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Aquacultural Potential of Derelict Waterbodies – A Case Study

H.K. Dash*, P.K. Sahoo and J. Biswal
National Research Centre for Women in Agriculture (ICAR), Bhubaneswar-751 003

Abstract

Derelict waterbodies could be an important source to boost fish production for meeting the future fish demand of the country. The study has shown that fish yield from these waterbodies could be as high as 4.6 t/ha. Overall, net income per hectare through scientific management of derelict waterbodies has been found to be Rs 104443, with maximum and minimum net incomes per hectare being Rs 207416 and Rs 64033, respectively. Benefit–cost analysis has indicated that all waterbodies are favourable for aquaculture. Overall B-C ratio under the project has been found to be 3.82 and interestingly, scientific management of waterbodies could yield good income even from low level of investment. Such an activity can provide enormous income and employment opportunities in the rural areas. To encourage large-scale utilization of available derelict waterbodies for aquaculture, a prudent and well-conceived policy for leasing out derelict waterbodies and transfer of relevant technologies to the needy and interested farmers should be evolved. These steps would not only boost fish production in the rural areas, but would also provide much needed impetus to the growth and diversification of rural economy.

Introduction

Fish constitutes an important component of diet of a significant part of country's population. The aggregate fish demand at the national level has been projected at 6.7-7.7 million tonnes by 2015 and aquaculture would hold the key for meeting the future demand challenges (Kumar *et al*., 2005). Therefore, expansion of area under aquaculture has to become an important option to boost fish production. In this context, derelict waterbodies could be immensely useful.

Coastal Orissa is endowed with large areas of unutilized waterbodies like derelict canals and drains. According to the Department of Water Resources, Govt. of Orissa (2002), huge water areas occur in the form of drainage in-between different river systems. They are termed as 'doabs' (water area between rivers). There are 17 'doabs' in the nine coastal districts of Orissa. These drainage systems have secondary and tertiary branches also. While the main drainages have flowing water, the secondary and tertiary drainages have stagnant waters for most part of the year, and are usually infested with aquatic weeds, mainly, water hyacinth. These drainage systems allow draining of excess water during rainy season and serve no major purpose in the remaining part of the year, except meeting irrigation requirements to a limited extent, despite maintaining good water depth. Can these systems be put to any productive uses? The most immediate feasible option seems to be using such waterbodies for aquaculture. But, before committing resources to bring derelict waterbodies into culture system, it is important to assess their yield potential. In this context, an attempt was made to bring some patches of derelict waterbodies in the Nimapara block of Puri district of Orissa under aquaculture through technological and institutional interventions and study the economics

* Author for correspondence;
E-mail: hkdash_nrcwa@ yahoo.co.in
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of these waterbodies. The results of this study have been reported in this paper.

Materials and Methods

A SWOT analysis was conducted involving scientists, local NGOs, village leaders and groups of people to assess the prospect and problems of aquaculture in derelict waterbodies. Subsequently, 1.24 ha water area occurring in seven patches under the Dhanua Drainage System (doab-VI) was selected to study aquaculture. The scheduled caste families residing on the periphery of selected waterbodies were sensitized to take part in the experiment. Looking at the interest shown by the people around the waterbodies, 94 scheduled caste families were included in the project. They were given necessary orientation and training on various packages of practices, including procedure for pond cleaning and its management.

Pond Preparation

Water samples from the selected waterbodies were collected and tested for important parameters such as pH, dissolved oxygen (DO), total alkalinity (TA), free carbon dioxide (CO_2), total hardness (TH), and concentrations of ammonia (TAN), nitrites (NO_2^-), nitrates (NO_3^-), and phosphates (PO_4^{3-}) to assess the suitability of water for aquaculture using the standard methods (APHA, 1989). Wherever required, waterbodies were suitably treated. Pen materials, viz. bamboo and nylon nets were used for making necessary partitions across the waterbodies. It was done to (i) allow free flow of excess water in the drainage systems during heavy rains, (ii) check the escape of cultured fishes from the waterbodies, and (iii) prevent entry of unwanted fishes into the cultured system. In certain cases, flow of water was also partly checked by constructing short bunds across waterbodies from both sides and then pen materials were used as partition. As a common management practice, bleaching powder @ 350kg/ha-m (30% chlorine) was applied, followed by repeated netting to remove the undesirable predatory and weed fishes from the culture system (Jena *et al*., 2006).

