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Status and economy of community fish farming in rural Odisha

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ABSTRACT

An investigation on community fish farming and its economy was carried out in eighty-one randomly chosen typical community fish ponds from two representative districts (Khurda and Puri) of rural Odisha. Study reveals a low level of technological adoption of aquaculture with very traditional and extensive methods of carp culture, which may be termed as rural aquaculture. The lease arrangement was the predominant institutional arrangement with lease period of 1, 3 and 5 years and the respective fish production of 769, 930 and 1634 kg $ha^{-1}yr^{-1}$. It was found that the system responded quite well to the changes in the technology and management. The impact of a few management measures was found to be positive on the fish productivity improvement. Presence of aquatic macrophytes, weed and predatory fishes, under-dose manure and fertilizer application and/or no use of manure and fertilizer, stocking of small size fish seed in unprepared ponds, under feeding and/or not feeding to fish had adverse effect on fish production and net income generation in village community ponds. There was significant increase in fish production ($p<0.05$) by stocking fingerlings (large size fish seed) instead of stocking fry, and by feeding fish with rice bran/ ground nut oil cake (GNOC). Share of feed to mean expenditure was found to be 7% only, indicating poor feed input use in community fish ponds. Expenditure on labour charge for community based aquaculture management was 48%, suggesting labour intensive rather than feed intensive fish farming. Average cost of fish production was ₹ 37 kg^{-1}; net return on expenditure was 134.4% with profitability index of 1.34 in spite of poor pond management and less input uses, indicating it as a highly profitable venture for community farmers. For horizontal expansion of aquaculture in rural area, techno-input intensification is recommended and the socio-political problems need to be mitigated. This may lead to enhanced fish production from community ponds in order to provide family income, self employment, improvement of the livelihood and nutritional security of rural poor.

Keywords : Aquaculture, Community fish farming, Economy, Rural ares

Introduction

Rural Odisha is endowed with diversified freshwater resources with immense potentialities for finfish and shellfish farming. In order to utilise these resources at sustainable level, Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar has developed various resource and region specific technologies for augmenting fish production. Majority of these freshwater resources in rural Odisha falls under community ponds vested with community or local level institutions, religious bodies without and/or with resources and local self government for multiple use and multiple users (Sinha, 1999). There are 2.414 million ha of freshwater ponds and tanks in the country and many more are added through schemes like National Rural Employment Guaranty Scheme (NREGS), watershed development projects, irrigation projects *etc.* Integration of the aquaculture use in these resources in addition to other uses can enhance value, utility and water productivity through implementing appropriate management practices. In view to stagnation of fish production from marine and inland capture fisheries, freshwater aquaculture resources need to play a significant role in producing finfish and shellfish to meet the demand of fish from the increasing fish eating population. There is ample scope for horizontal and vertical expansion in freshwater aquaculture in the country. Out of the total freshwater ponds and tanks, about 43.74% are in use for aquaculture, producing 3.38 million t of fish at national average productivity of 2.9 t ha^{-1} yr^{-1}. Paradoxically, little is known about the rest 56.26% freshwater ponds and tanks. The fish productions in these areas are unreported, locally consumed and ignored in the policy domain. The Chinese proverb "where there is water, there is fish" is the starting point for relooking at these resources in greater perspective of serving food and nutritional security of the large number of people. The typical nature of aquaculture in rural areas in scattered distributed manner is termed as rural aquaculture and it includes farming under traditional and extensive system to meet the needs of small scale farming households, fitting the resources available (De and Saha, 1999; Edwards *et al*., 2002; Littlem, 2003; Radheyshyam *et al.,* 2009).

