COMMUNITY BASED FISH FARMING IN LOWLAND PADDY FIELDS IN MOYNA, WEST BENGAL, INDIA

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Paddy-cum-fish culture in lowland at Moyna block of Purba Medinipur district, West Bengal, India now enjoyed a national importance for development of socio-economic conditions of the rural community. It seems to have a great potential in India which requires small cash outlays and could provide significant increases in rural employment in short time frame. Several factors are regulates the economic efficiency in the combination system of fish farming. Likewise, reliable sources of quality fish seeds, supplemental feeds and antibiotics, control of predators and pests as well as water quality plays the key factors. Rearing of Indian Major Carps as culture species and minimize the other input cost fishermen become economically beneficial. Consequently, a challenge already proven to protect the bio-geo texture of land and environment by adopting the sustainable management practices within the culture based areas at Moyna, West Bengal, India. A thought provoking analysis based approaches has been done to reveal the freshwater fish production scenario, cost-profit structure and physico-chemical condition of mentioned areas displayed zone wise. To protect, the dilemma of negative impacts of unscientific fish farming practices the urgent need of several significant strategies must be taken by local fish farmers as well as policy makers. Otherwise, the consistent aquatic environment along with the fish farming system will be disrupting in upcoming days.

INTRODUCTION

The past decade has seen growing identification of the crisis facing the world's water resources and the need for concerted action to use them more efficiently. The efficiency of water productivity can be increased by producing more output per unit of water used or by reducing water losses at some areas (Evans and Sadler, 2008). Fish culture, is no well-suited with paddy farming wherever the latest high yielding varieties of paddy are cultivated. These developments have substantially reduced fish culture in rice fields in Japan, where a greater crop of rice alone with the preferred over a supplementary crop of fish with lowland rice crop (Jhingran, 1991). Nevertheless, wherever paddy continues to be cultivated on traditional lines, fish culture in paddy fields is common, in countries like Japan, Italy, Malaysia, Taiwan,

several African countries, in Arkanas (USA) and to some extent in India. Paddy-cum-fish culture has been reported in India (Hora, 1951; Chacko and Ganapati, 1952; Iyengar, 1953; Alikunhi, Vijayalakshmanan *et al*., 1960; Tripathi, 1989). Fish is greately consumed as food in West Bengal, India where per capita consumption per year is estimated to be 15.6 kg in comparison to other state of India is reported 9.0 kg. It is considered to be the major source of animal protein for the majority of peoples in Asian countries and a major source of vital micro-nutrients (Hasan, 2000; Demaine and Halwart, 2001; Hara *et al.,* 2017). Freshwater fish, because of its relatively low price, represents a vital source of animal protein for lower income groups (FAO, 2001), especially in West Bengal where about 94% of farmers were classed as poor (Economist, 2004). Rice and fish are considered to be the two significant sources of food in Moyna region. It has been estimated that rice constitutes as much as 60% of the daily food intake of the majority of Asian people (Hasan, 2000; Adhikari *et al.,* 2011).

Several studies was performed during 1980's to assess the technical feasibility of culturing fish at seasonally flooded paddy fields in India (Parashar *et al.,* 1996), Bangladesh (Ali and Talukder, 2008), Cambodia (Gregory and Guttman, 1996; Gutmann, 1999) and Vietnam (Rothuis *et al.,* 1998). It was estimated that out of the 42 million hectares of paddy cultivated land in India, about 20 million hectares is suitable for paddy-fish integration but only 0.23 million hectares managed as lowland paddy-fish systems (Shyam *et al*., 2012; Rao *et al.,* 1998). It also supports to the peoples as alternative income generation opportunity even the landless individuals may be involved (Dey and Prein, 2006).

Paddy- fish farming is nicely practiced to proper utilized the low lying water logged areas after making the renovation of paddy plots, into perimeter type, central pond type and lateral type trenches. Rohu, catla, mrigal and others common carps along with the giant prawns are grown in freshwater paddy culture system as major cultured species. The paddy-fish farming in the freshwater paddy field is not traditionally in a perfect trend within India. Unfortunately, the carrying capacity of these suitable lands in India has not been utilization of entire extent. When this is done by bringing them integrated paddy-cum-fish/prawn culture system, it would help to recover the economic losses in rice production brought about by natural calamities.