Stocking and Fertilization

Four patches of waterbodies of about 0.72 ha area were stocked with IMC fry (catla, rohu, mrigal) in the ratio 40:35:25 with a combined density of 10,000/ha and another three patches covering water area of 0.52 ha were stocked with catla: rohu: mrigal: silver barb in the ratio of 20:30:30:20 with a combined density of 12,000/ha in the month of August 2004.

Observing a high organic load in the waterbodies, fertilization was restricted to only basal application. Groundnut oilcake (GNOC @ 175kg/ha) was soaked in water overnight and mixed with cow dung (@ 50kg/ha) to make the slurry. The slurry was then applied all over the waterbodies before stocking. To enhance fish growth and obtain higher yields, supplementary feeding with finely powdered GNOC and rice bran in 1:1 ratio was done @ 5 per cent of the body weight of fishes, after the release of fry (Jena *et al*., 2006). In the following year, all waterbodies were stocked with IMC comprising catla, rohu and mrigal in the ratio of 40:35:25.

Integrated Fish Farming

Integrated fish farming refers to a combination of practices, incorporating the recycling of wastes and resources from one farming system to the other, with a view to optimizing production efficiencies and achieving maximal biomass harvest from a unit area, with due environmental considerations (Ayyappan *et al.,* 1998). To harness the benefits of integrated fish farming, fish-duck integration was introduced in 0.67 ha water area in the first year and in 1.04 ha area in the second year. Twenty-day old ducklings of 'Khaki Campbell' variety were introduced @ 400 per ha during the first week of December, i.e. after three and a half months of fry release. Fish-duck production system can play a crucial role in improving the food security and nutrition among the labour households (Rajasekaran, 2001). After the introduction of ducklings, the feed rate was decreased slowly to 2 per cent of bodyweight. Fish was cultured for 8-10 months, depending on water depth.

Method of Analysis

Production data from the experiment were analyzed to find out fish yield in different waterbodies. Gross income vis-à-vis the cost involved is an indicator of economic feasibility of an activity. Therefore, income and B-C analysis were carried out following standard procedure to assess economic feasibility of the activity. Gross income from the derelict waterbodies was estimated by taking quantity of fish produced, number of live birds sold, number of eggs produced, and unit sale prices of components at different points of time during the project period. Cost involved in the activity was estimated by taking into account all the direct costs, i.e. expenditure incurred on developing pen materials, sheds and inputs like bleaching powder, fry, groundnut oilcake, fish feed, duck, duck feed, labour, medicine, etc., and imputed value of the family labour as applicable to different waterbodies. Gross income from the waterbodies was taken as the benefit.

Results and Discussion

SWOT Analysis

The SWOT analysis conducted involving different stakeholders revealed that derelict waterbodies have high natural productivity and maintain good waterdepth for most part of the year; hence, are favourable for aquaculture. Further, their close proximity to human settlement offers advantages like easy supervision. On the other hand, many such waterbodies, including drainage systems, do not have developed dykes, and rainwater flows into them, raising the water level. In the case of drainage systems, the fluctuation in water level is more frequent. Such waterbodies with stagnant water are also prone to weed infestation. Therefore, controlled management may be difficult.

The derelict waterbodies offer immense opportunities for sustaining livelihood of rural people through enhanced fish production and consumption. Moreover, a prudent leasing policy for the use of derelict waterbodies can generate a good revenue for the government also. There are some potential threats too in using waterbodies for aquaculture. These include poaching and nuisance by the unscrupulous persons, spilling over of chemicals and pesticide-residues from the nearby fields into the waterbodies, gush of rainwater into the waterbodies, etc. These could cause heavy economic losses.

Water Quality Parameters

The mean values of different parameters recorded during the study indicated that the water quality in the selected waterbodies was suitable for aquaculture (Table 1). The mean pH values of waterbodies ranged between 7.22 and 7.90, which meant that pH of water in the selected waterbodies was within the optimum range for culture of carps (Jhingaran, 1991). The total alkalinity in all the waterbodies, except the one in Hansapara, was found to be within the optimum range. The level of inorganic nutrients, viz. nitrates (0.1-0.29 mg/L) and phosphates (0.17-0.3 mg/L) indicated high productivity of most the waterbodies (Banerjea, 1967; Jena *et al*., 2002).