The community based aquaculture is a subset of the rural aquaculture in which governance and management are community centric with the central role played by the community institutions. Such system is characterised by locally based small scale farming, using extensive technology without government involvement. But, very little is known about the system of farming, management and its implications. Under such condition, it is required to record and update the status of community based aquaculture along with its economy at national level to bring it into mainstream and advocate possible measures for scientific fish culture in these water bodies. Although a few scattered cases of community-based aquaculture demonstrations are on record (Lakshmanan *et al.,* 1978; Sinha and Ranadhir, 1980; Sharma *et al.,* 1988; Sharma and Thakur, 1988; Radheyshyam and Tripathy, 1992; Radheyshyam, 1998, 1999, 2000, 2002, 2009), but published records of traditionally practised fish farming in community ponds by rural fish farmers are scanty. In this context, the present study was carried out in randomly chosen typical community fish ponds to record fish production and economic profitability in relation to lease period and various aspects of management practices from two representative districts of Odisha. The information generated from this investigation would be useful for policy makers, planners, researchers and aquaculturists for making use of community water resources for horizontal and vertical aquaculture extension. This may also help rural communities to produce food fish for increasing household food security, improving nutritional security and generating self employment within the village in a socially, culturally, environmentally as well as economically sustainable manner.

Materials and methods

The study was carried out in Balipatana, Balianta, Chilika and Banpur blocks in Khurda District and Pipli as well as Nimapara blocks in Puri District, of Odishaa, India. The lease procedure of village community ponds was recorded from secondary sources. Data were collected from 81 randomly chosen village community ponds. Community leaders were interviewed followed by thorough interaction with beneficiaries using a structured questionnaire. Pond-wise information on pond area, lease period, lease values, mode of water use, culture types, pond preparation, manure and fertilizer application, liming, natural fish food assessment, fish seed stocking pattern, periodical monitoring of water and soil quality, fish health management, fish harvesting mode, marketing pattern, fish yields, operational costs in aquaculture and gross income generation were recorded separately for each pond. The data collected were categorised in to pairwise sets and analysed statistically using ‘t’ test (two samples assuming unequal variances) to compare the level of fish production and income generation from the ponds

Results and discussion

Community access to resources

As per the state reservoir policies and other polices of the government, all of the water bodies with less than 40 ha are being handed over to the decentralised governance system of Panchayat for utilisation and management. Under the present system, the Panchayat Secretary arranged pond leasing after due approval from the District Sub-collector. The system of open auction is followed in presence of Gram Panchayat Officer (GPO), Panchayat Secretary and Sarpanch (elected leader of Panchayat) at Panchayat level. The highest bidder was given the lease for 1, 3, 5 and 10 years based on the recommended proposal submitted by the Panchayat. The proposal is sanctioned by GPO at Tehsil level (for one year), the Block Development Officer (BDO) at Block level (for three years), District Magistrate at District level (for five years), and Panchayatiraj Commissioner at government level (for ten years). Lease was granted to Women Self Help Groups (WSHGs), Men Self Help Groups (MSHGs), registered cooperative societies, village communities and individuals on priority basis in descending order (Sethi, 2008). The communities seek access to the resources primarily through the lease but in some cases through the formal and informal contact with the Panchayat or government functionaries. In most of the cases, the accesss is primarily dependent on the activity of the community as well as their interest and capabilities in managing the resources.

Leasing pattern of village community ponds

About 78% of the village community ponds were leased for short-term period (1-3 years). It was observed that 22% of community ponds were leased for 1 year, 56% for 3 years and 15% for 5 years. None of the surveyed farming communities were provided with 10 year lease. Although communities were granted lease in the month of April or June, the actual possession took about 3 to 6 months due to bureaucratic procedures. A few cases of ponds were found to be either open access or with community access which were not leased by government due to various reasons. It was also found that some of the village revenue ponds were vested permanently with the community and few fisher community had constructed own ponds for fish culture permanently which together accounted for about 7%.

Community pond management status

Actual management practices adopted by fish farmers for community based fish farming were analysed for each pond. The aquatic macrophytes were eradicated manually from 54% community ponds. From 35.8% community ponds, weed and predatory fishes were removed by repeated netting, pond dewatering/drying and piscicide application. In 34.57% ponds, raw cow dung (RCD) was used as manure @ 3182 kg 1ha^{-1} yr^{-1}. Inorganic fertilizer application was limited to only 3.7% community ponds @ 168 kg ha^{-1}yr^{-1}. About 71.6% ponds were treated with lime @ 153 kg ha^{-1} yr^{-1}. Fish were fed with rice bran @ 638 kg ha^{-1} yr^{-1} in 39.5% ponds whereas, in 29.63% ponds fish were fed with GNOC @ 221 kg ha^{-1} yr^{-1}. Water and soil quality monitoring, periodical sampling, health care and plankton assessment were carried out from 9.88%, 18.52%, 9.89% and 2.47% community fish ponds respectively (Table 1).