Physical factors (water, soil, temperature, air and light) and biological factors (plant, animal and microorganisms) are always interrelated and interdependent in any ecosystem (Patra *et al.,* 2017). They form a compatible ecosystem of unilateral functions. Change in any one factor triggers a chain reaction within the aquatic ecosystem (Kar *et al.,* 2017). The low land paddy field is a built-in system where paddy predominantly covers the land surface. In the biological community of the paddy field ecosystem the primary producers are weeds, plankton, humus and bacteria. The modern technologies are complicated in nature and high input which is definite to interdependent on so many interrelated practices each one of which has to be applied rationally in time and manner specific recommended by the scientists or researcher.

MATERIALS AND METHODS

Location

Moyna block located in Latitude 22°14′00″N and Longitude 87°47′00″E under East Midnapore District of West Bengal, India consisting with 84 nos. villages (Wikipedia, 2018). The area has divided into three potential culture zone relating to this integrated culture namely Northern Zone (40 hectare) consisting the Gram Panchayet namely Gokulnagar, Paramanandapur and Tilkhoja; South Western Zone (55 hectare) having the Gram Panchayet Ramchak and Bakcha; lastly the South Eastern Zone (70 hectare) consisting with the Gram Panchayet Gijina, Naichanpur –I, Naichanpur – II, Moyna – I, Moyna – II. The total area has been showed in Fig. 1. Other supportive data are also collected by the help of GPS (Global Positioning System) and by the interaction with Block development officers and fishermen.

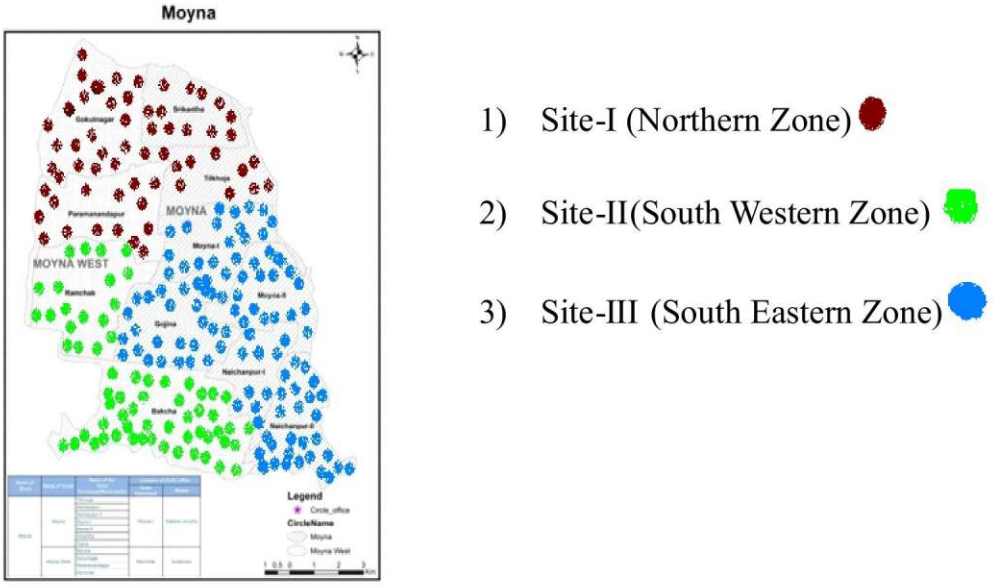

Fig. 1. Area map of Moyna block.

Climatic condition

The climatic conditions were divided into four main seasons: i.e. summer (January to March), Pre monsoon (April to June), monsoon (July to September), Post-monsoon (October to December). The supportive meteorological data of three zone was retrieved from the official records of Regional Meteorological Department, Kolkata, Government of India (Fig. 2).

