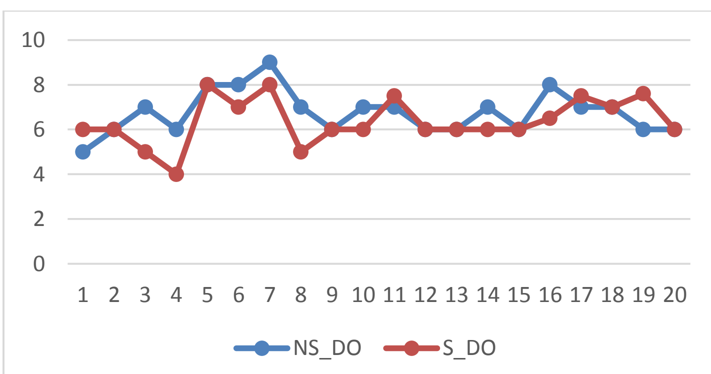

Fig 1. Average DO in non-experimental (NS) and experimental (S) pond throughout the culture period

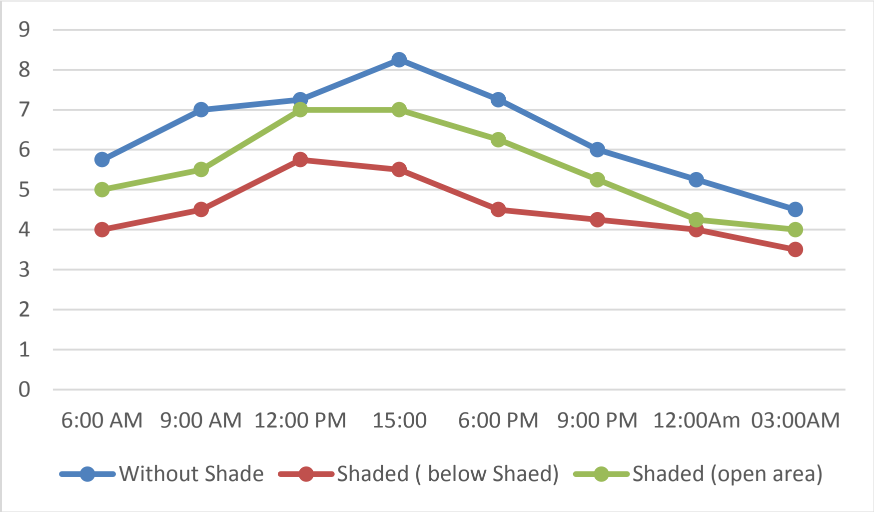

Fig 2. Diurnal variation of DO (from 6 am to 3 am) in the control pond, open area of the experimental pond and below the shade of the experimental pond at 3hr intervals

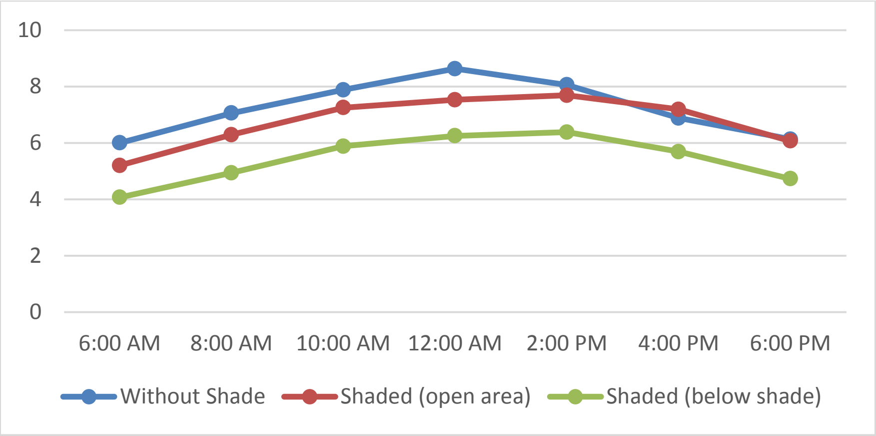

Fig 3. Diurnal variation of DO in the control pond, open area of the experimental pond and below the shade of the experimental pond in normal days

