



# Fisheries governance in the tropical archipelago of Andaman and Nicobar – opinions and strategies for sustainable management

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## Abstract

Globally, marine fisheries sector provides livelihood, food security and employment to the fishers engaged in subsistence, artisanal and industrial fishing activities. The dependency on marine fish supplies keeps rising globally leading to intense competition, fishery conflicts and unsustainable fishing practices which threatens the sustainability and leading to the depletion of marine fishery resources. Andaman and Nicobar Islands (ANI) in India is a tropical archipelago cited as an example where marine fishery resources were considered to be highly underutilized vis-a-vis the harvestable potential. Developmental plans often envisage the enormous scope to harness the oceanic fishery resources however, the overriding issues which affect the sustainable fishery management were least understood or addressed. Offshore fisheries were trade and economy based whereas small scale fisheries are livelihood and food security-based, operating with small to medium scale commercial prospects. Radical management approaches in artisanal and industrial fisheries is essential to foster community resilience and sustainable fishery management. The emerging body of evidence suggests the critical need to reliably estimate the fish catches and population dynamics for sustainable fisheries management. Comprehensive opinions on prevailing issues, complexities in governance, challenges faced and the management strategies that need to be adopted were discussed to ensure the robust governance and sustainability of marine fisheries sector.

**Keywords** Livelihood · Small-scale · Industrial · Conflicts · Data · Policy · Management

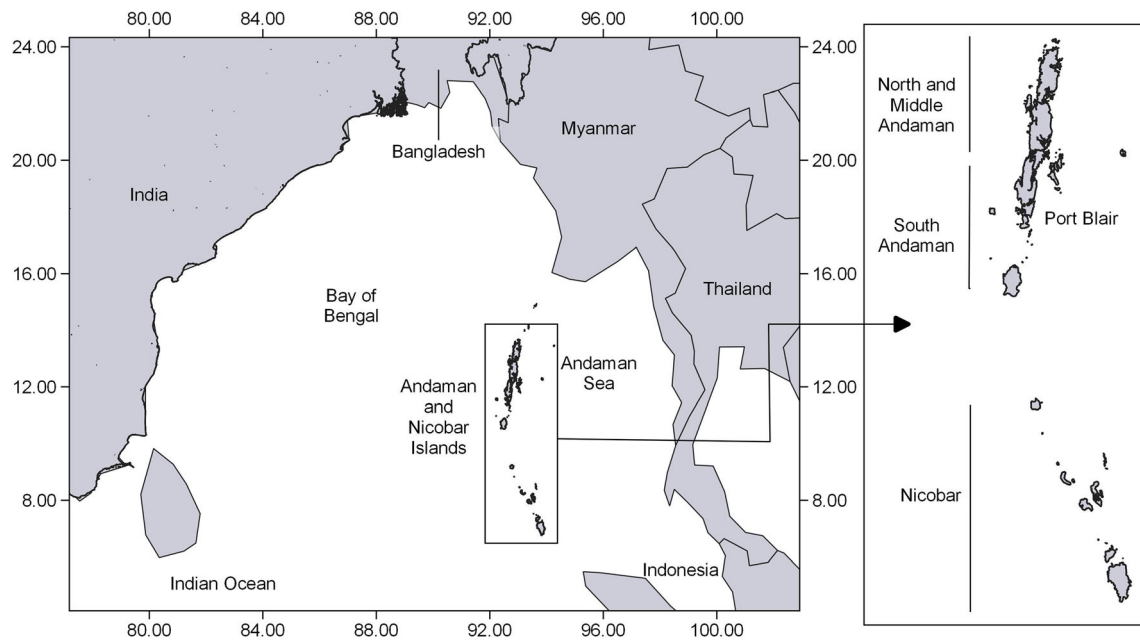
## Introduction

Marine fisheries sector can be broadly classified as artisanal or small-scale fisheries, industrial or large-scale fisheries (Granzotto et al. 2004; Dubois and Zografos 2012; Belhabib et al. 2016; Dey et al. 2016; Shamsuzzaman et al. 2017; Teh and Pauly 2018; Belhabib et al. 2019) and subsistence or food