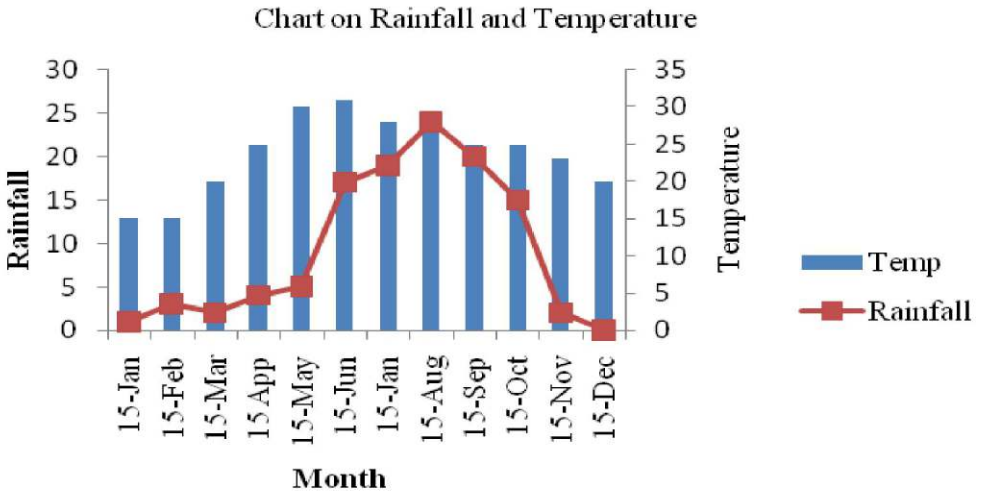

Fig. 2. Climatic condition at Moyna 2015.

Culture Process of Paddy & Fish

Paddy cum fish culture system at Moyna was visualizes and collected in a long term real field observations truly depending on field survey in every 15 days interval of every zones covered up to three years. The culture process also described sequentially as following sub sections.

a. Preparation of Paddy Field

Practically, it has been observed that the paddy-fish integration in Moyna water logged ecosystem, out of the paddy field with infield areas (1.5-2 m depth) 30-40% part of paddy field, where the peripheral trench of 0.5 m depth and 2.0 m width consisting with moderate slope towards low and medium land ecosystem. Paddy field with dyke height of 50 cm, infield refuge (1.2-1.5 m depths) of 15-25% area of paddy field, peripheral trench of 0.5 m depth and 1.0 m width with a moderate slope of 0.5% towards the refuge is most preferred, for better adoption of paddy-cum-fish farming system.

b. Mutualism of Paddy and Fish

During the end of February to middle of March in every year, the farmers of Moyna were made ready for sowing the paddy plants. After proper management of the soil racking, manuring the paddy seed was broadcast @ 150-200kg/ha followed by soil land leveling. As the fields were used for pisciculture together with paddy or alternating the same they found to be preferred pest resistant varieties cross variety of paddy seed which take minimum time period for higher production. According to the report of CIFRI (2005) the time of harvesting (120-130 days period) the farmers cut the paddy plant part from the top with 0.3-0.5 m.

length above the water level of low land. Afterwards, remaining part of the paddy plants automatically decomposed in the respective field and finally enriching the water body as organic manure. That manure catalyzes and enhances the quantity of periphyton and benthos, plankton which accelerated growth of fishes.

After proper refuge preparation, application of lime at the rate of 500-750 kg/ ha, manuring with raw cattle dung @ 5,000-6,000 kg/ ha as basal dose was carried out at the onset of monsoon during June month. Before fingerlings are released in the paddy field refuge, it is essential to clear it from aquatic vegetation and predatory fish species during the month of July-August. During the rainwater starts accumulating in the refuge and paddy fields, early fingerlings of catla, rohu, mrigal, silver carp, common carp and prawn juveniles become stocked with a composition of 30:25:45 (surface feeder: column feeder: bottom feeder). *Labeo bata* can also form a better stocking component in this system. As the farming duration enjoying short time periods, fingerlings (> 15g size) should be stocked at a higher density of 15,000 - 20,000 nos per ha for continuous rearing in duration of 4-5 months or advanced fry (1.5g size) at a higher density of 75,000-1,00,000 nos. per ha for advanced fingerling production. To augment growth supplementary feed comprising mustard oil cake and ground nut oil cake and rice bran in 1: 1 ratio may be given to fishes daily at 3% of body weight initial two months and then at 2.5% rate of mean body weight of stocked fish /prawn. In this farming system the fish or prawn will grow for a period of 3-4 month covered the entire area and then for 2-3 months in the confined area of infield refuge. Basic ecological requirements of paddy and fish are similar and this provides the basis of their synchronized growth under one integrated ecosystem. Afterwards fishes (especially herbivorous and carnivorous nature) are introduced into the paddy fields they add a new connecting channel to the prevailing food chains. Principally, fish consume the primary producers, planktons and others aquatic organisms followed to reduce energy losses, improve the use of photosynthetic products and promote transformations in the paddy field ecosystem that definitely increase the carrying capacity of the paddy field. Paddy plants provide a stable protection to fish and prawn from predation by birds and fish gets sufficient oxygen released by paddy and phytoplankton for survival and better growth. Several diseases were rare in paddy-cum fish culture, due to clear aquatic environment, high oxygen content and rich natural food that produces strong disease resistant variety fish/prawn. Subsequent to the harvesting of paddy plants, the roots and remaining parts of straw (straw contain 9-13% cellulite, 1.5-3% potassium and 30-40% cellulose) provide organic matter that favors growth of microorganism, the ultimate natural food of fishes and prawns.

