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Sustainable Livelihood through Fish Cage Culture: Case of Chandil Reservoir in Jharkhand

Shweta Kumari and Arpita Sharma*

Indian Council of Agricultural Research-Central Institute of Fisheries Education (ICAR-CIFE), Deemed University, Versova, Mumbai-400 061, India
**E-mail: arpitasharma@cife.edu.in*

***Abstract*:** Chandil is one of the largest reservoir with 18000 hectare (ha) area in Jharkhand and has 933 cages from which about 4 tonnes of fish is produced/cage/year. Impact assessment of cage culture on livelihoods of fisheries dependent people was done using sustainable livelihood framework having human, social, natural, physical, and financial capital as the asset pentagon. Interviews were done with 200 fisheries dependent people who scored their perceptions on a 5 point Likert scale for each livelihood capital before and after adoption of cage culture and percent changes were computed along with Wilcoxon sign-rank test to test if differences were statistically significant. There was positive impact on all livelihood capitals with human capital having maximum impact (34.66%) followed by social capital (30.99%), financial capital (28.90%), physical capital (25.95%) and natural capital (20.85%). However, area of agricultural land had decreased and had a statistically significant negative impact as people lost agricultural land due to reservoir construction. Statistically significant difference was found between before-after scores at 5% level of significance for all livelihood capitals. Cage culture has been able to provide flow of financial capital and had capacity to contribute to other forms of livelihood capitals like investment in assets, food, health, production equipment, education, and housing.

***Keywords*:** Reservoir, Cage culture, Jharkhand, Livelihood, Impact assessment

Reservoirs of India have a combined surface area of 3.25 million hectares (ha) so they are an important inland water resource. Realising the huge untapped potential of reservoirs, India has undertaken culturing of fishes in cages in a big way. Cage culture is a technique where fish are reared from fry to fingerling, fingerling to table size, or table size to marketable size while captive in an enclosed space that maintains the free exchange of water with the surrounding water body. Fish yields of 50 kg/ha/year from small reservoirs, 20 kg/ha/year from medium-sized reservoirs and 8 kg/ha/year from large reservoirs have been realized while still leaving scope for enhancing fish yield through capture fisheries, including culture-based fisheries (Das et al 2009). National Fisheries Development Board (NFDB), which is under the administrative control of the Department of Fisheries, Ministry of Fisheries, Animal Husbandry & Dairying, Government of India was set up in 2006 and has supported several initiatives on cage culture in reservoirs, wetlands and beels in the states of Tamil Nadu, Telangana, Assam, Maharashtra, Rajasthan, Jharkhand and Chhattisgarh. A total of 3117 inland cages have been installed across the country, of which 2553 are in reservoirs, 560 in wetlands/beels and 2 in coal pits. It is expected that, these successful models will encourage several entrepreneurs to undertake cage culture in reservoirs across the country (NFDB, 2018). It has been recognized by many researchers that the cage fish farming in reservoir helps in generating employment (Ali et al 2008; Kumari et al 2019) and improving socio economic conditions for the rural people (Manasi et al 2009, Ali et al 2008). Cage culture is considered as an opportunity to increase fish production (Syandri et al 2015, Karnatak and Kumar 2014) from reservoirs as well as to create livelihood for the displaced people due to reservoir construction (Gurung et al 2009). One such reservoir in which cage culture is adopted is Chandil which is one of the largest reservoirs in Jharkhand state in India. Department of Fisheries (DoF), Government of Jharkhand has installed 933 cages with the help of fisher cooperative societies. It is reported that from each cage about 4 tonnes of fish is being produced. This helps rural unemployed, displaced people of Chandil to sustain their livelihood (Kumar 2018).

It is necessary to conduct livelihood impact assessment of people who are involved in cage culture in this reservoir. Impact assessment is a special form of evaluation that deals with the effect of intervention programme output on the target beneficiaries (Sanginga et al 1999). One of the frameworks of impact assessment is the Sustainable Livelihood Framework (SLF) of DFID (2008) which consists of five inter related dimensions. According to DFID (1999), the SLF seeks to take a more comprehensive and integrated approach to poverty

than traditional interpretations, which largely consider poverty in relation to a narrow set of indicators (such as income and productivity). At the heart of the framework is the asset pentagon including human, social, natural, physical, and financial capital (Chambers and Conway 1992). In context of aquaculture, Sharma (2019) has used this framework. This study was undertaken with the objectives of assessing the impact of cage culture on the livelihood capitals of fisheries dependent people in Chandil reservoir, Jharkhand.

