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Impact of cage culture in reservoir on the livelihood of fishers: A case study in Jharkhand, India

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ABSTRACT

Cage fish farming in Indian reservoirs has the potential to enhance the reservoir production manifold. The present study estimated that around 14,000 cages have been installed in different reservoirs of the country which are producing around 16% of the current reservoir fish production. Around 7.5 lakh mandays of labour are being generated by cage fish farming in the country. An empirical study in the state of Jharkhand State found that the adoption of cage culture contributed around 30% to the livelihood of fishers. Cage culture not only increased monthly family income but also reduced the occupational migration. The fishermen households who adopted cage farming also accumulated some durable assets due to improvement in household income. However, high initial cost of cage culture operation, high feed cost and low market price of cultured pangas fish (*Pangasianodon hypophthalmus)* were some of the major constraints in adopting the technology as reported by the fishers. The study recommends that the state departments need to promote the use of low cost galvanised iron (GI) cages designed by the ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI) in reservoirs which may play a significant role in fulfilling the vision of blue revolution in the country.

Keywords: Cage fish farming, Livelihood, *Pangasianodon hypophthalmus*, Reservoir

Introduction

Population growth, economic development and health concerns are the key drivers of increasing demand of fish in India. Several estimates suggest that the demand in coming years will be manifold of the current fish production (Tacon and Halwart, 2007). The inland sector has to play a significant role in meeting the surging demand, as marine capture fish production has almost stagnated in recent years. Among the inland fisheries resources, India has a wealth of reservoirs numbering 19,370 with an estimated area of 3.5 million ha at full capacity (Sugunan *et al.*, 2013). Scientific fisheries management guidelines recommended for reservoirs by ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI), Barrackpore, over the years enhanced average fish production in a number of reservoirs of various categories to 110 kg ha^{-1} year^{-1} in 2012-13 from 20 kg ha^{-1} year^{-1} in 1990s (Sharma and Suresh, 2013). However, still there exists a huge gap between potential and current fish yield. At this juncture, cage culture has been considered as a potent tool to enhance fish production from reservoirs. In the past 20 years there has been a rapid growth in cage culture of fish throughout the world. A lot of research and development work are going on for cage designing, suitable fish species, fish feed and other management aspects in cage fish farming.

ICAR-CIFRI started cage culture experiments in 1970s with the production of air-breathing fishes in cages with encouraging results. Later on, a number of attempts have been made to produce cage cultured fish especially for raising fry to fingerlings (Natarajan *et al.,* 1979, Banerjee and Govind, 1979). Production of fingerlings (stocking materials for reservoirs) was tried in Govindsagar Reservoir, Himachal Pradesh; in Getalsud Reservoir, Jharkhand and in Gularia Reservoir, Uttar Pradesh. Experiments were conducted in floating cages for raising stocking materials in Kabini Reservoir, Karnataka during 2005-06 with moderate success (CIFRI, 2006). Trials on cage aquaculture for production of fingerlings as well as table fish were undertaken in wetlands of West Bengal and Assam in 1998 onwards. It was found that Indian major carps (IMC) were not suitable candidate species for cage culture in wetlands and biofouling was found to be the most hindering factor towards success of cage aquaculture in wetlands (CIFRI, 2012).

The cage materials and designs were also modified in subsequent experiments of ICAR-CIFRI. Many experiments were conducted using bamboo as cage material particularly in Assam (Manna and Hassan, 2004; Manna *et al.*, 2004; Bhattacharjya *et al.*, 2007; 2008). ICAR-CIFRI got overwhelming success in producing stocking materials in floating cages installed in Pahuj Reservoir, Uttar Pradesh and Dahod Reservoir, Madhya Pradesh during 2007-09 under Challenge Program on Water and Food Project of Consultative Group on International Agricultural Research (CGIAR) implemented through World Fish, Cairo. The institute has ventured into raising table fishes of economically important species by installing durable galvanised iron (GI) framed cages in Maithon Reservoir, Jharkhand in 2011. The institute also demonstrated and facilitated the implementation of cage culture technology in various parts of the country and achieved a production level of 50 kg m^{-3} against a moderate stocking of 60 nos. m^{-3} (Sharma *et al*., 2015). Jharkhand and Chhattisgarh achieved tremendous success in cage culture in their reservoirs. Many states are adopting the technology after observing the promising results. With this background, the present study empirically assessed the impact of cage culture on fish yield from reservoirs and on socio-economic and livelihood of the fisher households.