RESULTS

Fish culture and production efficiency

In this fish culture system the production ranged between 2800-3200 kg/ ha (stocking size > 15g) per crop with a survival rate of 65-90 percent. Zone wise fish seed densities of Moyna were recorded (Table 1). Production rate of different type of fish species

are shown zone wise in Fig. 3, Fig. 4 and Fig. 5 respectively. Where high growth rate of north zone showed 25% growth of silver carp, south western zone shows 25% of silver carp and south zone showed 23% of *Cyprinus* sp. respectively.

Afterwards the completion of deeply rooted paddy plants the fish seeds were introduced in different ratio at the paddy fields based on observed biota. The application of feed have been observed at the rate of 6-8% of total body weight during first 3 months and later on it is 3-4% during rest cultural period.

Table 1: Zone wise fish seed density of Moyna

Name of the Zone	Indian major carp (IMC)/sq.mt.	Minor carp (MC)/sq.mt.	Exotic carp (EC)/sq.mt.
Northern	2-3 nos.	4-12 nos.	2-4 nos.
South Western	1-3 nos.	6-9 nos.	2-3 nos.
South Eastern	2-3 nos.	4-9 nos.	1-3 nos.

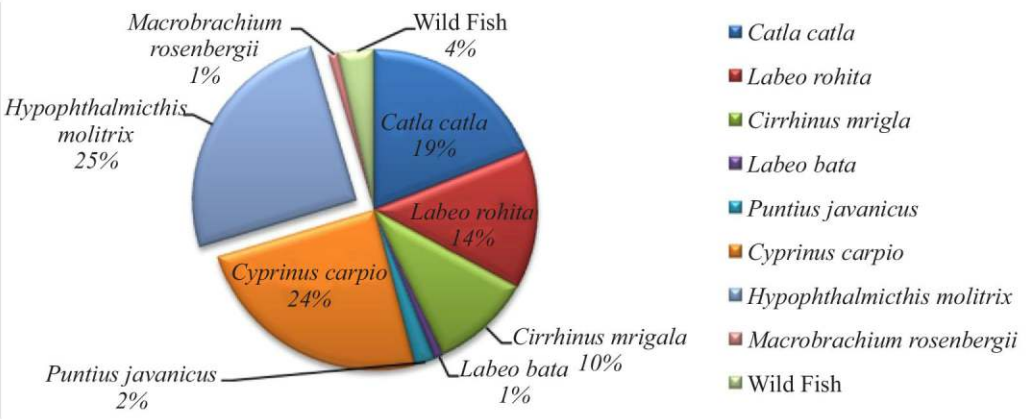

Fig. 3. The production percentage of fish species in North Zone.

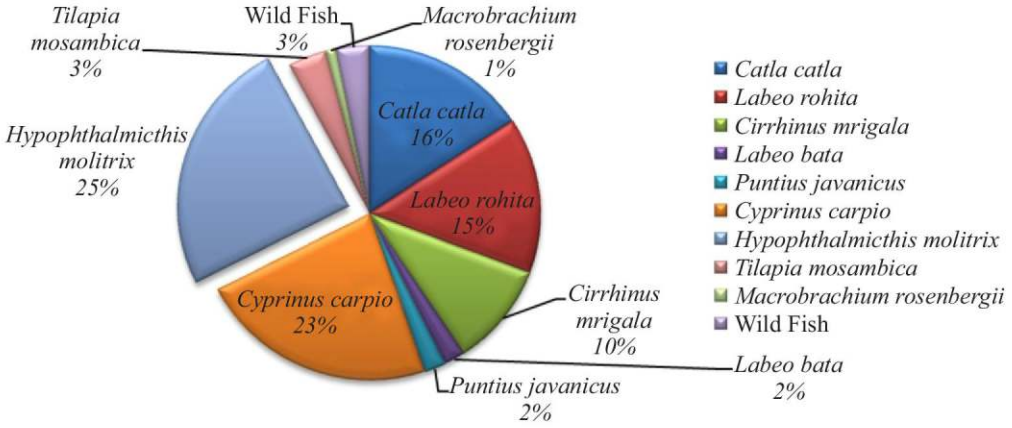

Fig. 4. The production percentage of fish species in South West Zone.