Water and soil quality monitoring

An appropriate physico-chemical environment of pond sediment and water is pre-requisite for successful proliferation of natural fish food organisms, fish growth and production in aquaculture system. Imbalances in critical parameters of sediment and water affect fish production adversely. Hence periodical monitoring of water and sediment quality is essential not only to correct soil and water parameters but also to recommend liming and fertilization schedule in culture system to maintain balance level of nutrients. During the study it was found that, over 90% community ponds were not subjected to such monitoring and only 10% were able to do so with the support from CIFA. Earlier studies on these ponds indicated that the village community ponds are characterised by anaerobic benthic sediments (Olah and Sinha, 1984; Olah *et al*., 1987; Kumar, 1992), excessive silt deposition from the village catchments area and other critical inputs including addition of organic matters to the bottom sediment (Olah *et al,* 1986; Radheyshyam *et al.,* 1986 a, b), nutrient sink in pond bottom under anaerobic conditions (Olah *et al.,* 1986; Kumar, 1992) and release of harmful gas and depletion of oxygen level (Radheyshyam *et al.,* 1986a). In older ponds, especially those having thick anaerobic sediment, the biochemical oxygen demand ranges between 70 and 90% causing anoxic condition leading to fish kills (Radheyshyam *et al.,* 1986 a, b; Kumar, 1992). The factors like aquatic weed infestation (Olah and Sinha, 1984) and removal of nutrients from the pond water (Radheyshyam and Naik,1988), non-application of manure and fertilizers cause nutrient deficient conditions in a majority of community ponds (Radheyshyam *et al.,* 2003), even though optimum availability of the nutrients are prerequisite for plankton (phytoplankton, bacterio-plankton, planktonic detritus and zooplankton) production (Radheyshyam *et al*., 2003) which constitute the basic food for the fine filter feeder fish species and also for the zooplankton which form the main food of the rough filter-feeder (Olah and Sinha, 1984; Kumar, 1992). To avoid the risks of detrimental effects of ever changing complex aquatic environmental factors in community ponds, regular monitoring of water and sediment characteristics are advocated to get better fish growth and sustainable production.

Table 1. Adoption level of management practices in community ponds (N=81)

Parameters	Not adopted %	Adopted %
Eradication of weed and predatory fishes	64.2	35.8
Aquatic weeds removal	45.68	54.32
Raw cow dung application	65.43	34.57
Inorganic fertilizer use	96.3	3.7
Lime treatment	28.4	71.6
Use of GNOC as feed	70.37	29.63
Use of rice bran as feed	60.49	39.5
Periodical sampling to check fish growth and health	81.48	18.52
Fish health management	90.11	9.89
Water and soil quality monitoring	90.12	9.88
Plankton assessment	97.53	2.47
Netting by community members for sampling and fish harvesting	83.95	16.05

Manure and fertilizer application and assessment of natural fish food organisms

After eradication of aquatic weeds, predatory and trash fishes from the ponds, waters are made productive by applying lime, manure and inorganic fertilizers in appropriate quantities. In the present investigation, about

72% village community ponds were treated with lime @ 153 kg ha^{-1} yr^{-1} against the recommended rate of 250 kg $ha^{-1}yr^{-1}$. This suggested under-dose lime application in community ponds. Annually application of 156-225 ha^{-1} yr^{-1} urea and 200-300 ha^{-1} yr^{-1} single super phosphate is recommended to accelerate plankton production, while in community based aquaculture, 96.3% ponds were deprived of inorganic fertilizer application. Even if rarely (in 3.7% ponds) applied, it was too low (168 kg $ha^{-1}yr^{-1}$) to contribute towards desired level of plankton production. This scenario led to significantly low fish production in community ponds. In rural aquaculture (extensive fish culture) natural fish food organisms play a significant role in fish production and their abundance needs to be quantified periodically to regulate artificial feeding as well as manure and fertilizer application. Generally, community fish farmers seldom practise this. In 91.3% community ponds, plankton assessment was never done by the fish farmers. Study suggested need for scientific interventions for enhancing fish production in community ponds, by way of mobilising community fish farmers and skill training followed by demonstrations through techno-input support system.