MATERIAL AND METHODS

Locale of the study was Chandil reservoir which is spread over 18,000 ha area in the district of Saraikela-Kharsawan district in Jharkhand state, India. Total number of cages installed in the reservoir is 933 which is maximum among all reservoirs of the state. The size of cage is 6m (length) x 4m (width) x 4m (height) and the species cultured are Pangasius (Sutchi fish), tilapia and carps. There are 5 fisheries cooperative societies in Chandil reservoir. Care was taken to randomly select about 50% of members from each fisheries cooperative society. The total number of members in each of these societies and members selected for the study presented in Table 1. These cooperatives constitute of people who were displaced by the construction of reservoir.

To achieve the objectives of the study, information was collected from members of the fisheries cooperative society using an interview schedule which was prepared keeping DFID (1999) Sustainable Livelihood Framework (SLF) and included the livelihood capitals human, social, natural, physical and financial. For using the SLF framework, a list of indicators which were related to these 5 capitals were collected from review of literature, field study and 3 discussions with expert group. Expert group consisted of 2 social scientists, 1 aquaculture scientist, and 1 Department of Fisheries (DoF) official and 1 key informant each from the 5 cooperative societies. Relevancy of these indicators was tested by expert group with indicators using a 5 point Likert scale with score 4 assigned to very high relevance, 3 to high relevance, 2 to medium relevance, 1 to low relevance and 0 to no relevance. Indicators having average relevancy score of 2 and above were selected. Reliability of the scale was established by 'test-retest' method which was administered on all 9 experts within an interval of 15 days. Reliability coefficient was found to be 0.75. All indicators having an average relevancy score of 2 or above were included in the interview schedule. A total of 38 indicators were included with human capital having 11, social capital having 9, natural capital having 5, physical capital having 7 and financial capital having 6 indicators which are discussed in results section.To achieve the objectives of the study, randomly selected 200 members of the cooperative society were asked to score their perceptions of impact of cage culture on a 5 point Likert scale (0 to 4) for each indicator of 5 livelihood capitals before and after the adoption of cage culture using recall method. The scale had five scores Very high impact (Score: 4), High impact (Score: 3), Moderate impact (Score: 2), Low impact (Score: 1) and Very low impact (Score: 0).

Reliability of this scale was tested using Cronbach's Alpha (Cronbach 1978) calculated using equation 1 and was found to be 0.78. Thus the scale was considered reliable.

$$\alpha = \frac{N\bar{c}}{\bar{v} + (N-1)\bar{c}} \qquad (1)$$

Here, N = the number of items, $\bar{c}$ = average covariance between item-pairs, $\bar{v}$ = average variance.

The obtained scores were normalized using equation 2.

$$\text{Dimension value} = \frac{\text{Actual value} - \text{Minimum value}}{\text{Maximum value} - \text{Minimum value}} \qquad (2)$$

The normalized scores were between 0-1 and a score of 0-0.25 was classified as low impact, 0.25-0.5 as moderate impact, 0.5-0.75 as high impact and 0.75-1.0 as very high impact. Change in 'before and after' scores were measured in percentage and this was considered as the percentage impact for that respective livelihood capital.

Wilcoxon signed rank test was performed to test the hypothesis whether there was any significant difference

Table 1. Sample information

Name of fisheries cooperative society	Total number of members	Members selected for study	Members selected for study (%)
Chandil Bundh Visthapit Matsyjiwi Swawlambi Sahkari Samiti (CBVMSSS)	275	137	49.82
Lawa Gram Matsyajivi Sahyog Samiti (LGMSS)	28	14	50.00
Swarnarekha Bandh Visthapit Matsyajivi Sahkari Samiti Ltd. Chandil (SBVMSS)	36	18	50.00
Visthapit Matsyajiv Sahyog Samiti Ltd. Rasuniya (VMSS)	50	25	50.00
Visthapit Matsyajivi Swawlambi Sahkari Samiti Ltd. Bandveer (VMSSS)	12	6	50.00
Total	401	200	49.87

between before and after scores. Wilcoxon singed rank test was calculated using equation 3.