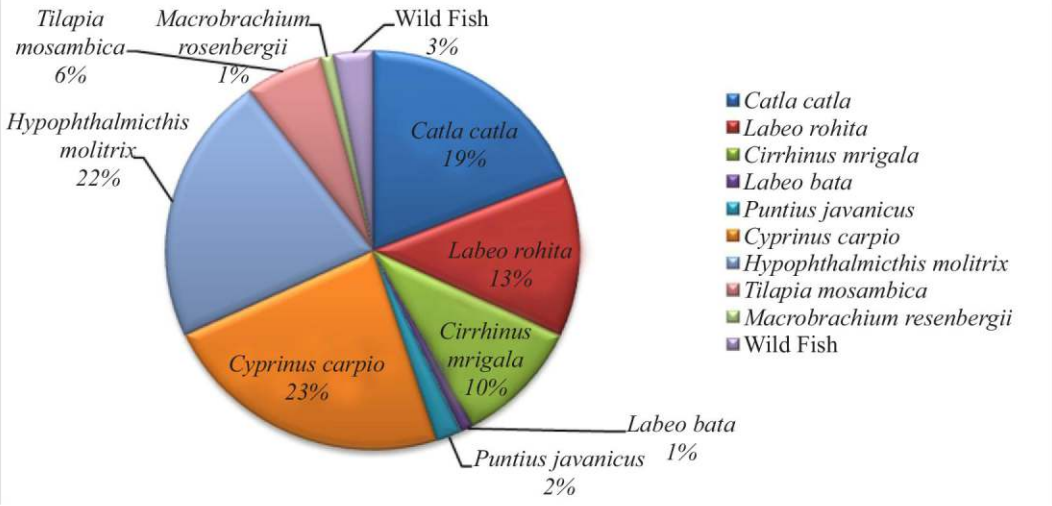

Fig. 5. The production percentage of fish species in South East Zone.

Average growths of fish are recorded 500-750 gms except minor carp. Whereas exotic carps has been observed to attain a growth of 1-1.5 kg. The total production was estimated 2.8-3.5t/ha (Table 2). Zone wise growths of cultured fishes are imposed in Fig. 6, where *Cyprinus* sp. production was higher in south zone than others zone.

Apart from the normal procured fish the farmers also obtained various wild fish during harvesting e.g. *Channa striatus, Channa marulius, Channa punctatus, Anabas*

testudineus, Clarias batrachus, Heteropneustes fossilis, Amblypharyngodon mola, Colisa faciatus, etc. Zone wise yield are recorded in Fig. 7 and Table 3, where north zone shows high yielding capacity.

Table 2: Production details of Fish in Moyna paddy-cum-fish culture

Name of the Zone	Amount paddy harvest(ton/ha)	Amount of fish harvest (ton/ha)
Northern	2-3 (2.5 ton)	2.8-3 (2.9 ton)
South Western	2.5-3.5 (3.0 ton)	3-3.5 (3.25 ton)
South Eastern	2.8-3.5 (3.15 ton)	3-3.5 (3.25 ton)

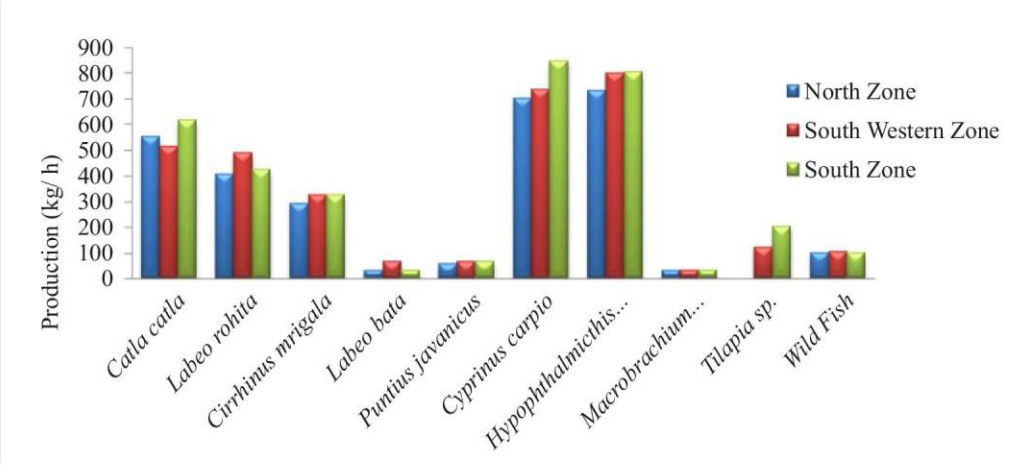

Fig. 6. Zone wise yield of fresh water fish species.