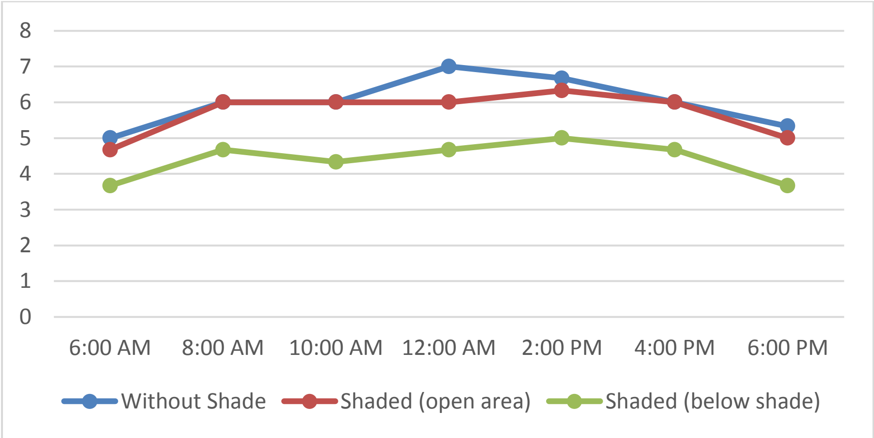

Fig 4. Diurnal variation of DO in the control pond, open area of the experimental pond and below the shade of the experimental pond in cloudy/rainy days

In shrimp culture, temperature is another important properties of water. Water temperature was measured throughout study period and found within the range of 22 to 28^{0}C in the experimental pond and 22 to 30^{0}C in the control pond. In the control pond temperature was 3.1% higher than the experimental pond. Trend of water temperature in the both pond throughout the study period shown in figure 5.

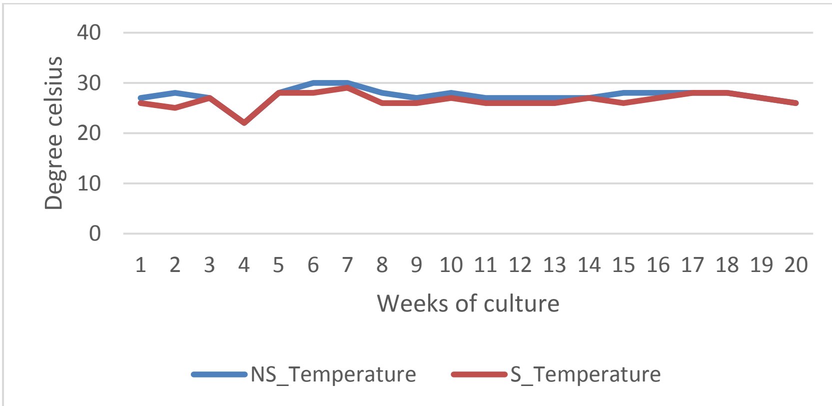

Fig. 5. Water temperature of the experimental and control pond

Ammonia plays an important role in shrimp farming. Higher concentration of ammonia can cause mass mortality. Range of ammonia in the experimental and control pond was 0 to 0.4 mg/L however, in the experimental pond ammonia found to be 22.67% higher than the control pond (Fig 6). Like ammonia pH has great importance in shrimp health management. But shading shows no significant impact on the pH (Fig 7). The pH of the control pond was 0.9% higher than the experimental pond. Overall pH in the both pond was within the range of 8 to 8.5, however, in the experimental pond lowest recorded value of pH was 7 for once only.

Recently in the costal river, increasing trend of iron became a great concern. In the research ponds, iron concentration found to be higher (44.8%) in the control pond than the experimental pond (Fig 8), however, the range of iron the both pond was within 0 to 0.3 mg/L.

While pond preparation, it was observed that the bottom soil type of the control pond was muddier than the experimental pond. The sandy behavior of the experimental pond bottom could be an important factor in reducing iron concentration. Salinity was recorded 7.4% higher in the control pond than the experimental pond (Fig 9) however, highest salinity recorded for the both pond never exceed 2ppt.

