Indian Journal of Animal Sciences **91** (12): 1122–1126, December 2021/Article
https://doi.org/10.56093/ijans.v91i12.119843

Ecosystem service approach for community-based management towards sustainable blue economy

GREEN SEA K[1]✉, RAJAKUMAR M[2], UMAMAHESWARI T[1], SUJATH KUMAR N V[1], JAWAHAR P[2], NARESH RAJ KEER[3] and RAJPAL YADAV[3]

Fisheries College and Research Institute, Toothukudi, Tamil Nadu 628 008 India

Received: 27 July 2021; Accepted: 20 October 2021

ABSTRACT

The present study was undertaken to examine the role of community-based fishers in blue economy taking ecosystem and livelihood development and sustainability of Gulf of Mannar, Tamil Nadu, India. A questionnaire was designed to capture context-specific community-based blue economy practices. The virtual factors and environmental determinants which affect the sustainability of ecosystem between resource benefitters were evaluated. A significant difference is noticed between male and female beneficiaries for preference to all the variables except enhanced waste management practices variable (insignificant difference- 0.183; Mann-Whitney U test). All the variables significantly advance the livelihood sustainability of ecosystem-dependent population and the ecosystem service evaluation process. The present survey also resulted that the better sustainability of blue economy involved the significant implementation of growth agendas by minimizing the effluent and sewage disposal, developmental activities in industrial areas, disaster outbreak and eliminating harmful fishing practices, overfishing and instead incentivizing approaches that promote growth, improve conservation, build sustainable fisheries, and terminate the IUU (illegal, unreported and unregulated) fishing. An ecosystem-based management framework, improved governance is required to grow and improve the sustainability of livelihood and ecosystem towards a blue economy. Innovative financing to direct investments into economic activities is also needed to enhance ocean health. A further step would be to assess how such human inputs or improved management practices could be included in the set of ecosystem service indicators.

Keywords: Blue economy, Ecosystem, Gulf of Mannar, Resource users, Sustainability

The Gulf of Mannar (GOM) is the first Marine Biosphere Reserve in south and southeast Asia. It stretches from Rameswaram to Kanyakumari in Tamil Nadu. It has vast biodiversity of about 4,223 species of various flora and fauna, covering 21 islands among the four districts, namely from Ramanathapuram, Tuticorin, Tirunelveli and Kanyakumari. The stretch of the Gulf of Mannar is compactly populated with coral reefs and seagrass beds which play an important role in the global biochemical process and are also important in breeding, spawning, and feeding areas for many important fishes (Hughes *et al*. 2003, Patterson *et al*. 2012).

Blue economy (BE) refers to the need for improved human wellbeing and social equity, while significantly reducing environmental risks and ecological scarcities (UNEP 2015), thus placing the society, economy and environment at the core of the discourse. It was defined as "comprising the range of economic sectors and related policies that together determine whether the use of oceanic resources is sustainable" (UNECA 2016, Wenhai *et al.* 2019, Lee *et al.* 2020). The concept of Blue Economy (BE) is recognized as central for sustainable development that incorporates socio-economic benefits and ecological conservation. Ecological sustainability and socio-economic development are well-explaining nature's functions in securing the human's livelihood and explores the implication in empowering and enhancing the competence of local communities as the eco-services (Nabhan 1997, Michel 2016, Osterblom *et al.* 2020).

Fishing is the major source of food and income in developing countries (Kelleher *et al.* 2012). In Tamil Nadu, marine fisheries account for 84% of all active fishermen and are also responsible for employment opportunities. Thus, it is an important foundation of livelihood security for fisheries, allied sectors and sub-sectors. The need to balance the economic, social, and environmental dimensions of sustainable development to the marine ecosystem is a key component of the blue economy. The main purpose of the current research is to examine the role of community-based fishers in the blue economy, taking an ecosystem and livelihood development and sustainability.

Present address: [1]Fisheries College and Research Institute, Thoothukudi, Tamil Nadu. [2]Tamil Nadu Dr J. Jayalalithaa Fisheries University, Nagapattinam, Tamil Nadu. [3]ICAR-Central Institute of Fisheries Education, Mumbai, Maharashtra. ✉Corresponding author email: greensea93@gmail.com

This study would be helpful in ecosystem protection, management and conservation.