$$Z = \frac{T^{+} - \mu_{T+}}{\sigma_{T+}} \qquad (3)$$

Where,

$$\mu_{T^{+}} = \frac{T^{+} - (N + N)}{4}$$

$$\sigma_{T^{+}} = \sqrt{\frac{N(N+1)(2N+1)}{24}}$$

T^{+} = sum of ranks for smaller sample size (of singed-rank) ,N = sample size

Wilcoxon signed rank test for ties rank and large samples

$$\sigma^{2}T^{+} = \frac{N(N+1)(2N+1)}{24} - \frac{1}{2}\sum_{j=}^{g} t_j(t_j - 1)(t_j - 1)$$

Where, g = the number of groupings of different tied ranks, $t_{j=}$ the number of tied ranks in grouping j

The 'before after design' was used as it offered better evidence about intervention effectiveness than the other non-experimental designs. Information was collected about any other major programme being undertaken in the study area. No other major programmes and interventions were reported in the study area that could have obscured the effects of the intervention of cage culture thus reducing the threats to internal validity. Few schemes undertaken by State/Central Government posed minimal threat. So internal validity was established. This was done because more threats to internal validity, would give less confidence in the results that the different livelihood impacts are actually due to the intervention of cage culture. This helped in establishing the evidence of causality and attribution to impact of cage culture on different livelihood capitals. Attempts were made to explore people who could form a control group but this could not be done, so the traditional impact evaluation method of using randomised control was not used as it was not able to provide satisfactory answers. Due to this reason, counterfactual design where participants are compared to non-participants was not used. However, hypothetical counterfactual was constructed where enquiries were done by asking what would have happened if intervention of cage culture in this reservoir was not done and adopted by them and if this was a case of sole/joint/alternative (multiple) causal paths. This study represents a before and after comparison among the same population rather than a comparison of different groups at a given point in time. In addition to the before and after scores, enquires were made if the impacts were indeed due to the intervention of cage culture or some other reason/intervention. Judgements were made to include or rule out possible alternative explanations if any by using approach of 'ruling out alternatives' and 'process tracing'. SLF was used as an overarching framework complemented with approach of ruling out alternatives as suggested by Rogers (2014) and process tracing as given by Befani and Mayne (2014) resulting in stronger inferences. To strengthen causal attribution, approach of 'ruling out alternatives' was applied. This approach given by Rogers (2014) identifies possible alternative causal explanations and seeks information to see if these can be ruled out. In this, expert group was asked to identify other possible explanations for the observed impact of cage culture in this reservoir. Based on their judgements, the livelihood impacts were ascertained to be from cage culture. The records/ registers/ documentary proofs/ discussions with key informants were used as evidence-based process. Effort was made to undertake process tracing to rule out alternative explanatory variables. Process tracing holds potential as a rigorous ex-post approach to assess causal change, without having to rely on a control group. As per Punton and Welle (2015) this method of process tracing is relatively recent, and its application still requires further development and refinement but has been used beyond identifying statistical correlations. For process tracing, expert group was asked to identify other possible explanations, using evidence to rule out alternative explanatory variables and general elimination methodology was used. Thus attempts were made to design a rigorous method to establish causal inference, within the given time frame, resources and absence of detailed baseline data or counterfactual evidence.

RESULTS AND DISCUSSION

Background of fisheries in Chandil reservoir: In the year 1978 Subarnarekha Multipurpose Project (SMP) was conceptualized in Bihar state. It was a multipurpose project that envisioned drinking water, irrigation and hydel power generation. The project consisted of two dams; one across river Subarnarekha at Chandil and the other across river Kharkai at Icha. Beside these two dams one barrage across Kharkai at Ganjia and the other across Subarnarekha at Galudih were also envisioned. Both these barrage consisted of canal system to take water for irrigation purpose. The estimated annual irrigation area was about 2, 36,846 hectare (ha). Members of this cooperative were from different villages of the submergence zone and they became part of a cage culture fishing initiative in collaboration with the Jharkhand Government. The DoF is responsible for fisheries management like leasing of reservoir, enhancing fish production and construction of temporary infrastructure like