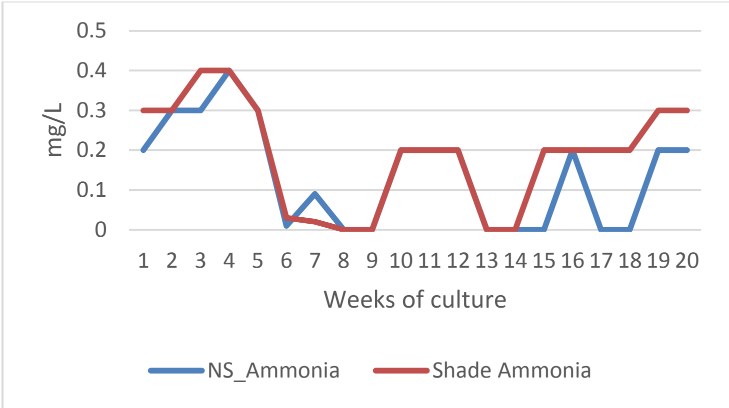

Fig 6. Ammonia concentration in experimentaland control pond

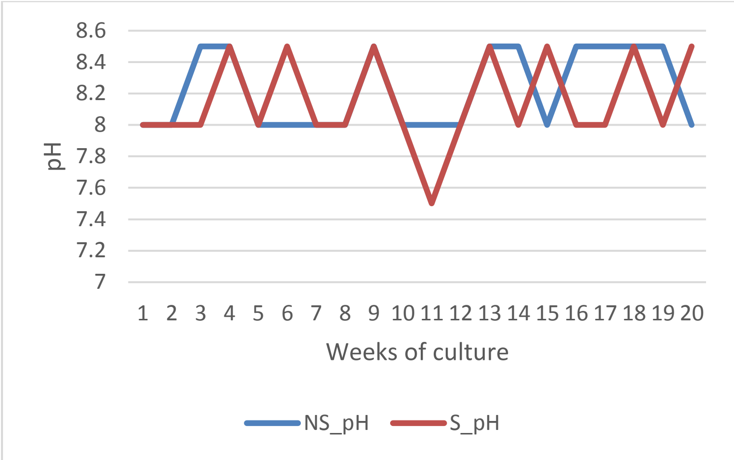

Fig 7. pH level in experimentaland control pond

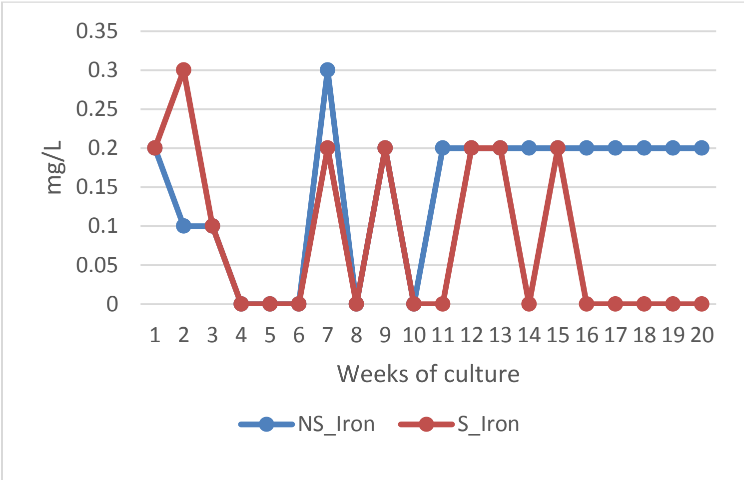

Fig 8. Iron level in experimentaland control pond

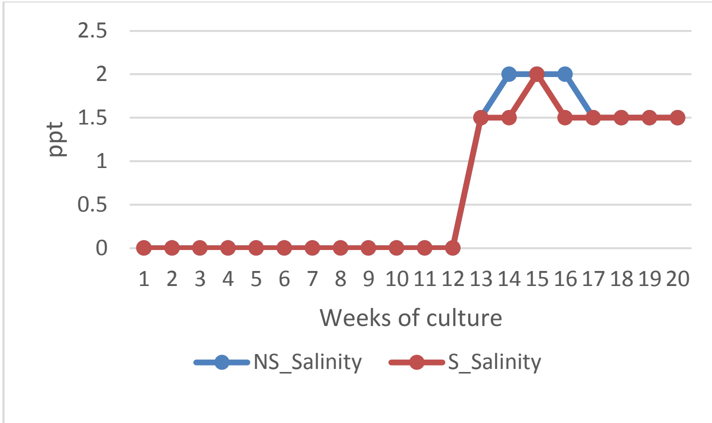

Fig 9. Salinity level in experimentaland control pond

The main objective of the study was to evaluate the primary productivity of the experimental and control pond as primary productivity is directly related with the growth and productivity of the shrimp. It was hypothesized that the shade will cause less sunlight penetration into the pond, thereby, will hamper the primary and secondary production in terms of phytoplankton and zooplankton abundance. But interestingly, in the experimental pond, abundance of phytoplankton and zooplankton was 13% and 22.5% higher than the control pond respectively (Fig 9, Fig 11). Total count of phyto and zooplankton was 17% higher in the experimental pond compared to the control pond (Fig 12). Interestingly, chlorophyll a was found lower in in the experimental pond than the control pond instead of higher phytoplankton and zooplankton abundance (Fig. 13).