Materials and methods

Both secondary as well as primary data were collected for the study. A questionnaire was sent to Fisheries Departments of all the states of the country seeking details of cage culture. The information included name of the reservoir, number of cages, cage size, cage material, stocking and harvesting details, commencing year and the executing agencies. The information so collected were compiled and analysed. Jharkhand, Chhattisgarh, Odisha, Maharashtra and Gujarat together possess around 80% of cages of India. For assessing impact of adoption of cage culture on fisher's livelihood, Jharkhand State was taken into account as a case study as it was the pioneer state in inland cage culture adoption. The state Government's objectives for cage culture were to provide low cost protein supplement and to create livelihood opportunities for the displaced fishers. This state also has the distinction of operating highest number of cages (5809) in India. Jharkhand adopted cage culture earlier than many other states and the number of cages has been consistently increasing in the state and therefore, was selected for assessment of impact of cage culture on livelihood of fishers. Four reservoirs namely, Chandil, Tenughat, Tilayia and Patratu were selected purposively. Because, in these reservoirs cage culture was started 5-6 years back and almost simultaneously. Seventy cage fishers and 30 ordinary fishers' households were selected for data collection following the simple random sampling without replacement (SRSWR) strategy. The study considered before-after approach for estimating the impact on livelihood.

A logitstic regression model was fitted to measure the effect of different variables on the decision to adopt cage fish farming. Land holding, family size, age and education of the head of the household were used as independent variables. The dependent variable in this model is dichotomous in nature which assumes a value 1 for cage fishers and 0 for non-cage fishers. The probability of adopting cage farming is expressed in terms of logistic distribution. The logit is defined as the natural logarithm of the ratio of the probability of being a cage fisher (p_i) to ordinary (non-cage) fisher ($1-p_i$)., which is called log-odds ratio. The logit is then regressed on the variables as mentioned above. The logit model used is of the form:

$$\text{In}\left[\frac{P_i}{(1-P_i)}\right] = b_1 X_{1i} + b_2 X_{2i} + \ldots + b_{ki} X_{ki} + e_i$$

where, X_1, $X_2 \ldots X_k$ are independent variables. e_i is the random error assumed to follow normal distribution with constant and homoscedastic variance matrix. The coefficients were estimated using maximum likelihood estimation (MLE) method in SPSS software package.

Results and discussion

In the past 3-4 years, there has been a phenomenal increase in cage culture in reservoirs of India and the present status of adoption of cage culture in reservoirs in different regions of the country are presented in Table 1. Cage culture was widely adopted in India through National Mission for Protein Supplement (NMPS) scheme in 2011-12.

The table shows that western and eastern regions possess maximum number of cages (76.9%). Eastern region, mainly the states of Jharkhand and Chhattisgarh, are the front runners in adopting this technology in

Table 1. Region-wise status of cage fish farming in India (2017-18)

Region	Total no. of cages	GI cages	% of total cages in India	Species preference	Undertaken by
Northern	116	8	0.75	Pangasius	State Department, Fishers
Central	1183	144	8.51	Pangasius, Tilapia	Fish Fed, Fishermen Cooperatives, Private
Western	4684	986	33.69	Pangasius,Tilapia	Private, Fishermen Cooperatives
Eastern	6011	2719	43.23	Pangasius, Tilapia, Carps	Primary Fisheries Cooperative Society, Private.
Southern	718	90	5.12	Pangasius, Tilapia, Carps	State Department, Fishermen Cooperatives, Fishers
North-eastern	1318	216	9.48	Carps, Pengba, Pangasius, Magur, Tilapia	State Department, Fishermen Cooperatives
Total	14018	4163	100.00		

reservoirs. Pangas (*Pangasianodon hypophthalmus)* is the most popular fish species for cage culture throughout India. Tilapia, Pengba and IMC are other fishes cultured in reservoir cages. State Governments are introducing different schemes to make cage culture more popular among fishermen community. Cage structure is mainly of two types *viz*., modular and galvanised iron (GI) cages and from the table it is evident that GI cages form almost 30% of the total cages. The GI cages designed by ICAR-CIFRI are cheaper and is becoming more popular among fishermen/entrepreneurs.

Impact of cage culture on fishers' livelihood

The investigation on impact of cage culture in reservoir on the fishers' livelihood was carried out in Chandil, Tenughat, Tilayia and Patratu reservoirs of Jharkhand State. The analysis showed that around 100 displaced families undertook cage culture in the Chandil Reservoir. The reservoir is surrounded by several villages with lot of tribal population (fishermen and women) depending on fishing in the water body. The displaced fishers formed a fisher cooperative *Chandil Bandh Visthapit Matsyajibi Swabalambi Sahakari Samiti* (CBVMSSS). The state Fisheries Department provided technical support and training to CBVMSSS. Pangas was the major fish species reared in cages.

