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Between the ban and the Blue Sea: Socioeconomics and livelihood choices of small scale Rushikulya fishers, Odisha, India

Ramasubramanian V. [a], Pritam Tripathy [b], M. Krishnan [c,*], Ananthan P.S. [b]

[a] ICAR – Indian Agricultural Statistics Research Institute, New Delhi, India
[b] ICAR – Central Institute of Fisheries Education, Mumbai, India
[c] Department of Forests, Andhra Pradesh, India

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ABSTRACT

The Rushikulya fishers residing nearby the sea turtle conservation area of Ganjam district of Odisha, India face immense pressure of job loss during the fishing ban period of seven months (i.e., November–May) every year. In this study, logistic regression (LR) modelling and Analytic Hierarchy Process (AHP) technique were employed for understanding the socio-economic status and the alternative livelihoods choice priority by those small scale fishers during the ban period. The results of LR modelling revealed that fishing experience, primary and secondary household occupations were significantly contributing to the increase in the fisher household's per capita income. AHP technique suggested that fish marketing and poultry keeping topped the list of preferences within fisheries-related and non-fisheries related groups of alternative livelihood choices, respectively. Such prioritization of livelihood choice preferences will enhance targeted policy implementation leading to minimizing negative economic impact of the ban period on fishers.

1. Introduction

India is endowed with sea turtle rookery sites sporadically along the coastline of 8129 kilometres (km) shared by nine coastal states and a union territory. There are seven sea turtle species found in the world (Frazier, 1980), out of which five are found along coastal India, namely *Cheloniamydas* (green sea turtle), *Carettacaretta* (loggerhead sea turtle), *Eretmochelysimbricata* (hawksbill sea turtle), *Lepidochelysolivacea* (olive ridley sea turtle) and *Dermochelyscoriacea* (leatherback sea turtle). The International Union for Conservation of Nature and Natural Resources (IUCN) classifies the Olive Ridley turtle as an endangered species (Brahma et al., 2011). A large proportion of its population is found only in a few rookeries (mass nesting sites) along the coasts of Mexico, Costa Rica and on the east coast of India (Pritchard, 1997).

In India, the three rookeries are located in Gahirmatha, Devi and Rushikulya in the state of Odisha. The Rushikulya sea turtle (Olive Ridley) rookery is located on the sandy spit along the northern side of Rushikulya river mouth situated in south Odisha coast of Ganjam district at lat. 19°22′ N and lon. 85°02′ E. Five coastal villages viz. Kantiagarha, Gokhurkuda, Purunabandha, Nuagaon and Arjipalli adjacent to the sea turtle congregation site at Rushikulya rookery depend on traditional fishing. About 95% of the population are employed in fishing while the rest are involved in daily wage labour, private service, small trade etc. (Sridhar, 2005; Tripathy, 2009). The Government of Odisha has banned all kinds of nets operating in the near shore waters of Rushikulya during November–May since this period coincides with the breeding season of Olive ridley turtles (Panda et al., 2014; Chhotray, 2016). This fishing ban period has a legitimate impact on the local community and ultimately alters human–environment relations on both land and water (Campbell, 2010).

Varied opinions abound on fishing ban due to turtle conservation in Odisha. It was reported that the fishers who, for generations, revered and protected the turtles because of traditional beliefs, have started to lose income due to fishing ban (The Hindu, 2016a). It has also been felt that such extreme approaches to conservation have repeatedly proved counterproductive in India (The Hindu, 2016b).

The implementation of fishing ban period has an adverse impact on the socio-economic condition of small scale fishers (Béné, 2003; Knudsen, 2016) causing loss of primary source of income, aggravating indebtedness and poverty (Siddiqui, 1996; Lakshman et al., 2012; Deepthi et al., 2014; Kumar and Shivani, 2014). Apart from that, they were deprived of employment, losing their primary occupational activity (i.e. fishing) for a long period,

* Corresponding author.
E-mail addresses: ram.vaidhyanathan@gmail.com (Ramasubramanian V.), tripathy.pritam@gmail.com (P. Tripathy), mkrishnan57@gmail.com (M. Krishnan), ananthan@cife.edu.in (Ananthan P.S.).

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pushing the community's growth to abysmally low levels (Chandrana et al., 2017). The need for an alternative livelihood is of paramount importance, as it holds promise of income, employment and food security for the poor (Martin et al., 2013). Fishers with options of moving into other livelihood avenues were more likely to exit fisheries (Cinner et al., 2009). Many studies are available that addressed alternative livelihoods, policies and schemes for fishers (to cite a few, (Allison and Ellis, 2001; Salagrama, 2006; Aswathy et al., 2011) but none with respect to alternate livelihoods for fishers in Gahirmatha, Devi and Rushikulya, Odisha. Tripathy et al. (2019) conducted some preliminary investigation and found that alternative livelihoods yield significantly lower incomes as compared to primary fishing activity among Rushikulya fishers of Odisha. In the present study, logistic regression (LR) modelling and Analytic Hierarchy Process (AHP) technique have been employed for understanding the socio-economic status and the alternative livelihoods choice priority respectively by these small scale fishers during the ban period.