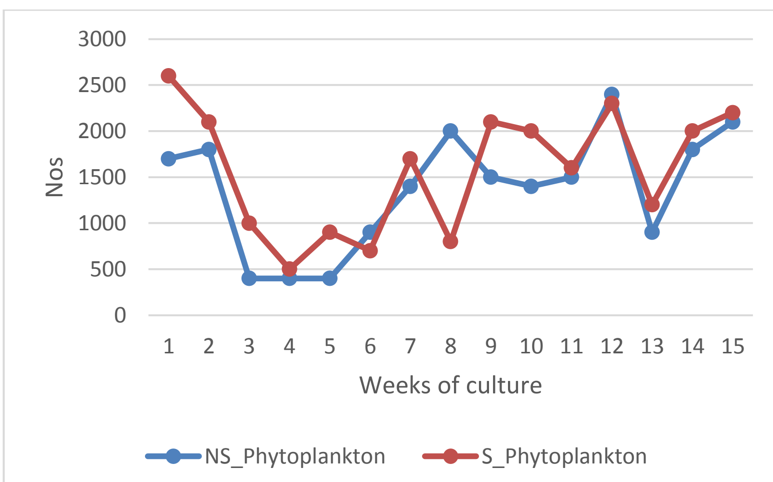

Fig 10. Phytoplankton abundance in experimentaland control pond

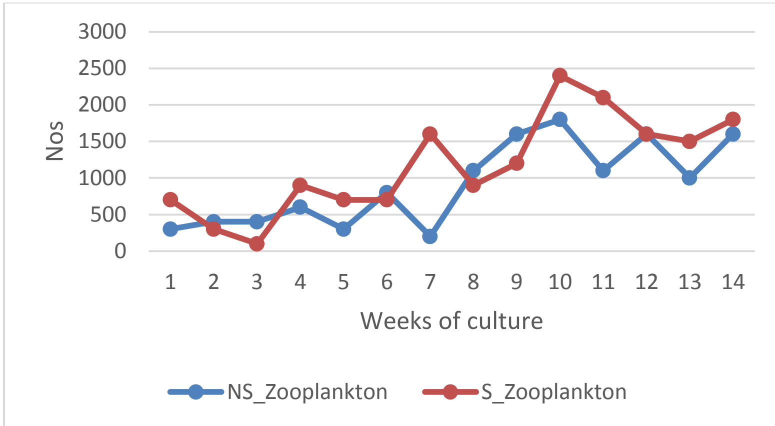

Fig 11. Zooplankton abundance in experimentaland control pond

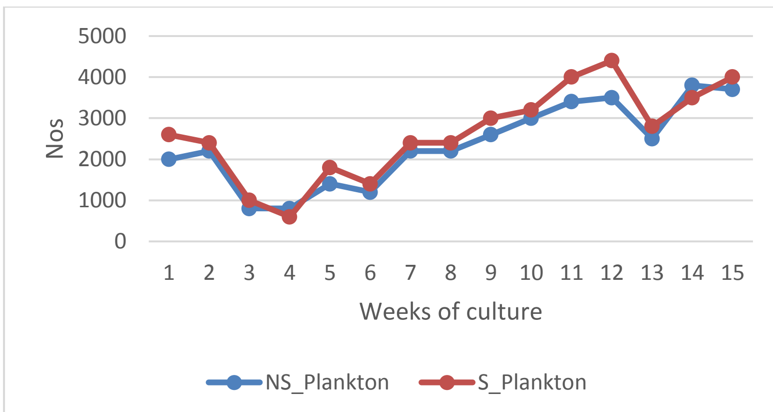

Fig 12. Total plankton count in experimentaland control pond

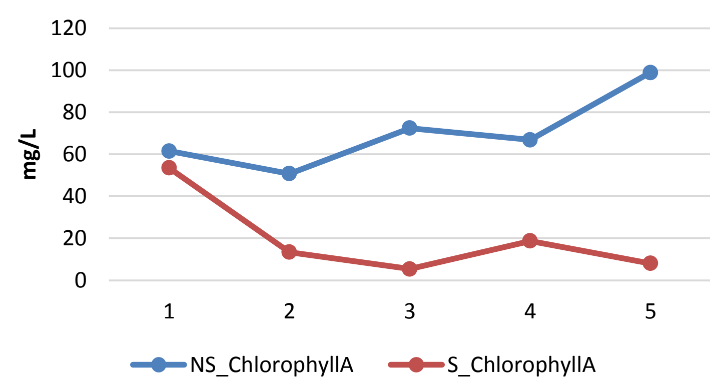

Fig 13. Chlorophyll a concentration in experimental and control pond

The most important part of the experiment was to monitor the growth rate of the shrimp in the experimental ponds. Instead of higher primary productivity, average weight of shrimp in the experimental pond was 28% lower than the control pond. Similarly, the average length of shrimp in the control pond was 13% higher than the experimental pond (Fig 14, Fig 15).