hatchery. Stocking in the reservoir is done by the DoF under different schemes/programmes of the NFDB. It was in 2011 when the cage culture activities started in the reservoirs of Jharkhand. As per the records of DoF, there are 933 cages in Chandil reservoir and *Pangasianodon hypophthalmus* is cultured in these cages. In the beginning, other than Pangassius; Anabas, Rohu, Tilapia and Grass Carp were also cultured on trial basis. But now Pangasius is cultured because it can be stocked at high density, grows faster and attains a size of 1 kg in 6-8 months of culture. So, it is considered as a candidate fish for cage culture.Members of the cooperative societies manage the fish rearing. NFDB provides 50% subsidy for cage fabrication and inputs and rest 50% is borne by the beneficiaries. In 2011, fish culture was done in 70 cages and the numbers have been increasing every year. In 2019, there were 933 cages (Table 2).

The number of cages has increased, average production per cage has not shown increasing trend. This was due to non-availability of seed. Sometimes cages were left unstock due to absence of seeds. It was reported that Pangas seeds were purchased from West Bengal and dependency for seed is from other states. Fish seed production has increased from 64.50 million fry (2003-04) to 103629.11 million fry (2018-19) in Jharkhand but is still dependent on seed from other states. As per the NFDB guidelines, 5000 cages can be installed in a reservoir of >10000 ha.

Livelihood impact of cage culture: There was impact in the range of 20 to 35% for all (Table 3). Interpreting the empirical evidence, it is clear that highest impact of cage culture was on human capital (34.66%) followed by social, financial, physical and natural capital. Wilcoxon signed rank test revealed a significant difference between the before and after scores at 5% level of significance for all livelihood capitals. Results highlights that there has been a positive impact for all livelihood capitals. Pant et al (2014) obserevd that aquaculture was able to benefit ethnic communities in Bangladesh. Gupta and Haque (2011) also found that due to cage based fish fingerlings, livelihoods of tribal households in north-east and north-west Bangladesh showed improvements. Gurung et al (2009) have suggested that cage fish culture was a good alternative livelihood option for communities displaced by reservoir impoundment in Kulekhani, Nepal. In Indian context, research has shown that fisheries have brought positive changes in the livelihood of people like studies by Dube (2014) in Dimbhe reservoir, Maharashtra, Kumari et al (2017) in Chandil reservoir, Jharkhand, Gautam et al (2017) in Rihand reserevoir, M.P., Kumari and Sharma (2015), Kumari et al (2017) in Raipur, Chhattisgarh and Babu et al (2021) in Andhra Pradesh. Sharma et al (2019) however reported that climate change impacted the livelihoods of fishers in Bhadra reservoir, Karnataka. In the present study impact of climate change was not studied which might be one of the vulnerability issue faced by the members and detailed study is needed for this.

Differences in the livelihood capitals are depicted through a radar chart in Figure 1.

A discussion on individual livelihood capitals is presented as follows.

Physical capital: This capital included nature of house, drinking water facility at home, electricity facility at home, medical facility, transportation facility, fish market facility and sanitary facility at home. It was reported by members that they had their own house and majority (61.5%) had pucca house. A total of 70% members had drinking water facility at home. Cycle as a means of transport was used by 70.5% members. Members reported that due to increase in income with cage culture, they were able to have better facilities of drinking water, electricity and sanitation facilities at home. Fish market facilities had also relatively improved.All the indicators of physical capital had positive impact. Out of the 7

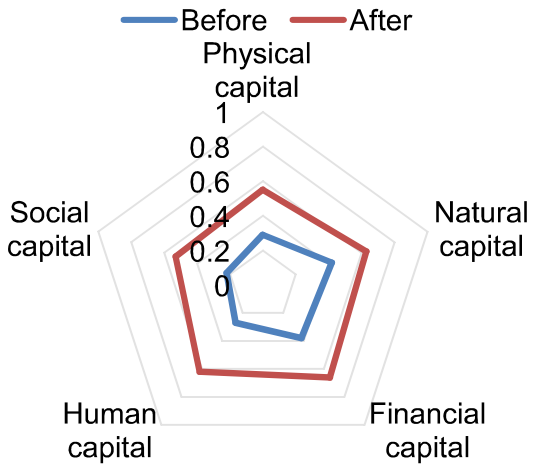

Fig. 1. Radar chart depicting impacts on livelihood capitals

Table 2. Year wise fish production in Chandil reservoir

Year	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Fish production (tonnes)	110	150	180	220	350	400	180	250
Number of cages	70	196	487	487	593	821	897	933
Average production per cage (tonnes)	1.57	0.76	0.37	0.45	0.59	0.49	0.20	0.27

indicators, some facilities like electricity, transportation, nature of house were those which improved at household level and some which improved at the community level like fish market facility, sanitary facility, drinking water facility (Table 4). Wilcoxon sign rank test revealed that there was a statistically significant difference between before and after scores.

