Impact of Pond Fish Culture on Household Livelihood Capitals: An Empirical Analysis in Mymensingh District of Bangladesh

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ARTICLE INFO	ABSTRACT
	Pond fish culture is the cornerstone to increase livelihood capitals. This study made an attempt to determine the relationship between livelihood capitals and pond fish culture to measure the changes of livelihoods capitals. The study is based on field survey covering six Upazilas in Mymensingh district of Bangladesh. Only 10 pond fish farmers were randomly selected from 21 villages and stood at 210. Six Key Informant Interview (KII), twenty four FGDs and face to face interviews were done to collect primary information. Analytical technique as ordered probit model was followed to make a relationship between livelihood capitals (financial, natural, physical, human, and social) and pond fish culture. Under physical capitals, sources of credit, input availability and marketing facilities were inadequate in the development of pond fish farmers which directly affects pond fish culture. In terms of the social capital, changes in basic needs, contact with other farmers and political consciousness were significant and positive. In terms of human capital, age, working experiences, and child and adult education were significant and positive but households nutrients and food consumption, visit to health care centre, and water and sanitation conditions were negatively impact on pond fish culture. The overall result of the study found that livelihood capitals were significant and positively impact on pond fish culture. It was, therefore necessary to pay attention on physical, human and financial capitals of pond fish farmers through the provision of institutional credit, training facilities, and market establishment.

Introduction

The fisheries sector is one of the potential industries in the agrarian economy of Bangladesh. It contributes 3.61% to the national GDP and around 24.41% to the agricultural GDP (DoF, 2017). It is important for the source of animal protein, employment opportunities, food security, foreign earnings and socioeconomic development (FRSS, 2017) as a whole. About 11 million people are directly or indirectly dependent on fish production for their livelihoods and income (DoF, 2018). As a result, fish production in Bangladesh is increasing day by day and many new areas being used for fish production and it is known as the fourth largest fish producer in the world (DoF, 2019). Its contribution directly impact on three different levels also as i) at the producer level for higher productivity, income and better livelihoods; ii) at the consumer level for increasing fish

supply and price reduction; and iii) at the trade and export level for increasing the national income and employment generation that benefited overall national development (Dey *et al*, 2006).

Total pond area of Bangladesh in 2018-19 was 1.85 million ha with 4.97 MT/ha (DoF, 2019). Pond fish production is a profitable practice than many other forms of agriculture, for example, the gross return of a hectare of land growing a combination of Pajam and BRRI Dhan 29 rice is TK 81098, but a hectare of pond land returns TK 115788 by carp polyculture (Dey *et al.,* 2008). Consequently, the rural farmers have taken pond fish culture as their earning source and directly improved their household livelihood capitals and employment opportunities as well. Its potentiality is shown as a promising to achieve self-sufficiency in food sector and

also to alleviate poverty (Al-Amin *et al.*, 2012), to enhance fishermen's capabilities and assets both now and in the future (Chambers and Conway, 1992), and to livelihood as a social context (Hasan *et al.*, 2012; Amin *et al.*, 2012). A livelihood is the set of capabilities assets and activities as that furnish the means for people to meet their basic needs (Scoones, 1998). The building of livelihoods reflects and seeks to fulfill both materials and experiential needs. It is estimated that about 70% of the population are living in the rural areas (Edward, 2000). Therefore, pond fish culture should be considered as an important issue of personal, social, and economic development in which the first requirement is to satisfy the basic needs of the poor. It also has a subtle relationship with household livelihood capitals. Evidence from the field studies in developing countries indicated that rural poor households typically derived a large share of their cash income from their own ponds than better-off households (Karim 2006; Islam, 2007). Regarding this, it was necessary to do an in-depth research, identify livelihood capitals and to sketch up the real scenario of pond fish culture in particular area. If pond fish culture improved farmer's livelihood capitals in a particular area, it would be easy to give a recommendation which can be a representing part of the national policy. If pond fish culture is recommended to continue for the rural poor, government and non-government institutions need to be in place to create a policy environment also.