MATERIALS AND METHODS

Observational site and societal groups: This research addresses analysis of the marine resource user or beneficiaries of Gulf of Mannar. The research investigations were performed from the four districts, namely Ramanathapuram, Tuticorin, Tirunelveli and Kanyakumari, under Gulf of Mannar Bio Reserve Trust (GOMBRT). The full potential of the blue economy realized by the effective inclusion and active participation of all societal groups, especially fishermen, fisherwomen, tourists, researchers, non-fishers.

Conceptual framework: Data on the determinants of factors that promotes the sustainable livelihood and blue economy of the marine resource users of the Gulf of Mannar includes fishermen, fisherwomen, tourists, researchers, research students, non-fishers (derives payback from Gulf of Mannar via any means) were collected randomly from the four districts namely Ramanathapuram, Tuticorin, Tirunelveli and Kanyakumari come under Gulf of Mannar Bio Reserve Trust (GOMBRT), Tamil Nadu. A questionnaire was distributed to more than 100 resource users from four districts to collect these on-the-ground practices. The questionnaire was designed to capture context-specific community-based blue economy practices in binary format (yes/no). The questions were open-ended and related to management and development intervention, enhanced waste management, responsible farming, fishing practice and tourism, institution participation in fishing and non-fishing commercial activity, awareness on sea safety, early warning information, SOP (standard operating procedure) on disasters, PFZ (potential fishing zone) and integration of community management and environment management principle.

Data analysis: The data were mainly dichotomous. The main interrogative survey was carried out from August to October 2020. To evaluate the virtual factors that affect the sustainability of the ecosystem based on gender criteria were tested with Mann- Whitney U tests. Mann- Whitney U test was employed to check whether there is a significant difference between the sustainability boosting factors among the resource use beneficiaries in marine ecosystems of the Gulf of Mannar. Information about determinants that determines livelihood sustainability among resource users was collected arbitrarily with the help of a telephonic interview schedule using binary format (yes/no). Additionally, to comprehend the determinants that impact sustainability of ecosystem services between resources, benefitters were evaluated through multivariate logit regression method (Hosmer *et al.* 2013) followed by Hosmer-Lemeshow test to assess the goodness of fit for binary response models.

The multivariate logistic regression model read as:

$$\text{logit}\,[\pi(X)]^n = \text{logx}\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) \quad ...(1)$$

$$\log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_n X_n + \alpha_i \quad ...(2)$$

where the relationships between multiple dependent variables- measures of multiple repeated observations j within cluster i- and a set of predictor variables (X_1, X_2, ..., X_p) are examined. Note π (x) represents the probability of an event that depends on p covariates or independent variables. X_1, X_2, …, X_p, are the predictors in the multivariate model. For this equation, a random effect, α_i, is often assumed to follow a normal distribution with mean zero and constant variance [i.e. $\alpha_i \sim N(0, \sigma^0_\alpha)$] (Hosmer *et al.* 2013). The following equations show the logistic regression which transfers the dichotomous outcome by logit transform. β_0 is the coefficient that sets the "baseline" event rate through the above function. β_1, β_2, ... β_p show the effect on the probability of an event as X changes by one unit in the univariate case.

RESULTS AND DISCUSSION

The wellbeing of humans is important for global development, which has been promoted by high-level policies for equitable economies within and between nations (Osterblom *et al.* 2020). This study has examined the extent to which equitable and sustainable benefits were likely to be achievable in ocean economies, based on currently available resources and governance conditions. The finding showed that the factors influencing the livelihood sustainability of the Gulf of Mannar ecosystems of Tamil Nadu (GOMBRT), among different districts, also influenced ecosystem sustainability. This study highlighted the significant and insignificant differences exerted among the beneficiaries categorized on the gender's parity through Mann-Whitney U test (Table 1).

The observations showed that male beneficiaries were highly concerned about management and development intervention on health, education, social security, legal and judicial services (64.30) determinant that promote livelihood sustainability followed by enhanced waste management practices in all sectors, viz. domestic, primary, secondary and tertiary sector (55.75) which provide the hygiene and create a pristine eco-friendly environment and thereby enhancing the sustainable livelihood. The other determinants, viz. responsible farming, fishing practice and tourism (36.28), public and private institution participation in fishing and non-fishing commercial activity (25.07), awareness on sea safety, early warning information, SOP on disasters, PFZ (22.41) and integration of community management and environment management principle (16.81) were moderately affecting the livelihood sustainability and their eco-service evaluation. Whereas the female beneficiaries were highly concerned about integration of community management and environment management principle (82.89) and awareness on sea safety, early warning information, SOP on disasters, PFZ (77.29), followed by public and private institution participation in