Fish health care

As discussed earlier, village community ponds have an excessive silt deposition, high biochemical oxygen demand, release of harmful gas and aquatic weed infestations causing stress of anoxic and hypercarbic condition (Kumar, 1986; Das, 2006) leading to fish kills (Radheyshyam *et al,* 1986 a, b; Kumar, 1992; Radheyshyam *et al*., 2011). Aquatic weed infestation results in removal of nutrients from the pond water and insufficient application of manure and fertilizers cause nutrient deficient conditions in community ponds, adversely affecting plankton production. In addition, when fish are deprived of balanced supplementary diets it leads to malnutrition diseases in fish. The stressed fish are vulnerable to pathogens and conducive for pathogen proliferation leading to disease outbreak (Kumar, 1986; Radheyshyam, 2001).Under such conditions, fish health care needs to be given due importance. But, in the present investigation, over 90% community ponds were deprived of any care for fish health management. Only in 10% community fish ponds, lime, potassium permanganate, common salt *etc* were used as prophylactic treatment and CIFAX (CIFA, Bhubaneswar) for the control of epizootic ulcerative syndrome (EUS). Farmers facing fish health problems need to be trained to understand the factors affecting fish health and risk of disease outbreaks so as to enable them to produce healthy fish from the community ponds.

Periodical sampling

In rural aquaculture, only 19% community fish ponds were netted out for sampling to check fish growth and health during the time of partial fish harvesting whereas, over 81% community fish ponds were not netted for the purpose. Periodical sampling to check fish growth and health is one of the recommended practices in carp culture due to several merits. Periodical estimation of fish standing crop in ponds is required to decide daily feeding rate in the subsequent month. Fish health conditions are also checked for prophylactic treatments. Monthly drag-netting disturbs bottom sediments and makes sediment nutrients available in water at soil-water interface for plankton production. It also removes obnoxious gases from sediment and reduces aquatic weeds from the ponds. Hence village community fish farmers are advocated to follow the recommended practice to optimise fish production.

Arrangements for harvesting

The community fish farmers do not have their own nets for periodical sampling and fish harvesting. They hire nets from professional fishermen of local area for the purpose. About 84% community fish ponds were netted out by employing hired labour and 16% by community members using hired nets. The harvesting groups were involved on share basis. Share of professional fishermen varied from 20 to 50% depending upon availability of fish stock in ponds and ease of harvest. In some cases, the harvesting group used to buy whole fish at relatively lower price in addition to their share of harvesting (Radheyshyam *et al.,* 2011). The lack of knowledge on use and handling of fishing equipments was found to be one of the major constraints for the self sufficiency of the community. Therefore, community fish farmers should be trained to prepare and operate the net on the principle of learning by doing.

Evaluation of the community aquaculture

The community aquaculture is an outcome of the interaction of the diverse ecological, technological, managerial and sociological factors. Therefore, each of the unit is unique and diverse from each other. Community based aquaculture management was found to be very complex. In this a number of limiting and stimulating factors are acting together. At a given time in community pond system, the factor which limits fish production and income generation, did not limit in other community pond system. At the same time, within the system one factor limits and other factor stimulates the biological structure and function of the community ponds to influence the fish production. As such, it was very difficult to conclude the effect of a single limiting factor on the fish production and net income from the community pond. Hence, a cumulative effect of socio-political, economic, bio-physico-chemical factors and their interactions need to be emphasised. A few critical parameters like lease period, seasonality, stocking, weed infestation, manuring *etc* were taken up to characterise the system and implications of these selected parameters on the community aquaculture were assessed.