2. Materials and methods

Ganjam district, Odisha, India was selected owing to the problems associated with the ban period implemented for sea turtle conservation, which in turn causes loss of livelihood for the fishers by restricting them from fishing (Wright et al., 2001; Rajagopalan, 2009; Sridhar et al., 2011). Stratified two-stage sampling set up has been used even though the ultimate sampling units, i.e. fishers were purposively selected. In first stage of sampling, three villages Kantiagarha, Gokhurkuda, and Purunabandhawere selected as the rookery extends six km from Purunabandha village (one km north of the Rushikulya River mouth) to Kantiagada village. These villages were also relatively more affected by fishing ban due to sea turtle conservation as compared to other villages, since the rookery lay in their territory. In the second stage, 70, 30 and 80 households respectively from the three villages Kantiagarha, Gokhurkuda, and Purunabandha were purposively selected to get a sample size of 180 out of 1266 total households for collection of data with the help of a pre-tested interview schedule.

The survey was conducted during the period October to November 2016. Personal interviews were conducted with the fishers and the responses were recorded. Secondary data were collected from various published sources, officials of Department of Fisheries (DoF), Ganjam district, Odisha and also from marine fishery census in 2010.

Socio-economic characteristics of the respondents like family type, occupation, age-group, caste, education, house type etc.were tabulated and the documentation of ongoing livelihood activities of that particular region was done. As recorded in response elicited using the interview schedule, the preferences to the alternative livelihood options expressed by the fishers was analysed using Analytic Hierarchy Process i.e. AHP (Saaty, 1988).

The binary logistic regression model was used to estimate the probability of a binary response (fishers' per capita income) based on predictor variables. This model measures the relationship between the categorical (dichotomous) dependent variable and predictor variables by estimating probabilities using a logistic link function (Hosmer and Lemeshow, 2000) and is given by

$$p\,(y) = \frac{1}{1 + e^{-\left(\beta_0 + \sum_{i=1}^{k} \beta_i x_i\right)}}$$

where $p(y)$ is the probability of occurrence (of a particular group, say, of '1' discussed subsequently) dependent variable (y), β_0 is intercept, β_i's are the coefficients of predictor variables x_i for $i = 1, 2, \ldots, k$ with k as number of predictor variables.

Table 1
Codes given for different predictor variables.

Predictor variables	Levels	Code
Experience in Fishing	0–10 years	0
	10–20 years	1
	≥20 years	2
Family Type	Nuclear	0
	Joint	1
Sub-Caste	Keuta	0
	Nolia	1
Primary household occupation (PHO)	Fishing labour/Fish marketing/business	0
	Fishing	1
Secondary household occupation (SHO)	No	0
	Yes	1
Education	Non-literate	0
	Primary	1
	Secondary	2
Age	in years	Continuous

For fitting the model, monthly per capita income of the fishers' household (made dichotomous by forming two categories viz., low per capita income group coded as 0 and high per capita income group coded as 1) has been taken as dependent variable and fishing experience, family type, caste, primary household occupation, secondary household occupation and education were taken as predictor variables. This had been done by taking the poverty line of USD 1.25 per person per day (INR89.26) into consideration (World Bank, 2015). Thus monthly poverty line income was determined to be INR 2678. The monthly per capita income of the households below this value was considered as poor ('low' or '0') and rest as better-off families ('high' or '1'). The codes corresponding to the categorical predictor variables are given in Table 1 and the variable age, was taken as a continuous variable.

The null hypothesis assumed for this analysis was that there was no significant effect of the predictors on the expenditure of the fishers' households. It is noted here that income has been taken as a proxy for the expenditure in question. The model was fitted using R software package. Out of 180 households of fishers, 80% (144 households) of the households were randomly chosen and the model was fitted. Thereafter, the model was validated for the rest of the 20% observations (36 households) not included in model fitting, to see whether a new person performing fishing activity with associated socio-economic profile could be categorised correctly as earning less or more income (and in turn whether expenditure is 'low' or 'high').

To evaluate the performance of a logistic regression model, the standard metrics such as correct classification rate (CCR), sensitivity etc. (discussed in a subsequent section) have been considered (Hosmer and Lemeshow, 2000) by forming confusion matrix between the actual status and the status classified by the model fitted and Receiver Operating Characteristic (ROC). ROC summarizes the model's performance by evaluating the trade-offs between true positive rate (sensitivity) and false positive rate (1- specificity). For plotting ROC, a probability p of 'success' of getting a fisher to lie in high per capita income group and $p > 0.5$ has been assumed. Thus ROC summarizes the predictive power for all possible values of probability $p > 0.5$. The area under curve (AUC), or the index of accuracy (A) or concordance index, is a perfect performance metric for ROC curve. Higher AUC shows better prediction power of the model. The ROC of a perfect predictive model has true positive equal to 1 and false positive equal to 0.