fishing aimed for personal and household consumption (Islam and Berkes 2016). Artisanal and small-scale fisheries are often used interchangeably (Big Numbers Project, 2008; Dey et al. 2016; FAO 2016), refers to fishing operations carried out in inshore waters forming an important source of food, protein and income for coastal fishers (Batista et al. 2014; Belhabib et al. 2019; Smith and Basurto 2019) with certain commercial prospects whereas industrial fishing targets deep-sea resources having commercial prospects in national and international markets. Artisanal fishing requires lower fishing effort in relation to the industrial fishing (Belhabib et al. 2018) which demands a distinctive management approach (Allison and Ellis 2001; Hanich et al. 2018). Andaman and Nicobar Islands (ANI) in India is a tropical archipelago (Fig. 1) of 572 islands, islets and rocks, located in the Bay of Bengal (Indian Ocean) close to South-East Asian countries (ANDFISH 2005; Roy et al. 2009). The archipelago is divided into Andaman group and Nicobar group of Islands by the ten-degree latitude (ANDFISH 2005; Ravikumar et al. 2015; Patankar 2019). The islands have an aggregate coastline of 1912 km with Exclusive Economic Zone (EEZ) of 0.6 million

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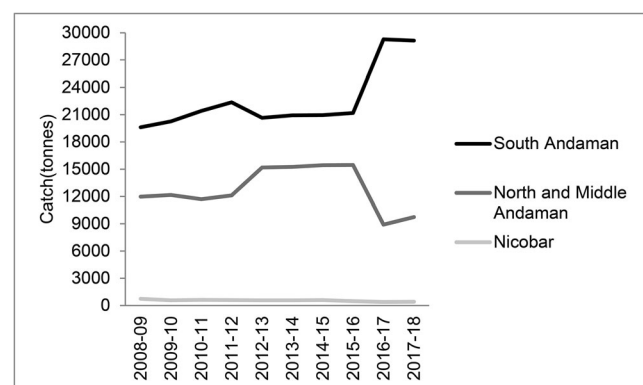


**Fig. 1** Map showing the location of Andaman and Nicobar Islands, India

sq. km which is nearly one-third Indian EEZ (ANDFISH 2005; Roy and George 2010; ANI Fisheries policy 2018; Patankar 2019). The fishermen communities of the ANI are composed of settler population brought from mainland India and tribal fishing community (Advani et al. 2013; Ahmed et al. 2013; Ravikumar et al. 2016).

The marine fisheries sector of ANI is identified as multi-species multi-gear fishery (Roy and George 2010; Kiruba-Sankar et al. 2019) and the fish harvest stands at 39284 t in 2017–18 against the estimated annual harvestable potential of 1.48 lakh tonnes (ANI Fisheries policy 2018). While majority of this production is from the coastal waters, fishery resources in deeper waters are yet under-exploited (ANDFISH 2005; Roy et al. 2009; Roy and George 2010; Kiruba-Sankar et al. 2019). The contribution of fish landings from different districts (North and Middle Andaman, South Andaman and Nicobar) of ANI is shown in Fig. 2 (Source: Department of Fisheries, A&N Administration). More than 95% of the annual fish production from marine sector comes from Andaman group of Islands since Nicobar group of Islands are predominantly inhabited by aboriginal tribes engaged in fishing activities by primitive fishing methods for their subsistence (Ravikumar et al. 2016; Jaini et al. 2017; Kiruba-Sankar et al. 2020). Technological interventions through Potential Fishing Zones (PFZ) advisories were proven to be beneficial for harnessing the coastal fishery resources (George et al., 2011, 2014; Arur et al. 2020) whereas oceanic resources still remains underutilized. The marine fisheries sector in the islands is facing various issues such as logistical support, lack of information on fish stock status, increasing pressure on coastal resources, conflicts in the fishing sector, poaching of

resources, lack of proper policy support etc. Issues regarding fisheries data management, sector prioritization, fisheries monitoring, illegal fishing and sector conflicts require innovative approaches and continuous efforts for management. Marine resource exploitation should be managed scientifically (Fu et al. 2018) as lack of fishery data could result in underestimating the impacts on the ecosystem and fish stocks (Belhabib et al. 2018). Scientists expert opinions could assist in safeguarding fishery resources against unsustainable fishing practices and could assist the policymakers in appropriate decision-making process (Mora et al. 2009; Rose and Parsons 2015). Considering this, this opinion article is explicitly intended to provide critical insights on the potential barriers that could hinder the sustainable marine fisheries management in the Islands and to suggest possible solutions to overcome the issues.