Fish production and net income in relation to lease period of community ponds

Ponds leased for one year period were found to be least managed from aquaculture point of view. Such ponds were stocked in unprepared condition with fry and/or fingerlings of carps. Fishes were reared without any supplementary feed. Before lease period expiry, ponds were harvested with very low fish production of 769 kg $ha^{-1}yr^{-1}$. Those ponds which were leased for three years only and extensive fish culture was carried out for about 2 ½ years because of delayed possession and pond preparation. From some of the community ponds aquatic weeds and predatory and weed fishes were removed while other ponds were stocked without eradicating them. Supplementary feeds were rarely given. After harvesting first fish crop, ponds were stocked for second crop without improving its productivity. During third year lease period, ponds were harvested by repeated netting without any capital investment for pond management due to uncertainty of next lease term. Aforesaid accounts might be responsible for low fish production (930 kg $ha^{-1}yr^{-1}$). However, in three year leased ponds, fish production was significantly higher ($p < 0.05$) than one year lease ponds.

Out of the surveyed ponds 78% were leased for 1-3 years where fish production was lower than the national and/or state average fish production (2600 kg $ha^{-1}yr^{-1}$). Five year leased ponds had better opportunity for culture operation which resulted in higher fish production of 1634 kg $ha^{-1}yr^{-1}$. It was 121.33% higher than in one year leased ponds and 64.48% higher than in three year leased ponds. Statistically fish production increment from 1 to 3 years leased ponds and from 3 to 5 years leased ponds was significant ($p<0.05$). The net income increase with the increase in leasing period being ₹ 23597, ₹ 32557, and ₹ 66244 $ha^{-1}yr^{-1}$, from 1, 3 and 5 years leased ponds respectively (Table 2). This indicated that with the increase of leasing tenure of ponds, fish production, net income, percentage return on expenditure and profitability index increased whereas, C:B ratio decreased, suggesting needs of longer lease period for better production in community ponds.

Fish production and net income in perennial and seasonal ponds

Out of the surveyed community ponds 91.33% were perennial and 8.64% seasonal. It was interesting to note that the average fish production (1275 kg $ha^{-1}yr^{l}$) and net income (₹ 43629 $ha^{-1}yr^{l}$) from seasonal community ponds were higher than perennial community ponds (fish production, 1068 kg $ha^{-1}yr^{l}$; net income, ₹ 39287 $ha^{-1}yr^{l}$), though it was insignificant. There was not much difference in cost of fish production in both the conditions (Table 3).

Fish production and net income from weed infested and weed-free community fish ponds

About 46% community fish ponds were utilised for stocking fish seed without eradicating aquatic weeds whereas from 54% ponds aquatic weeds were removed manually before stocking. Aquatic weed infestation causes removal of nutrients from the pond water (Olah and

Table 2. Fish production and net income from 1, 3 and 5 year leased community ponds

Lease period of ponds	Fish yield (kg $ha^{-1}yr^{-1}$)	Total expenditure (₹ $ha^{-1}yr^{-1}$)	Cost of fish (₹ kg^{-1})	Net income (₹ $ha^{-1}1yr^{-1}$)	% Net return on expenditure	Profitability index	C:B ratio
1 year	768.75	27775.5	36.13	23596.94	84.95	0.85	1.18
3 year	929.80	32453.37	34.90	32557	100.32	1.00	1.00
5 year	1634.42	42893.97	26.24	66244.42	154.44	1.54	0.65

Table 3. Fish production and income generation in perennial and seasonal ponds

Pond types	Fish yield (kg $ha^{-1}yr^{-1}$)	Total expenditure (₹ $ha^{-1}yr^{-1}$)	Cost of fish (₹ kg^{-1})	Net income (₹ $ha^{-1}yr^{-1}$)	% Return on expenditure	Profitability index	C:B ratio
Perennial	1068.46	34228	32.04	39987.16	116.8	1.16	0.86
Seasonal	1275.00	41081	32.22	43628.80	106.2	1.06	0.94

Sinha, 1984; Radheyshyam and Naik, 1988),cut off sun light penetration during day, depletes oxygen level at night (Radheyshyam *et al.,* 1986 a) and leads to poor production of natural fish food organisms and stress to fish. Cumulative effects of foresaid factors might be responsible for low fish production (954 kg $ha^{-1}yr^{1}$) in weed infested community ponds. This was less than the fish production of 1183 kg $ha^{-1}yr^{1}$ in weed cleared ponds (Table 4). The cost of fish production was relatively low (₹ 28.24 kg^{-1}) in weed infested ponds in comparison to weed cleared community ponds (₹ 34.50 kg^{-1}). Although the net income from weed free ponds (₹ 41,735 $ha^{-1}yr^{-1}$) was higher compared to weed infested ponds (₹ 36,830 $ha^{-1}yr^{-1}$), the percentage return on the expenditure was higher (136.69%) in weed infested ponds than weed free ponds (102.27%) probably due to less material inputs in weed infested ponds. From the unit area, less fish production and net income in weed infested ponds suggested that the community fish ponds should be made free from the aquatic weeds for accelerating fish production.

