International Journal of Ecology and Environmental Sciences
www.ecologyjournal.in
Online ISSN: 2664-7133; Print ISSN: 2664-7125; Impact Factor: RJIF 5.28
Received: 06-09-2020; Accepted: 10-10-2020; Published: 07-10-2020
Volume 2; Issue 4; 2020; Page No. 289-293

Floodplain aquaculture and its potentiality in Bangladesh: A review

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Abstract
Floodplain water-bodies are one of the major common-pool resources (CPRs) of Bangladesh. Floodplain aquaculture can generate income, employment and food security. It can also contribute significantly to alleviate rural poverty. Floodplain aquaculture continues to diversify and develop rapidly. It has seen as the most realistic way to secure the nation's future fish supply. The current review depicts the production and economic performance of floodplain aquaculture of Bangladesh. It has many positive effects on local economies, social security and safety as well as nutritional status. The study concluded that Government initiative can be the way of utilizing the huge number of floodplain as potential aquatic resources.

Keywords: floodplain, aquaculture, fish production, rural poverty alleviation

1. Introduction

Bangladesh is a country with vast floodplains [1] and one of the world's most important wetlands [17]. Bangladesh is a delta and most of its area (147,570 km^2) [3] is mainly composed of alluvial deposits borne by the Ganga-Padma, Meghna and Jamuna-Brahmaputra rivers and their branches. Floodplains constitute more than 55% of the land, and on annual basis from 26,000 km^2 to 82,000 km^2 of them get inundated in the monsoon and remain so for the next few months. Bangladesh has 2.8 million ha of floodplain water-bodies [11]. The current production level in floodplain area is only 283 kg/ha [10], which can be increased ten folds with minimum institutional support, but sincere and co-ordinate efforts are required from the community. On the contrary, if fish production can be increased 1.5MT/ha, about 12 lakh MT fish would be added to our national fish production. If five persons are involved in the fish production activities per ha, it will create the employment opportunity for about 40,000 people per year [16]. About one third lower areas of Bangladesh become inundated during rainy season. The areas of the country which become flooded and hold water for 4-5 months is termed as floodplain. Some parts of these are rice fields. Although the fish production from inland water increased but the total production from floodplains and beels decreased from 63% to 46% [8]. These wetlands provide habitats to hundreds of fish, plants, birds and other wildlife species and most importantly, a source of income for millions of rural people [7, 19]. The floodplain provides habitat in the form of feeding, breeding and nursery ground for a wide range of wild life including fish [25]. However, there has been a gradual decline in the production of fish from floodplains over the last two decades due to the reduction of wetlands and biodiversity, over fishing, siltation and management problem [20]. The floodplain aquaculture projects can conserve local biodiversity in better way. Once the project is filled with floodwater from the neighboring river or canals, there happens automatic introduction of all kinds of natural fish available in local habitat. At the onset of monsoon, the fish can breed; spawn can grow and survive safely because of no public fishing takes place inside the project. On the other hand, free access in open water allows fishing by using all types of gears. In case of floodplain aquaculture projects, the ditches are not dried completely which allows some residual fish in the super market. Koi (*Anabas testudineus*), Magur (*Clarias batrachus*), Shing (*Heteropneustes fossilis*), Shol (*Channa striata*), Foli (*Notopterus notopterus*) etc. are the live fish variety sold in city market at 4-5 times higher price than the cultured fish.

The economic study of aquaculture provides a basis for decision making for fish farmers and assists in formulation of public policies. However, in many developing countries such interest and the capacity to carry out extensive economic studies is presently lacking, thus making it difficult for sound development policies to be formulated [24]. Many factors are involved in affecting the aquacultural economics. Bayley (1988) [4] estimated the maximum potential yields is more highly exploited tropical floodplains at 110-160 kg/ha/yr while [21] reported that it is possible to increase production up to 1976 kg/ha/yr by seasonal fish culture in floodplains. The study is expected to provide some valuable information to the floodplain farmers and organizations dealing with such project. It is expected that the findings of the work will be helpful to prepare a guideline for a sustainable floodplain aquaculture practices.

2. Materials and Methods

The study was carried out based on the information through review of related thesis, journals, reports and books. Some practical knowledge was gained through observing research

presentation related with floodplain aquaculture. The necessary data were collected from internet, different annual statistical yearbooks of Bangladesh, National Fish week compendiums, newspapers, watching with different on-going researches in YouTube and consulting associated consultants and researchers.