In the interview schedule, the respondent was asked to judge the importance level of each alternative livelihood option and each criterion. The questionnaire used 3-point Likert scale: 1 = Low preference (LP); 2 = Medium preference (MP) and 3 = High preference (HP) for criteria importance weights to estimate the scores for alternative livelihood options. Analytic Hierarchy Process (AHP) is a Multi-Criteria Decision Making (MCDM) method proposed by Saaty (1988). Before employing AHP, to start with, a linear combination scoring method was used to identify the important factors. To achieve this, for each alternative within the criteria scored by the respondents on a comparable linguistic scale i.e. within High preference (HP), medium preference (MP) and low preference (LP), the frequency counts of respondents were determined. Thereafter a weighted total score defined as a linear combination of these individual counts against factors where the weights for low preference (LP), medium preference (MP) and high preference (HP) taken as $w_{LP} = \frac{1}{6}, w_{MP} = \frac{2}{6}$, *and* $w_{HP} = \frac{3}{6}$ respectively has been computed for each factor. The score can be calculated by using the formula,

$$Score = \sum_{i=1}^{n} w_i f_i$$

where, w_i = weighted score for each preference level; f_i = frequency counts of respondents for each preference level and n = 180 is the number of respondents. Two criteria viz., Fisheries related livelihood and non-fisheries related livelihood and four top most important alternatives under each of these criteria were identified for further analysis by writing the factors in descending order of these scores.

AHP yields the preferences of the decision criteria which are compared in a pairwise manner with regard to the criterion just preceding them in the hierarchy. The verbal judgements of the experts were transformed into numerical quantities representing the values in a AHP matrix with elements a_{ij} (i and j represent the rows and columns of the matrix of order, say, n) by using a 9-point scale available in Saaty (1988) (Table 2). The entries a_{ij} in the AHP matrix in the (i, j)th position, are governed by the following properties:Positive, $a_{ij} > 0$ for all $i, j = 1, 2, \ldots, n$; (i not equal to j); Reciprocal, $a_{ij} = l/\ a_{ji}$ for all $i, j = 1, 2, \ldots, n$; (i not equal to j) and unit diagonals, $a_{ii} = l$ for all $i = 1, 2, \ldots, n$. Thus, the judgemental AHP matrix A is a positive reciprocal pairwise comparison matrix.

Note that the AHP matrix has been developed by the procedure discussed subsequently rather than the conventional practically cumbersome way of seeking preferences from respondents in a pairwise manner.

A novel index called Alternative Livelihood Choice Index (ALCI) was developed to assess the respondent preferences for each of the eight alternative livelihood choices (these choices are given in Table 6), as have been tried by other workers as well albeit in a different manner (Crawford, 2002; Singh and Hiremath, 2010; Kimengsi et al., 2019). The responses for eight alternative choices were weighted and normalized to get an index value that ranged between 0 and1, where "0" represented the worst choice among the sample respondents and "1" represented the best choice. Besides providing a single measure to gauge the strength of each livelihood preferences, the ALCI could help understand the differences, if any, among respondents with respect to important socio-economic variables of interest.

Table 2
The nine point scale for pairwise comparisons in AHP (Saaty, 1988).

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favour one activity over another
5	Strong importance	Experience and judgement strongly favour one activity over another
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	For compromise between the above values	Sometimes one needs to interpolate a compromise judgement numerically because there is no good word to describe it
Reciprocals of above	If activity i has one of the above nonzero nos. when compared with activity j, then j has reciprocal value when compared with i	A comparison mandated by choosing the smaller element as the unit to estimate the larger one as a multiple of that unit

3. Results and discussion

3.1. Socio-economic profile

The social variables considered for the study were age, gender, caste, education, marital status, family type, house type, sanitation facilities, transportation facilities, cooking fuel and source of drinking water. Economic variables considered were membership in cooperatives, primary household occupation (PHO), secondary household occupation (SHO), household expenditure, credit, and average monthly per capita income.

The study revealed that 28 (15.56%) respondents were within the age group of ≤35 years, 128 (70%) falling in the age group of 36–59 years and rest 26 (14.44%) were in 60 and above years of age. Same percentage age distribution could be observed within the three selected villages. It meant that about three-fourth of the sample were middle aged and were involved in fishing occupation. Also, majority (91.67%) of respondents were males. It was observed that there were no female respondents from Gokhurkuda whereas in other two villages Kantiagada and Purunabandha, the percentages of female respondents were 12.86% and 7.5% respectively. About 71% of the respondents belonged to Nolia caste and the rest were Keuta. It was observed that all the respondents of the villages Gokhurkuda and Kantiagada (100%) belonged to Nolia caste but in case of Purunabandha village the majority of them belonged to Keuta (65%) and the remaining were Nolia (35%).