There have been several reviews of the fisheries and aquaculture challenges (Ghose 2014; Hossain 2014); recent studies in various regions of Bangladesh indicated that poorer households receive many benefits from fish production (Barman 2000; Karim 2006); the ponds of the poor are often ignored because of their very small size and tendency to be seasonal, but fulfil important livelihood functions none-the-less (David *et al.*, 2007); the changes of annual rainfall, percolates into the ground, and raising the water table close to ground level may affect natural and human systems independently or in combination with other determinants to alter the productivity, diversity and functions of ecosystems and livelihoods (Perry *et al.,* 2009); in addition, some scholars (Shi *et al.,* 2014; Su *et al.,* 2009; Zhang *et al.*, 2013; Zhao *et al.*, 2011) have conducted some studies on farm household livelihood assets and livelihood strategies but no studies have been carried on the contribution of livelihood capitals and its importance. Thus, it is important to determine an area where fish play an important role in culturing and distribution. Mymensingh is one the most important districts for fish culture in Bangladesh and considered as one of the ideal fish production areas in the districts. Although the involvement of large numbers of people in pond fish culture with available huge fisheries resources surprisingly, no study of fish farmer's livelihood capitals

and emerging problems in that area is reported yet. Therefore, the enhanced fish production and good fish production practices would be ensured in that areas if fishers improved their livelihood capitals. So it is very important to analyse whether the livelihood capitals of the pond fish farmers are positively affected by the pond fish culture or not. Based on research question, nature, regional variation, and different forms of pond fish culture were required to analyze in-depth analysis in order to understand the impact on household livelihoods capitals corresponding conclusions and policy implications. The findings of the study would also be implemented in putting forward various suggestions which could help the policy makers to undertake various development interventions of continuing pond fish culture. Considering the above fact, the study was carried out to determine the livelihood capitals of pond fish farmers in Mymensingh district of Bangladesh.

Materials and Methods

The study was conducted at six upazilas as Bhaluka, Trishal, Muktagachcha, Fulbaria, Phulpur, and Mymensingh sadar covering twenty-one villages. Several types of waterbodies and fish farms located in different villages and urban areas were selected and monitored. Most of the areas were also out of flood. Hundred percent of ponds of this region were perennial. Major parts of produced fish are distributed from Mymensingh district to others. To prepare the population frame, voter lists were used and sub-assistant agriculture officer (SAAOs), Upazila Fisheries Officers, NGO workers and local elites were also consulted. To ensure involvement of respondents in pond fish culture, 438 pond fish farmers were identified where 10 pond fish farmers were selected randomly from each village. Consequently, the sample size stood at 210.

For this reason, it is necessary to use a systemic approach (Fussel & klein 2006; Carr 2014) to obtain a more complete livelihood assessment. Both primary and secondary information were collected through the survey, monitoring, participatory rural appraisal (PRA) tool such as twenty-four (24) focus group discussion (FGD), six key informants and face to face interviews with seventeen participants in each group. For face to face interviews, a set of preplanned interview schedule was prepared to address several issues of pond fish culture, and livelihood capitals of fish farmers. In addition, a number of published books, journals, annual reports, and internet documents were considered for secondary information. The following analytical technique has been utilized to investigate the relationship between livelihood capitals and pond fish culture using Stata software.

Relationship between livelihood capitals and pond fish culture

Livelihood is not simply a localized phenomenon, but connected with environmental, economic, political and cultural process to wider national, regional and global arenas (Carney 2002; Complain 1998; Redelift 1990). While Frank Ellis (2000) provided a good working definition as "the assets (natural, physical, human, financial, and social capitals), the activities, and the access to these (mediated by institutions and social relations) that together determine the living gained by the individual or household." To measure the relationship between livelihood capitals (financial, natural, physical, human and social) and pond fish culture and catch out the changes of livelihood capitals, the ordered probit regression model used in this study (Della Lucia *et al.,* 2013).

$$Y_n^* = \sum_{i=1}^{n} \beta_{1i} \, I_{1i} + \cdots \ldots \ldots . \sum_{i=n}^{n} \beta_{ni} \, I_{ni} + \varepsilon_n$$

Where, $I_{1i} \ldots \ldots \ldots \ldots . I_{ni}$ are indicator variables (dummy variables) for the i-th capital and the test with information.