3. Introduction to Floodplain Aquaculture

Bangladesh is endowed with huge amount of fisheries resources. It is very conducive climatic conditions to use these resources to earn peoples livelihoods particularly in rural area. Aquaculture could be one of the best options for the rural people which can generate income, employment and food security and can contribute significantly to alleviate rural poverty [24]. There has been steady growth of 5-6% in aquaculture production in the recent years and currently about 39% of total fish production coming from aquaculture [9]. The growth and successes in aquaculture is replenished from about 0.5 million ha of inland water area including ponds, ditches, oxbow lakes and coastal shrimp farms. Whereas, there remains about 2.8 million ha floodplain areas having about 17.97% contributions in total fish production. Table 1 shows that the current production level from floodplain is 283 kg/ha which was about 150 kg/ha in 2009 [10].

Table 1: Comparison between floodplain aquaculture productions with other sectors according to annual fish production [5]

Fisheries sector	Water area (hectare)	Total production (metric ton)	%
A. Inland fisheries			
i. Inland open water (capture)			
1. River & estuary	853863	320598	7.50
2. Sundarbans	177,770	18225	0.43
3. Beels	114,161	99197	2.32
4. Kaptai lake	68,800	10152	0.28
5. Floodplain	2712618	768367	17.97
Sub-Total=	39,27,142	12,16,539	28.45
ii. Inland closed water (culture)			
6. Pond	391753	1900298	44.43
7. Seasonal cultured water-bodies	136622	216353	5.06
8. Baor	5488	8072	0.19
9. Shrimp/prawn farm	258681	254367	5.95
10. Crab culture *	9854	11787	0.28
11. Pen culture	5294	11015	0.24
12. Cage culture**	-	3523	0.10
Sub-Total=	7,97,851	24,05,415	56.25
Total in Inland fisheries	47,24,993	36,21,954	84.69
B. Marine fisheries			
13. Trawler	-	120087	2.81
14. Artisanal	-	534600	12.50
Total marine fisheries=	-	6,54,687	15.31
Total=	-	42,76,641	100.00

*Crab culture areas are included in Shrimp/Prawn culture areas, ** Cage culture areas are included in River and Beels areas

4. Fish production

The fish production obtained from the flood the floodplain aquaculture projects in and around Daudkandi area ranges from 1.5 to 2.9 ton/ha [5]. It is very encouraging for the landowners and farmers to have the income coming additionally from their lands within 4-6 months period usually left fallow. There are some projects reported to produce exceptionally high ranging from 2.5 to 3 mt./ha. Pankowri Fisheries in Eliotgonj and Shoibal Fisheries in Roypur are the examples of such exceptionally productive projects [5]. It was found that the average fish production from the study area was 2920.43 kg/ha. Both cultured and naturally grown fish species were found in the study area, which yields a total of 27 different fish species [5]. MPO (1984) [18] cited that the major river systems of Bangladesh represent a per hectare production of 240 kg and the floodplain production figure of 50-200 kg/ha/yr has assumed. The estimated production per ha from dewatered beels can be quite high as 1819 kg/ha/yr; the range has been reported to be 100-600 kg/ha in rivers whereas, floodplain productivity tends to be somewhat higher and in some cases has been reported to be as high as 6000 kg per hectare [5]. Gupta *et al.* (1991) [12] reported the production of fish in floodplains as 1000 kg/ha under natural condition.

Table 2: Detailed breakdown of species wise production and their incomes per ha area in Daudkandi, Comilla [5]

Fish species	Average production (Kg/ha)	Average selling price (Tk./Kg)	Average income (Tk./ha)	Contribution of the total income (%)
Silver carp	626.35±199.59	46.51±7.66	29134.20	16.75
Bighead carp	235.66±124.85	41.51±10.26	9782.08	5.63
Catla	68.59±65.26	80.55±14.62	5524.66	3.18
Rui	252.32±136.18	63.01±7.41	15897.51	9.14
Mrigal	270.18±175.27	65.24±2.90	17627.48	10.14
Carpio	208.53±118.06	65.42±4.08	13642.47	7.85
Thai SarPunti	73.59±59.71	64.17±16.09	4722.34	2.72