Tenughat is also a large reservoir (area 12,000 ha at Full Reservoir Level, FRL) and is constructed across the Damodar River. There were 21 Fishermen Cooperative Societies in this reservoir. Around 400 cages were installed and operationalised under the supervision of State Fisheries Department, Jharkhand. Cage culture was started in the year 2012-13 in this reservoir. Tilaya is a medium reservoir having area around 6,000 ha in FRL situated in Koderma District of the state. It is constructed in the River Barakar. Cage culture was started in the year 2012-13 and at present around 426 cages are in operation. Twelve cooperative societies are present in this reservoir. Patratu is a small reservoir having an area of around 1,000 ha on the river Nalkari and cage culture is practiced in this reservoir since 2012-13. Presently around 200 cages are operated in this reservoir

Socio-demographic characteristics of the cage fishers' household (HH)

Table 2 presents the basic socio-economic characteristics of the fishers' households (HH). It revealed that the average family size of the fishers was around 5.5. The literacy rate of the respondents was also good, 84% in cage fishers and 74% in ordinary fishers which are comparable to the national literacy rates. In general, the socio-economic characteristics of the cage fishers are better than those of ordinary fishers. The monthly income was also significantly higher ($p<0.01$) in the case of cage fisher group although the number of economic activities was almost equal in both categories of fishers. This is because, cage culture contributed proportionately more income than other components. Cage farming also reduced the occupational migration, being evident from the fact that occupational migration happened in 11.1% households of non-cage fishers as against 8.8% in cage farmers. Sex ratio was almost same in both category of fishers. The extent of agricultural land holding and livestock owned were low among cage fishers. Probably the cage fishers did not get sufficient time for engaging in agriculture or animal husbandry activities.

Impact of cage culture on livelihood of fishers' household

The fishers family manage their livelihood by professing many occupations, like crop farming, animal husbandry, wage, petty business, service and other self employment avocations. The present study further revealed that after adoption, cage farming contributed around 30% of their livelihood (Table 3) and the monthly income of cage fishers increased from ₹12,087 to ₹17,548 after adopting cage farming. Cage culture also imparted favourable impact on labour migration as occupational migration reduced to 9 from 29%.

Table 2. Socio-demographic characteristics of the cage fishers' household (HH)

Socio-economic parameter	Cage fishers (N=70)	Ordinary fishers (N=30)
Average age of the respondent (in years)	36	43
Years of education of the respondent	9.41	5.19
Average family size	5.49	5.74
Literacy rate (% of population: 6 yrs or more)	83.99	74.07
Female per 1000 males	974.69	962.03
Number of income generating activities per HH	3.66	3.37
Occupational migration (% of HH)	8.82	11.11
Agriculture land holders (% of HH)	61.76	77.78
Livestock/Poultry owners (% of HH)	42.65	62.96
Monthly income (₹)	17547.79	11092.59

Table 3. Sources of livelihood of the fishers' households (% of fishers household)

Sources of livelihood	Before adoption	After adoption
Crop farming	7.35	5.44
Animal husbandry/poultry	1.71	1.12
Labour wage	5.78	5.41
Capture fishing	29.31	18.31
Petty business	13.63	10.22
Govt. service	17.95	12.19
Pension	5.11	3.52
Private service	16.12	11.10
Self employed	3.04	2.30
Cage culture	0.00	29.54
Others	0.01	0.84
Total income per month (₹)	12,087	17,548

Impact of cage culture on high value asset possession/ creation

Results of the study also throws some light on impact of cage culture on possession of high value assets. Table 4 shows that there are positive differences in asset possession after adoption of cage culture. Possession of pucca house, own toilet, electricity and colour televison were much higher after adopting cage culture.

Impact of cage culture on household expenses

A similar exercise was carried out to assess the impact of cage culture in the pattern of expenses in the households. Table 5 reveals that the expenses on fuel, education and household items increased by around 97, 76 and 39%, respectively. Expenses towards other items like clothing, medical and household utilities also increased significantly ($p<0.01$).

Table 4. Impact on high value asset possession/creation (% of assets owned by fishers's household)

Asset	Cage fishers	
	Before adoption	After adoption
Pucca house	35.29	44.12
Own source of drinking water	30.88	33.82
Own toilet	45.59	70.59
Agriculture land	63.24	61.76
Tractor/Power tiller	2.94	2.94
Electricity	77.94	91.18
Mobile phones	69.12	95.59
Computer/laptop	10.29	13.24
Colour television	36.76	50.00
Fridge	13.24	19.12
Bicycle	63.24	64.71
Motorcycle	41.18	69.12

Table 5. Increase in household expenses after adopting cage culture

Items	% Increase in expenses after adoption of cage culture
Food	24.50
Fuel	97.05
Clothing	36.17
Medical	31.78
Utilities	28.71
Household items	39.04
Education expenses	76.41

All the figures are significant at $p<0.01$

The study considered before-after approach for estimating the extent of changes in asset and expenses to minimise other socio-economic factors. Table 2 and 3 reveal that the monthly income of the non-cage (ordinary) fishers was almost similar to the income of cage fishers before adopting cage culture. It can be said that cage culture largely contributed to increase in asset possession and increase in house hold expenditure, though some other factors also might have contributed.