Education played an important role in the social and economic wellbeing of an individual. About 54.44% of respondent fishers were found to be non-literate. Among the villages, Kantiagada showed 60% of respondent fishers as non-literate, while in Gokhurkuda and Purunabandha the percentage of non-literates were 50 and 51.25 respectively. These findings substantiate the report of CMFRI census (CMFRI, 2010) wherein it was observed that about 47% were non-literate and 53% were literate among the marine fisherfolk population of Odisha. The findings showed that the majority of the respondents were married (88.33%). The study also revealed that the majority of respondents (61.11%) lived as a nuclear family and rest in joint family i.e.14.44%in Gokhurkuda,

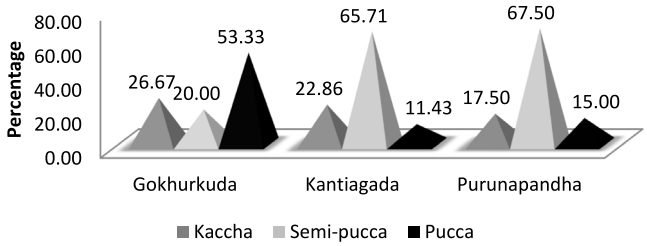

Fig. 1. Distribution of types of dwelling of respondent fishers.

13.33%in Kantiagada and12.08% in Purunabandha. The average family size was 4.2 for the sampled respondents.

Majority of the respondents (58.89%) were living in semi-pucca houses, whereas 21.11% were living in Kaccha houses and the rest 20% in Pucca houses. In Gokhurkuda, more respondents had pucca houses while in Kantiagada and Purunabandha, most lived in semi-pucca houses (Fig. 1). Majority (83.88%) of the respondents were having sanitation facilities. While all the households in Purunabandha village had sanitation facilities, in the case of Gokhurkuda and Kantiagada only 73.33% and 70% households had them respectively.

Majority of the respondents (53.33%) used public transport facilities. Bicycles (28.33%) and motorcycles (18.34%) were other important modes of transport. About 90% of respondents of Kantiagada village depended on other public transport facilities whereas 50% of respondents of Gokhurkuda and 42.5% of Purunabandha relied on their bicycle for mobility. Nearly two third of households (63.88%) used firewood for cooking purpose and some were found to use primitive electric stoves for cooking purposes. In Purunabandha, 58.75% of respondents were using electric stoves, while in 86.66% of Gokhurkuda and 80%of Kantiagada were using firewood. It may be noted here that all the households did not have cooking gas facility but most of them have now registered under the government initiated *Ujjwala Yojana* (PMUY-BPL list, 2018) and hope to benefit from this scheme soon.

In Purunabandha, 51.25% of respondents were using tube-well while in other two villages, 100% of respondents were using tube well water for their drinking and daily use purposes whereas the rest were using tap water for drinking purposes. The study showed that 70% of respondents were not members of any fishery cooperatives. It was observed that in Gokhurkuda, 43.33% of respondents were members of cooperatives, whereas in other two villages 28.57 and 26.25% of respondents respectively were members of cooperatives. The study revealed that 50% of respondents were engaged as casual labour in fishing as their primary occupation, 44.44% were in fishing and rest 5.56% were involved in fish marketing/business. The study also revealed that 62.22% of respondents did not have any secondary occupation and around 35% were working as casual labour. It was evident that average household expenditure per month of the total respondents was INR 9202. The village wise average household expenditure for Gokhurkuda, Kantiagada and Purunabandha were found to be INR 9337, INR 8669 and INR 9601 respectively. The study showed that two-third of respondents (69.44%) did not borrow any money while the remaining one third availed some kind of credit mainly from relatives and friends at an interest rate of 1.5% to 2% per month (Sehara et al., 1992). It may also be noted here that the average monthly household income of all the respondents was found to be INR 15,276 and village wise this was INR 19,670 for Gokhurkuda, INR 14,250 for Kantiagada and INR 14,525 for Purunabandha.

Table 3
Variables in the logistic regression model.

Variables	β_i	S.E.(β_i)	Wald	P value	Exp(β_i)
Experience [1]	$\beta_1 = -0.276$	0.698	0.157	0.692	0.758
Experience [2]	$\beta_2 = -1.305$	0.541	5.807	0.016	0.271
Family Type [1]	$\beta_3 = 1.176$	0.455	6.681	0.010	3.241
PHO [1]	$\beta_4 = -1.057$	0.445	5.657	0.017	0.347
SHO [1]	$\beta_5 = -1.977$	0.537	13.566	<0.001	0.138
Constant	$\beta_0 = 2.539$	0.586	18.765	<0.001	12.667

3.2. Logistic regression

As per methodology and details given in Section 2, logistic regression yielded the following fitted model with the significant variables entering the model via stepwise selection procedure:

$$p\,(y) = p\,(\text{Expenditure}) = \frac{1}{1+e^{-\beta_0+\beta_1(\text{Experience}[1])+\beta_2(\text{Experience}[2])+\beta_3(\text{Family Type}[1])+\beta_4(\text{PHO}[1])+\beta_5(\text{SHO}[1])}}$$

where, PHO = Primary household occupation and SHO = Secondary household occupation (and the categorical variables and codes and levels associated with them were as given in Table 1) and the coefficient values were as given in the following Table 3.

Thus from Table 3, the fitted LR model is given by

$$p\,(y) = p\,(\text{Expenditure}) = \frac{1}{1+e^{-1.98+2.54(\text{Experience}[1])-0.28(\text{Experience}[2])-1.31(\text{Family Type}[1])+1.18(\text{PHO}[1])-1.06(\text{SHO}[1])}}$$

Even though, the above model is written in a non-linear form, referring to last column of Table 3, the coefficients represent the change in the logit of the outcome variable (y) associated with per unit change in the predictor variables. The logit of the outcome is simply the natural logarithm of the odds of the outcome variable $p(y)$ in order to consider the model to be transformed linearly so that interpretation can be done accordingly.

