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

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In Andhra Pradesh, India, the culture of marine finfishes such as Indian pompano and Asian seabass has been demonstrated in cages in Krishna and Godavari backwaters by the Regional Centre, ICAR-Central Marine Fisheries Research Institute (ICAR-CMFRI), Visakhapatnam, 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 of Andhra Pradesh. From the 14 success stories documented, enhancement in net income in the range 50.32%–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 to marine finfish farming. The benefit ratio of cage farming among the adopted farmers was 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.

Keywords: Cage aquaculture, livelihood enhancement, marine finfishes, success stories, techno-social impact.

MARINE aquaculture is still in its infancy 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 India. 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 tonnes (mt), while the current mariculture production is around 0.05 mt. Towards the development of the mariculture sector, several initiatives on research and development were initiated by the ICAR-Central Marine Fisheries Research Institute (ICAR-CMFRI), Kochi. With a focus on mariculture for increasing national fish production and with the need for species diversification, a 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 was developed at the Regional Centre of ICAR-CMFRI, Visakhapatnam, Andhra Pradesh, India[1–3]. Realizing the importance of skill development and technology dissemination for achieving the true potential of mariculture, multiple training programmes and demonstrations were conducted 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 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 in the coastal states, ideal for mariculture, commercial fish farming in India is still in its infancy[5]. Factors such as increased fish consumption, declining stocks of wild fishes and poor farm economy have increased interest in fish production in cages. Cage farming also offers the fishermen/farmers 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 the 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 little/no land area, this farming method is ideal for artisanal fisherfolks as an alternative or diversified livelihood option. It can be taken up as a household activity as well 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 improving global food security, their socio-economic status, and achieving sustainable and maximum utilization of fishery resources. In this

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background, the present study was undertaken to document a few success stories of doubling farmers' 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 the Regional Centre of ICAR-CMFRI, Visakhapatnam, for different stakeholders in the marine and estuarine sectors on various aspects, which included 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 have been organized since 2014 at different locations in Visakhapatnam, Srikakulam, East Godavari, West Godavari and Krishna districts of Andhra Pradesh. Since 2014, 1058 individuals have been imparted skills in cage aquaculture, and 106 have adopted the marine and coastal cage culture technologies with reasonable success. The marine cage culture technology of Indian pompano and orange-spotted grouper 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 technology of Indian pompano and Asian seabass, which is considered apt for small-scale fishermen and fish farmers with low economic capacity, was disseminated to 598 fish farmers and 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 respectively.

The present study was conducted in 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 farmers' 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 an extensive literature search and the opinion of experts. The questionnaire was pre-tested and standardized using the test and retest method. Validity was measured as content validity as discussions with experts and the relevant literature on the subject[7]. The responses to the qualitative assessment of techno-social impact were obtained on a three-point continuum, viz. agree, undecided and disagree. Frequencies and percentages were used for the analysis. Considering 2016–17 as the base year, the income enhancement by 2021–22 was also recorded for the documentation of 14 success stories on doubling farmers' 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 were documented (Table 1). The benefit cost ratio of cage farming for estuarine cages and sea cages among the adopted farmers was also worked out (Table 2).

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:

$$\text{Per cent position} = (100(R_{ij} - 0.5))/N_j,$$

where R_{ij} is the rank given for the ith item by the jth individual and N_j the number of items ranked by the jth 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[8].

Results and discussion

A total of 14 success stories of technological interventions on cage farming resulting in the doubling of farmers' income were documented from a sample of 44 respondents (Table 1). For example, the joint family of Gandham Nagaraju from Lakshmipuram village, Kruthivenu mandal, Krishna district, Andhra Pradesh, belongs to the Yenadhi community and is recognized as Scheduled Tribes. The primary occupation of the family members was artisanal fishing in the coastal backwaters, earning an annual net income of about Rs 1.0 lakh. They faced problems like declining catches, non-consistent income, etc. Later, with the proposed technological interventions to double 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/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 observed that the family's net income had increased more than 80% with the introduction of coastal cage farming of Asian seabass, in addition to their artisanal fishing in coastal backwaters.

