Title: Success of cage farming of marine finfishes in doubling farmers' income: A techno-social impact analysis

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ABSTRACT

Given the high production achievable in the cage aquaculture system, it can play a significant role in increasing overall fish production and household income of fishers. In Andhra Pradesh, the culture of marine finfishes such as Indian pompano and Asian seabass has been demonstrated in cages in Krishna and Godavari backwaters by Visakhapatnam Regional Centre of ICAR-Central Marine Fisheries Research Institute (ICAR-CMFRI), by involving fishermen and marginal landless aqua farmers. Open sea cage culture of orange spotted grouper and Indian pompano has also been demonstrated in Visakhapatnam, Srikakulam and East Godavari districts. Different training and awareness programmes were organized to bring awareness and instil specialized skills on cage culture of marine finfishes among the beneficiaries. From a collection of case studies from Andhra Pradesh, this study analyses the success of the adoption of cage farming of marine finfishes in doubling farmers' income and the techno-social impact. From the 14 success stories documented, enhancement in net income in the range of 50.32 % to 257.14 % was evident, by transforming people from different avocations such as agriculturists, wage earners in agriculture and allied sectors, business professionals, fish traders, traditional fish farmers and artisanal fishers into farmers of marine finfish farming. The mean B:C ratio of cage farming among the adopted farmers were found to be 1.33 and 1.31 for estuarine and marine cages respectively. The impact was realized on livelihood enhancement due to the technological interventions of cage culture under the technological, social and economic dimensions. Perceptible change was observed with 80.00% reporting expertise on the technology and an enhanced production, 73.33% expressed diversified livelihood options due to technology intervention, and almost 60% opined more access to resources. Improved social status and recognition were experienced by the adopters with 73.33% informing elevated social participation, improved standard of living and increased level of self-confidence. Economy improved significantly, and more than 80% reported an increase in income with subsequent enhancement of savings and purchasing power, and 53.33% stated a reduction in indebtedness and repayment of old debts. Therefore, with earlier income generating activities supporting only food without savings, present technology adoption resulted in livelihood enhancement and socio-economic empowerment.

Keywords: Cage aquaculture, Doubling Farmers' Income, Marine finfishes, Success stories

Introduction

Marine aquaculture is still in its infancy when compared to fresh and brackish water aquaculture sectors, and commercial farming is yet to take off despite its huge potential to enhance seafood production in the country. The projected mariculture potential of the country based on the resources available in the maritime states and union territories and islands is 8-16 million t, while the current mariculture production is around 0.05 million t. Towards the development of the mariculture sector, several initiatives on research and development were initiated by ICAR-Central Marine Fisheries Research Institute (ICAR-CMFRI). With a focus on mariculture for increasing national fish production, and with the need for species diversification; package of practices on breeding and seed production and culture for three economically valued marine finfish species *viz.*, orange spotted grouper, Indian pompano and John's snapper[1,2,3] was developed at Visakhapatnam Regional Centre of ICAR-CMFRI. Realizing the importance of skill development and technology dissemination for achieving the true potential of mariculture, multiple training programmes and demonstrations were performed on different culture methodologies. These include marine cage farming of Indian pompano and orange spotted grouper, and coastal cage farming of Indian pompano and Asian seabass.

The inherent economic uncertainty associated with the small-scale fisheries sector owing to the higher degree of risks and the high investment in relation to economic profitability warrants immediate economic incentives and financial assistance[4]. Cage farming is not subjected to the same degree of uncertainty and risk attributable to environment parameters and inherent stock dynamics influencing fish catch. Despite the vast pristine ocean space available in the coastal states ideal for mariculture, commercial fish farming in the country is still in its infancy[5]. Factors such as increasing consumption of fish, declining stocks of wild fishes and poor farm economy have increased interest in fish production in cages. Cage farming also offers the fisherman/ farmer a chance to utilize existing water resources, which in most cases have only limited use for other purposes. Suitable locations in India's long coastline, vast brackish water areas available in coastal states and other underutilized water bodies can be better utilized by adopting cage culture. In view of the high production attainable in the cage culture system, it can play a significant role in increasing the overall fish production and household income[6]. Since the investment is comparatively low and requires very little/ no land area, this farming method is ideal for artisanal fisherfolks as an

alternative or diversified livelihood option. This can be taken up as a household activity too since the labour involved is minimal and can be managed by a small family. Empowering small-scale fishers through finfish cage culture would guarantee their commitment to improve global food security, move forward their socioeconomic status and achieve sustainable and maximum utilization of fishery resources. In this background, this study was taken upto document a few success stories on doubling farm income with cage culture interventions, and for a qualitative assessment of the techno-social impact of cage culture on livelihood enhancement of fishers.