Fish Production and Yield

Fish culture was carried out for two years, viz. 2004-2005 and 2005-2006. Before implementation of the project, derelict waterbodies were mostly inhabited by weed and predatory fishes. The mean fish yield of these waterbodies was estimated to be 0.17 t/ha. It was worked out based on the quantity of

Table 1. Mean values of important water quality parameters

Sl No.	Name of village	pH	Dissolved oxygen (mg/L)	Total alkalinity (mg/L)	CO_2 (mg/ L)	TH (mg/ L)	TAN (mg/ L)	$[NO_2^-]$ (mg/ L)	$[PO_4^{3-}]$ (mg/ L)	$[NO_3^-]$ (mg/ L)
1	Kothisahi - 1	7.64	5.7	88	6.8	124	0.04	0.04	0.29	0.28
2	Kothisahi-2	7.88	2.3	148	5.9	144	0.22	0.03	0.21	0.29
3	Sagada	7.22	4.4	80	5.2	96	0.03	0.04	0.30	0.27
4	Hansapara -1	7.36	4.7	62	20.9	76	0.04	0.04	0.48	0.26
5	Hansapara -2	7.9	3.4	52	0	108	0.02	0.002	0.17	0.10
6	Rhoedopara-1	7.76	2.9	96	12	124	0.05	0.02	0.23	0.18
7	Rhoedopara-2	7.53	1.2	106	11.2	124	0.42	0.03	0.26	0.25

fish harvested after the repeated netting before putting the waterbodies into culture. Analysis of fish production data from these waterbodies indicated that in the first year, the mean yield of fish was 2.24 t/ha, with maximum and minimum yields as 4.33 t/ha and 1.37 t/ha, respectively. In the second year, the mean fish yield increased to 2.95 t/ha, the maximum yield being 4.66 t/ha and minimum 2.0 t/ha. Incidentally, during both the years, the highest yield was obtained from the smallest waterbody of about 0.06 ha area (Table 2). A perusal of Table 2 reveals that fish yield of more than 4.5 t/ha was achievable through proper management of derelict waterbodies (Case 6).

Fish-duck integration was introduced in four out of the seven waterbodies in the first year, and six waterbodies in the second year. The production data from these waterbodies indicated that fish yield was higher in the fish-duck integrated than non-integrated waterbodies, except in one case which was affected by intrusion of water from outside. In the first year, the average fish yield was 2.38 t/ha from the integrated systems and 2.07 t/ha from non-integrated systems. In the second year, the average fish yield of integrated systems increased to 3.13 t/ha while that of the lone non-integrated waterbody remained lower at 2.0 t/ha. Some of the waterbodies that did not have integration in the first year, recorded a sharp increase in fish yield after introduction of fish-duck integration (Cases 4 & 5). Therefore, it could be inferred that fish-duck integration is a useful option for the management of derelict waterbodies.

Income and B-C Ratio

The appropriate management of derelict waterbodies could provide a good income to the farmers by augmenting fish production in the rural areas. In addition, the sale of live birds and eggs from fish-duck integration added to the income of rural poor.

The average gross income in the second year was about 14 per cent higher at Rs 1,75,320 than in the first year (Rs 1,53,940) (Table 3). It was largely due to the integration of duck in the system. It was also observed that while income from fish production in the second year showed a marked improvement over the first year, there was a decline in the income

Table 2. Production and Yield of fish from different waterbodies : 2005 and 2006

Sl No. of Water-bodies	Water area (ha)	No. of farmers involved	Production in 2005 (t)					Yield in 2005 (t/ ha)	Production in 2006 (t)					Yield in 2006 (t/ ha)
			C	R	M	S	Total		C	R	M	S	Total	
1	0.15	17	0.26	0.15	0.10	-	0.51	3.4	0.28	0.16	0.10	-	0.54	3.6
2	0.20	16	0.18	0.11	0.09	-	0.38*	1.9	0.17	0.12	0.11	-	0.40*	2.0
3	0.32	17	0.13	0.12	0.10	0.09	0.44	1.37	0.42	0.31	0.19	-	0.92	2.88
4	0.22	30	0.25	0.15	0.11	-	0.51*	2.3	0.33	0.20	0.15	-	0.68	3.1
5	0.15	30	0.15	0.09	0.05	-	0.29*	1.9	0.21	0.12	0.09	-	0.42	2.8
6	0.06	4	0.073	0.064	0.068	0.055	0.26	4.33	0.11	0.09	0.08	-	0.28	4.66
7	0.14	10	0.15	0.10	0.075	0.065	0.39	2.78	0.18	0.125	0.115	-	0.42	3.0
Overall under the project	1.24	94	1.193	0.784	0.593	0.21	2.78	2.24	1.70	1.125	0.835	-	3.66	2.95

Notes : *Without fish-duck integration, C – Catla, R – Rohu, M – Mrigal, S – Silver barb
In the second year, silver barb was not stocked due to non-availability of fish seeds.