The livelihood capital framework for sustainable development was adopted here. These livelihood capitals included natural, financial, physical, social, and human capital (Carney, 1998; Davies, 1996; Soussan *et al.*, 2000). Each of these capitals was, in turn, dependent on various indicators. *Financial* capital was dependent on income, employment and savings; *physical* capital was dependent on household assets, road and transport, market and health care service; *natural* capital was dependent on water, land, and temperature; *social* capital was dependent on the social institutional role (early marriage, dowry), decision ability, social prestige, solve conflict and cooperation and *human* capital was dependent on health, education, training, knowledge and skills, etc.

Results and Discussion

These capitals provide a useful starting point of household livelihood analysis, as it influences farmers to take into account all the different kinds of capitals or resources.

Physical capital

The result of the ordered probit model investigated the relationship between different physical capital indicators and pond fish culture with seven explanatory variables and dependent variables ordered score (0=no change, 1=decreased and 2=increased). Table 1 shows that health care facilities and local government had significant and positive bearing with physical capital. Pond fish farmers received health care facilities (good=1, bad=0) after pond fish culture. Due to the presence of general practitioners, government hospital, NGOs health and local community clinic in the areas, they are now more concerned about their health than before. Moreover, sources of credit (NGOs=1, Bank=0) were insignificant but positive association. Most of the pond fish farmers met up their financial crisis by their relatives or other sources.

Table 1 also shows that availability of input supply (available=1, not available=0) was positive but insignificant association with physical capital. Inputs (fish fry, feeds, labour, etc.) were the main ones that had a negative relationship with physical capitals but were constantly at a disadvantage due to lack of roads, high prices, shortage of workers during production and distance from sales outlets. Pond size (better=1, bad=0) positively correlated but insignificant because the farmers do not follow the instructions of the Fisheries Office, they cultivate more fish in a pond with different types of fish. Water and sewerage systems (increased=1, not increased=0) was insignificant but positively correlated with physical capital. It was reported that most fishermen are concerned about safe water and drainage, but the desire to spend money on housing, education, medicine, and communications is more important than this. Local government support (good=1, bad=0) was positive and significant association with physical capital. Marketing facilities (better=1, bad=0) were significant but negative because farmers do not get the benefits of fish culture due to lack of local storage facilities, low price of produced fish, and lack of timely transportation in study areas.

Social capital

The ordered probit model made a relationship between social capital (0=no change, 1=decreased, and 2=increased) and 5 pond fish culture related variables. Table 2 shows that, changes in basic needs, and political consciousness (voting) and support from family were significant and positive where contact with other farmers was significant but negative association with pond fish culture. Changes in basic needs were also significant and had positive association with social capital. Food and non-food items were considered as basic needs including rice, meat, vegetables, fish, eggs, pulse, and milk and cloth, medicine, education and housing for pond fish farm households. If people suffer from hunger then they would be mentally disturbed, in this way they engaged any illegal or unlawful activities. After fulfilling their basic requirement, they enjoyed additional activities as mental stability, self-employment opportunities and family member's requirement.

Table 1. Coefficients of the ordered probit regression estimation of physical capital

Name of the variables	Coefficients	Z-statistics
Water and sewerage systems	0.242	0.52
Pond size of the fish farming	0.003	0.59
Health care centre/hospitals	0.565	1.85*
Local government support	0.513	1.73*
Input supply availability	0.291	0.55
Sources of credit	0.495	1.23
Marketing facilities	-0.987	-4.10***
/cut1		-1.886164 (1.335289)
/cut2		-1.533464 (1.333133)
Log likelihood		-62.644581
Pseudo R^2		0.2121
Generalized Likelihood Ratio (LR) test		33.72***

Field survey, 2016; Note: Figures in the parenthesis indicate the standard errors, *and ***denote significance at 10% and 1% level of probability, respectively.