**Fig. 2** Contribution of fish landings from different districts of Andaman and Nicobar Islands

## The context of artisanal and industrial fishing activities

The importance of artisanal fisheries is unarguable (Batista et al. 2014; Garcia-Florez et al. 2014; Smith and Basurto 2019) displaying enormous diversity and cultural richness (Jentoft et al. 2018) however, their contributions to food security are often poorly quantified (Crona et al. 2019). Majority of the world's fishers are engaged in small-scale fishing activities in inshore waters (Dey et al. 2016; Temple et al. 2017; Teh and Pauly 2018) that are vulnerable to various threats (Ratner et al. 2014; Stanford et al. 2017). Considering their importance, countries such as USA, Brazil, Canada, Spain, United Kingdom, Mexico, France, Australia, Portugal and Chile have prioritized their research in small-scale fisheries (Junior et al. 2016). Despite their easy access to the coastal fishery resources their contribution are often underestimated (Teh and Pauly 2018) and issues such as lack of bargaining capacity (Jentoft and Finstad 2018) place them in receiving end of societal forces leading to vulnerability and poverty (Jentoft et al. 2018). Food and Agriculture Organization of the United Nations (FAO) adopted voluntary guidelines in 2015 for securing small-scale fisheries (FAO 2015) owing to their dynamic, diverse and complex nature (Cohen et al. 2019). Artisanal fishing activities are also linked with marine ecosystems such as mangroves and coral reefs which harbour various protected marine species (Bartholomew et al., 2018). Of the total 2728 fishing crafts in ANI, 1346 are country crafts and 1353 are motorized and the rest 85 are mechanized thus making the marine fisheries sector of ANI predominantly small-scale (ANI Fisheries Policy 2018). Country crafts are particularly engaged in small-scale fishing activities whereas motorized boats engage in commercial as well as small-scale fishing activities in the Andaman and Nicobar Islands. In case of Nicobar group of Islands, fishing activities are also carried out by spearing, harpooning, hand lines, cast net, gill net, shore seine and fish traps using traditional craft locally known as hodi and motorized outrigger canoe (Ravikumar et al. 2015, 2016). On the contrary, industrial fisheries have not witnessed the anticipated growth in the Islands due to overriding issues such as lack of infrastructure, logistical support, and skilled manpower etc. Initiatives were taken by research and development departments to attract investment in the industrial fishing sector to harness the tuna and other deep-sea fish resources of the Islands (ICAR News 2017) since oceanic tunas remain largely underexploited in the Islands against their estimated potential (Roy et al. 2009). Despite such initiatives, industrial fisheries still remains an underutilized sector in the Islands. In the case of pacific Islands, tuna fishing is an important revenue-generating sector (Barclay 2014; James et al. 2018) delivering great economic benefits (Bell et al. 2015). Despite the importance on industrial tuna fisheries (Barclay 2014; James et al. 2018) the livelihood of the Pacific Island

communities largely relies on the lagoon and coastal fishing activities (Sulu et al. 2015; Eriksson et al. 2017; Hanich et al. 2018). In South-East Asian countries (Cambodia, Vietnam, Thailand, and Malaysia) small-scale fishing is an important contributor and a crucial sector for the fishermen community (Teh and Pauly 2018). Industrial fishing activities are also criticized in the context of unsustainable fishing (Norse et al. 2012; Roberson et al. 2020) as they demand a comprehensive monitoring and surveillance mechanism. Development in fisheries sector should consider and recognize the overlap between small-scale and industrial sector (Stobutzki et al. 2006). Owing to the differences in nature of fishing activities, conflicts might arise between and within the sector due to competition for space and resources which demands comprehensive understanding towards decision making (Dubois and Zografos 2012; Jentoft 2017; Spijkers et al. 2018). Coastal and offshore fisheries differ with respect to the size of vessels, participants in fishing, resources targeted and fishing effort (Gillet 2014; Belhabib et al. 2018). Economic interactions between artisanal and industrial vessels were also confirmed by James et al. (2018). Conflicts mostly impact the artisanal fishermen due to the possible confrontation with larger fishing vessels interacting with their fishing gears, fishing grounds and fishes caught (Bailey 1986; Leroy et al. 2016; Islam et al. 2017) which demands comprehensive monitoring and management mechanisms to protect the interests of traditional fishermen community.