Materials and methods

Capacity building, by virtue of hands-on training, was organized by Visakhapatnam Regional Centre of ICAR-CMFRI for different stakeholders in the marine and estuarine sectors on various aspects, which include cage fabrication and installation, fish seed stocking, fish feeding, cage net exchange and cleaning, and other routine management measures. More than 20 skill development programmes were organized since 2014 at different locations in Visakhapatnam, Srikakulam, East Godavari, West Godavari and Krishna districts of Andhra Pradesh. Since 2014, 1058 individuals were imparted skills in cage aquaculture, and 106 had adopted the marine and coastal cage culture technologies with reasonable success. The marine cage culture of Indian pompano and orange spotted grouper technology was disseminated to 460 marine fishermen and was adopted by 28 individuals, with accrued revenue of Rs. 93.47 lakhs from 33.77 tonnes of harvest. Coastal cage culture of Indian pompano and Asian seabass technology, which is considered apt for small-scale fishermen and fish farmers with low economic capacity, was disseminated to 598 fish farmers and was adopted by 78 individuals. Around 47.32 tonnes of Indian pompano and 5.34 tonnes of Asian seabass were harvested with accrued revenue of Rs. 147.07 lakhs and Rs. 17.88 lakhs.

The present study was conducted from Visakhapatnam and Krishna districts of Andhra Pradesh, among a sample of 44 farmers from both marine and estuarine cage aquaculture, for the techno-social impact assessment, including 14 success stories exclusively on doubling farm income. The techno-social impact was assessed through personal interviews using structured data collection templates. The indicators for the qualitative assessment of the social, technical and economic impact were selected through extensive literature search and judges' opinion. The questionnaire was pre-tested and standardized using test and re-test

method. Validity was measured through content validity through discussions with experts and relevant literature on the subject (Jeeva *et al*, 2006)[7]. The responses on the qualitative assessment of techno-social impact were obtained on a three-point continuum *viz.*, agree, undecided and dis-agree. Frequencies and percentages were used for the analysis. Keeping 2016-17 as the base year, the income enhancement by 2021-22 was also recorded for the documentation of 14 success stories on doubling farm income. The net income during the base year 2016-17, before the adoption of marine finfish aquaculture, and the net income during 2021-22, after the adoption of marine finfish culture, and the percentage increase in net income have been documented (Table 1.). The mean B:C ratio of cage farming for estuarine cages and sea cages among the adopted farmers were also worked out.

The Garrett ranking technique was used to prioritize the constraints perceived by the respondents in the adoption of cage farming. The orders of the merit assigned by the respondents were converted into ranks using the following formula.

Percent position = $(100(R_{ij}-0.5))/N_j$

Where,

R_{ij}= Rank given for i^{th} item by the j^{th} individual

Nj = Number of items ranked by j^{th} individual

The per cent position of each rank, thus, obtained was then converted into scores by referring to the table given by Garrett and Woodworth (1969)[8].

Results and discussion

Totally, 14 success stories of ICAR-CMFRI's technological interventions on cage farming resulting in doubling of farmer's income were documented from the sample of 44 respondents (Table 1). For instance, the joint family of Shri Gandham Nagaraju of Lakshmipuram Village, Kruthivenu Mandal, Krishna District, belonging to *Yenadhi* community, which is recognized as Scheduled Tribe. Their primary occupation was artisanal fishing in coastal backwaters, from which they were getting an annual net income of about Rs. 1.00 lakh. They faced problems like declining catches, non-consistent income, etc. Later on, with ICAR-CMFRI's technological interventions, with the aim of Doubling Farm Income

(DFI), they ventured into coastal cage farming of Asian seabass with two cages in November 2020. They achieved a production of 10 quintals, fetching a price of Rs.300/- per kg, which generated a gross income of Rs. 3 lakhs. From income analysis for the base year of 2016-17 till 2020-21, it was witnessed that the net income of the family has increased more than 80 % with the introduction of coastal cage farming of Asian seabass, in addition to their artisanal fishing in coastal backwaters.