Table 1. The variables that affect the livelihood sustainability of ecosystem dependent population of Gulf of Mannar, Tamil Nadu

Variable	Mean value		p value
	Male	Female	
Management and Development intervention on health, education, social security, legal and judicial services	218.49	121.46	<0.005*
Responsible participation of public and private institution in fishing and non-fishing commercial activity	85.32	254.11	<0.001**
Awareness on sea safety, early warning information, SOP on disasters, PFZ etc.	76.65	262.91	<0.001**
Enhanced waste management practices - Domestic, primary, secondary and tertiary sector	189.45	150.34	0.183^{NS}
Responsible Farming, fishing practise and tourism	123.67	216.45	<0.001**
Integration of community management and environment management principle	57.68	281.12	<0.001**

Asterisk (*) shows the level of significance at p<0.01 (***, high significance; **, moderate significance; *, least significance). NS, non-significance.

fishing and non-fishing commercial activity (74.90), enhanced waste management practices in all sectors (44.24), and management and development intervention on health, education, social security, legal and judicial services (35.69) (Fig. 1). This result stated that female beneficiaries were more concerned about societal integrity and sea safety, monitoring and management of economic activity, and taking home responsibility in fishing practiced for livelihood sustainability (FAO 2007). There was a significant difference between male and female beneficiaries for preference to all the variables except Enhanced waste management practices - domestic, primary, secondary and tertiary sector variable which exhibited insignificant difference (p=0.183) between male and female beneficiaries (p<0.01; Mann-Whitney U test- Table 1). The beneficiaries vividly demarcated the importance of waste disposal treatment and hygienic environment maintenance for leading a healthy life and sustainable livelihood, which further significantly advanced the livelihood sustainability of ecosystem-dependent populations and had influenced the ecosystem service evaluation process.

There was another critical factor, i.e. Integration of community and environment management, which had different affecting roles between beneficiaries towards livelihood sustainability. Therefore, its contribution to the blue economy would need to be weighed against principles and policies that have been established globally, regionally, and/or nationally (FAO 2014, WWF 2018, UNDESA 2014). According to Cicin-Sain *et al.* (1998), integration of community and environment management and their coordination were critical to attaining sustainable development, to conserve the ecological integrity, life-supporting functions and biodiversity of the ecosystem. Integration of community management, fishing activities, non-fishing commercial activities etc. was important for achieving a balance between social, economic and environment, and for facilitating cooperation across different agencies, departments and levels of government.

Anticipating and adapting to the impacts of environmental determinants is an essential component of a blue economy approach. Assumptions about the contribution of social or environmental factors to capacity

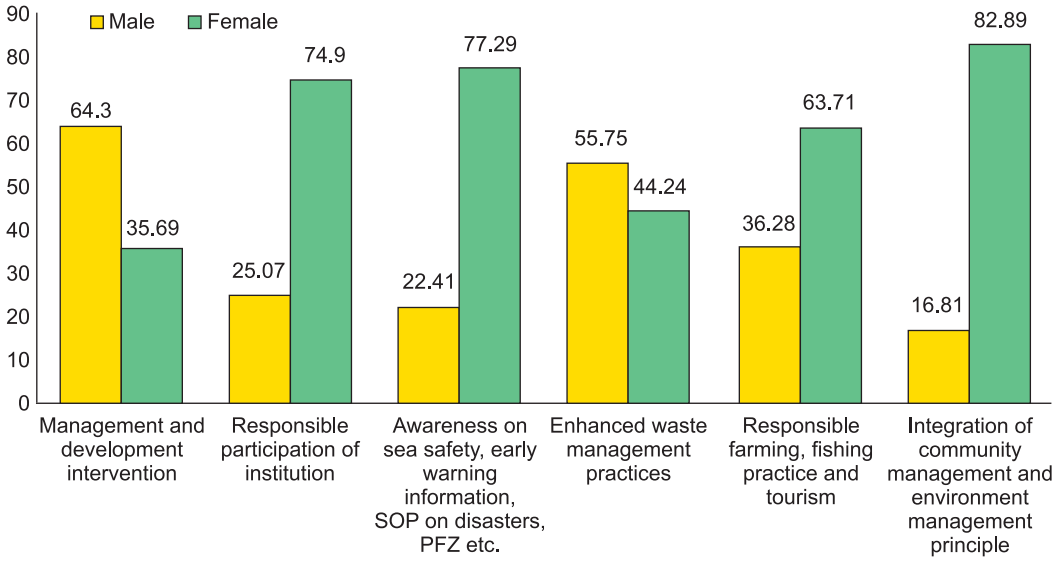

Fig. 1. Distribution of the variables among the male and female populations that affect the livelihood sustainability of marine ecosystem of Gulf of Mannar, Tamil Nadu.