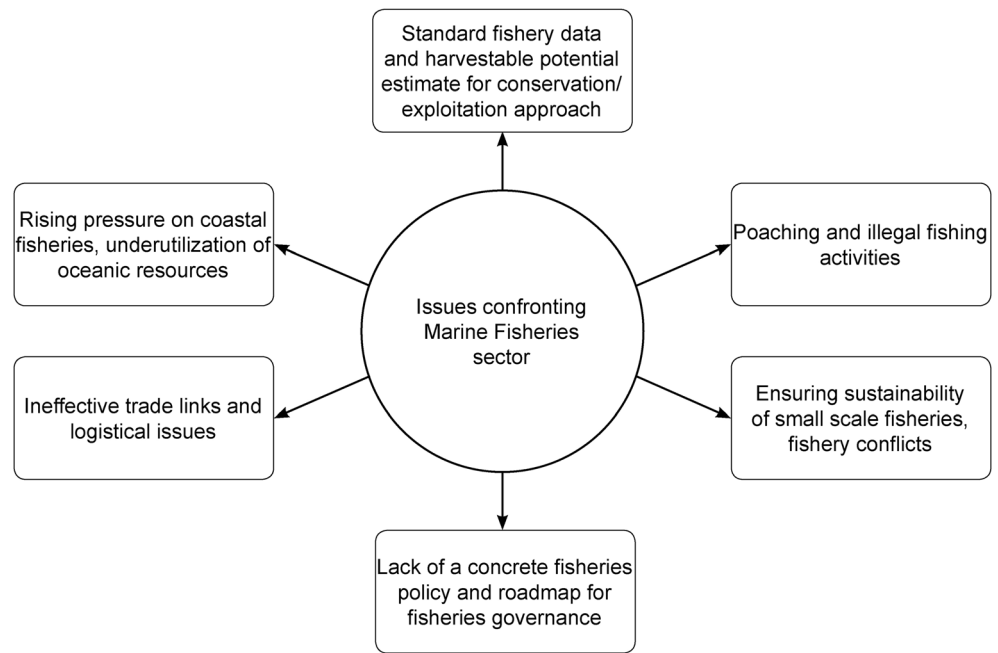
## Issues identified in fisheries resource exploitation and governance

Some of the critical issues confronting the marine fisheries sector of Andaman and Nicobar Islands are shown in (Fig. 3) and were discussed in details as follows,

### Natural calamities and extreme events

Climate change events could cause a shift in marine fisheries sector posing significant impacts on fish catch and landings (Weatherdon et al. 2016; Liang et al. 2018; Cisneros-Mata et al. 2019; Holsman et al. 2019). Incidences such as increased sea surface temperature, rising sea levels, ocean acidification and increased rainfall could impact the coral reefs, mangroves and intertidal habitats which could subsequently affect the productivity of coastal fisheries (Gillet 2014). Weather events of extreme nature such as cyclones, storm surges and rogue waves are to be considered as natural calamities (National Policy on Marine Fisheries 2017). In case of ANI, marine ecosystems that support fisheries such as coral reefs, mangroves and sea grass beds were seriously impacted by events such as increased sea surface temperature, tsunamis, earthquake, cyclones, storm surges etc. (Roy and Krishnan 2005;