Table 1.

Another success story of open sea cage culture was witnessed by the 'Mutually Aided Traditional Fishermen Society', a group of 10 fishermen from Pedajalaripeta in Visakhapatnam District. The fishers used to get an annual net income of Rs. 12.50 lakhs from marine fishing with motorized craft. They faced problems like declining catches and increasing operational expenses. With DFI interventions, like marine cage farming of orange spotted grouper in 10 cages, they are getting an additional annual net income of Rs. 19.50 lakhs. Similar to the two success stories previously stated, totally 14 individual success stories were documented (Table 1), from which enhancement in net income in the range of 50.32% to 257.14% was evident, by transforming people from different avocations such as agriculturists, wage earners in agriculture and allied sectors, business professionals, fish traders, traditional fish farmers and artisanal fishers into farmers of marine finfish farming.

The mean B:C ratio of cage farming for estuarine cages and sea cages among the adopted farmers were also worked out (Table 2)

Table 2.

From the analysis of economic performances of estuarine and marine cage culture as presented in Table 2, it is conclusive that marine and estuarine cage farming is viable alternatives to small scale fishing as the benefit-cost ratio (BCR) was more than 1. It is worthwhile mentioning, that once the practice expands with a manifold increase in the number of cage units, the cost will automatically decline due to the economies of scale of operation.

In a study from Kerala backwaters on the economic feasibility of Asian seabass cage culture, Vipin *et al* (2021)[9] reported an average benefit-cost ratio of 2.5:1 for the first year. Similarly, in Lakshmipuram village of Krishna district, coastal cage farming of Asian seabass by a group of artisanal fishers resulted in a production of one ton, with a gross income of Rs.3.00 lakhs at a selling price of Rs. 300 per kg, and a comparison to their prior income from other occupations revealed a doubling of net income through cage farming[10]. Cage farming at Nagayalanka in Krishna district had reported an average body weight of 745 g at harvest, with a survival of 97.3% and feed conversions of 1:1.62, and biomass of 10.86 kg/m^3. Harvest was sold to Maxwell Sea Foods, Cochin at the rate of Rs. 330 per kg. A part of the revenue generated was shared among the beneficiaries and the remaining amount was kept as a common corpus fund to meet the operational expenditure for the next culture. At Peddapalem earlier, Indian pompano after seven months of rearing reached 675 g, and 600 kg was harvested from individual cages and sold at Rs. 295 per kg to wholesale fish traders in Chennai, Tamil Nadu. The income was also shared among the beneficiaries[11].

From the successful case studies documented in the Krishna district of Andhra Pradesh, Sekar *et al* (2021b)[11] reported that most of the beneficiaries of tribal families were landless and without any permanent source of income. They meet their daily expenses by working as daily wage earners in different sectors including agriculture, shrimp farming, artisanal fishing in a small scale, and other small-scale works. Many had initially hesitated to venture into the cage culture of finfishes, since it is a new area of work for them that would take at least 8–12 months to reap the benefit. However, many fisherfolks after attending several awareness and training programmes organized by Visakhapatnam Regional Centre of ICAR-CMFRI, showed a willingness to venture into the cage culture of marine finfishes.

The impact realized on livelihood enhancement due to the technological interventions of cage culture demonstrations and training was documented under three dimensions; technological, social and economic. The results on the indicators such as awareness, knowledge, skills acquired, diversification in livelihood, access to resources, attitude and production have been given in Fig.1.

Figure 1.

From Fig.1, it could be understood that all the respondents (100%) had reported that their awareness level on cage culture had improved. More than eighty percent of them (86.67%) reported that they had developed a positive attitude towards improved practices of cage culture. An equal percentage of them (80%) reported that their knowledge level on cage culture had improved, that they had acquired new/ more skills on cage culture techniques, and that they had experienced increased annual production. Nearly three-fourth (73.33%) of them reported that the interventions facilitated diversified livelihood options, and 60% of them reported that it facilitated more access to resources.