Monosex (Tilapia)	516.47±278.35	67.64±6.93	34932.10	20.09
Black carp	15.47±12.73	61.00±7.13	943.51	0.54
Kalibaush	47.33±41.01	67.78±5.89	3207.80	1.84
Gaunia	40.60±38.08	58.23±2.47	2364.30	1.36
Pangus	81.39±67.81	43.11±5.17	3508.65	2.02
Piranha	66.06±44.50	81.62±3.72	5392.06	3.10
Grass carp	49.74±29.40	67.09±12.18	3337.50	1.92
Chital	4.00±2.11	152.70±33.72	611.48	0.35
Air	22.86±19.19	173.09±58.19	3957.48	2.28
Cross	118.21±102.80	52.55±8.68	6211.69	3.57
Sub-Total	2697.35		160797.30	92.47
Shol	11.33±10.49	112.63±19.83	1276.55	0.73
Taki	12.11±11.47	50.71±15.74	614.12	0.35
Mola	58.17±52.23	50.00±15.25	2908.33	1.67
Tengra	2.96±1.92	51.30±19.07	151.84	0.09
Baim	15.73±14.62	94.28±30.15	1483.38	0.85
Koi	5.11±4.77	179.31±40.10	915.92	0.53
Shing	3.94±3.59	223.42±63.87	881.03	0.51
Foli	2.76±2.32	89.47±29.19	246.73	0.14
Punti	29.76±25.80	38.14±1.58	1135.24	0.65
Gura	73.70±60.32	36.29±2.37	2674.81	1.54
Chingri	5.98±1.31	95.77±48.47	572.96	0.33
Boal	1.51±1.43	150.19±17.17	227.28	0.13
Sub-Total	223.08		13088.18	7.53
Total	2920.43		173885.49	100
From miscellaneous sources			2500	
Total return (TR)	-	-	176385.49	
Total cost (TC)	-	-	115308.55	
Net income (TR-TC)	-	-	61076.94	
BCR			1.53	

5. Production costs

The costs of fish production included the cost items like-embankment/road construction and or repair, human labor, material inputs (includes cost of fertilizer and lime, feed and fingerling, office set up) and miscellaneous are mentioned in Table 3. The amount of various cost items and contribution of different cost items to the total cost (percentage) has been illustrated. It required a minimum cost for the development of embankment or adjacent roads. It was invested Tk. 1918.28/ha on average which was 1.66% of the total investment for fish culture purposes in floodplain projects [5]. As the floodplain area had lower land elevation, it became flooded regularly depending on the water level in the adjacent rivers. To convert a piece of floodplain area into aquaculture project, it required encircling the area by constructing good embankment and sluice gates. Such construction of common infrastructure happens to be very expensive in low-lying areas and often impossible for the community. Most of the projects had to invest big amount of money for infrastructure development during the inception year. The average amount of cost for both nursery and land lease was fond Tk. 9490.08 /ha and it was 8.23% of the total investment [5].

6. Rice farmer benefit

The rice farmers under cooperative floodplain aquaculture projects are happy now because of flood control embankment can protect his crop from flash floods. For late flood and slow recede of water, the cooperative projects can use LLP (Low lift pump) to drain water for timely seed bed preparation and plantation of boro (winter season) rice. In most cases irrigation and drainage facilities are built-in with the aquaculture package or otherwise a system is in place where the same management looks after the irrigation and water management matter in better ways than a place without aquaculture project. Land owners are benefited from higher productivity and it is claimed that output in agricultural land has increased by 15-20%. On the other hand input costs have declined by 25-35% because no cleaning and ploughing is necessary, no pesticides are used, irrigation is provided to the members at a lower cost, and lower fertilizer doses are required due to the residual impact of manure and feed use in aquaculture. Due to aquaculture activities the land remain clean, fertile and without any grass compared to non-project floodplain land thereby the farmer get benefit to grow rice comparatively in less production cost.

7. Return from floodplain fish production

Total return is the monetary value of different items such total production fish (Kg), sacs (of fertilizer, lime and feed). Sometimes additional income was gained such as, donation and fine of the fish poachers. All of the income was gained by multiplying the total amount of yields by their respective market prices. The detailed breakdown of species wise production and their monetary values are illustrated in Table 2. Total income from fish and other sources was Tk. 176385.49 /ha on average. Net returns were calculated considering full costs. Annual net return in full cost was Tk. 61076.94 /ha on average considering all farms together [5]. Ahmed (2005) [2] found that the total income, total cost and net profit gained from the Bhandardah baor in Chuadanga was Tk. 18469.38, 10093.00 and 8375.60 /ha respectively with the stocking density of 2600 fingerlings per ha. Hossain (2006) [14] estimated a net profit of Tk.24988 from floodplain aquaculture in Daudkandiupazilla in 2005. Khaleque *et al.*, (1998) [16] reported that, the average cost for fish production

under semi-intensive culture and management was estimated to be Tk. 86913.17 against the gross income of Tk. 166350.46 indicating a net return of Tk. 79437.29. The benefit cost ratio was 1.91.