The Z value, which is given as Wald test Chi-square statistic $W = \left(\frac{\hat{\beta}}{\text{SE}(\hat{\beta})}\right)^2$ explained the statistical significance of each coefficient (β values) in the model (Table 3). Wald statistic helps us know how well the model has fitted the data and also the contribution of each predictor. Exp(β) indicated the change in an odds-ratio before and after a change in the level of predictors, taking the reference or base level category as '0' for all variables viz., experience, family type, PHO and SHO (Tables 1 and 3). If the Exp(β) value is more than 1, it implied, as the predictor increases, it increases the odds of the occurrence. Conversely, if the Exp(β) value is less than 1, it indicated that as predictor increases, the odds of the outcome occurring decreases.

It can be observed from the same table that the size of Exp(β) was above 1 for those who had a larger family type. By this, it can be concluded that the larger families tend to have significantly higher monthly per capita income by 3.24 times than the smaller families. In addition, variables such as fishing experience, primary household occupation and secondary household occupation were found to significantly contribute to the per capita income of the household even though their Exp(β) were less than one. It is also noted here that even though one of the levels of the variable experience was not significant, it has been included in the model as its other level was found to be significant. It can be inferred that the households with fishing experience of more than 20 years, live in a joint family, have fishing as a primary occupation with some members having a secondary occupation, tend to have higher per capita income.

Table 4 provides the confusion matrix of the fitted logistic regression model. In this table, the abbreviations TN, FN, FP and TP represent True Negative (actual is '0' and model also predicts

Table 4
Confusion Matrix for the fitted model.

		Actual Per Capita Income group	
		Low (0)	High (1)
Predicted Per Capita Income group	Low (0)	TN = 19	FN = 08
	High (1)	FP = 23	TP = 94

it as '0'), False Negative (actual is '1' but model predicts it as '0'), False Positive (actual is '0' but model predicts it as '1') and True Positive (actual is '1' and model also predicts it as '1'), respectively computed from the outcomes of the fitted logistic regression model.

The accuracy of prediction is discussed subsequently. For this, several measures have been used. Correct Classification Rate (CCR), also called the hit rate, is the number of correct predictions divided by sample size. Thus from Table 4, CCR = (TN + TP)/(TN + FN + FP + TP) = 0.7847 which when expressed in percentage is 78.47%. On the other hand, the misclassification rate is thus 21.53%. To supplement the accuracy measure, further measures are given here.

The false positive rate (FPR) is the number of cases who belong to low per capita income group but were predicted as belonging to high per capita income group (all FPs), divided by the total number of cases who belong to low per capita income group (includes all TNs and FPs). Thus FPR = FP/(TN + FP) in percentage is 54.76%.

The false negative rate (FNR), also called the miss rate, is the number of cases who belong to high per capita income group but were predicted as belonging to low per capita income group (all FNs), divided by the total number of cases who belong to high per capita income group (includes all FNs and TPs). Thus FNR = FN/(FN + TP) in percentage is 7.84%.

True Positive Rate (TPR), also known as sensitivity (the ability of the model to predict '1' correctly), is the proportion of cases that belong to the high per capita income group and were predicted as belonging to high per capita income group. Thus TPR = TP/(FN + TP), is 92.16%.

True Negative Rate (TNR), also known as specificity (the ability of the model to predict '0' correctly), is the proportion of cases that belong to the low per capita income group and were predicted as belonging to low per capita income group. Thus TNR = TN/(TN +FP), is 45.24% .

Note that (FPR+TNR) and also (TPR+FNR) each total to 100% and thus the pairs within the respective brackets complement each other. For a good model, it is expected that both sensitivity and specificity to be large enough and the false positive and false negative rates to be small. However, it is observed here that while sensitivity is higher, the specificity is good but not that better. By the same token, false negative rate is less but false positive rate is a bit higher. Hence the ability of the model to predict '1' correctly is higher. It is noted here that the left hand side of the LR model considered was $p(y)$ which was nothing but the probability that the fisher belongs to the high income group.

Thus the classification (confusion) matrix gives an idea about the predictive power of the fitted model. It can be seen that the model correctly classified 19 and 94 households respectively whose expenditure is less/more than the given reference value. In short, the overall accuracy of the classification is almost 80% suggesting that the model is fitted adequately.

The area under Receiver Operating Characteristic (ROC) curve shows the predictive power of the fitted model (Fig. 2). Higher the area under the curve (AUC), better the prediction power of the model as already mentioned in Section 2. For the model fitted

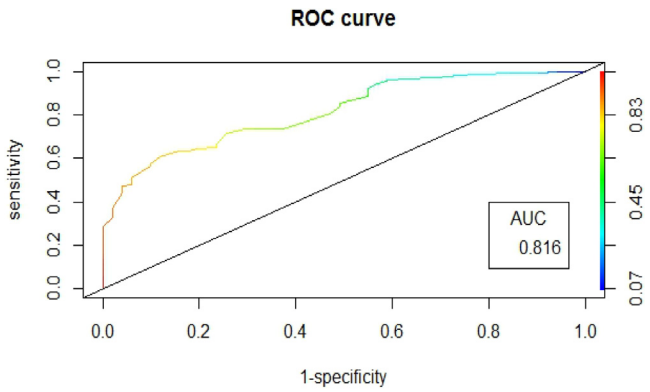

Fig. 2. Area under curve for logistic regression model prediction.