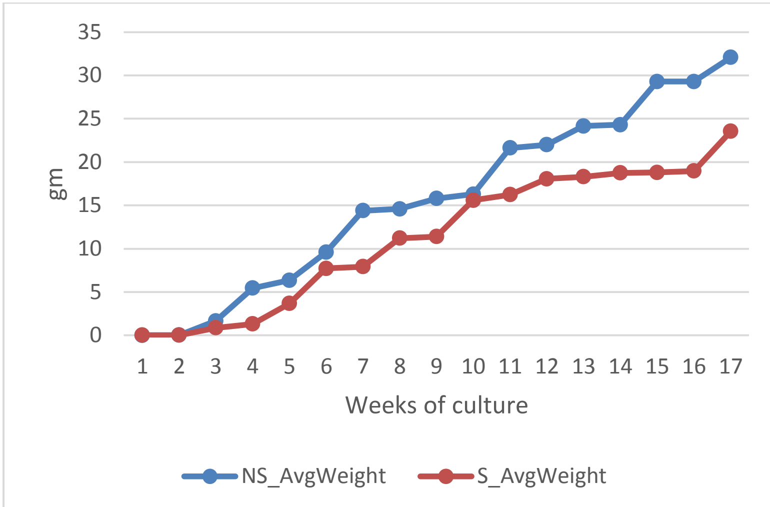

Fig 14. Average weight of shrimp in experimentaland control pond

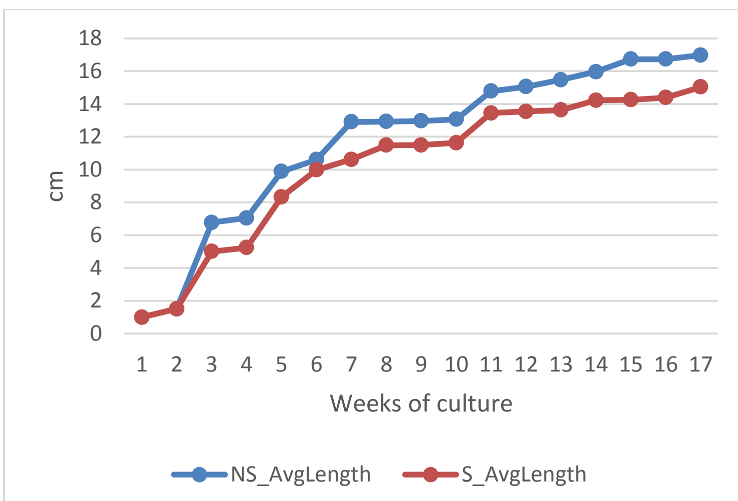

Fig 15. Average length of shrimp in experimentaland control pond

4.2 Technical Benefits

South west coastal belt of this country harbor a wide range of area with high salinity. In the long drought, the shrimp farms suffers with low water depth and higher salinity level. In the early rain, maximum farms face white spot disease infestation due to sudden change of salinity, temperature and pH.

In the pilot project of shading effect, none such occurrence was appeared. Lowering the water temperature shades can help to buffer the sudden fall in temperature due to rainfall. If pipe lines could be installed with the panel shade, fluctuations of salinity and pH of the pond could be easily managed. Thus this system can help to minimize disease occurrence in the shrimp industry.

4.3 Economic Benefits of using the technology

In Bangladesh, near about 275000 ha of land in used in shrimp farming. Usually the average production of the shrimp in traditional farming system is 350~400kg/ha. If we consider the production 1200kg/ha per crop and two crop per year, one farmer can earn 12000tk from per decimal land. If solar panel is installed over the land/pond, considering the reduced growth rate, he can earn 9000/- tk. per year by selling shrimp while he can earn 20000~30,000/- approximately by selling the electricity produced from the solar panel. Thus a farmer can earn at least a total 9000(from shrimp) +20000(from electricity)= 29000/- in a year.

Ney that, in the remote coastal area, people need to buy drinking water that is supplied from the upstream area of the country. If solar panel is installed with the pipe line and rain water harvesting system, this can fulfil the need of fresh water of the inhabitants of the rural people engaged with shrimp farming. Moreover, draining out the rain water from the shrimp farm can minimize the sudden fluctuation of salinity, pH and temperature of the pond that ensure better environmental condition to cope with WSD infestation into shrimp farm.