Table 2. Coefficients of the ordered probit regression estimation of social capital

Name of the variables	Coefficients	Z-statistics
Changes in basic needs	2.833	7.61***
Leadership in group meeting	0.001	0.00
Participation in social gathering	-0.126	-0.68
Political consciousness (voting) and support from family	0.386	2.66**
Contact with other farmers	-0.809	-3.21***
/cut1		0.9247576 (0.6615955)
/cut2		3.400461 (0.7033757)
Log likelihood		-142.20975
Pseudo R^2		0.253
Generalized Likelihood Ratio (LR) test		96.33***

Field survey, 2016; Note: Figures in the parenthesis indicate the standard errors, **and ***denote significance at 5% and 1% level of probability, respectively.

So it was sufficient for them to get a remarkable positive impact on social capital. Contact with other fish farmers (increased=1, not increased=0) means a better networking system that helps them solve problems related to pond fish culture, and management as well as help them developing knowledge and leadership. Political consciousness and support from family (increased=1, not increased=0) was an important issue that highlighted its positive and meaningful importance in raising awareness about their voting power and engaging in local government politics. Participation in social gathering (increased=1, not increased=0), was also negative and inconsistent with pond fish culture. It is known that people interact with their friends, relatives, and neighbour through joining in the wedding ceremonies, sports programs, school or club annual programs or local recreation activities, etc., which make them more civilized and cultured life. But pond fish farmers are now much busier than before and have less time to attend social gatherings.

Human capitals

Table 3 shows the relationship between human capital and pond fish culture where dependent variable ordered score (0, 1 and 2) considering nine explanatory variables as independent variables in the model. In the Table 3, age, working experiences, and child and adult education were positive and had significant association with human capital where household nutrients and food consumption, visit to health care centre, and safe water and sanitation facilities were negative but significant relationship. Household nutrients and foods consumption (very good=2, good=1 and bad=0) refers to family status in society which was the subject of insufficient and less concern in the study. It means that they facilitate only fish to their family which fulfilling the animal protein but was insufficient in getting meat, egg, milk, and vegetables, etc. Although they produce fish, ignorance about adequate and nutritious food and not knowing how much protein and calories a family member needs was paramount. Knowledge about pond fish culture (high=2, medium=1 and low=0) was vital but the negative and insignificant association effected their human capital. Because of indigenous or lack of technical knowledge in fish culture practices such as brood fish preservation, pond size requirement, fertilizer applications and appropriate harvesting time, grading process or marketing activities, etc. continuously interrupted getting the expected level of fish.

Ages of pond fish farmers were positive and significant. In the study, the average age was 36 years meaning that they were more active and able to do more risky activities of fish culture. In addition, the child and adult education expenses were significant and positive association with human capital. They were more aware than ever about the cost of educating their children due to the increase in income. Due to technological

advancement and globalization, they are also aware of the benefits of higher education and are trying to educate their children by adopting advanced technology. Visiting health care centre (yes=1, no-0) was significant but had negative association with human capital because of ignorance or lack of health consciousness. Moreover, the increased human rights, literacy rates, standard of living, and household income, etc. helps them to go to the doctor and be health conscious but lack of service and centralization, lack of easy access to specialized doctors prevent them from having an adverse effect on human capitals. Further, working experience (year) on pond fish culture was significant and positive correlation with human capital. Table 3 also revealed that safe water and sanitation awareness (good=1, bad=0) was significant but negative effect on human capital. I was not enough in the study areas. They are using tube-wells and good sanitation but need to pay more attention to safe drinking and good drainage systems.