Table 5
Confusion matrix from the fitted logistic regression model for the remaining 20% households.

Observed		Predicted		
		Expenditure		Percentage correct
		0	1	
Expenditure	0	8	1	88.90
	1	6	21	78.80
Overall Percentage				80.60

Note: Shows the correct classification of the test data.

above, the AUC value is 0.816 (81%), indicating higher accuracy of predictability of this model. The utility of the model became evident when the datasets of remaining 20% of the households on which the model was not fitted earlier was used for validation of the fitted logistic regression model. For this, we substituted the values of predictor variables (such as experience in years, family size, caste, primary household occupation (PHO), secondary household occupation (SHO), education and Ownership) from remaining 36 households (20% of sample) in the fitted model and the results are available in Table 5 [after classifying the resultant output as either '0' or '1' according as $p(y)$ is (less than 0.5) or (greater than or equal to 0.5) obtained after plugging in the values of the variables on the right hand side in the model given just before Table 3]. The overall correct classification percentage which can be taken as the predictive capacity of the model is 80.60%. The other accuracy measures utilized earlier for the confusion matrix on the 80% used for model fitting above has not been computed here on this 20% dataset (which is not used for model fitting) due to the small sample size (36) upon which these measures would be based and hence may not be appropriate.

In a predominantly agrarian economy, the rural poor mostly worked as labour to support their family. An addition of each member in a large household is considered an added workforce/feeding hand. Thus, large traditional households/joint family were a norm rather than an exception. However, economic development, urbanization and the attendant modernization has resulted in preference for the nuclear family over joint family (Manasi et al., 2009; Karnani, 2011; Campbell and Ahmed, 2012). However, certain rural areas, as in the present case, still seem to place a premium on large families due to their over dependence on primary sector (fishing in our case) and limited penetration of education, family planning support, and limited penetration/ impact of developmental interventions.

Table 6
Frequency counts of the fishers with respect to their preference for alternative livelihood activities.

Alternative livelihood	LP(0.17)	MP(0.33)	HP(0.50)	Score
Fish marketing/business	3	25	151	84.33
Poultry keeping	3	28	145	82.33
Small business (like shop keeping, transportation, etc.)	10	49	121	78.50
Ornamental fish farming	20	108	49	63.83
Seaweed culture	41	89	32	52.50
Casual labour services to private sector	93	37	19	37.33
Cage fish culture	62	74	3	36.50
Mushroom farming	61	6	0	12.17

Note: Shows the scores of each alternative livelihood activities. The notation shows the low preference (LP), medium preference (MP) and high preference (HP) of alternative livelihood activities.

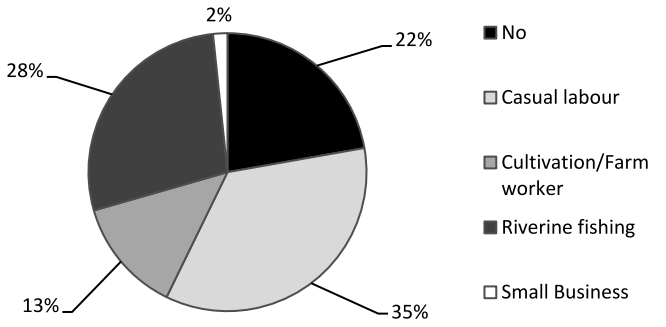

Fig. 3. Alternative livelihood activities.

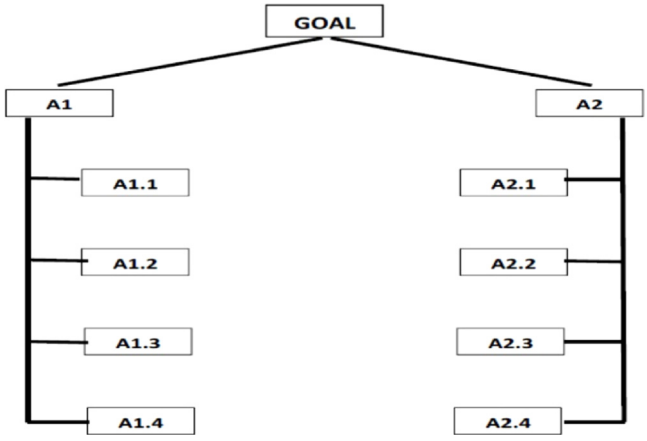

Fig. 4. AHP tree depicting the hierarchy of alternative courses of actions within decision criteria.