The findings pertaining to social dimensions on the indicators such as linkage, social participation, social recognition, standard of living and self-confidence have been presented in Fig.2.

Figure 2.

From Fig.2, it could be comprehended that they achieved improved linkage with research and development institutions due to the cage culture-related interventions such as training, demonstrations and site-specific advisories. Improved social status and recognition were experienced by 80% of the respondents. Nearly three-fourth (73.33%) of them reported increased social participation, improved standard of living and increased level of self-confidence.

Income, savings, purchasing power, repayment of old debts, days of employment, entrepreneurial skills and marketing were the parameters on which the data were collected under economic dimensions, and the results of which have been presented in Fig.3.

Figure 3.

It is evident from Fig.3, that 80% of the respondents reported an increase in their average monthly income and the cage culture interventions had improved the marketing opportunities. Sixty percent reported that their average monthly savings, purchasing power and the number of days of employment had increased. More than half of them (53.33%) reported that they could repay their old debts and that, their level of indebtedness had reduced with the adoption

of cage culture technologies. Improved entrepreneurial capacity was reported by 40 % of them.

The constraints perceived by the respondents have been prioritized using Garrett ranking, and the results have been presented in Table 3.

Table 3.

The constraints and concerns expressed by the respondents were the high cost of the feed and with the quality of seeds. They perceived that pelleted feed should be available at a cost less than Rs. 70 per kg, and an alternate low-cost protein feed should be explored. Zero salinity during the months of July-September was also reported as a constraint. Mortality due to mud slips was also reported. Operational expenses were required for painting the cage structures once a year, replacement of walking platforms and drums damaged due to floods, and for the damages caused to the iron threads of the drums. It was also perceived that cement poles for tying cages would be better, and proper approach road is an issue, especially during monsoon. From the focussed group discussions, it was envisaged that for improved adoption of cage culture, the following issues are vital; policy guidelines on access to water resources for cage culture, access to raw materials for cage construction, timely availability of seed and feed, availability of labourers, access to market and remunerative price for the harvest, technical know-how/ timely advisories, government support/ subsidy/ schemes, access to institutional finance, transportation and logistics, storage availability and support from the peer group.

Conclusion

From the success stories documented, substantial enhancement in net income was evident, by transforming people from different avocations such as agriculturists, wage earners in agriculture and allied sectors, business professionals, fish traders, traditional fish farmers and artisanal fishers into farmers of marine finfish farming. The present technological interventions on cage farming impacted positively the livelihood of traditional fishers under various dimensions *viz.*, technological, social and economic. Prior, their day-to-day earnings from different income-generating exercises were only sufficient for

their daily nourishment. They barely had any savings or investment funds. The cash-in-hand created in bulk from cage culture moved forward their investment capacity, capacity to reimburse their old commitments and liabilities, and eventually progressed their standard of living. The marine and estuarine fish cage culture model established in Visakhapatnam and Krishna districts is perceived by the community as a role model for landless farmers, who do not have any reliable source of income. This model is expected to be emulated by different groups of landless populations living in various coastal districts of Andhra Pradesh, for their livelihood improvement in the future.

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Conflict of interest: The authors declare that they have no conflicts of interest.

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Table 1. Success stories of farmers adopting marine finfish aquaculture in cages (14 Nos.)