4.4 Environmental benefits

Solar energy generation is considered as the potential source of green energy. If 50% of the total area (275000 ha) of shrimp farmis converted like the experimental pond type, it could generate a considerable amount of electricity in an environmental friendly way. Moreover, in the experimental pond large diversity of microbial community was observed along with maximum primary productivity. It also helped to lower the environmental temperature thus can be a way of minimizing the adverse impact of global warming. Similarly generating solar energy can help in carbon deposition thus can ensure healthy environment for everyone.

5. Conclusion and Recommendations

From the study it is revealed that covering 44% of the pond surface do not impact much on the properties of the water quality. However, shrimp in the experimental pond performed lower growth rate compared to the control pond. Extending the culture period to one more month can make up the production differences within the ponds. Moreover, higher primary productivity helped in better growth of the finfishes (as in traditional shrimp farming, farmer also stock finfishes for own consumption) which can add extra income to the farmer. In addition, considering the optimum weather condition, farmer can earn around 20,000-30,000/- taka from per decimal area per year by selling the electricity produced from the solar panels.

The study was conducted in the late summer and in low saline zone with only shrimp. Funding constraints also limit the number of replication among the treatment. Therefore, to evaluate the total impact of shade on aquaculture system, a year-round study in different location with multiple species and replication would be worth exploring.