Comparative fish production with and without weed and predatory fish in community ponds

In the study area, about 64% community pond fish farmers did not eradicate weed and predatory fishes (Table 1) before stocking with fish seed. From 36% community ponds they were removed using repeated netting, drying/dewatering and piscicide application in descending order. From 55% of community pond fish farmers eradicated the weed and predatory fishes using repeated netting, but practically it is too difficult to remove all undesirable fishes through drag netting. About 28% ponds were dried and/or dewatered and about 17% ponds were treated with bleaching powder or mahua-oil cake to eradicate the weeds and predatory fishes. Predatory fish (*Wallago attu, Channa* spp. *Clarias batrachus, Heteropneustes fossilis, Notopterus chitala, N. notopterus, Pangasius pangasius, Mystus* spp., *Ompok* spp., *Glossogobius giuris*, *Mastacembelus* spp., *Amphipnous cuchia, Anabas testudineus etc.*), prey upon the fry and fingerlings of carps and the weed fish (*Puntius* spp., *Oxygaster* spp., *Gudusia chapra, Amblypharyngodon mola, Chela* spp, *Esomus danricus, Osteobrama cotio etc*.) compete with carps for food, space and oxygen (Sinha, 1979; Sinha and Ramchandran, 1985; Kumar, 1992; Jena 2006). This caused low fish production (961 kg $ha^{-1}yr^{-1}$) and net income (₹ 33,999.86 $ha^{-1}yr^{1}$) in those community ponds from where predatory and weed fishes were not eradicated (Table 5). Community ponds which were made free from weed and predatory fishes recorded 38.29% higher fish production and 44.28% higher net income than the ponds having weed and predatory fish. This indicated the need of training and demonstration to community fish farmers on removal of unwanted fishes prior to stocking the community ponds.

Comparative fish production and net income in manured and non-manured ponds

Raw cow dung *(*RCD) along with inorganic fertilizers is the vital nutrient input source to proliferate natural fish food organisms under low cost fish production. In 65.43% ponds, RCD was not applied. Although in 34.57% ponds RCD was applied, it was at very low dose (@ 3.18 t $ha^{-1}yr^{-1}$), whereas, at least 10-15 t $ha^{-1}yr^{-1}$ RCD is recommended to increase plankton production. Therefore there was not much difference in fish production and net

Table 4. Comparative fish production and net income from weed infested and weed-free community fish ponds.

Aquatic weed conditions	Fish yield (kg $ha^{-1}yr^{1}$)	Expenditure (₹ $ha^{-1}yr^{-1}$)	Cost of fish (₹ kg^{-1})	Net income (₹ $ha^{-1}yr^{-1}$)	Net return on expenditure (%)	Profitability index	C:B ratio
Weed free	1183.04	40810	34.50	41734.93	102.27	1.02	0.98
Weed infested	953.92	26945	28.24	36830.44	136.69	1.37	0.73

Table 5. Comparative fish production and net income with and without weed and predatory fish in community ponds

Conditions of ponds	Fish yield (kg $ha^{-1}yr^{-1}$)	Expenditure (₹ $ha^{-1}yr^{-1}$)	Cost of fish (₹ kg^{-1})	Net income (₹ $ha^{-1}yr^{-1}$)	% Return on expenditure	Profitability index	C:B ratio
Free from weed and predatory fish	1329	40802	30.70	49054.92	120.23	1.20	0.83
Presence of weed and predatory fish	961	32360	33.67	33999.86	105.06	1.05	0.95