**Fig. 3** Major issues confronting the marine fisheries sector of ANI



Krishnan et al. 2011, 2012; Sachithanandam et al. 2014; Yuvaraj et al. 2015; Majumdar et al. 2018). Coral reefs, mangroves and sea grass beds harbour major fish diversity of ANI (Rajan et al. 2013) hence any impact on these ecosystem can adversely affect the fish diversity of these ecosystems ultimately affecting fishermen who are dependent on these ecosystems for livelihood and income generation. During the Tsunami of 2004, subsistence fishermen fishing in mangrove areas of Andaman were affected by the shift in mangrove stands (Roy and Krishnan 2005). Mangroves are the nursery grounds of marine and estuarine fishes and they also play a defensive role against the coastal disasters (Roy and Krishnan 2005; Kiruba-Sankar et al. 2018). Decline in fish catches to 44–55 kg/boat were reported post-tsunami compared to 200–270 kg/boat during pre-tsunami (Roy and Krishnan 2005). The impact of natural calamities on fishers' livelihood was also discussed in National Policy on Marine Fisheries (2017) as the Bay of Bengal witnesses high number of adverse events causing extreme hardships to the fishers.

### Poor knowledge of fishery dynamics

Data-poor fisheries remains a persistent problem across the globe (Dowling et al. 2019; Prince and Hordyk 2018) as understanding the dynamics of fish stocks is essential for policy planning and sustainable fishery management (Faunce 2011; Ruiz et al. 2015; Rude 2016). Well assessed fisheries are moving towards sustainability (Costello et al. 2012) and there is a growing need to manage the un-assessed fisheries as well managed fisheries demand less precautionary approach (Hilborn and Ovando 2014). The case of under exploitation of fishery resources against the harvestable potential has been

emphasized a lot over these years however the importance of unreported/unaccounted fish catches are evident in the catch reconstruction studies of Hornby et al. (2015). Estimation of a standard reliable marine fishery potential remains a critical issue as there were various estimates put forth over the years (ANDFISH 2005, Anrose et al. 2009). The loss of valuable marine faunal diversity due to poaching and illegal fishing activities (Das 2011, MOEF 2011, Kiruba-Sankar et al. 2019) also lending poor credentials in accounting fish catches. Another limiting factor that hinders the organized fishery data collection and monitoring is the lack of skilled manpower and standard methodologies. Schemes and subsidies in fisheries are planned based on the scope available for expansion of fisheries, hence reliable estimation and analysis of fish landings is a crucial component to be addressed.

### Infrastructure and logistical support

Fisheries based infrastructure (National Fisheries Policy 2020) and port infrastructure (Munim and Scramm 2018) with good transport links could play a crucial role in sector development. The Andaman and Nicobar Islands are closer to South-East Asian (SEA) countries whereas the market focus is still towards mainland Indian ports. At present, there is transport of frozen fishes, shark fins, crabs, lobsters etc. to mainland Indian markets. Some processing plants transport reef fishes such as Groupers and Snappers to Chennai and further routed to European markets. Despite these activities, the growth is not as expected as the industry faces range of issues. The processing plants are also severely impacted by the limitations in logistical facilities. Lucrative markets such as live grouper exports are found to be promising for Island entrepreneurs

however, the lack of direct flight and transportation to SEA markets remains a disadvantageous situation. Fish processing industry faces issues such as acute freshwater shortages at times to manage the activities of the processing plant. Lack of technically qualified manpower is also a concern as at present the fish processing plants in ANI recruits the manpower and train them at mainland India. The processing plants also face the issue of limited land availability as the construction of effluent treatment plants (ETP) and other procedures as per standard protocols are hindered with the existing facilities and limitations of the Islands.

