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## **Assessment of Cage Culture Practices in Chandil Reservoir, Jharkhand**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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### **ABSTRACT**

The present study was carried out in Chandil reservoir which is situated in Saraikela-Kharsawan district, Jharkhand and has 933 cages installed for fish culture. The objective of the study was to assess cage culture practices in this reservoir. The assessment was done using the NFDB guidelines of cage culture in inland open water bodies of India using 15 parameters. Interviews with officials of Department of Fisheries and fishers was done to enquire if the guidelines were followed using a 3 point scale. This was corroborated by observation and field visits, so as to adopt the triangulation method. It was found that 66.67% of the guidelines were being followed fully. However, 33.33% of guidelines like water quality, cage maintenance, fish health monitoring, use of safety measures and environment precaution and assessment, guidelines were partly followed due to certain reasons. Accordingly suggestions have been provided. It was concluded that the cage culture practices followed in Chandil reservoir is good. Improvements can be done on those parameters where guidelines are being partly followed.

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## 1. INTRODUCTION

Cage culture is a culture technique in which fry or fingerlings are reared to table size or marketable size in an enclosed space that maintains the free exchange of water with the surrounding water body [1]. Cage culture is a type of enclosure culture and involve holding organisms captive within an enclosed space whilst maintaining a free exchange of water. It is totally enclosed on all, or all but the top, sides by mesh or netting [2].

The reservoirs of India accounts 3.15 million ha area and reservoirs fisheries is one of the two main pillars of growth of fish production [1]. Sharma et al. [3] also stated that reservoir offers enormous scope for enhancing productivity through culture based capture fisheries. Harvesting is a major problem in most of the reservoirs and lakes in the country as most of them are either weed-choked or having obstructions in the form of boulders or tree stumps limiting operation of many a fishing gear [2016]. Thus cage culture in inland open waters is being looked upon as an opportunity to utilize existing reservoirs to enhance fish production and posed as an answer to increased demand for animal protein in the country [4]. In the National Inland Fisheries and Aquaculture Policy [5] it has been mentioned that cage culture should be promoted in reservoirs based on recommendations of scientific organizations.

Cage aquaculture, though relatively new to the inland aquaculture scenario of the country, brings in new opportunities for optimizing fish production from the reservoirs and lakes, and also developing new skills among fishers and entrepreneurs to enhance their earnings [5].

All over India there are 19,386 reservoirs [6] and more than 15 states are practicing cage culture in the reservoirs [3]. Among all the states Jharkhand has shown immense potential for cage culture. As reported by Hassan et al. [7] Jharkhand is the premier state of India to have successfully introduced cage culture in reservoirs. Kumari et al. [8] stated in their study on emergence of new employment opportunities through cage culture in Jharkhand state that cage culture is an emerging area of employment for people living in the vicinity of the reservoirs. The success of cage farming in Jharkhand set a benchmark and proved the potential of cage

culture in the country [3]. Radhakrishnan et al. [9] stated that a significant income was generated from cage culture of *Pangasius Sutchi*. In the state cage culture is practiced in more than 25 reservoirs of different districts amongst which major are Chandil, Tillaiya, Tenughat, Maithan, Konar, Patratu and Getalsud reservoirs (DoF, Jharkhand).

In Jharkhand, Chandil reservoir is the largest reservoir of the state having an area of 18,000 ha and maximum number of cages (933) have been installed in this reservoir. A comprehensive study on livelihood impacts, performance of fisheries cooperatives and assessment of cage culture practices has been recently completed. This paper presents part of this study i.e., assessment of cage culture practices in Chandil reservoir.

## 2. METHODOLOGY

Information was collected about the Chandil reservoir with reference to area, fish species cultured, governance, cooperatives, members, number of cages etc. Assessment of cage culture practices was done using the guidelines of the National Fisheries Development Board (NFDB). NFDB [5] has published a guidelines for cage culture in inland open water bodies of India in 2016 in which there is a description about various aspects of cage farming based on 15 parameters such as Shape of cages and materials to be used for making cage, Size of cage, Selection of waterbody for cage installation, Selection of site for installation of cages, Depth of waterbody, Quality of water, Maintenance of cage, Species to be cultured, Monitoring of health of stocked fish, Use of safety measures, Management of marketing, harvesting and post-harvest, Environment precaution and assessment, Carrying capacity & limit of cage culture in reservoir, Ownership, beneficiaries and governance and Social relevance.