Table 6. Fish production and net income in RCD manured and non-RCD manured ponds

Manure use	Fish yield (kg $ha^{-1}yr^{1}$)	Expenditure (₹ $ha^{-1}yr^{1}$)	Cost of fish (₹ kg^{-1})	Net income (₹ $ha^{-1}yr^{1}$)	% Return on expenditure	Profitability index	C:B ratio
RCD applied	1116.36	37737	33.81	38806.43	102.8	1.02	0.97
RCD not applied	1062.64	33015	31.06	39950.72	121.0	1.21	0.83

income. In RCD treated ponds, average fish production and net income were (1116 kg $ha^{-1}yr^{1}$; net income ₹ 38806 $ha^{-1}yr^{-1}$) more or less similar (Table 6) to that in non-RCD treated community ponds (fish production 1063 kg $ha^{-1}yr^{-1}$; net income ₹ 39,951 $ha^{-1}yr^{-1}$). Study suggested that community ponds should be treated with RCD at recommended dose to increase natural fish food organisms so as to increase fish production and net profit.

Fish production and net income in fry and fingerling stocked pond

In village community ponds without eradicating aquatic weeds as well as predatory and trash fishes, carp fry and fingerlings were stocked in improper ratios. This adversely affected the fish production. Of the total surveyed ponds, 46.92% were stocked with carp fry and 53.08% with fingerlings. Comparative fish production and net income in fry and fingerlings stocked community ponds are given in Table 7. Fry stocked ponds fetched relatively lower fish yield (830.84 kg $ha^{-1}yr^{1}$) than the ponds stocked with fingerlings (1302.47 kg $ha^{-1}yr^{1}$) and the fish yield difference was highly significant ($p<0.001$). Though in fingerling stocked community ponds, net profit (₹ 45814.77 $ha^{-1}yr^{-1}$) was higher than fry stocked ponds (₹ 32471.92 $ha^{-1}yr^{-1}$), it was statistically insignificant. Higher fish yield and net income in fingerling stocked ponds suggested the need of stocking large sized fish seeds (fingerlings/yearlings) in community ponds.

Fish production and net income in fed and non-fed ponds.

In village community ponds, natural fish food organisms may not be enough to meet the nutritional requirement of the stocked fish. Therefore, exogenous balanced feed need to be supplemented to get optimum fish production. Traditionally, groundnut oil cake (GNOC) and rice bran mixture are fed to fish in the ratio of 1:1 by weight @ 3-4% of standing crop of fish daily. However, in present investigation, in 70.37% of community ponds, fishes were not fed with GNOC and in 69.49% of ponds, were not fed with rice bran, resulting in poor fish production. Only in 29.36% of ponds fishes were fed with GNOC @ 221 kg $ha^{-1}yr^{-1}$ and in 39.5% of ponds with rice bran @ 638 kg $ha^{-1}yr^{-1}$ which was far below the recommended dose of about 3000 kg $ha^{-1}yr^{-1}$ each. This indicated malnourishment of fish in community ponds resulting in low fish yields. In community ponds where feeding was done with rice bran, significantly ($p < 0.05$). high fish production was recorded (1334.15 kg $ha^{-1}yr^{-1}$) as compared to non-feeding ponds (907.37 kg $ha^{-1}yr^{-1}$) (Table 8) However, net return on expenditure was 115.93% in ponds provided with rice bran as supplementary feed whereas in ponds without rice bran feed, it was relatively higher (112.42%). Similarly, in GNOC fed ponds, fish production was 1593 kg $ha^{-1}yr^{-1}$ against 866 kg $ha^{-1}yr^{-1}$in non-GNOC fed community ponds (Table 9). The fish production and net income generation was significantly higher ($p<0.05$) in GNOC fed ponds. This indicated that the rice bran and GNOC need to be fed to fish at recommended dose to increase fish production and net income from the unit area of community ponds.