Table 2. Regression estimates of multivariate logit model of environmental determinants bang on the sustainability of the marine ecosystem

Environmental determinants	Coefficient	Standard error	Wald coefficient	Significance	Exponential of (β)
Effluent and sewage disposal	–9.387	1.232	15.679	0.001**	70.922
Tourism	–9.366	0.548	13.242	0.001**	85.249
IUU non-fishing activities	–4.067	0.656	12.830	0.005*	32.560
IUU fishing	–9.321	0.392	10.530	0.001**	80.430
Developmental activities	–1.267	0.831	4.679	0.011*	15.922
Climatic impacts	–3.376	0.428	13.242	0.001**	40.249
Disaster outbreak/ Exotic species introduction	–1.333	0.295	0.388	0.507	3.285
Marine traffic	–0.948	0.701	2.660	0.105	1.649
Income/ Revenue	3.100	0.403	0.158	0.005*	20.013
Constant	–1.233	1.151	4.008	0.047	0.195

Asterisk (*) shows the level of significance at p<0.01 (**, high significance, *, low significance).

of blue economy may also change as new technologies enable the new or more efficient industries, climate effects alter marine ecosystems, and shifting social objectives and preferences change desired sectors or pathways of development (Allison *et al.* 2020, Ertor and Hadjimichael 2020). Hence, based on the standard inference of environmental determinants that evolved of a multivariate logit model, the log odds ratio of Tourism (85.249) negatively affected the sustainability of the marine ecosystem. So, the findings suggested that it can be used as a tool to, directly and indirectly, support coastal and biodiversity conservation for the protection of natural resources and long-term sustainability of the tourism sector and the economy. On the other hands, the log odds ratio of IUU fishing (80.43), effluent and sewage disposal (70.922), climatic impacts (40.249), IUU nonfishing activities (32.56), developmental activities (15.922), disaster outbreak/ exotic species introduction (3.285), marine traffic (1.649) favoured against the probability of sustainable ecosystem and showed significant pessimistic role in ecosystem sustainability whereas the Income/ Revenue log odds ratio (20.013) propel the beneficiaries to contribute to a certain extent for the sustainability of ecosystem (Table 2). Climate change has become the most significant threat to coastal areas. This may have a wide range of possible effects on marine ecosystem currents and processes that can affect fish resources, the ecosystem and the health of the dependent communities (Barry 2006, Jelle *et al.* 2013). The present study revealed that for the better sustainability of blue economy in developing countries like India the implementation of growth agendas by minimizing the effluent and sewage disposal, developmental activities in industrial areas, disaster outbreak and eliminating harmful fishing practices, over fishing and instead incentivizing approaches that promote growth, improve conservation, build sustainable fisheries, and end IUU (illegal, unreported and unregulated) fishing should be involved (FAO 2017).

The present study's findings were significant following the goodness of fit model test (p=0.909), which proves that there was a significant relationship between the environmental determinants and resource users from household and industries and sustainability of the marine natural resource. The outcome of the present study results showed clear trends in available resources and current enabling conditions that can inform transitions towards a blue economy.

This research foregrounds the analysis of issues or variables which would significantly impact the livelihood and ecosystem sustainability towards the blue economy. It addresses the core factors or determinants by conceptualizing Blue Economy as a balance of economic activities and ecosystem resilience. A sustainable blue economy is a marine-based economy that ensures better livelihood and a sustainable ecosystem by providing social and economic benefits, employment, health, safety, equity, livelihood, food security, poverty eradication (WWF 2018). In India, coastlines are generally dominated by fishers, research organizations, fisheries based and non-fisheries industries dependent on marine resources, fish consumers, tourism industry, etc. Ecosystem-based management framework, improved governance is required to grow and improve the sustainability of ecosystem towards blue economy. Therefore, NGOs and Government institutes has to be involved in creating awareness and aim proving essential services in improving the sustainability of livelihood of the fishers as well as marine natural ecosystem in the present and also in future. A further step would be to assess how such human inputs or improved management practices could be included in the set of ecosystem service indicators. To achieve this, customized monitoring, surveillance, co management, community management and participation has to be integrated through proper education and introduction of the expertise in every aspect suited to the sectoral need.