Annex 1(a): Data monitoring template/framework

Solar Aquaculture under GIZ REEEP Program RE Component version 22-3-18												
Parameter	DO / Temp /											
DATE:												
TIME (actual):												
	Location pond 2							Location pond 1				
Distance from pond bottom	A	B	C	D	E		Distance from pond bottom	A	B	C	D	E
3’’							3’’					
6’’							6’’					
12’’ / 1 foot							12’’ / 1 foot					
24’’ / 2 feet							24’’ / 2 feet					
36’’ / 3 feet							36’’ / 3 feet					
48’’ / 4 feet							48’’ / 4 feet					
2’’ under surf.							2’’ under surf.					
TIME:												
	Location pond 1							Location pond 2				
	A	B	C	D	E			A	B	C	D	E
Distance from pond bottom							Distance from pond bottom					
3’’							3’’					
6’’							6’’					
12’’ / 1 foot							12’’ / 1 foot					
24’’ / 2 feet							24’’ / 2 feet					
36’’ / 3 feet							36’’ / 3 feet					
48’’ / 4 feet							48’’ / 4 feet					
2’’ under surf.							2’’ under surf.					

Annex 1(b): Data monitoring template/framework

Solar Aquaculture under GIZ REEEP Program RE Component version 22-3-18												
Parameter	pH											
DATE:												
TIME (actual):												
	Location pond 2							Location pond 1				
Distance from pond bottom	A		C				Distance from pond bottom	A		C		
3’’							3’’					
24’’ / 2 feet							24’’ / 2 feet					
2’’ under surf.							2’’ under surf.					
TIME:												
	Location pond 1							Location pond 2				
	A		C					A		C		
Distance from pond bottom							Distance from pond bottom					
3’’							3’’					
24’’ / 2 feet							24’’ / 2 feet					
2’’ under surf.							2’’ under surf.					

Annex 1(c): Data monitoring template/framework

Solar Aquaculture under GIZ REEEP Program RE Component version 22-3-18											
POND						**POND**					
DATE						**DATE**					
Target time 9.00 AM											
	Target range	TIME	Location	Depth			Target range	TIME	Location	Depth	
Ammonia	NH3, <0.02 mg/L Unionized Form)	Daily	A	10 cm		Ammonia	NH3,<0.02 mg/L Unionized Form)	Daily	A	10 cm	
Nitrate	(NO3)<1.0 mg/L	Daily	A	10 cm		Nitrate	(NO3)<1.0 mg/L	Daily	A	10 cm	
Nitrite	(NO2)<0.2 mg/L	Daily	A	10 cm		Nitrite	(NO2)<0.2mg/L	Daily	A	10 cm	
Salinity	10 - 25 ppt	Weekly / at water exchange	A	10 cm		Salinity	10 - 25 ppt	Weekly / at water exchange	A	10 cm	
Alkalinity (CaCO3)	50 - 200 mg/L	Daily	A	10 cm		Alkalinity (CaCO3)	50 - 200 mg/L	Daily	A	10 cm	
Turbidity (Secchi)	30 - 40 cm	Daily	A			Turbidity (secchi)	30 - 40 cm	Daily	A		
Iron						Iron					
Chlorophyll-a		2/week	A	10 cm		Chlorophyl-a		2/week	A	10 cm	
Zooplankton						Zooplankton					
Phytoplankton						Phytoplankton					

Annex 1(d): Data monitoring template/framework

Shaded Pond (Water Quality Parameter)

Date	**Time**	Tem	pH	Sal	Alk	Amo	Oxy	Nitrite	Nitrate	Iron	Po$_4$-P

Date	**Time**	Oxy

Shaded Pond (Plankton)

Date	**Time**	Zooplankton			Phytoplankton		
		Name	Count	Total	Name	Count	Total

Annex 1(e): Data monitoring template/framework

Non-shaded Pond (Water Quality Parameter)

Date	**Time**	Tem	pH	Sal	Alk	Amo	Oxy	Nitrite	Nitrate	Iron	Comment

Annex 1(f): Data monitoring template/framework

Shaded Pond (Oxygen)