Sl. No.	Farmer Details (Name, Address, Age & Education)	Before the Technological Interventions (Base Year 2016-17)					After the Technological Interventions (2021-22)					Percentage Increase in Net Income
		Avocation	Asset	Prodn. (Qtl)	Gross Income (Rs. in Lakhs)	Net Income (Rs. in Lakhs)	Avocation	Asset	Prodn. (Qtl)	Gross Income (Rs. in Lakhs)	Net Income (Rs. in Lakhs)	
1.	Shri. Vijaya Babu; Kammanamolu Village, Nagayalanka Mandal, Krishna District, Andhra Pradesh, Pin-521120; 39 Yrs; Intermediate	Fish trader (packing/ marketing)	-	-	3.12	1.12	Coastal cage culture of Indian pompano	4 cages	25 qtl/ 4 cages	7.24	2.16	92.85
2.	Shri. T. Raghu Sekar; Nagayalanka Village, Nagayalanka Mandal, Krishna District, Andhra Pradesh, Pin-521120; 45 Yrs; Intermediate	Fish trader (packing/ marketing)	-	-	5.10	3.00	Fish trader (packing/ marketing)	-	-	5.10	3.00	
							Coastal cage culture of Indian pompano and Asian seabass (nursery rearing in cages)	15 cages (5x5x3m)	1000 fingerlings per cage	10.25	3.14	
							Total			15.35	6.14	104.66
3.	Shri. G. Nagaraju; Lakshmipuram Village, Kruthiveedu Mandal, Krishna District, Andhra Pradesh, Pin-521324; 35 Yrs; Primary School	Artisanal fishing in coastal backwaters	-	-	1.22	1.12	Artisanal fishing in coastal backwaters	-	-	1.22	1.12	
							Coastal cage culture of Asian seabass	2 cages	10 qtl/ 2 cages	3.12	0.92	
							Total			4.34	2.04	82.14
4.	Shri. T. Venkateswara Rao; Edurumundi, Nagayalanka Mandal, Krishna District, Andhra Pradesh, Pin-521120; 45 Yrs; Under Graduate	Marine fishing with motorized craft	FRP canoe (1) with OB engine	-	5.04	3.06	Marine fishing with motorized craft	FRP canoe-OB engine	-	5.04	3.06	
							Coastal cage culture of Indian pompano	3 cages	18 qtl/ 3 cages	5.56	1.54	
							Total			10.60	4.60	50.32

5.	Mutually Aided Traditional Fishermen Society (Group of 10 Fishermen; Shri. L. Pydanna-Secretary); Pedajalaripeta, Visakhapatnam District, Andhra Pradesh, Pin-530017; 60 Yrs; Primary School	Marine fishing with motorized craft and wage earning as crew	FRP canoe (1) with OB engine	-	16.20	12.52	Marine fishing with motorized craft	FRP canoe (1) with OB engine	-	16.22	12.52	
							Marine cage culture of orange spotted grouper	10 cages	165 qtl/ 10 cages	49.52	19.54	
							Total			65.74	32.06	156.07
6.	Shri. Karnam Anil; Murali Nagar,Visakhapatnam, Andhra Pradesh, Pin-530007; 28 Yrs; BE	Business	-	-	4.20	3.16	Business	-	-	4.20	3.16	
							Marine cage culture of Indian pompano	2 cages	42 qtl/ 2 cages	13.54	5.08	
							Total			17.74	8.24	160.75
7.	Shri. S. Narasingha Rao; Pandurangapuram, Visakhapatnam District, Andhra Pradesh, Pin-530003; 50 Yrs; Degree	Fish trading/ business	-	-	10.25	6.36	Fish trading/ business	-	-	10.25	6.36	
							Marine cage culture of Indian pompano	2 cages	36 qtl/ 2 cages	11.53	5.24	
							Total			21.78	11.60	82.39
8.	Shri. Tirumeni Balaraman; Ettipagaru Pallipalem, Krishna District, Andhra Pradesh, Pin-521001; 32 Yrs; Degree	Agriculture and business	1 acre	-	3.10	1.50	Agriculture and business	1 acre	-	3.10	1.50	
							Coastal cage culture of Asian seabass	2 cages	16 qtl/ 2 cages	5.62	2.54	
							Total			8.72	4.04	169.33
9.	Shri. Nagamalleswara Rao; Lakshmipuram Village, Kruthiveedu Mandal, Krishna District, Andhra Pradesh, Pin-521324; 38 Yrs; Primary School	Artisanal fishing in coastal waters	-	-	1.24	1.02	Artisanal fishing in coastal backwaters	-	-	1.24	1.02	
							Coastal cage culture of Asian seabass	2 cages	10 qtl/ 2 cages	3.04	0.92	
							Total			4.28	1.94	90.20
10.	Shri. Samaturalu; Mariapalem Village, Nagayalanka Mandal, Krishna District, Andhra Pradesh, Pin-521120; 50 Yrs;Primary School	Daily wages in agriculture and allied sectors	-	-	1.22	1.22	Daily wages in agriculture and allied sectors	-	-	1.22	1.22	
							Coastal cage culture of Indian pompano	2 cages	12 qtl/ 2 cages	3.41	1.03	
							Total			4.63	2.25	84.42