### Conflicts in fisheries sector

Conflicts over the marine fishery resources exist between artisanal and industrial fishermen (Payne 2000; Granzotto et al. 2004; Dubois and Zografos 2012; Belhabib et al. 2019) over sharing of resources, encroachment in fishing grounds and the nature of targeted species. Conflicts also exist between the marine nature conservancy and fishery interests (Grip and Blomqvist 2020) which could include fishing in protected areas and fishing of scheduled fishes. These conflicts pose a serious threat to the harmonious fishing activities and could give rise to disputes within fishermen and with fishery managers. Conflicts between fishermen and administration could arise due to poor knowledge of fishermen on the aquatic resources that are banned from fishing. Low level of awareness among the stakeholders about the few protected marine species was also reported in Andaman Islands (Patankar 2019). The incidence of fishermen apprehended with Giant grouper (*Epinephelus lanceolatus*) in the Andaman Islands in 2019 (The Daily Telegrams 2019) can also be attributed to reason such as lack of awareness about the protected status of the marine species. Fishermen accidentally trespassing into protected areas and marine national parks could also create management conflicts. Lack of awareness and sensitization are the major cause of such incidences. Conflicts could also arise between the fishermen groups of the Islands over the sharing of resources, fishing grounds, nature of gears, crafts and the targeted species hence demands precautionary approaches for sustainable resource management.

### Poaching of marine faunal groups

Irresponsible fishing activities do not value national and international obligations (Agnew et al. 2009) thereby posing a threat to the sustainable management of fish stocks (Prمود et al. 2017). ANI is located close to South-East Asian countries such as Myanmar, Indonesia and Thailand and there were frequent incidences of poachers apprehended from nearby countries while fishing marine resources such as shells, sea cucumbers, reef fishes, tunas etc. (Hornby et al. 2015; Kiruba-Sankar et al. 2019). The apparent loss of vulnerable and

protected marine diversity due to poaching activities is a serious issue which calls for management actions to curb the incidences. Poaching activities in the Islands were well emphasized by Das (2011); MOEF (2011); Hornby et al. (2015); Kiruba-Sankar et al. (2019) which needs to be addressed through appropriate surveillance mechanisms to deter such incidences in future.

### Rising pressure on pelagic and demersal fishery resources

Of the 39,284 t of marine fish landings during 2017–18, the contribution of pelagic fishes was maximum (19,478 t) followed by demersal (16,731 t) and oceanic fishes (3075 t) (ANI fisheries policy 2018). The pelagic and demersal fishery resources are facing challenges in terms of fishing pressure (ANDFISH 2005; Kirubasankar et al. 2013) and unsustainable fishing practices (Thomas et al. 2017; Kiruba-Sankar et al. 2019). The rising demand for seafood due to tremendous surge in the tourism sector in the recent years has intensified the pressure on the coastal fishery resources as the seafood delicacies in demand are mostly constituted by pelagic and demersal fishery resources. There is relatively lesser fishing pressure on oceanic fishery resources in comparison to demersal and pelagic fishery. Intense competition in the light of burgeoning tourism activities and market requirements could lead to intense fishing pressure, resource conflicts and unsustainable fishing practices.

### Policy support and governance

Developing robust policies for sustainable fisheries remains a major challenge (Pan et al. 2014) due to the complex nature of the fisheries sector (Aguado et al. 2016). Robust policy directives and roadmap could assist in effective management of marine fisheries sector. Developmental programmes most often envisage the possibilities of expanding the fisheries in due consideration of livelihood and economic benefits however, do not practically engage through policy directives backed with science-based observations. Development of a policy directive with pragmatic roadmap could be a crucial step for successful fisheries management. Policies should provide emphasis on understanding the root cause of the problems and to provide suggestions to overcome those hindrances. Considering the strategic location, remoteness and vastness of fisheries resources, an inclusive marine fisheries policy is essential as the sector provides livelihood and employment to thousands of fishers. Marine fisheries sector in Andaman and Nicobar Islands are often dependent on coastal ecosystems such as mangroves and coral reefs (Rajan et al. 2013) and hence policy planning should include the ecosystem management as an integral component in policy planning for sustainability of fisheries sector and the associated ecosystems.

Policy preparations should integrate the existing practical issues by taking the opinions of fishery managers, scientists and stakeholders. Lack of a concrete policy directive remains one of the main hindrances in the development of marine fisheries sector.