Another success story of open sea cage culture was witnessed by the Mutually Aided Traditional Fishermen Society, a group of ten fishermen from Pedajalaripeta in Visakhapatnam district, Andhra Pradesh. The fishers used to earn 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 the technological interventions, like marine cage farming of orange-spotted grouper in ten cages, they are now earning an additional annual net income of Rs 19.50 lakhs. Similar to the two success stories stated above, a total of 14 individual success stories were documented (Table 1), from which enhancement in net income in the range 50.32%–257.14% was evident by transforming people from different avocations

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

Farmer details (name, address, age and education)	Before the technological interventions (base year 2016–17)					After the technological interventions (2021–22)					Percentage increase in net income
	Avocation	Asset	Production (quintal)	Gross income (Rs in lakhs)	Net income (Rs in lakhs)	Avocation	Asset	Production (quintal)	Gross income (Rs in lakhs)	Net income (Rs in lakhs)	
Vijaya Babu; Kammanamolu village, Nagayalanka mandal, Krishna district, Andhra Pradesh 521 120; 39 years; Intermediate	Fish trader (packing/marketing)	–	–	3.12	1.12	Coastal cage culture of Indian pompano	Four cages	25/four cages	7.24	2.16	92.85
T. Raghu Sekar; Nagayalanka village, Nagayalanka mandal, Krishna district, Andhra Pradesh 521 120; 45 years; 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 (5 × 5 × 3 m)	1000 fingerlings per cage	10.25	3.14	
						Total			15.35	6.14	104.66
G. Nagaraju; Lakshmipuram village, Kruthiveedu mandal, Krishna district, Andhra Pradesh 521 324; 35 years; 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	Two cages	10/two cages	3.12	0.92	
						Total			4.34	2.04	82.14
T. Venkateswara Rao; Edurumundi, Nagayalanka Mandal, Krishna district, Andhra Pradesh 521 120; 45 years; Undergraduate	Marine fishing with motorized craft	FRP canoe (1) with OB engine	–	5.04	3.06	Marine fishing with motorized craft	FRP canoe with OB engine	–	5.04	3.06	
						Coastal cage culture of Indian pompano	Three cages	18/three cages	5.56	1.54	
						Total			10.60	4.60	50.32
Mutually Aided Traditional Fishermen Society (Group of ten fishermen; L. Pydanna – Secretary); Pedajalaripeta, Visakhapatnam district, Andhra Pradesh 530 017; 60 years; 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	165/10 cages	49.52	19.54	
						Total			65.74	32.06	156.07
Karnam Anil; Murali Nagar, Visakhapatnam, Andhra Pradesh 530 007; 28 years; BE	Business	–	–	4.20	3.16	Business	–	–	4.20	3.16	
						Marine cage culture of Indian pompano	Two cages	42/two cages	13.54	5.08	
						Total			17.74	8.24	160.75

(*Contd*)

Table 1. (*Contd*)

Farmer details (name, address, age and education)	Before the technological interventions (base year 2016–17)					After the technological interventions (2021–22)					Percentage increase in net income
	Avocation	Asset	Production (quintal)	Gross income (Rs in lakhs)	Net income (Rs in lakhs)	Avocation	Asset	Production (quintal)	Gross income (Rs in lakhs)	Net income (Rs in lakhs)	
S. Narasingha Rao; Pandurangapuram, Visakhapatnam district, Andhra Pradesh 530 003; 50 years; Degree	Fish trading/ business	–	–	10.25	6.36	Fish trading/business	–	–	10.25	6.36	
						Marine cage culture of Indian pompano	Two cages	36/two cages	11.53	5.24	
						Total			21.78	11.60	82.39
Tirumeni Balaraman; Ettipagaru Pallipalem, Krishna district, Andhra Pradesh 521 001; 32 years; 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	Two cages	16/two cages	5.62	2.54	
						Total			8.72	4.04	169.33
Nagamalleswara Rao; Lakshmipuram village, Kruthiveedu mandal, Krishna district, Andhra Pradesh 521 324; 38 years; 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	Two cages	10/two cages	3.04	0.92	
						Total			4.28	1.94	90.20
Samaturalu; Mariapalem village, Nagayalanka mandal, Krishna district, Andhra Pradesh 521 120; 50 years; 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	Two cages	12/two cages	3.41	1.03	
						Total			4.63	2.25	84.42
Namburi Lenka Babu; Mariapalem, Nagayalanka mandal, Krishna district, Andhra Pradesh 521 120; 32 years; 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	Two cages	10/two cages	3.05	1.15	
						Total			4.20	2.30	100.00
K. Ramesh; Peddapalem village, Nagayalanka mandal, Krishna district, Andhra Pradesh 521 120; 50 years; Higher secondary	Traditional fish farming	2 acres	20	2.12	1.10	Traditional fish farming	Two acres	20	2.12	1.10	
						Coastal cage culture of Indian pompano and Asian seabass	Indian pompano (one cage) Asian seabass (two cages)	Indian pompano (5) Asian seabass (10)	4.75	1.80	
						Total			6.87	2.90	163.63
Kanagala Eliyadar; Peddapalem, Nagayalanka mandal, Krishna district, Andhra Pradesh 521 120; 50 years; 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	Two cages	10/two cages	3.02	1.11	
						Total			4.14	1.85	150.00
Laxmi Pawan Kumar; Ollipalem, Koduru mandal, Krishna district, Andhra Pradesh 521 328; 30 years; Higher secondary	Paddy cultivation	1.50 acres	35	0.74	0.42	Paddy cultivation	1.50 acres	35	0.74	0.42	
						Coastal cage culture of Indian pompano	Two cages	10/two cages	3.16	1.08	
						Total			3.90	1.50	257.14