3.3. Current livelihood during fish ban period

The current livelihood of fishers during the ban period has been depicted in Fig. 3. The study also revealed that the access to riverine fishing was the only major (62.5%) alternative livelihood activity of Purunabandha respondents while the fishers of the other two villages were engaged as casual labourers as major alternative livelihoods (56.67 and 48.57% for Gokhurkuda and Kantiagada respectively).

3.4. Preferences for alternative livelihood activities during fishing ban period

It can be inferred from the linear combination scoring approach that, among the alternative livelihood options, fish marketing/business had high score of 84.33, followed by poultry keeping (82.33), small business (78.50), ornamental fish farming (63.83), seaweed culture (52.50) and others (Table 6).

AHP was employed to build a hierarchy consisting of "decision criteria" leading to various "alternative courses of actions/factors" within each of them for achieving the goal of a greater income generation during ban period from the provided activities. The AHP tree thus obtained is given in Fig. 4 (the notations herein are given in Table 7).

Qualitative judgements obtained through questionnaires from respondents for prioritization of specific factors that will help achieve the goal are given in Table 7 against criteria along with alternatives.

For constructing AHP, decision matrices were obtained at each level of the tree and at the overall level. The pairwise comparison is an integral part of the AHP. The frequency counts of criterion A1 are considered to explain the process in a stepwise manner. Using hierarchical weighting scheme analogous to the one used by Wittkowski et al. (2004), the scoring was constructed.

Score of each alternative = [total frequency to the power one i.e. $(180^{1}) * (\text{frequency count for HP}) + [\text{total frequency to the power root two i.e. } (180^{\sqrt{2}})] * (\text{frequency count for MP}) + [\text{total frequency to the power root three i.e. } (180^{\sqrt{3}})] * (\text{frequency count for LP})$.

Note that the maximum frequency count that any of the linguistic scales HP, MP and LP has been taken as 180, as there were at the most 180 responses for each alternative (Table 8.i).

From these hierarchical cum exponentially weighted scores generated, the relative increase in (A1.i) with respect to (A1.j) $j \neq i = 1, 2, 3, 4$ are obtained. With each criterion, pairwise comparisons between alternatives are done as computed in the last four columns of Table 8.i.

Now, following Wittkowski et al. (2004), the multivariate variable (HP, MP, LP) is converted to (HP, HP + MP, HP + MP + LP) and then comparisons are made pairwise for ordering of alternatives particularly to see the direction of change i.e. whether there is an increase or decrease (Table 8.ii).

The relative scores were converted into 1–9 scale by gauging the relative decrease (over and above 1.00) as given in Table 9.

Conversely, relative increase in (A1.i) with respect to (A1.j) $j \neq i = 1,2,3,4$ are scored as 1 through 9 scales by making use of the reciprocal property of the decision matrix. Also by definition, the diagonal elements are taken to be unity. Hence we get the AHP matrix for pairwise comparison of criterion "Fisheries related livelihood" as viewed in Table 10.

The pairwise comparison criteria is (Table 11) derived by dividing each column elements by their respective column totals and find marginal row averages.

This exercise was also done for the matrix of 'decision criteria' at the second level (considering A1 and A2 only) whose row means were given by (0.50, 0.50) which when converted to percentages works out to be 50%for each priority setting on fisheries related livelihood and non-fisheries related livelihoods

Table 7
Frequency counts for various decision criteria and alternatives within them.

Decision criteria A1 & A2 and alternatives within them	LP	MP	HP
A1. Fisheries related livelihood			
A1.1. Fish marketing/business	3	25	151
A1.2. Ornamental fish farming	20	108	49
A1.3. Seaweed culture	41	89	32
A1.4. Cage fish culture	62	74	3
A2. Non-fisheries related Livelihood			
A2.1. Mushroom farming	61	6	0
A2.2. Casual labour services to private sector	93	37	19
A2.3. Poultry keeping	3	28	145
A2.4. Small business (like shop keeping, transportation, etc.)	10	49	121

Table 8
Initial steps for computation of AHP matrices.

i. Scores and comparison								
	HP	MP	LP		Comparison with			
	$180^{\sqrt{3}}$	$180^{\sqrt{2}}$	180^{1}	Score	A1.1	A1.2	A1.3	A1.4
A1.1	1216812.08	38670.25	540	1256022.30	1.00			
A1.2	394859.55	167055.50	3600	565515.02	2.22	1.00		
A1.3	257867.46	137666.10	7380	402913.55	3.12	1.40	1.00	
A1.4	24175.07	114463.90	11160	149799.01	8.39	3.78	2.69	1.00
ii. Cumulative frequencies								
	HP	MP	LP					
A1.1	151	176	179					
A1.2	49	157	177					
A1.3	32	121	162					
A1.4	3	77	139					

Table 9
Relative scores for populating AHP matrices.

If Relative increase	undetermined or 0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	>8
Then score	1	2	3	4	5	6	7	8	9

Table 10
Pairwise comparison of criteria — original matrix.

	A1.1	A1.2	A1.3	A1.4
A1.1	1	3	4	9
A1.2	1/3	1	2	4
A1.3	1/4	1/2	1	3
A1.4	1/9	1/4	1/3	1
Col. Sum	1.69	4.75	7.33	17

Table 11
Pairwise comparison of criteria — adjusted matrix.