Natural capital: This capital included impact on agriculture land area, water area, fish production, availability of fish seeds and availability of various fish species and the scores (Table 5). Agricultural land had decreased after reservoir construction. This change was negative and statistically significant. It was reported that due to reservoir construction, people lost their agricultural land. Most of the cooperative society members (88%) had less than 1 ha agriculture land. Before the construction of reservoir, they were involved in agricultural activities. Panwar and Upreti (2015) also stated that agriculture is the main stay of surrounding villages of Tehri dam in Uttarakhand state which has been severely affected due to submergence of fertile agricultural land. Even though the agricultural land was reported to be reduced; the other indicators of natural capital, especially fisheries, had a positive impact and this change was statistically significant at 5% level of significance. McCartney (2018) also has reported that by creating reservoirs, potential for fish production can be increased in Malaysia. Ghosh et al (2016) also reported that fish biodiversity improved due to floating cages in Godavari Estuary, Andhra Pradesh and in a study by Uddin et al (2015) in Bangladesh natural capital was improved due to integrated farming.

Financial capital: This capital included annual respondent's income, annual family income, annual family expenditure, annual savings, general assets and fisheries assets. Average annual income of members from cage culture was reported to be ₹3, 50,000 which is more than the national average annual income of ₹1, 26,406. National Statistical Office, Ministry of Statistics & Programme Implementation Government of India (2020). Average annual income of cooperative society members was more than the average annual income of Jharkhand state which is ₹83,592. Planning cum Finance, Govt. of Jharkhand (2020). ($1=Indian Rupees/₹ 74.38). The changes in the financial capital of the members due to cage culture is presented in Table 6.

All the indicators related to financial capital, positive impact was reported which was statistically significant. It can thus be inferred that cage culture contribute to the flow of financial capital available to members. This has the

Table 3. Livelihood capital scores before and after adoption of cage culture

Livelihood capital	Before		After		% change	|Z| values	Decision
	MS*	NMS**	MS*	NMS**			
Physical capital	8.14/28	0.29	15.42/28	0.55	25.95	12.352	Reject H_0
Natural capital	8.42/20	0.42	12.59/20	0.63	20.85	12.089	Reject H_0
Financial capital	9.01/24	0.38	15.94/24	0.66	28.90	12.297	Reject H_0
Human capital	11.82/44	0.27	27.08/44	0.62	34.66	12.281	Reject H_0
Social capital	7.85/36	0.22	19.01/36	0.53	30.99	12.284	Reject H_0
Overall	45.23/152	-	90.04/152	-	29.48		

MS*: Mean score, NMS**: Normalized mean score

Table 4. Impact of cage culture on physical capital

Livelihood capital	Before		After		% change	|Z| values	Decision
	MS*	NMS**	MS*	NMS**			
Nature of house	0.84	0.21	2.02	0.50	29.13	13.155	Reject H_0
Drinking water facility at home	0.90	0.23	2.20	0.55	32.38	12.780	Reject H_0
Electricity facility at home	1.01	0.25	2.24	0.56	30.75	12.821	Reject H_0
Medical facility	1.03	0.26	2.05	0.51	25.50	13.185	Reject H_0
Transportation facility	1.01	0.25	2.09	0.52	26.75	13.184	Reject H_0
Fish market facility	1.48	0.37	2.26	0.57	19.75	10.124	Reject H_0
Sanitary facility at home	1.87	0.47	2.56	0.64	17.38	11.251	Reject H_0
Overall	8.14		15.42		25.95		