such as agriculturists, wage earners in agriculture and allied sectors, business professionals, fish traders, traditional fish farmers and artisanal fishers to marine finfish farming.

From the analysis of the economic performance of estuarine and marine cage culture, as presented in Table 2, it can be concluded that marine and estuarine cage farming is a viable alternative to small-scale fishing as the benefit cost ratio is more than 1. It is worth mentioning here, 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 operation.

In a study from Kerala backwaters on the economic feasibility of Asian seabass cage culture, Vipinkumar[9] reported an average benefit cost ratio of 2.5 : 1 for the first year. Similarly, in Lakshmipuram village, Krishna district, Andhra Pradesh, coastal cage farming of Asian seabass by a group of artisanal fishers resulted in a production of 1 tonne, with a gross income of Rs 3 lakhs at a selling price of Rs 300/kg; and a comparison with their earlier income from other occupations revealed a doubling of net income through cage farming[10]. Cage farming at Nagayalanka in Krishna district reported an average body weight of 745 g at harvest, with a survival of 97.3%, feed conversions of 1 : 1.62, and biomass of 10.86 kg/m^3. Harvest was sold to Maxwell Sea Foods, Kochi, Kerala, at Rs 330/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. Earlier, at Peddapalem village, Krishna district, Andhra Pradesh, Indian pompano, after seven months of rearing, reached 675 g and 600 kg was harvested from individual cages and sold at Rs 295/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, Andhra Pradesh, Sekar *et al.*[11] reported that most of the beneficiaries of tribal families were landless and without any permanent source of income. They met their daily expenses by working as daily-wage earners in different sectors, including agriculture, shrimp farming, artisanal fishing on a small scale and other small-scale works. Many had initially hesitated to venture into the cage culture of finfish, since it is a new area of work for them that would take at least 8–12 months to reap the benefits. However, after attending several awareness and training programmes organized by the Regional Centre of ICAR-CMFRI, Visakhapatnam, many fisherfolks showed willingness to venture into the cage culture of marine finfish.

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. Figure 1 shows the indicators such as awareness, knowledge, skills acquired, diversification in livelihood, access to resources, attitude and production.

From Figure 1, it can be observed that all the respondents (100%) reported that their awareness level of cage culture had improved. About 86.67% reported that they had developed a positive attitude towards improved practices of cage culture. An equal percentage (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 witnessed increased annual production. Nearly three-fourths (73.33%) reported that the interventions facilitated diversified livelihood options, and 60% reported that they facilitated more access to resources.

Figure 2 presents the findings pertaining to social dimensions on the indicators such as linkage, social participation, social recognition, the standard of living and self-confidence.

From Figure 2, it can be comprehended that the respondents had achieved improved linkage with research and development institutions due to the cage culture-related interventions such as training, demonstration and site-specific advisories. Improved social status and recognition were experienced by 80% respondents. Nearly three-fourths (73.33%) 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 for which data were collected under the economic dimension. Figure 3 shows the results.

It is evident from Figure 3 that 80% of the respondents reported an increase in their average monthly income and that the cage culture interventions had improved their marketing opportunities. Sixty per cent reported that their average monthly savings, purchasing power and the number of

Table 2. Economic performance of estuarine and sea cage culture during a crop period of eight months

Economic indicators	Estuarine cage culture	Marine cage culture
Cost of production (Rs)	223,445	535,378
Gross return (Rs)	297,000	700,000
Benefit cost ratio	1.33	1.31