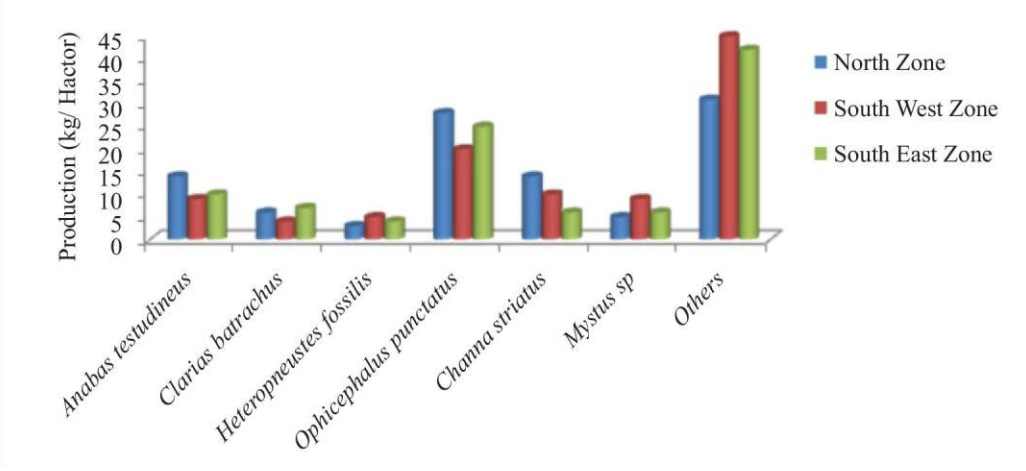

Fig. 7. Zone wise production percentage of wild fish species of Moyna.

Table 3: List of Wild Fish Production in Moyna Block

Sl.No.	Cultured Species	Initial weight (g)	Final harvest weight (g)
1	Catla (*Catla catla*)	50-70	500-750
2	Rohu (*Labeo rohita*)	40-50	400-600
3	Mrigal (*Cirrhinus mrigala*)	35-50	300-500
4	Bata (*Labeo bata*)	10-15	50-75
5	Punti (*Puntius javanicus*)	4-8	75-100
6	Cyprinus (*Cyprinus carpio*)	75-100	800-1000
7	Silver carp (*Hypophthalmichthys molitrix*)	75-100	1000-1500
8	Tilapia (*Oreochromis mossambicus*)	4-10	50-75
9	Galda (*Macrobrachium rosenbergii*)	3-5	30-60

Paddy Production and Paddy cultivation

Zone wise different varieties of paddy production were estimated which is shown in Fig. 8. Ravi paddy becomes ready for harvesting within 4 months and the production ranged 2500-3150 kg /ha. Recorded total amount of paddy and fish are presented in Table 4.

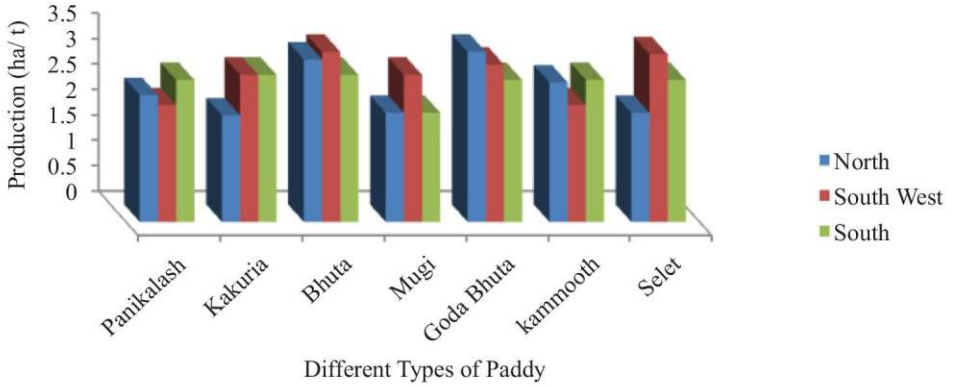

Fig. 8. Zone wise yield of different paddy varieties.