	A1.1	A1.2	A1.3	A1.4	Row Mean
A1.1	0.59	0.63	0.55	0.53	0.57
A1.2	0.20	0.21	0.27	0.24	0.23
A1.3	0.15	0.11	0.14	0.18	0.14
A1.4	0.07	0.05	0.05	0.06	0.06

Table 12
Total average score for each preference activities.

i of III level	A1.*i*	A2.*i*
1	28.71	14.82
2	11.44	12.32
3	7.07	12.32
4	2.78	10.54
II level—>	50	50

respectively. Thus 50% of 'fisheries related livelihood' factor contribution can be further subdivided at the second level into (0.50 × 0.57) = 28.71%, (0.50 × 0.23) = 11.44%, and likewise 7.07% and 2.78% for the 'alternatives' A1.1, A1.2, A1.3 and A1.4, with 0.57, 0.23 etc. taken from the last column of Table 11. The percent contributions at first and other sublevels calculated from each of the remaining matrices of the 'alternatives' at the third level are given in Table 12.

The results showed that "fisheries related livelihood" as well as "non-fisheries related livelihood" criteria contributed equally (50%) in achieving the set goal i.e. understanding the individual's basket of preferred livelihood options. Among the fisheries related livelihoods, the contribution of fish marketing/business is high (28.71%) followed by ornamental fish farming (11.44%), seaweed culture (7.07%) and the least is cage fish culture (2.78%). On the other hand, the contribution of poultry keeping is 14.82% followed by mushroom farming and casual labour services to private sector have made similar contribution of 12.32% and the small business contribute 10.54% to the non-fisheries related livelihood.

3.5. Alternative Livelihood Choice Index (ALCI)

The Alternative Livelihood Choice Index (ALCI) for each of the 180 respondents were computed by taking the sum of simple weights across the eight ALCs with 'No preference' weight as 0 apart from the 3-point Likert scale weights 1, 2 and 3 given in Section 2 and then normalizing this sum by dividing by the maximum obtainable value of 24 (as 3 is the maximum weight that can be given for any of the 8 ALCs). The t-test (non-parametric versions viz., Mann Whitney test for any predictor variable with two classes and Kruskal Wallis test for those with more than two classes) revealed that alternative livelihood choices (ALCI value) among respondents differed significantly with respect to their

education levels ($p < 0.05$), whereas no statistically significant differences ($p > 0.05$) could be ascertained in relation to age, experience, caste categories, family type, primary and secondary occupations, and the per capita income of the households. Higher education levels (i.e. though who have completed secondary education) are associated with higher ALCI values indicating the greater tendency to move away from fishing or at least the willingness to consider other livelihood options to supplement their income (Carter and Garaway, 2014). Higher education levels may also be considered as proxy for greater awareness thereby leading to additional livelihood options opening up. It may be underscored that there is minimal heterogeneity among the respondents in terms of most of the socio-economic variables as almost all of them are either small scale fishers or wage labourers in both villages. On the other hand, the ALCI score of 0.52 indicates moderate preference when all the eight livelihood choices are pooled (obtained as a simple average of ALCI values) though individual livelihood choice scores ranged from as high as 0.84 for fish marketing/business to as low as 0.12 for mushroom farming (refer scores given in Table 6 normalized i.e. divided by 100, to lie between 0 and 1).

4. Concluding remarks

The fisher community of the study area were traditional fishers and depended on fishing activities for their sustainable livelihood. Due to ban on fishing for a seven months long period, the fishers start migrating to other states in search of jobs. This is a matter of great concern for the government of Odisha to take proper action to restrict the migration process (Nayak, 2017). The socio-economic condition of fishers can be improved by providing them alternative livelihood options during the ban period. The study has shown that the per capita income of the household is mainly influenced by the family type (greater number of working hands and less number of dependants). The fisherfolk in the study villages had expressed moderate level of willingness to opt for the alternative livelihood options though the lead preferences were for 'fish marketing', 'poultry farming' and 'small businesses'. As higher education level is associated with improved ability to perform tasks requiring higher levels of skill and knowledge, the future holds much promise as education levels across the state is expected to improve overtime. This study will help the government and policy makers to develop better livelihood alternatives for the fishers for sustaining their livelihood and ensuring the greater success of the fishing ban. During primary data collection, the fishers expressed that eco-tourism facilities should be developed as alternative livelihood during the mass congregation period of turtle in the near shore areas of the beach (Tisdell and Wilson, 2002). Establishment of a fish processing industry in the district could also provide related employment opportunities to the fishers and mechanization of boats for offshore fishing activities could take the pressure off the near shore waters providing safe passage for the nesting turtles while at the same time protecting the livelihood and income of fishers.

CRediT authorship contribution statement

Ramasubramanian V.: Conception and design of study, Analysis and/or interpretation of data, Writing – original draft, Writing – review & editing. **Pritam Tripathy:** Acquisition of data, Analysis and/or interpretation of data, Writing – original draft. **M. Krishnan:** Conception and design of study, Analysis and/or interpretation of data, Writing – review & editing. **Ananthan P.S.:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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