Date		**Oxygen**						
	Time	6: am	8: am	10: am	12: pm	2: pm	4: pm	6: pm
	Oxygen							
	Time							
	Oxygen							
	Time							
	Oxygen							
	Time							
	Oxygen							
	Time							
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	Time							
	Oxygen							
	Time							
	Oxygen							

Annex 1(g): Data monitoring template/framework

Non-Shaded Pond (Oxygen)

Date		Oxygen						
	Time	6: am	8: am	10: am	12: pm	2: pm	4: pm	6: pm
	Oxygen							
	Time							
	Oxygen							
	Time							
	Oxygen							
	Time							
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	Time							
	Oxygen							
	Time							
	Oxygen							

Annex 2(a): O&M guideline/template and Any other template/log sheet

Solar Aquaculture under GIZ REEEP Program RE Component															
Aeration Operation Records															
Date	../../.. to ../../..														
POND	POND 1					POND 2					POND 2				
Operation time	Paddle wheel (10/20/30/40/50/60 min) 60 min = V				Total (hrs)	Paddle wheel (10/20/30/40/50/60 min) 60 min = V				Total (hrs)	Solar pump flow in pond (10/20/30/40/50/60 min) 60 min = V				Total (hrs)
	1	2	3	4		1	2	3	4		1	2	3	4	
6-7 AM															
7-8 AM															
8-9 AM															
9-10 AM															
10-11 AM															
11-12 AM															
12-1 PM															
1-2 PM															
2-3 PM															
3-4 PM															
4-5 PM															
5-6 PM															
6-7 PM															
7-8 PM															
8-9 PM															
9-10 PM															
10-11 PM															
11-12 PM															
12-1 AM															
1-2 AM															
2-3 AM															
3-4 AM															
4-5 AM															
5-6 AM															
TOTAL															

Annex 2(b): O&M guideline/template and Any other template/log sheet

Solar Aquaculture under GIZ REEEP Program RE Component version 27-3-18																		
Feed and feed adjustment																		
Date **../../..**	Conditions:		1. Average day Temperature (°C)				2. Rain (mm)						3. Clouds (%)				4. Moulting (%)	
Feeding records	Feed provided (gram)						Amount of feed remaining in feed tray (%)						Feed planned for next day (gram)					
Pond 1	Feeding tray				Broadcast (..%)		Feeding tray						Feeding tray (.. %)				Broadcast (..%)	
Feeding time	A	B	C	D		Total	A	B	C	D	Total feed removed from tray (gram)	Total actual feed provided (gram)	A	B	C	D		Total
6.00 AM																		
11.00 AM																		
5.00 PM																		
10.00 PM																		
Total																		
Pond 2	Feeding tray (.. %)				Broadcast (..%)		Feeding tray						Feeding tray (.. %)				Broadcast (..%)	
Feeding time	A	B	C	D		Total	A	B	C	D	Total feed removed (gram)	Total feed provided (gram)	A	B	C	D		Total
6.00 AM																		
11.00 AM																		
5.00 PM																		
10.00 PM																		

Annex 2(c): O&M guideline/template and any other template/log sheet

Solar Aquaculture under GIZ REEEP Program RE Component version 27-3-18										
Relation sunlight - electricity use – electricity stored										
Date	../../..									
	Sunshine (10/20/30/40/50/60 min) 60 min = V	Solar Pump Operation (10/20/30/40/50/60 min) 60 min = V				Total (hrs)	Charge Controller status (Battery charge)			
Operation time		1	2	3	4		1	2		
6-7 AM										
7-8 AM										
8-9 AM										
9-10 AM										
10-11 AM										
11-12 AM										
12-1 PM										
1-2 PM										
2-3 PM										
3-4 PM										
4-5 PM										
5-6 PM										
6-7 PM										
7-8 PM										
8-9 PM										
9-10 PM										
10-11 PM										
11-12 PM										
12-1 AM										
1-2 AM										
2-3 AM										
3-4 AM										
4-5 AM										
5-6 AM										
TOTAL										

Annex 3: ToR

Annex 4: Presentation

Annex 5: Photo