Assessment of cage culture in Chandil reservoir was performed using this guideline and it was verified if these guidelines were being followed or not. Triangulation was done through discussions with DoF officials, discussion with fishers, corroborated by site visit and personal observation [10] Altrichter et al. [11] have explained that triangulation gives a more detailed and balanced picture of the situation. Denzin [10] has explained different kinds of triangulation

i.e., Investigator triangulation, Theory triangulation, and Methodological triangulation. In this study methodological triangulation i.e., using more than one method to gather data was adopted. The three methods used were interviews, observations and field visits.

A 3 point scale was used to give scores with reference to guideline being followed or not. When the guideline was completely followed that parameter was given a score of 3, if it was partly followed it was given a score of 2 and if it was not followed it was given a score of 1. Interviews were also done with fishers in order to get an insight why they were unable to follow the guidelines.

### 3. RESULTS AND DISCUSSION

Chandil reservoir was constructed for hydroelectric, irrigation and water storage purpose. The water level of the reservoir is 180m. The reservoir is used for fish culture and tourism now. Management of fisheries in the reservoir is done by the Department of Fisheries (DoF) and the 5 fisheries cooperative societies jointly.

As reported by Himadri et al. [4] the construction of Chandil dam displaced 37600 people and among them 87.92% were tribal. These displaced people lost their livelihoods. The protest against the construction of reservoir was experienced from its inception in 1975 and, in 1978, some 10,000 of them demonstrated against the dam at the construction site. During protest in 1978 four people were killed by police in an anti-resettlement rally at Chandil dam as per a report by World Commission on Dams [12].

Visthapit Mukti Vahini which is a NGO initiated vital livelihood measures for those displaced by the Chandil dam in Seraikela-Kharsawan district, Jharkhand [13].

The idea of using the reservoir for pisciculture dates back to 1991 when the dam was being constructed. Bihar Government had then taken initiatives to hold an auction of the dam for fish farming. But a local NGO, Vishtapit Mukti Vahini, protested, demanding that displaced villagers should hold fishing rights. No progress was made for years. Later, after the formation of Jharkhand, a cooperative society was formed by the displaced villagers as Chandil Bundh Visthapit Matsyajibi Swabalambi Sahakari Samiti Limited.

The cooperative society was registered in the year 2005. After a long agitation, the fishing rights in the reservoir was awarded to the cooperative society in 2007. But as the cooperative society did not have the expertise in fisheries, they approached the DoF with a proposal to develop Chandil reservoir into a fishing zone. The DoF in turn, approached the NFDB, Hyderabad, for providing expertise and support for the project. Since then, the NFDB has been providing all necessary assistance to undertake fish culture in Chandil reservoir. NFDB provided fund to the state under different schemes. The fund provided in different years under reservoir fisheries development are given in Table 1.

Information was collected about the Chandil reservoir with reference to area, number of cooperatives, number of cages installed, size of cages and fish species cultured and the same is presented in Table 2.

Chandil reservoir is spread over 18000 ha area in the district of Sarikela-Kharsawan district of Jharkhand. There are 17 cooperatives in the district but it was reported that 5 fisheries cooperative societies are functional. They are Chandil Bundh Visthapit Matsyjiwi Swawlambi Sahkari Samiti Ltd., Lawa Gram Matsyajivi Sahyog Samiti, Swarnarekha Bandh Visthapit Matsyajivi Sahkari Samiti Ltd., Visthapit Matsyajivi Sahyog Samiti Ltd. Rasuniya and Visthapit Matsyajivi Swawlambi Sahkari Samiti Ltd. Bandveer. Total number of cages installed in the reservoir is 933 which is a maximum in number among all reservoirs of the state. The size of cage is 5m (length) x 4m (width) x 4m (height) and the species cultured are Pangasius (Sutchi fish) in major and tilapia and carps in experimental basis.