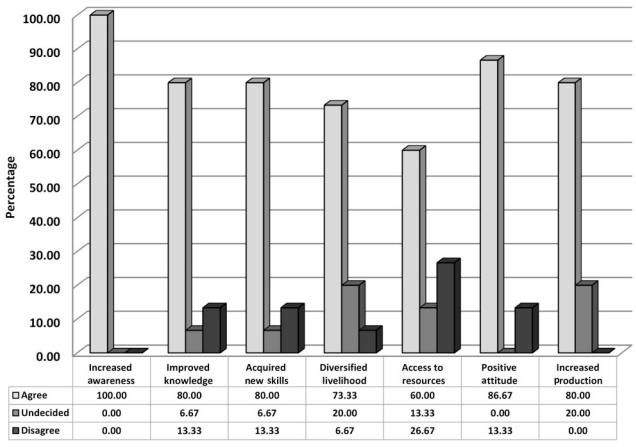
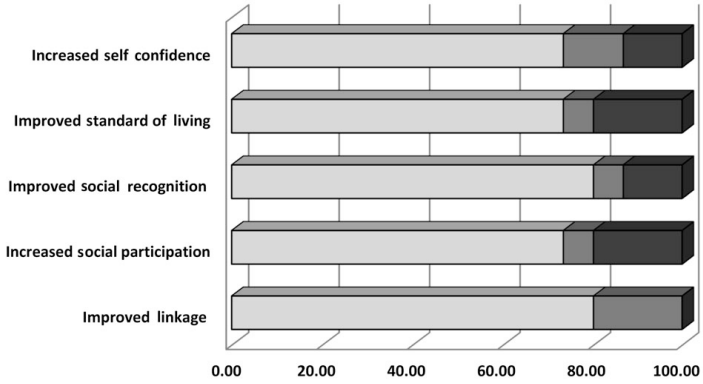
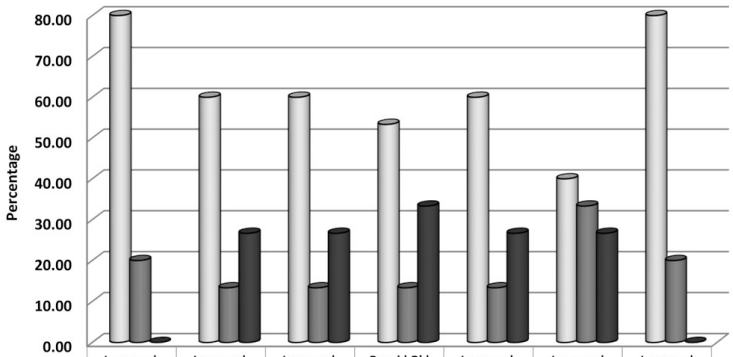


Figure 1. Technological dimensions of impact assessment.



	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

Figure 2. Social dimensions of impact assessment.



	Increased income	Increased savings	Increased purchasing power	Repaid Old debts	Increased days of employment	Improved entrepreneur-ship	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

Figure 3. Economic dimensions of impact assessment

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

Constraints	Score	Rank
Zero salinity during July–September	47.60	6
High cost of the feed	64.70	1
Mortality due to mud slips	44.10	7
Lack of policy guidelines on access to water bodies	52.00	4
Timely availability of seeds	59.20	2
Quality of seeds	51.60	5
Infrastructural facilities/approach roads	43.90	8
Operational expenses for cage maintenance	57.00	3

days of employment had increased. More than half (53.33%) reported that they could repay their old debts, and their level of indebtedness had reduced with the adoption of cage culture technologies. Improved entrepreneurial capacity was reported by 40% of the respondents.

The constraints perceived by the respondents were prioritized using the Garrett ranking. Table 3 presents the results.

The constraints and concerns expressed by the respondents were the high cost of the feed and the quality of the seeds. They perceived that pelleted feed should be available at a cost less than Rs 70/kg and an alternate low-cost protein feed should be explored. Zero salinity during July–September was also reported as a constraint. Mortality due to mud slips was 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 damages caused to the iron threads of the drums. It was also perceived that cement poles for tying cages would be a better option, and a proper approach road was necessary, especially during monsoon. From the focused 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 seeds and feed, availability of labourers, access to market and remunerative price for the harvest, technical knowhow/timely advisories, Government support/ subsidies/schemes, access to institutional finance, transportation and logistics, storage availability and support from the peer group.

Conclusion

From the success stories documented here, substantial enhancement in net income was evident among the respondents by transforming those from different avocations such as agriculturists, wage earners in agriculture and allied sectors, business professionals, fish traders, traditional fish farmers and artisanal fishers to marine finfish farming. The present technological interventions on cage farming positively impacted the livelihood of traditional fishers under various dimensions, viz. technological, social and economic. Earlier, their day-to-day earnings from different income-generating activities 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 improved their investment capacity, capacity to reimburse their old commitments and liabilities, and eventually, their standard of living. The marine and estuarine fish cage culture model established in Visakhapatnam and Krishna districts of Andhra Pradesh is perceived by the community as a boon for landless farmers, who do not have reliable sources of income. This model is expected to be emulated by different groups of landless people living in various coastal districts of Andhra Pradesh for their livelihood improvement in the future.

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

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