Table 4: List of wild fish production in Paddy-cum fish culture, Moyna

Name of Species	North Zone (Kg/ hectare)	South West Zone (Kg/ hectare)	South East Zone (Kg/ hectare)
Anabas testudineus	14	9	10
Clarias batrachus	6	4	7
Heteropneustes fossilis	3	5	4
Channa punctatus	28	20	25
Channa striatus	14	10	6
Mystus sp.	5	9	6
others	31	45	42
Total Production	101 kg/ ha	102 kg/ ha	100 kg/ ha

Water parameters

The monthly variations of physicochemical parameters of water at three sampling sites recorded during the period of investigations are shown in Table 5, which support to the better growth and survivability of fish species. Water temperature showed variations in different months of the study period in three water bodies. The present communication is an attempt to analysis the water quality of the paddy cum fish culture field at Moyna Block with respect to water depth, water temperature, pH, alkalinity, dissolve oxygen, nitrite and hardness.

Table 5: Physico- chemical water quality parameters

Name of the Zone	P^H		Temp. (^{0}C)		DO (ppm)		Alkalinity (ppm)		Hardness (ppm)		Nitrite (ppm)		Water Depth (mt.)	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Northern	7.2	8.1	26.2	31.4	6.4	7.6	134	186	88	113	0.01	0.08	1.2	1.6
South Western	7.4	7.9	26.4	30.8	6.2	7.9	167	204	102	156	0.02	0.07	0.8	1.3
South Eastern	7.4	7.7	27.2	30.6	5.8	7.8	118	197	93	134	0.04	1.02	1.2	1.9

Cost Profit Analysis

In average Zone-I, Zone-II & Zone-III showed gross expenditure for rice cultivation & fish culture which was Rs 2, 28,328.00 and sale of paddy & fish was Rs. 3,36,724.00 where net profit was 1,08,396.00 ,which are recorded in Table 6. There is no extra manure cost for fish culture, which are more beneficial to the community base fish farmer. Moyna Block under Purba Medinipur is one of the backward areas in West Bengal where the inhabitants are the mixed caste communities with patches of concentration either SC or ST or Minority community as the case may be. The socio-economic conditions of the rural community at Moyna Block are most important factors for development and utilization of paddy-cum-fish culture.

Table 6: Average Cost & Profit Inputs (Calculation as per hectare)

Item	Quantity	Rate (Rs.)	Expenditure (Rs.)
1. Rice Cultivation			
A.) Dyke renovation by dresser	2 hour	1000/hour	2,000.00
B.) Land plough	1 hectare	6.48/ decimal	1,600.00
C.) Cow dung	3600 kg	1/kg	3,600.00
D.) Organic manure	1000 kg	5/kg	5,000.00
E.) NPK fertilizer	500 kg	22/kg	13,000.00
F.) Labour	100 Man/day	120/day	12,000.00
G.) Rice Seed	74 kg	22/ kg	1,628.00
H.) Miscellaneous	1 hector	-	2,000.00
Total Expenditure for rice cultivation			= 40,828.00
Sale of 2883kg Rice @18/Kg = 51,894.00			
Profit of Rice Sale			**= 11,066.00**

Item	Quantity	Rate (Rs.)	Expenditure (Rs.)
2. Fish Culture			
A.) Fingerlings 1000-1100	1050 kg	70/ kg	73,500.00
kg./ha. (stocking size >15g)			27,000.00
B.) Fish Feed	900 kg	30/kg	9000.00
Medicine , fish nutrient		-	9000.00
C.) Transportation	1 hectare	-	14000.00
D.) Labour	100	140/ day	50,000.00
E.) Lease rent	1 hectare	200/decimal	5000.00
F.) Miscellaneous	-	-	
Total Expenditure for fish culture			= 1,87,500.00
Sale of 3130 kg Fish @ Rs 91/kg = 2,84,830.00			
Profit of fish sale			**= 97,330.00**

3.Return	
Total expenditure for rice cultivation and fish culture	2,28,328.00
Sale of paddy & fish	3,36,724.00
Net profit	**1,08,396.00**

To increase the production efficiency of the paddy fields and advanced utilization of land and water resources the paddy-cum-fish culture is one of the best practice in sorts of higher profit. When fish are introduced into paddy field ecosystem, the population and composition of aquatic organisms are changed accordingly. The Paddy-cum-fish farming can change the direction of energy flow in the specified ecosystem where the stocked fish

transform stagnant energy (e.g. weeds) and possibly lost energy (e.g. phytoplankton, zooplankton, and aquatic insects) into reusable products. Through several physical techniques the common carp and other omnivorous fishes may minimize the infestation rate of human beings in the culture areas.