It was found that the fishers involved in cage culture had membership of any one cooperative society. As regard to culture practice, before adopting the practice fishers attended training on cage culture which was organised by the state DoF who also provide necessary guidance.

In order to assess the cage culture practices being done here NFDB guidelines were used as explained in the section of methodology based on 15 parameters. Table 3 presents the assessment of the cage culture as per the guidelines along with scores.

**Table 1. Year wise fund sanctioned for reservoir fisheries development**

Year	Fund released (in lakhs)	No. of cages
2010-11	70.90	-
2011-12	82.42	70
2012-13	51.01	196
2013-14	413.60	487
2014-15	15.91	487
2015-16	23.62	593
2016-17	2298.90	821
2017-18	-	897
2018-19	-	933

**Table 2. Information about Chandil reservoir**

Area of reservoir	18000 ha
No. of cooperatives working	6
Number of cages installed	933
Size of cages	6m (length) x 4m (width) x 4m (height)
Fish species cultured	Pangas

It is clear from the Table 3 that out of 15 parameters 10 i.e., 66.67% were completely followed and 5 i.e., 33.33% were partly followed. Average score for following NFDB guidelines was 2.67/3 (40/45) which was considered good. Discussion on each aspect is presented as follows.

### 3.1 Shape of Cage and Materials to be Used

The cages installed in Chandil reservoir were found rectangular or square shaped and these are made up of nylon netting materials and the fabrications are of rust free materials of either GI (Galvanised Iron) or HDPE (High Density PolyEthelene). These all are considered good as per the NFDB guidelines. Therefore, based on the NFDB guidelines, it can be said that the shape of cage and materials used for cage culture practices completely follow the guidelines and thus scored 3.

### 3.2 Size of Cages

NFDB Recommends the standard size of cage for fish culture in reservoir as 6m (length) x 4m (width) x 4m (height) in dimension and a battery should be comprised of 6, 12 or 24 cages as per requirement. In Chandil reservoir, the cages installed were having dimension of 6x4x4 with 6 cages in a battery indicates that NFDB guidelines were followed completely and thus this parameter scored 3.

### 3.3 Selection of Water Body

NFDB recommends that only those water bodies should be used for cage culture which are having a surface area  $\geq 1000$  ha and have average water depth of 10m. Chandil reservoir has an area of 18000 ha and cages are installed at more than 10 m depth. It was found that the guidelines are completely followed and thus this parameter also scored 3.

### 3.4 Site Selection

It was reported by the DoF and fishers that the selection of site for installation of cages were based on the safety of the location so that smooth culture can take place. Cages were installed at the place where wind and wave action is limited and water bodies is without obstruction. NFDB has also mentioned the same in its guidelines. Therefore the guidelines are followed completely and thus this aspect scored 3.

### 3.5 Depth

Depth is an important criterion for selecting the reservoir and also the cage site. Reservoir should have at least 10 metres of mean depth and the cage site needs a water depth of at least 10 metres round the year. It was reported by DoF and fishers that in this respect NFDB guidelines were completely followed. This was also verified and thus this parameter also scored 3.