MS*: Mean score, NMS**: Normalized mean score

capacity to be converted to other forms of capital, for example, an investment in assets, food, health, production equipment, education, and housing. Principle explained by Mwebaza-Mdawula (1990) that you cannot change just one thing (YCCJOT) is applicable here that all elements are connected, directly or indirectly, so that a change in one element is eventually having some impact on every other element. Khatun et al (2013) in Bangladesh revealed that the socio-economic status of farmers of Charbata, Noakhali,Bangladesh improved with pond fish farming. Syandri et al (2015) in their study on social status of the fish farmers of floating net cages in lake Maninjau, Indonesia reported about the increase in fish production and income of the fish farmers from cage culture. Palita (2014) studied the fisher's livelihood and institutional arrangement in Hirakud reservoir, Odisha and stated high income of fishers compared to non-fishers.The cost of construction of 1 battery (4 cages) is ₹300000/- ($1=Indian Rupees/₹ 74.38). Assistance is provided by the state government and NFDB towards cage, inputs i.e., seeds for stocking in cages and feeds for fishes are also provided at subsidized rate. As there is subsidy provided by the state government and NFDB, the cooperative society members are dependent on government for cage culture in reservoirs. In such situation there can be a question that if the government and NFDB will not provide subsidy for cage construction and inputs, will cooperative society members be able to sustain this cage culture? However, the effect of subsidy on economic viability has been discussed in studies with reference to the small scale marine fisheries but not much in case of reservoir fisheries. This is a technology with potential benefits so there will be Government support for better adoption rates.

Human capital: Members reported that there was a positive impact for all the indicators related to human capital and this change was statistically significant (Table 7). It was observed that DoF and NFDB play an important role towards human capital development by providing skill and training to the members. Members had gained skill of fishing from these training programmes. They did not have cage culture skill before. Before adoption of cage culture very few (18.5%) were involved in fisheries activities and few had experience in fisheries. In addition, members now have skill in construction of cages, fish identification, fish handling, stocking, netting, fish breeding, feed dosage and marketing.

Social capital: The indicators which were included for social capital were leadership capabilities, desire to be a leader, participation in social meetings, participation in social works, social relationships with family, neighbours, and others cooperative society members, women's

Table 5. Impact of cage culture on natural capital

Livelihood capital	Before		After		% change	|Z| values	Decision
	MS*	NMS**	MS*	NMS**			
Area of agri land	2.52	0.63	0.46	0.11	-51.63	12.377	Reject H_0
Area of water resource	1.48	0.37	3.36	0.84	47.13	12.080	Reject H_0
Fish production	1.52	0.38	3.30	0.83	44.50	11.912	Reject H_0
Availability of fish seeds	1.38	0.35	2.18	0.55	19.88	12.225	Reject H_0
Availability of various fish sps.	1.52	0.38	3.29	0.82	44.38	11.911	Reject H_0
Overall	8.42		12.59		20.85		

MS*: Mean score, NMS**: Normalized mean score

Table 6. Impact of cage culture on financial capital

Livelihood capital	Before		After		% change	|Z| values	Decision
	MS*	NMS**	MS*	NMS**			
Annual respondent Income	1.60	0.40	2.92	0.72	32.63	12.767	Reject H_0
Annual family income	1.88	0.47	3.09	0.77	30.25	13.107	Reject H_0
Annual family expenditure	1.92	0.48	2.97	0.74	26.38	12.463	Reject H_0
Annual saving	0.54	0.14	1.91	0.48	34.25	10.769	Reject H_0
General assets	1.67	0.42	2.72	0.68	26.38	12.108	Reject H_0
Fisheries assets	1.40	0.35	2.34	0.59	23.50	11.712	Reject H_0
Overall	9.01		15.94		28.90		

MS*: Mean score, NMS**: Normalized mean score

participation in fisheries work, contact with Government Organisations (GO)/NGO and participation of women in decision making (Table 8).All indicators of social capital, there was a positive impact due to cage culture and this difference was statistically significant. Members had better relationship with other fishers, cooperative members, participation in meetings was relatively high and they had more contacts with the officials of DoF. Relations and connectedness were further stimulated by the capacity building programmes with frequent gatherings and training. It was reported that this increase in social capital resulted in an increase in trust among the cooperative society members. This was similar to what DFID (2007) has stated that the connectedness and relations help in the facilitation of cooperation, reduction of transaction costs and providing the basis for safety nets. Communication tools which were commonly used were simple mobile phones. About 30% had television and 10% subscribed to newspaper. Participation in social and regional activities and few political gatherings was common. However, usage of the communication device