11.	Shri. Namburi Lenka Babu; Mariapalem, Nagayalanka Mandal, Krishna District, Andhra Pradesh, Pin-521120; 32 Yrs; Primary School	Daily wages in agriculture and allied fields	-	-	1.15	1.15	Daily wages in agriculture and allied fields	-	-	1.15	1.15	
							Coastal cage culture of Indian pompano	2 cages	10 qtl/ 2 cages	3.05	1.15	
							Total			4.20	2.30	100.00
12.	Shri. K. Ramesh; Peddapalem Village, Nagayalanka Mandal, Krishna District, Andhra Pradesh, Pin-521120; 50 Yrs; Higher Secondary	Traditional fish farming	2 acres	20 qtl	2.12	1.10	Traditional fish farming	2 acres	20 qtl	2.12	1.10	
							Coastal cage culture of Indian pompano and Asian seabass	Indian pompano (1 cage) Asian seabass (2 cages)	Indian pompano (5 qtl) Asian seabass (10 qtl)	4.75	1.80	
							Total			6.87	2.90	163.63
13.	Shri. Kanagala Eliyadar; Peddapalem, Nagayalanka Mandal, Krishna District, Andhra Pradesh, Pin-521120; 50 Yrs; Middle School	Traditional fish farming	1 acre	-	1.12	0.74	Traditional fish farming	1 acre	-	1.12	0.74	
							Coastal cage culture of Indian pompano	2 cages	10 qtl/ 2 cages	3.02	1.11	
							Total			4.14	1.85	150.00
14.	Shri. Laxmi Pawan Kumar; Ollipalem, Koduru Mandal, Krishna District, Andhra Pradesh, Pin-521328; 30 Yrs; Higher Secondary	Paddy cultivation	1.50 acre	35 qtl	0.74	0.42	Paddy cultivation	1.50 acre	35 qtl	0.74	0.42	
							Coastal cage culture of Indian pompano	2 cages	10 qtl/ 2 cages	3.16	1.08	
							Total			3.90	1.50	257.14

Table 2. Economic performances of estuarine and sea cage culture in a crop period of eight months

Economic Indicators	Estuarine cage culture	Marine cage culture
Cost of production (in Rs.)	2,23,445-00	5,35,378-00
Gross return (in Rs.)	2,97,000-00	7,00,000-00
Mean BCR	1.33	1.31

Table 3. Garret ranking on perceived constraints on improved adoption of cage culture