**Table 3. Cage culture practice of Chandil reservoir**

S. No.	Parameter	NFDB Guideline	Chandil Reservoir	Score
1.	Shape of cage & materials to be used	<ul style="list-style-type: none"> <li>Rectangular or square shape</li> <li>GI or HDPE</li> </ul>	<ul style="list-style-type: none"> <li>Rectangular shape</li> <li>GI and HDPE</li> </ul>	3
2.	Size of cage	<ul style="list-style-type: none"> <li>6m (length) x 4m (width) x 4m (height)</li> <li>6, 12 or 24 cages</li> </ul>	<ul style="list-style-type: none"> <li>6x4x4</li> <li>6 cages</li> </ul>	3
3.	Selection of waterbody	<ul style="list-style-type: none"> <li>having a surface area 1000 ha or more at FRL</li> </ul>	<ul style="list-style-type: none"> <li>18000 ha</li> </ul>	3
4.	Site selection	<ul style="list-style-type: none"> <li>Based on safety of the location and smooth culture operations.</li> </ul>	<ul style="list-style-type: none"> <li>Based on safety of location and smooth culture operation</li> </ul>	3
5.	Depth	<ul style="list-style-type: none"> <li>at least 10 metres</li> </ul>	<ul style="list-style-type: none"> <li>10 meter</li> </ul>	3
6.	Water quality	<ul style="list-style-type: none"> <li>Oligotrophic/mesotrophic</li> <li>Regular analysis of nitrogen and phosphorous concentration in water</li> </ul>	<ul style="list-style-type: none"> <li>Oligotrophic</li> <li>No regular measure of nitrogen and phosphorous concentration</li> </ul>	2
7.	Cage maintenance	<ul style="list-style-type: none"> <li>Should be painted with anti-corrosive paint and scrubbed at 15-days interval</li> <li>Physico-chemical parameters should be recorded regularly</li> </ul>	<ul style="list-style-type: none"> <li>painted with anti-corrosive paint and scrubbed at 15-days interval</li> <li>Physico-chemical parameters not recorded regularly by fishers</li> </ul>	2
8.	Species cultured	<ul style="list-style-type: none"> <li>Exotic pangasius (Sutchi Catfish), <i>Pangasianodon hypophthalmus</i></li> </ul>	<ul style="list-style-type: none"> <li><i>Pangasianodon hypophthalmus</i>, GIFT, IMC</li> </ul>	3
9.	Fish health monitoring	<ul style="list-style-type: none"> <li>Usage of suitable quality feed, maintenance of optimum stocking densities, adoption of preventive measures such as prophylactic treatment before stocking, regular monitoring of stock and periodic cleaning of cages are necessary to avoid outbreak of diseases and stock loss.</li> <li>A record on incidence of fish disease and control measures adopted including medicines used should be maintained.</li> </ul>	<ul style="list-style-type: none"> <li>Usage feed made in their own farm as well as feed purchased from dealers of Growel Company, the seeds were purchased from Nayhati, West Bengal.</li> <li>There is no records on incidence of disease and control measures even though the fungus disease observed in Pangas fish.</li> </ul>	2
10.	Safety measures	<ul style="list-style-type: none"> <li>Adequate number of life-saving equipment (lifebuoys) should be kept at the cages and in vessels used for managing the cages.</li> <li>The workers should wear life-jackets all the time while working in cages.</li> <li>An efficient watch and ward is required to protect stock from poaching/ trespassing.</li> </ul>	<ul style="list-style-type: none"> <li>Lifebuoys kept at the cages.</li> <li>The workers do not wear life-jackets while working in water and cages.</li> <li>There is no additional person for watch and ward. It is done by them only.</li> </ul>	2

S. No.	Parameter	NFDB Guideline	Chandil Reservoir	Score
11.	Market, harvest and post-harvest management	<ul style="list-style-type: none"> <li>Harvesting of stock may be done in phased manner and records of harvest should be maintained.</li> </ul>	<ul style="list-style-type: none"> <li>Harvesting is done in phased manner based on the market requirement and record of the production is also maintained</li> </ul>	3
12.	Environment precaution and assessment	<ul style="list-style-type: none"> <li>Environmental Impact Assessment (EIA) is necessary, Recording of water quality parameters on regular basis</li> </ul>	<ul style="list-style-type: none"> <li>EIA has done but assessment of water quality parameters on regular basis</li> </ul>	2
13.	Carrying capacity & limit of cage culture in reservoir	A reservoir having >10000 ha area maximum cages should be 5000.	<ul style="list-style-type: none"> <li>&lt; 5000 cages installed</li> </ul>	3
14.	Ownership, beneficiaries and governance	<ul style="list-style-type: none"> <li>Cage culture practices can be done collectively without conflicts.</li> <li>Cages should be owned by the community or a group of members of the community.</li> <li>A strong governance platform based on co-management principles is essential.</li> </ul>	<ul style="list-style-type: none"> <li>Cage culture practice is done by the members of the cooperative society.</li> <li>Cages were owned by the members of the fisheries coop. society.</li> <li>The activity was based on a public private partnership.</li> </ul>	3
15.	Social relevance	<ul style="list-style-type: none"> <li>Apart from the increased availability of fish there should be additional income and improved standard of living for the weakest sections of the society.</li> </ul>	<ul style="list-style-type: none"> <li>People get benefited both directly as well as indirectly from this activity.</li> <li>As they opened small shops or stalls nearby the dam area where visitors comes for picnic or tourism which helps them to generate additional income.</li> <li>Some have improved their standard of living but still some need to be improved.</li> </ul>	3
Average score				2.67