Specific framework of rural development through paddy-cum-fish farming having a great potential in worldwide which requires small cash outlays and could provide significant increases in rural employment and family incomes. However, several constraints, which faces the development of paddy-cum-fish farming in numerous approaches likewise the technical, socio-economic and management related in aquatic ecosystem. Further, the success of paddy-cum-fish farming depends on reliable sources of quality fish seed, reasonably priced supplemental feeds; proper control of predators and pests; definite supply of sufficient water during the post-monsoon seasons along with the best supported or adopted technology. Moreover, a significant drive must be required to formulate proper ecolog1cal guidelines for suitable fish cultivation in paddy fields. Besides, one of the important factors that have influenced the utilization and development of rice-fish farming of the research area is the socio-economic conditions of the rural poor community engaged with fish culture.

As known the agriculture, fishery practices are generally considered an important upcoming avenue in India and which may engage by the members of the rural farming communities. So that a proper planning is needed to uplift the socio-economic conditions of the engaged rural people is essential for proper development of the industries in relations to agriculture & fisheries at Moyna areas.

DISCUSSION

The culture of fish in paddy fields has a greater significance in the economy of rural areas like Moyna at West Bengal. It can provide a chief protein source and also provides additional income to the farmers. Insects and their larvae indirectly contribute to a better production of fish and in other hand fish feed, faecal matter of fish etc. also help for better production of paddy (Tangjang and Nair, 2015).

This approach helps to mitigate the trend of declining production from inland capture fisheries accompanied by increasing price of fish, making it less affordable to the poor. Dey and Prein, 2000) reported that in Bangladesh there are 3 million hector of medium and deep flooded area, out of which about 1.5 million ha are estimated to be suitable for community based fish culture. If this approaches adopted annual fish production will increase. In Africa, the potential for application of community based fish culture was greater in seasonal floodplains and in irrigation schemes. In the West African flood plains, 4,70,000 ha were used to grow deep water rice (Catling, 1992) which could be used for concurrent deep water rice and fish culture. In recent condition some fisher man have been changed their culture system i.e. paddy alternate fish culture which are more significant for their socio-economic status. The species of fish suited for fish culture in paddy fields are those that can (i) thrive in very shallow water (ii) withstand fairly very high turbidity (iii) tolerate relatively high temperature and (iv) to marketable size in a very short period.

In paddy-cum-fish fields at Moyna regions paddy monitored the temperature and quality of water. This support may provide a stable environment which is conducive to the reproduction of natural fish food organisms. The sequential relationship in the distribution of paddy and fish is apparent. Culture fishes in paddy field feed on available plankton (that competes with paddy for fertilizer), weeds (that competes with paddy for nutrients), insects, bacteria (that harm paddy plant) and mosquito larvae (harmful to human). Fishes assimilate only 3-4% of these feeds and discharge the rest into paddy field that acts as manure. Because the fish consume phytoplankton, zooplankton and weeds that compete with paddy, they play an important role in recovering lost energy and adjusting energy flow. When they swim in water, they release carbon dioxide that increases the amount of carbon available to the plants. They also break the soil surface and oxidize layers of soil, which increases the supply of oxygen, promotes root growth and tailoring capability of paddy plant. The excreta of fish left over supplemental feed and additional fertilizer used also help in increasing the soil fertility and productivity. Paddy-fish mutualism is therefore, the best way to maximize the output of the ecological system that turn material and energy into fish production, accelerate the growth of paddy and increase the solar energy fixation, thus raising the productivity of paddy fields.

CONCLUSION

Irrespective study revealed that the ecosystems of the indigenous farming of paddy and culture fish are mostly concurrent in nature. As a result, the frame based fishery and wild aquatic cropping systems are commonly found in those areas that are water logged during the rainy season and where flooded fields become connected with perennial water bodies. However, over exploitation of perennial water is only one of major threats to inland aquatic resources. The supplementary harvest of fish from paddy fields is an innovation to increase returns and require to maintaining sustainable development of culture field. Yet, these paddy come fish culture are of the highest importance for the rural poor for income, quality nutrition and food security.

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CONFLICT OF INTEREST

Authors declare there is no conflict of interest.

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