Financial capital

Financial capital includes flows as well as stock of capital and it can contribute to consumption as well as production. The study determined the relationship between financial capital and seven explanatory variables. The ordered probit estimations revealed that shared labour (share labour=1, other=0) was significant and had positive correlation with financial capital. Shared labour means fish farmers combine their work forces to create efficiency and also take the advantage of economic scale. Pond fish farmers also share labour with their family members and paid workers to run it properly, in this way, they earn more profit, accumulate more capital and reinvest. Lack of credit (yes=1, no=0) was positive but insignificant association meaning that fish culture is facing difficulties due to lack of working capital and not getting enough credit at the right time. Table 4 also shows that the number of loans was significant but negatively associated meaning that the getting loans from NGOs, relatives or others greatly changed their attitude and contributed to their economic and social development but insufficient for them. Table 4 shows that livestock and poultry rearing was significant but negative correlation with financial capital. In Bangladesh, livestock and poultry sector have got the top priority with high market demand. Livestock and poultry rearing were poor access and totally insignificant in the study areas because of paying more attention on pond fish culture rather than livestock and poultry rearing. Crop cultivation shows the significant and positive relationship with financial capital. Fish farmers can use the pond park for crop production very easily and at low cost which directly increases the crop production with the use of land.

Table 3. Coefficients of the ordered probit regression estimation of human capital

Name of the variables	Coefficients	Z-statistics
Age of the pond fish farmers	0.049	2.35**
Household nutrients and food consumption	-0.452	-2.03**
Working experience on pond fish farming	0.149	2.83***
Training on pond fish farming	-0.024	-0.09
Knowledge about pond fish culture	-0.259	-1.01
Child and adult education	0.799	2.13**
Safe water and sanitation awareness	-0.985	-1.98**
Attitude towards family planning	0.096	0.38
Visit to health care centre/hospitals	-0.758	-2.78***
/cut1	-0.4851076 (1.179263)	
/cut2	0.5629009 (1.142732)	
Log likelihood	-87.004631	
Pseudo R^2	0.1720	
Generalized Likelihood Ratio (LR) test	48.19***	

Field survey, 2016; Note: Figures in the parenthesis indicate the standard errors, **and ***denote significance at 5% and 1% level of probability, respectively.

Table 4. Coefficients of the ordered probit regression estimation of financial capital

Name of the variables	Coefficients	Z-statistics
Livestock and poultry rearing	-0.571	-2.27**
Amount of loan from NGOs and others	-0.743	-2.99***
Shared labour	0.660	2.46**
Deposit facilities in bank	-0.246	-0.98
Collateral condition	-0.145	-0.63
Crop cultivation	0.585	2.43***
/cut1	-1.329258 (0.4728002)	
/cut2	-0.844987 (0.4643427)	
Log likelihood	-95.584663	
Pseudo R^2	20.56***	
Generalized Likelihood Ratio (LR) test	-1.329258 (0.4728002)	

Field survey, 2016; Note: Figures in the parenthesis indicate the standard errors, **and ***denote significance at 5% and 1% level of probability, respectively.

Table 5. Coefficients of the ordered probit regression estimation of natural capital

Name of the variables	Coefficients	Z-statistics
Pond ownership	1.134	4.98***
Fertilizer	0.183	1.00
Pond availability	0.000	0.05
Ground water level	0.379	2.00**
Vegetation of the area	-0.692	-3.37***
Soil preservation	0.419	2.67***
/cut1	0.7869415 (0.3679196)	
/cut2	2.000736 (0.3804434)	
Log likelihood	-205.65431	
Pseudo R^2	0.0859	
Generalized Likelihood Ratio (LR) test	38.64***	

Field survey, 2016; Note: Figures in the parenthesis indicate the standard errors, **and ***denote significance at 5% and 1% level of probability, respectively.