### 3.6 Water Quality

For cage culture practice, water bodies should be either oligotrophic or mesotrophic in nature. Eutrophic reservoirs and water having total phosphorous and total nitrogen concentration excess of 0.02 mg/L and 1.2 mg/L respectively are strictly prohibited for cage culture practices. Chandil reservoir is oligotrophic in nature and as regards to total phosphorous and total nitrogen concentration, it was reported that this was not analysed regularly because of the nature of water body and also as no changes were found in the water quality. So this guideline was partly followed and scored 2.

### 3.7 Cage Maintenance

The cages installed in Chandil reservoir were found painted with anti-corrosive paint to prevent from rusting and increase its durability as well as cleaned with brushes at every 15 days interval which is as per the guidelines of NFDB. But the physico-chemical parameters of water was not recorded regularly and thus this guideline was followed partly and scored 2.

### 3.8 Species Cultured

In Chandil reservoir, *Pangasius* fish (*Pangasianodon hypophthalmus*) was in culture and along with it in some cages GIFT tilapia, anabas (*Anabas tesudineus*), grass carp (*Ctenopharyngodon idella*) were also cultured on experimental basis. These are recommended in NFDB guidelines too. Therefore, guideline was followed completely and thus this parameter also scored 3.

### 3.9 Fish Health Monitoring

As regards to fish health monitoring the guidelines of NFDB were followed partly in the cage culture practice of Chandil reservoir as there was no maintenance of records on incidence of disease and control measures. Optimum stocking density and periodic cleaning of cages was taken into consideration. Thus this guideline was followed partly and scored 2.

### 3.10 Safety Measures

Cage culture activities involves a risky working environment. Therefore, all security measures

should be taken to avoid injury and loss of life while installing cages and working in cages to manage the stock. In Chandil reservoir safety measures were observed in relation to life saving equipment keeping and its use. Life jackets were kept on the boat from which fishers reach to cage. But most of the times they did not use it while working on cage. It indicated that the guidelines were partly followed and thus scored 2.

### 3.11 Market, Harvest and Post-Harvest Management

The harvesting of stock was done in phased manner and record of the production was also maintained. Harvested fishes were sold not only to local market but also to other cities, districts and even other states also. Although ice facility is not available for storage and transportation but the facility for the live transportation of fish is maintained. Thus this guideline was completely followed and scored 3.

### 3.12 Environment Precautions and Assessment

The environment precautions and assessment guideline was found to be partly followed. Environment Impact Assessment (EIA) was not done for the reservoir. There were no regular assessment of nutrient load as the nature of waterbody is oligotrophic and the focus was on production and livelihood instead of minimizing nutrient load. Fishers reported that they do not measure the water quality but officials of DoF check the water quality at certain times. This indicated that the guidelines were partly followed and thus scored 2.

### 3.13 Carrying Capacity and Limit of Cage Culture in Reservoirs

On a precautionary approach basis, NFDB mentions the carrying capacity for cage culture in a reservoir as maximum of 5000 cages for reservoir having area >10000 ha (Table 4).

The Chandil reservoir has an area of 18000 ha and a total of 933 cages installed for culture practice. There is some scope to have more cages. This guideline was being followed completely and thus this parameter scored 3.