Table 3. Income from different components during 2005 and 2006

(in Rs)

Sl No. of water-bodies	Water-body area (ha)	First year (2005)			Second year (2006)		
		Income from fish production	Addl. income from fish-duck integration	Gross income	Income from fish production	Addl. income from fish-duck integration	Gross income
1	0.15	21930	10680	32610	24300	8500	32800
2	0.20	17100	-	17100	18000	0.0	18000
3	0.32	22000	7,280	29280	31500	5200	36700
4	0.22	21930	-	21930	29200	1750	30950
5	0.15	13450	-	13450	14900	2200	17100
6	0.06	10500	4920	15420	12880	2950	15830
7	0.14	17550	66 00	24150	19740	4200	23940
Total	1.24	124460	29480	153940	150520	24800	175320

from duck component. It was largely due to the killing of ducks by predators and poor management of duck sheds. Out of the six cases, only in two (Cases 1 & 6) income from duck component was more than the cost involved therein.

A considerable variation was observed in the performance of waterbodies as measured by per-hectare income (Table 5). It could largely be attributed to the management practices adopted by the farmers. A perusal of Table 5 reveals that both gross income and net income were higher in the second than first year. The per capita income was higher by 13.5 per cent at Rs 1378 in the second year than that in the first year (Rs 1021). The increase in per-ha income was of 28.5 per cent in the second year over the first year.

Benefit-Cost Analysis

The overall B-C ratio for the project and B-C ratios for the individual waterbodies indicated that aquaculture in the derelict waterbodies could be an economically viable option. In the first year, the overall B-C ratio was estimated to be 2.65, with maximum and minimum B-C ratios being 4.68 and 1.46, respectively. In the second year, the overall B-C ratio of project increased to 3.82, and the maximum and minimum B-C ratios of waterbodies were found as 10.7 and 2.28, respectively. In five out of the seven cases, the B-C ratio increased in the second year, indicating good returns and better prospect of aquaculture in the derelict waterbodies. It was largely due to increase in income from fish production and partly due to reduction in cost. The cost of inputs (Table 4) was higher in the first than second year. It was largely due to expenditure on labour for cleaning of waterbodies and on bleaching powder for eradication of weed and predatory fishes. For example, in the first year, more labour was required to clean the derelict waterbodies infested with weeds and therefore, cost on labour was high. In the second year, cost on labour was reduced considerably. Similarly, bleaching powder accounted for a good part of total cost in the first year, but in the second year, it was not applied. Similarly, groundnut oilcake was not applied in the second year due to high organic load in the waterbodies. All these contributed to overall cost reduction under the project.

A perusal of Table 5 indicates that high B-C ratio may not always be associated with high level of net income. Even waterbodies with similar B-C ratios had different levels of net income per hectare. In the first year, some of the waterbodies with high B-C ratio (B-C ratio more than 3) yielded less net income per-hectare than other waterbodies with high B-C ratios. In the second year, the waterbody with highest B-C ratio had lower level of net income per hectare as compared to other waterbodies with a similar B-C ratio. It was due to poor management of duck unit and waterbodies. On the other hand, there were cases

Table 4. Cost of different inputs used in the waterbodies in 2005 and 2006

(in Rs)

Sl No. of water-bodies	First year (2005)								Second year (2006)					
	Bleaching	GNOC/ fertilizer	Fish seed	Fish feed	Duck-lings	Duck feed	Labour	Total	Fish seed	Fish feed	Duck-lings	Duck feed	Labour	Total
1	1,650	260	300	720	1200	5,000	1350	10,480	225	720	600	6500	575	8620
2	2300	390	450	1080	0.0	0.0	1300	5520	300	1080	00	00	300	1680
3	3630	585	720	1720	3200	8000	2100	19,955	480	1720	900	7200	900	11,200
4	2475	390	500	1190	00	00	1750	6305	330	1190	800	4000	650	6970
5	1650	260	300	720	00	00	1000	3930	225	720	600	5500	450	7495
6	1650	260	300	720	800	2500	400	6630	90	720	400	2000	175	3385
7	660	130	135	325	1100	2000	800	5150	210	325	600	5000	325	6460
Total	14,015	2275	2705	6475	6300	17,500	8700	57,970	1860	6475	3900	30200	3375	45,810