Table 7. Comparative fish production and net income in fry and fingerling stocked ponds

Type of seed stocked	Fish yied (kg $ha^{-1}yr^{1}$)	Expenditure (₹ $ha^{-1}yr^{1}$)	Cost of fish (₹ kg^{-1})	Net income (₹ $ha^{-1}yr^{1}$)	% Return on expenditure	Profitability index	C:B ratio
Fingerling	1302.47	41849	32.14	45814.77	109.48	1.09	0.91
Fry	830.84	26499	31.89	32471.92	122.54	1.22	0.82

Table 8. Comparative fish production and net income on rice bran fed and non-fed community ponds

Feeding condition	Fish yield (kg $ha^{-1}yr^{1}$)	Expenditure (₹ $ha^{-1}yr^{1}$)	Cost of fish (₹ $ha^{-1}yr^{1}$)	Net income (₹ $ha^{-1}yr^{1}$)	% Return on expenditure	Profitability index	C:B ratio
Rice bran fed pond	1334.15	42305	31.71	49044.82	115.93	1.16	0.86
Rice bran non-fed pond	907.31	29383	32.39	33031.02	112.42	1.12	0.89

Economics of community aquaculture

For sustainable aquaculture implementation ₹1,50,000 to 2,00,000 ha^{-1}yr^{-1} operational cost is required. But in present investigation of community aquaculture, the average operational cost was estimated as ₹ 34,648 ha^{-1}yr^{-1}, suggesting very low input use towards pond preparation and material inputs including manure, fertilizer, fish feed *etc*. The mean expenditure in different items of community based aquaculture is depicted in Fig.1. Feed cost contributed nearly 7% of the total operational cost against the recommended contribution of 60-70%. This indicated that fishes were under fed or not fed with supplementary feed, resulting in malnutrition in fish with subsequent low fish production. Pond preparation and manure/fertilizer contributed only 1% and 5% respectively which is extremely low which suggested that there was poor adoption of management practices in community ponds. Maximum expenditure in community based aquaculture was towards labour charge (48%) followed by seed cost (16%) and pond rentals (12%). Highest expenditure towards labour charge was indicative of labour intensive rather than feed intensive fish culture. Thus the community aquaculture provided self employment to rural poor in their villages. Due to various limiting factors, the average fish production was to the tune of 1081 kg ha^{-1}yr^{-1} which was far below the national average fish production of 2006 kg. The cost of fish production was estimated as ₹ 37 kg^{-1} fish. Average net income was estimated to be ₹ 39, 555 ha^{-1} yr^{-1}. The percentage net return on expenditure was 134.39% with profitability index of 1.34. Inspite of low fish production, community aquaculture was found to be a profitable venture for the livelihood improvement and self employment of rural poor.

Table 9. Comparative fish production and net income in GNOC fed and without GNOC fed community ponds

Feeding condition	Fish yield (kg ha-1yr-1)	Expenditure (₹ ha^{-1}yr^{-1})	Cost of fish (₹ kg^{-1})	Net income (₹ ha^{-1}yr^{-1})	Net return on expenditure (%)	Profitability index	C:B ratio
GNOC fed ponds	1593	50036	31.41	59107.25	118.1	1.18	0.85
GNOC non-fed ponds	865.72	28168	32.53	31322.70	111.2	1.11	0.90

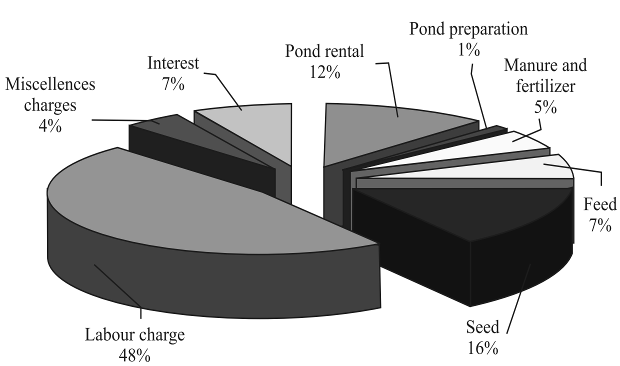

Fig 1. Mean expenditure contribution in different items in 81 community based aquaculture ponds

In community aquaculture development, human resources are the vital inputs and rural areas possess this resource for effective implementation of aquaculture operations. Need based suitable extension strategy is required to be planned and implemented. Farmers, sharing common interests and similar socio-economic status ought to be identified and organised by an effective community leader for successful operation of community aquaculture. Attention should be laid to mitigate the limitations and to educate the community fish farmers about different aspects of aquaculture operations in order to accelerate fish production for generating self employment as well as for improving rural food and nutritional security.

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