**Table 4. Limits set for cage culture in reservoirs**

<b>Reservoir Area (ha)</b>	<b>Maximum Number of Cages Allowed*</b>
<1000	Not allowed
1001 to 2000	500
2001 to 3000	1000
3001 to 4000	1500
4001 to 5000	1900
5001 to 10000	3000
>10000	5000

\*As Stand-alone or in Batteries (of 6, 12 or 24 Cage Units), as required

\*One Cage Unit is 6m x 4m x 4m

### 3.14 Ownership, Beneficiaries and Governance

The cage culture practice in Chandil reservoir is done by the members of the fisheries cooperative society i.e., Chandil Bandh Visthapit Matsyajivi Swawlambi Sahkari Samiti which is a society of displaced people. The cages were given to the members of the society only. The cage culture activity of Chandil reservoir was based on a public private partnership. Private parties includes farmers and private firms. The DoF develops the capacities of the fisher communities to enable them to take up cage culture. Fishers did not report any conflict among the members of the society. Members participate in meetings actively and are practicing culture cooperatively. All these are as mentioned in the NFDB guidelines also. Therefore, this guideline was followed completely and scored 3.

### 3.15 Social Relevance

As regards to social relevance, it was reported by the fishers that they had improved their income through this and cage culture had a positive impacts on their livelihoods. Due to the construction of dam, people had lost their livelihoods but after joining the cooperative societies they are now involved in cage culture. They are now able to generate income not only from the cage culture but also from using boat as transport. Some villagers also have opened small tea and snacks stall nearby. Thus in this aspect guideline were completely followed and thus this parameter also scored 3.

It is clear from the study that with 66.67% of the guidelines being followed it can be said that the practices adopted in Chandil reservoir are good. Devi et al. [14] have also stated that the cage culture activity with the minimum number of cages for short term duration does not have noticeable impact over the water quality at cage

sites, but the long term effects are need to be monitored for the sustainability of cage farming. Czerniak [15] has also stated that effective cage farming requires ensuring compliance to best practices like proper site selection; securing the environment; a proper site plan etc.

However, for the 5 parameters i.e., water quality, cage maintenance, fish health monitoring, safety measures, environment precaution and assessment for which NFDB guidelines were found to be partly followed, discussions were done with the fishers to find the reasons for the same.

It was found that in case of water quality and cage maintenance fishers were not measuring the nitrogen and phosphorous load and physico-chemical parameters of the water regularly. They reported that the reservoir is a large water body. Moreover, they did not find any changes in the water body so they have avoided testing the same.

As regards to fish health monitoring, it was reported that they have not seen much incidence of fish disease so they are not monitoring the same. They stock fish into the cage after treatment of fish seed with potassium permanganate (KMNO<sub>4</sub>).

With reference to life saving jackets fishers feel that they can work better on cages without jackets. But, they agreed that this was necessary for safety.

The officials of the DoF reported that EIA was not done because the water body is oligotrophic in nature and till now there were very less cages installed. It was also said that they still find the quality of water same as it was before installation of cage.

#### 4. CONCLUSIONS

It can be concluded from the assessment of the cage culture practices in Chandil reservoir that the practices followed are good. It is suggested that fisher members should measure nitrogen and phosphorous load of water near cage at regular intervals, keep records of diseases and water quality measures and wear life saving jackets while working on cage.

It is clear that as the fisher members adopt most of the guidelines during culture practices it helps them to generate good income and sustain his cage culture practices for long term. Fisher members reported improved livelihood and income through cage culture. After joining the cooperative societies and engaging in cage culture the displaced people have found a new livelihood opportunity for their betterment. The cage culture practices in Chandil reservoir is done by the members of the fisheries cooperative society i.e., Chandil Bandh Visthapit Matsyajivi Swawlambi Sahkari Samiti which is a society of displaced people.

Good management by the cooperatives and involvement of the community in following maximum guidelines of cage culture practices along with support from NGOs, Central and State Government organisations like NFDB, DoF, Jharkhand, ICAR-CIFRI have created successful livelihood opportunity to people who were displaced by reservoir construction.

#### DISCLAIMER

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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