Factors affecting adoption of cage culture

To identify various economic and demographic variables which are important for enhancing the probability of adopting cage culture, a logistic regression model was fitted. Results of the logit model are presented in Table 6. The table reveals that age and education of head of household were the significant factors which affect the probability of adoption of cage culture. Age negatively influenced the adoption, implying that young fishers were more likely to adopt cage culture. Further, the table also shows that educated fishers were more likely to adopt the new venture. The estimates of other factors indicate that the land holding size and family size had positive impact on the dependent variable, however the impact was not significant.

Constraints in adoption of cage culture

The responses of fishers regarding the constraints in adopting cage culture indicated that majority of them (76.5%) considered high initial cost (Fig. 1) as the major constraint. The per cage (6x4x4 m^3) capital cost is around ₹1.35 lakh for a modular cage. Again, around ₹1.5 lakh is required in the first year as operational cost for table fish production of pangas (*P. hypophthalmus)*. However, the GI cages of ICAR-CIFRI are much cheaper (around ₹80000-85000/- per cage of similar volume along with transportation cost). Many state government departments came forward and gave the cages on lease basis to the fishers. High feed cost and low market prices of pangas fish, lack of guarantee on availability of fish seed, non-availability of seed in time and disease/mortality were the other constraints faced by the fishers.

The study found that at present around 14,000 cages have been installed in different reservoirs of the country. Further, cage culture contributed around 30% to the livelihood of the adopted fishers and also reduced the occupational migration in the state of Jharkhand. Till now majority of the inland cage cultures are being undertaken under the patronage of State Fisheries Departments and the cages are leased out to the fishers/fisher groups.

Table 6. Factors affecting adoption of cage culture

Independent variables	Coefficient	Standard Error	p
Size of land holding	0.048	0.285	0.866
Age of head of household	-0.075	0. 036	0.040
Education of head of household	0.211	0.069	0.002
Family size	-0.062	0.135	0.649
Number of observations	100		

Overall Model Fit: Significance level: p = 0.0001; Nagelkerke R^2: 0.3253

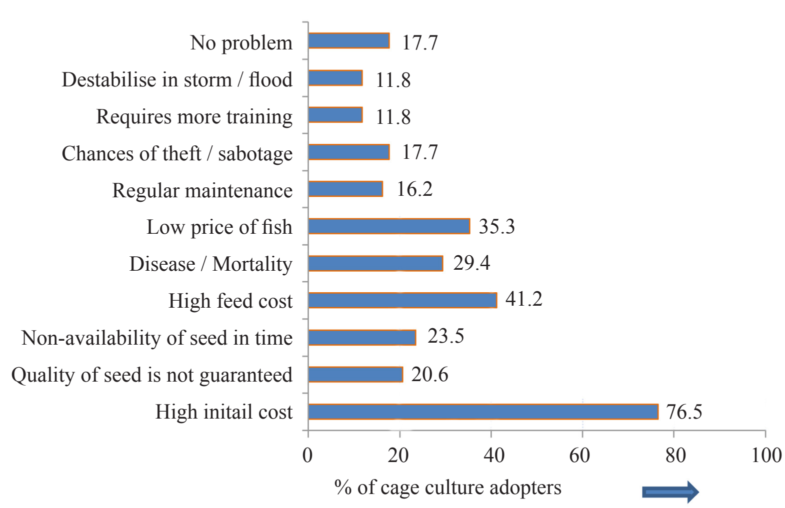

Fig 1. Constraints in adoption of cage culture

In India majority of the individual fishers are not financially strong enough to invest such a good amount of money to adopt this technology individually. In many places fisher cooperatives are also not functioning well and are not financially strong. Therefore, State Departments may promote ICAR-CIFRI's low cost GI cages more vigorously in reservoirs. Yearly lease amount will be much lower for these cages, thereby more fishers/fisher cooperatives can be attracted to adopt cage culture. The fishers and fisher cooperatives need to be technically empowered by imparting suitable trainings. Cage culture in reservoirs is expected to play a significant role in fulfilling the vision of blue revolution in the country.

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