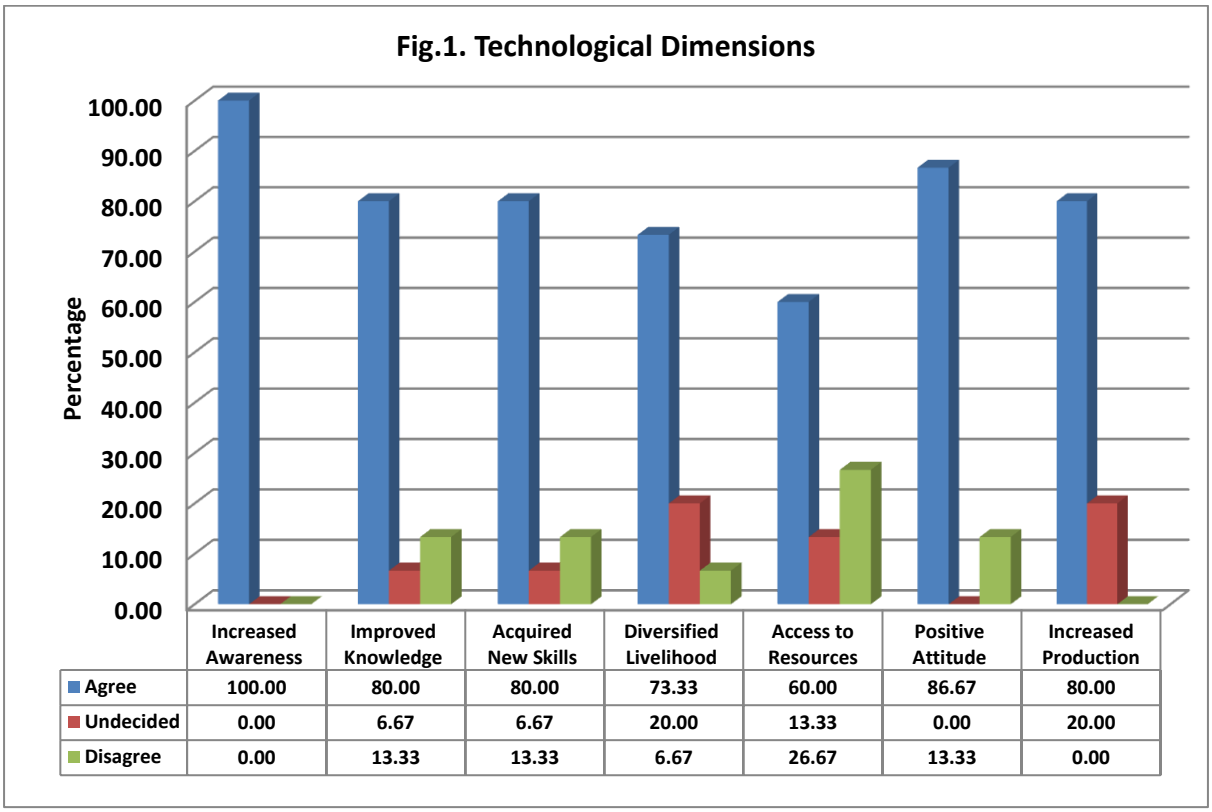
Sl. No.	Constraints	Scores	Rank
1.	Zero salinity during the months of July-September	47.60	6
2.	High cost of the feed	64.70	1
3.	Mortality due to mud slips	44.10	7
4.	Lack of policy guidelines on access to water bodies	52.00	4
5.	Timely availability of seed	59.20	2
6.	Quality of seeds	51.60	5
7.	Infrastructural facilities/ approach roads	43.90	8
8.	Operational expenses for cage maintenance	57.00	3

Figure Legends

Fig.1. Technological dimensions of impact assessment

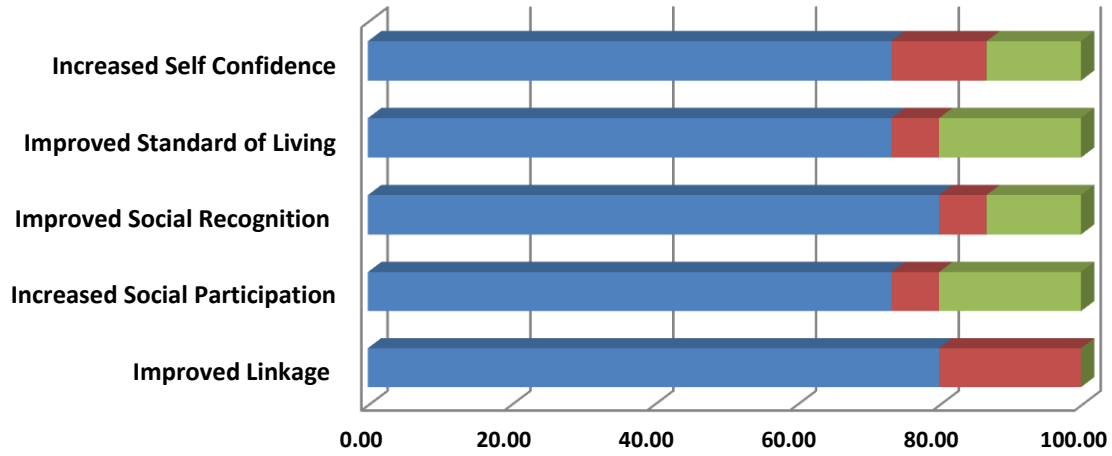
Fig.2. Social dimensions of impact assessment