ACKNOWLEDGEMENT

The authors are grateful to Vice Chancellor, Dr J. Jayalalithaa Fisheries University, Nagapattinam, for continuous support and encouragement acknowledge during the course of the study. The first author is grateful for the financial support obtained from institutional fellowship.

REFERENCES

Allison E H, J Kurien and Y Ota. 2020. *The Human Relationship with Our Ocean Planet. Discussion Paper*. The High-Level Panel for Sustainable Ocean Economy, Blue Paper, USA.

Barry M, and Clark. 2006. Climate change: A looming challenge for fisheries management in southern Africa. *Marine Police* **3**: 84–95.

Cicin-Sain B and R W Knecht. 1998. *Integrated Coastal and Ocean Management: Concept and Practices*. Island Press. Washington, DC Covelo, California. p 517.

Ertor I and Hadjimichael M. 2020. Blue degrowth and the politics of the sea: rethinking the blue economy. *Sustainable Science* **15**: 1–10.

FAO. 2007. Gender policies for responsible fisheries—policies to support gender equity and livelihoods in small-scale fisheries. New directions in fisheries—A series of policy briefs on development issues. *Food and Agriculture Organization of the United Nations*, *Rome* **8**.

FAO (Food and Agriculture Organization). 2014. Save Food: Global Initiative on Food Loss and Waste Reduction. Background paper on the economics of food loss and waste. Working paper. Rome.

FAO (Food and Agriculture Organization). 2017. Blue Growth Initiative. Rome.

Hosmer Jr D W, S Lemeshow and R X Sturdivant. 2013. Applied Logistic Regression. Hoboken N J. *John Wiley and Sons* **398**(2): 1–18.

Hughes T P, Baird A H, Bellwood D R, Card M, Connolly S R, Folke C, Grosberg R, Hoegh-Guldberg O, Jackson J B C, Kleypas J, Lough J M, Marshall P, Nystrom M, Palumbi S R, Pandolfi J M, Rosen B and Roughgarden J. 2003. Climate change, human impacts, and the resilience of coral reefs. *Science* **301**: 929–33.

Kelleher K, Westlund L, Hoshino E, Mills D, Willmann R, Graaf G de and Brummett R. 2012. Report no. 66469-GLB. *World Bank*.

Lee K H, Noh J and Khim J S. 2020. The blue economy and the United Nations' sustainable development goals: challenges and opportunities. *Environmental International* **137**(5): 1–6.

Michel J A. 2016. Rethinking the oceans: Towards the blue economy. Paragon House.

Nabhan G P. 1997. Cultures of habitat: On Nature. *Culture and Story*, *Counter-point Washington*, DC.

Osterblom H, Wabnitz C and Tladi D. 2020. Towards Ocean Equity. Commissioned by High Level panel for A sustainable Ocean economy. World Resources Institute, Washington, DC, Blue paper. 1–64.

Patterson Edward, Mathews G, Diraviya Raj K, Thinesh T, Patterson J, Tamelander J and Wilhelmsson D. 2012. Coral reefs of Gulf of Mannar, India Signs of resistence. Proceedings of the 12th International Coral Reef Symposium, Caims, Australia. **10**: 09–13.

UNDESA (United Nations Department of Economic and Social Affairs). 2014. *Blue Economy Concept Paper.* United Nations, New York.

UNECA (United Nations Economic Commission for Africa). 2016. Africa's Blue Economy; A Policy Handbook. Ethiopia: United Nations Economic Commission for Africa.

UNEP (United Nations Environment Programme). 2015. Blue Economy: Sharing Success Stories to Inspire Change. United Nations Environmental Programme Regional Seas Report and Studies, Nairobi. P 195.

Wenhai L, Cusack C, Baker M, Tao W and Yufeng Y. 2019. Successful blue economy examples with an emphasis on international perspectives. *Frontier in Marine Science* **6**: 261.

WWF (World wide fund for nature). 2018. Principles for a Sustainable Blue Economy.