Note : Cost of inputs was estimated taking into consideration the actual level of inputs used in each of the waterbodies as warranted by the situation and unit cost of inputs. Therefore, costs under same input heads vary between the years.

Table 5. Net income from different waterbodies and B-C ratio

Sl No. of water-bodies	Area of water-bodies (ha)	First year (2005)						Second year (2006)					
		Gross income (Rs)	Cost of inputs involved (Rs)	B-C ratio	Net income (Rs)			Gross income (Rs)	Cost of inputs involved (Rs)	B-C ratio	Net income (Rs)		
					Total	Per capita	Per ha				Total	Per capita	Per ha
1	0.15	32610	10480	3.11	22130	1301	147533	32,800	8620	3.8	24180	1422	161200
2	0.20	17100	5520	3.09	11580	724	57900	18000	1680	10.7	16320	1020	81600
3	0.32	29280	19955	1.46	9325	549	29140	36700	11200	3.27	25500	1500	79688
4	0.22	21930	6305	3.47	15625	521	71023	30950	6970	4.4	23980	799	109000
5	0.15	13450	3930	3.42	9520	317	63467	17100	7495	2.28	9605	320	64033
6	0.06	15420	6630	2.32	8790	2198	146500	15830	3385	4.6	12445	3111	207416
7	0.14	24150	5150	4.68	19000	1900	135714	23940	6460	3.7	17480	1748	124857
Overall	1.24	153940	57970	2.65	95970	1021	77395	175320	45810	3.82	129510	1378	104443

where despite reduction in total cost, income increased (Case 6). In such cases, farmers could capitalize on first year's investment on pond management. However, overall increase in B-C ratio was accompanied by increase in gross and net incomes from waterbodies.

The per-capita income is also an indicator to assess distributive aspect of benefits of the project. As evident from Table 5, in the first year, the lowest per capita income of Rs 317 was obtained in Case 5, while the highest per capita income was of Rs 2198 (Case 6). In the second year, there was virtually no improvement in the lowest per capita income, while the highest per capita income level increased to Rs 3111. Incidentally, the same waterbodies yielded the lowest per capita income (Case 5) and the highest per capita income (Case 6) in both the years. The overall per capita income under the project increased from Rs 1021 to Rs 1378.

Some of the important points that emerged from the study are:

- Even very low level of investment in the derelict waterbodies could yield good income (Case 2)
- Medium level of investment coupled with good management could provide a fairly high income (Case 6)
- High investment may not always bring expectedly high income (Cases 3 & 5)
- In all the cases, the potential of fish-duck integration could not be harnessed due to poor performance of duck units. Assessment of the situation revealed that even though women were given necessary orientation and training to manage the units, absence of an agreed mechanism to equitably share the responsibilities of management among women themselves led to poor supervision of duck units and neglect of birds.

Constraints

The most common problem in the management of derelict waterbodies was inflow of derelict water and entry of predators and weed fishes into the culture system following damage to the pen materials (bamboo linings and nets) caused due to either heavy rain or anthropogenic activities. As a result, there was a surge in the weed fish population in the culture system which affected the growth of cultured fishes adversely. At times, such developments were not easily noticeable as damage often occurred to the under-water portion of pen materials. Secondly, some people also reported poaching by unscrupulous persons. As a result, desired benefits did not accrue to the farmers.

Conclusions and Implications

The study has shown that derelict waterbodies can be productively and profitably utilized for aquaculture. These waterbodies could yield good income even from low level of investment. Such an activity can provide enormous income and employment opportunities in the rural areas. To encourage large-scale utilization of available derelict waterbodies for aquaculture, a prudent and well-conceived policy for leasing-out derelict waterbodies and transfer of relevant technologies to the needy and interested farmers should be evolved. These steps would boost not only fish production in the rural areas, but would also provide much needed impetus to the growth and diversification of rural economy.

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