Natural capital

Table 5 presented the result of the ordered probit estimation to investigate the relationship between natural capital (0, 1 and 2) and pond fish culture considering six explanatory variables. Results revealed that natural capitals like pond ownership, ground water level, vegetation and soil preservation were the vital for fish production. Here, pond ownership, ground water, and soil preservation were found a significant and positive relationship but vegetation negatively affected the natural capital as well. Pond availability was positive but insignificant correlation; without pond, fish culture is impossible. As a natural resource, the pond has direct impact on fish production process with water quality, water level, water types or fertility, etc. The study also proves that there is scope for more ponds in the area, as many more can come forward in fish production by converting the fallow land into ponds, which can solve the unemployment problem in the area as well as utilize the land. Pond ownership was also significant due to direct access to fish culture. Another important variable was the ground water level (availability=1, unavailability=0) which was positive and significant association with natural capital. For fish culture, it is important to have a certain level of ground water which helps a producer to manage the water required for the pond using ordinary pumps and indirectly reduces the cost of fish production. Soil preservation was also significant and positive with natural capital. Not all types of soil are suitable for ponds. Increasing the water holding capacity of the soil and the production capacity of the pond is important. For this, farmers use preservation technology such as cow dung, lime, and salt to make ponds suitable for fish culture.

Above all, the household livelihood capital of pond fish farmers has increased due to fish culture. Farmers were more aware of the basic needs that made them socially dignified. They want to achieve not only their economic development but also social status through pond fish culture. But still some obstacles are preventing them from reaching the desired goal. A number of scholars (Harrison,1983 and Twomlow *et al.*, 2002) reported that any technology that makes the most economic use of a country's natural resources and its relative proportions of capital, labour and skills that furthers national and social goals; but agriculturally, believed that livelihood strategies may include short-term yield enhancing strategies or longer-term soil improvement or conservation strategies; all of these study reflected a positive concept of livelihoods which has directly been focused on the present study. Pond fish culture is a semi-intensive type enterprise, which is also an attractable activity for rural farmers but need to pay attention on physical (i.e. pond size, input availability, and sources of credit, etc.), financial capitals (as lack of credit, deposit facilities, collateral conditions, etc.) and human capitals (i.e. training, knowledge, and attitude towards family planning, etc.).

Conclusions

Here there is a significant changes in the attitude of the pond fish farmers towards a positive relationship with the pond fish culture and livelihood capitals (financial, natural, physical, human and social). Different analytical criteria were considered for this, such as seven analysts for physical, five for social, nine for human, seven for financial and six analysts for natural capitals and significant relationships with each other. All these influential variables were to continue pond fish culture. But in reality, due to lack of sources of credit, lack of input supply and lack of suitable pond size, physical capitals were insufficient for the development of pond fish culture. As usual, participating in social gathering and interacting with others was a major obstacle to the development of social capitals. Three of the nine variables had significant but negative relationships with human capitals, meaning that nutritional food, sanitation, and health awareness were the measure of human capitals growth that directly contributed to fishermen's livelihoods. The probit estimate also found that the amount of loan from NGOs and others was negative but significant in the case of financial capitals. On the other hand, deposit facilities in a bank revealed

an insignificant and negative relationship with the financial capital. In the case of natural capitals, ownership of the pond, ground water level, and soil preservation were highly significant and positive, where vegetation of the area was a negative but significant relationship. In addition, fertilizer application on pond was found to be insignificant but had a positive effect on natural capitals. As a result, it can be easily said that fish culture in ponds was improved the livelihood capitals where income, savings, loan facilities, housing, sewerage systems, etc. were considered. Based on the key findings of the study, it is very important to pay close attention to the livelihood capitals especially on human, physical, and financial capitals of the fishermen. It is imperative that the development of human, physical and financial capitals were possible through the provision of training, input availability, and institutional loan facilities as well. In addition, institutional, private, and government support is needed which will act as a mediator in the development of pond fish culture. Finally, this is not to say that it is possible to improve the quality of life of pond fish farmers by improving livelihood capitals, need to review other aspects of qualitative research along with quantitative research of livelihoods. Which helps in better and realistic sustainable livelihood analysis for pond fish farmers.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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