Table 7. Impact of cage culture on human capital

Livelihood capital	Before		After		% change	|Z| values	Decision
	MS*	NMS**	MS*	NMS**			
Fisheries skills	1.10	0.28	2.73	0.68	40.75	12.552	Reject H_0
Production skills	1.11	0.28	2.20	0.55	27.13	13.368	Reject H_0
Marketing skill	1.05	0.26	2.26	0.57	30.38	13.032	Reject H_0
Technical skill	0.72	0.18	1.82	0.46	27.63	13.466	Reject H_0
Children going school for primary education	1.30	0.33	2.64	0.66	33.50	12.509	Reject H_0
Children going to school for higher education	1.27	0.32	2.48	0.62	30.38	12.823	Reject H_0
Knowledge about cage culture	0.07	0.02	2.40	0.60	57.75	12.880	Reject H_0
Awareness about government schemes	1.30	0.33	2.88	0.72	39.63	12.455	Reject H_0
Participation in training programmes	1.24	0.31	2.45	0.61	30.38	12.884	Reject H_0
Attitude towards DoF	1.34	0.34	2.66	0.66	32.88	12.831	Reject H_0
Attitude towards fish culture/ cage culture	1.32	0.33	2.56	0.64	30.88	13.133	Reject H_0
Overall	11.82		27.08		34.66		

MS*: Mean score, NMS**: Normalized mean score

Table 8. Impact of cage culture on social capital

Livelihood capital	Before		After		% change	|Z| values	Decision
	MS*	NMS**	MS*	NMS**			
Leadership capabilities	1.11	0.28	2.11	0.53	25.00	13.658	Reject H_0
Desire to have leader position	0.58	0.15	1.45	0.36	21.63	12.854	Reject H_0
Participation in social activities	1.20	0.30	2.46	0.62	31.38	12.763	Reject H_0
Participation in social meetings	1.40	0.35	2.45	0.61	26.13	12.228	Reject H_0
Participation of women in fisheries activities	0.37	0.09	1.97	0.49	40.13	12.425	Reject H_0
Participation of women in social activities	0.42	0.10	1.48	0.37	26.63	13.059	Reject H_0
Participation of women in decision making	0.76	0.19	1.81	0.45	26.13	13.282	Reject H_0
Contact with GOs & NGOs	1.17	0.29	3.04	0.76	46.88	12.522	Reject H_0
Membership in organizations	0.84	0.21	2.24	0.56	35.00	12.658	Reject H_0
Overall	7.85		19.01		30.99		

MS*: Mean score, NMS**: Normalized mean score

was not included in the impact study as it was difficult to attribute that this change was only due to cage culture.Results of hypothetical counterfactual where enquiries were done by asking what would have happened in the absence of adoption of cage culture in this reservoir revealed that in the absence of alternatives, migration to other places by the displaced would have happened. The results of the study have clearly shown that there is a demonstrated link between the interventions inputs of cage culture and the livelihood impact that are observed. Rogers (2014) has explained three conceptualizations of cause and effect as sole/joint/alternative (or multiple) causal attributions. In the present study 'sole causal attribution' was observed by field study as well as reported by the members and it could be established that the intervention of cage culture was able to produce the impacts independently (or relatively independently) of contextual factors or other interventions. Usually, programmes or policies are rarely sufficient to produce the intended impacts alone which was not the case as no other major development programme was reported and observed. Hypothetical counterfactual enquiries also revealed that in the absence of alternatives, migration to other places by the displaced would have happened. The approach of 'ruling out alternatives' and 'process tracing' was able to provide strong inference that the impacts were indeed due to the intervention of cage culture. So in this reservoir, the new stocks of potential resource were introduction of fisheries through cage culture which generated benefits for the human elements in the system. The benefits were distributed among the cooperative society members thus resulting in distributional impacts.

CONCLUSIONS

The adoption of fish culture in cages can be a good alternative livelihood option especially for displaced people. Cage culture can increase fish production and ensure sustainable livelihoods for people. The study has shown that cage culture in reservoirs had a statistically significant positive impact on all the livelihood capitals with highest impact being on human capital followed by social capital and physical capital. Cage culture in Chandil reservoir has been successful with synergetic efforts by GOs, NGOs and community participation.

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