Fig.3. Economic dimensions of impact assessment

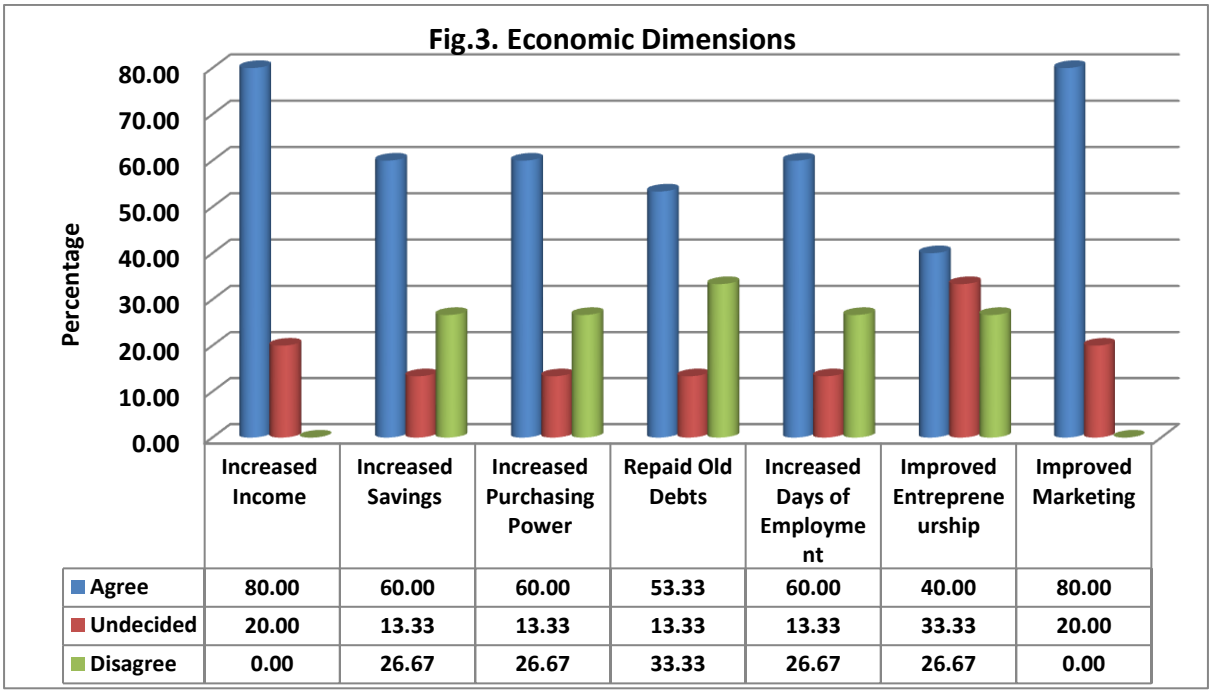


	Increased Awareness	Improved Knowledge	Acquired New Skills	Diversified Livelihood	Access to Resources	Positive Attitude	Increased Production
Agree	100.00	80.00	80.00	73.33	60.00	86.67	80.00
Undecided	0.00	6.67	6.67	20.00	13.33	0.00	20.00
Disagree	0.00	13.33	13.33	6.67	26.67	13.33	0.00

Fig.2. Social Dimensions



	Improved Linkage	Increased Social Participation	Improved Social Recognition	Improved Standard of Living	Increased Self Confidence
Agree	80.00	73.33	80.00	73.33	73.33
Undecided	20.00	6.67	6.67	6.67	13.33
Disagree	0.00	20.00	13.33	20.00	13.33



	Increased Income	Increased Savings	Increased Purchasing Power	Repaid Old Debts	Increased Days of Employment	Improved Entrepreneurship	Improved Marketing
Agree	80.00	60.00	60.00	53.33	60.00	40.00	80.00
Undecided	20.00	13.33	13.33	13.33	13.33	33.33	20.00
Disagree	0.00	26.67	26.67	33.33	26.67	26.67	0.00