Table 3: Detailed description of costs and returns of fish culture in floodplain [5]

Cost items	Amount (Tk/ha/year)	% of the total cost
Construction of embankment	1918.28	1.66
Nursery and land lease	9490.08	8.23
Fertilizer and lime	7351.54	6.38
Fingerlings	11879.18	10.30
Feed	50255.41	43.58
Office management	2307.23	2.00
Labor and staff wages	8157.75	7.07
Compensation	3362.13	2.92
Harvesting and marketing	8849.43	7.67
Miscellaneous	11737.49	10.18
Total cost (TC)	115308.55	100

8. Shareholders benefit

According to [22] the fish production obtained from the floodplain aquaculture projects around Daudkandi area became encouraging for the landowners and farmers to have the income coming additionally from their lands within 4-6 months period usually left fallow during pre-project situation. The benefit of increased rice/crop production goes individually to the landowners or sharecroppers. But profits of aquaculture are passed on to the members of the project in the form of dividends and land rent. The distribution of net profits from aquaculture amongst the members of SHISUK (Shikhya Shastha and Unnayan Karjakram) projects are given below: (i) 50% of profit as dividends to the owner of project shares (ii) 27% of profit as land rent to the owners of land inside the project (iii) 20% of profit is kept as reserve (for investment in the following year and contingencies) (iv) 3% is spent on social welfare (donation to mosques, temples, and poor household for their emergency family need like treatment, daughter marriage etc.).

9. Benefit for land owners

According to [23] there are two types of land rent. Land rent on cultivable land in the project is determined by the amount of profit. Normally it becomes equal to the amount of dividend paid per share for per Kani (30 decimal) of land. In 2009, a total of Taka 10,065,500 was distributed as dividend among the 16151 shareholders from six cooperative floodplain projects controlled by SHISUK (Shikhya Shastha and Unnayan Karjakram). It was also reported that the land owners were given equivalent land rent per Kani similar to the dividend paid per share. The calculation shows that 4100 Kani of land fall under six projects provided average Taka 2455/Kani for the aquaculture use of the land over a 6 month time.

10. Potentiality of Floodplain Aquaculture

Floodplain aquaculture improves the livelihoods strategies in rural area. Itreduces inequality and poverty in rural communities. It saves the aquatic biodiversity. Due to increase rural income people practice of good governance in their daily activates. It enhances social safety nets and community networking, law and order situation and conflict resolution. It also increases the women involvement in their communities.

11. Challenges of Floodplain Aquaculture

Floodplain should be restricted and floodplain water bodies should not be converted into agriculture land by filling soil. Channels connecting floodplain water bodies to the river should be kept open and siltation free. Natural mixes of vegetation should be managed or restored on the floodplain including grasslands and aquatic weeds. Embankments for road and rail that may disrupt flows over the floodplain should be equipped with adequate provisions for passage of water and fish. It is not necessary to restore all the floodplain as this would be impractical in most rivers. In any case the dynamics of floodplain fish populations suggests that there is an overproduction of young fish each year [13]. This provides the basis of the fishery but can also repopulate degraded reaches of river provided the fishery is not excessive. It is therefore suggested that only portions of the river be conserved or restored approach termed the string of beads principle by [6].

12. Conclusion

Floodplain aquaculture offer benefits in improving aquaculture production that could contribute to the achievement of sustainable development goals (SDG). This paper clearly showed that floodplain aquaculture has huge potential as this. This can increase fish production, supply vital nutrition to poor households and improve the overall welfare of the low-income and resource-poor marginal people. The innovations of the floodplains have been widely used in Bangladesh by different institutions including the Department of Fisheries, Government of Bangladesh, as well as in other countries of Asia. The CBFM (Community Based Fisheries Management) system has huge potential benefits, as a large number of people depend on the 2.8 million hectares of floodplains for their livelihoods. Improvements in floodplain productivity and ecosystem services are important, as are addressing issues of governance for how to manage floodplain sand make the system work. The promotion of the floodplains may thus be a useful tool to bring about dramatic positive changes in trends of overall productivity and livelihood gains for poor people in Bangladesh.

13. Acknowledgement

The authors are thankful and grateful to BAPARD faculty members, officers, staffs of Department of Fisheries, fishery for their kind help to supply data and information related to the floodplain aquaculture.

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