### Challenges and strategies ahead

Considering the issues highlighted, the challenges confronting marine fisheries sector are enormous that requires coordinated management and institutional support. The areas that need adequate attention are as follows,

1. Fishery data collection and monitoring
2. Marine fisheries policy directives and roadmap
3. Strengthening the infrastructure and logistical support
4. Promoting the industrial fisheries sector to harness oceanic fishery resources
5. Ensuring the sustainability of small-scale fisheries
6. Managing the issue of lack of skilled fishery managers
7. Conflict management through the collective support of stakeholders
8. Monitoring, Control and Surveillance in marine fisheries sector
9. Active linkages between stakeholders in decision-making processes.

Based on the challenges identified, we are looking forward to five action points which can resolve most of these challenges in the long run.

### Fishery data collection and monitoring

A schematic management approach is suggested for efficient planning and management of marine fisheries sector of ANI (Fig. 4). Fishery data remains the most critical component to be addressed (Kimura and Somerton 2006; Faunce 2011; Ruiz et al. 2015) hence marine fisheries management in ANI should adopt the approach of Assess-Regulate-Utilize (Fig. 5), a concept modified based on the three basic types of decisions in fishery management (conservation, regulation and allocation) by Hanna and Smith (1993) and adopted in Kiruba-Sankar et al. (2019). The approach emphasized in Fig. 5 highlights the critical need to assess the fishery resources and enforce regulatory measures in order to utilize the resources in a sustainable manner which is crucial in the context of Andaman and Nicobar Islands. The most common data collection and monitoring methods, their potential advantages, limitations and suitability in the Islands are discussed in Table 1 adopted and modified from Dowling et al. (2016); Rude (2016); Beauchamp et al. (2019) which can be adopted with the support of skilled manpower.

### Managing the fishery conflicts

Approaches such as participatory co-management of fishing grounds could be sensitized to the fishermen by scientists and administrators. Sensitization workshops and awareness programmes on the aspects of conflict management should be conducted regularly creating a platform to fishermen for face-to-face interactions to resolve their issues. Public participation is a crucial factor for good governance and management as encouraging the public participation could resolve conflicts and support decision-making process (Coffey 2005). In Bangladesh, FishCOM (fisheries conflict communication framework) was developed to manage fishery conflicts (Murshed-e-Jahan et al. 2014). Co-managing the fisheries resources and the concept of sustainability should be disseminated properly to the local fishermen. Gutierrez et al. (2011) suggest co-management as a practical solution to solve the problems faced by global fisheries. The issues arisen through conflicts and their possible ecological, environmental and monetary losses should be sensitized to the fishermen groups by the research and development organizations. Regular programmes on the aspects of sustainable fishing practices should be sensitized to the fishermen community. The list of aquatic groups of protected nature which are not to be fished, details of no-fishing zones and prohibited gears and craft types should be displayed in every landing centers for the knowledge of fishermen.

### Monitoring and surveillance mechanisms

Efforts to promote industrial fishing activities in ANI to harness the oceanic tuna resources are praiseworthy however, the sustainability of industrial fishing sector depends on the level of monitoring and control mechanisms. Fisheries management and monitoring remain a complex task (Caddy and Seijo 2005; Bartholomew et al. 2018; Nyman 2019). Deep-sea fishery management stands at crossroads (Norse et al. 2012; Oanta 2018) due to limitations in Monitoring, Control and Surveillance (MCS). Despite the complexity in monitoring systems, it is essential to combat Illegal, Unregulated and Unreported (IUU) fishing for the sustainability of fish stocks (Martinsohn et al. 2018; Kiruba-Sankar et al. 2019). FAO's Code of Conduct for Responsible Fisheries (CCRF) can be adopted in fisheries development policies for sustainable management of marine fisheries sector (Payne 2000). However, implementation of CCRF in the marine fisheries sector is a concern as the CCRF evaluation in 53 countries including India revealed poor compliances (Pitcher et al. 2009, Sunil et al. 2014). Sustainability of fisheries remains a concern (Pauly et al. 2002; Asche et al. 2018) due to various issues such as irresponsible and unsustainable fishing practices. Effective fisheries control, management and regulatory practices should be evaluated and practically implemented through

**Table 1** Fishery data monitoring and collection methods, limitations and suitability in the Islands adopted and modified from Dowling et al. (2016); Rude (2016); Beauchamp et al. (2019)

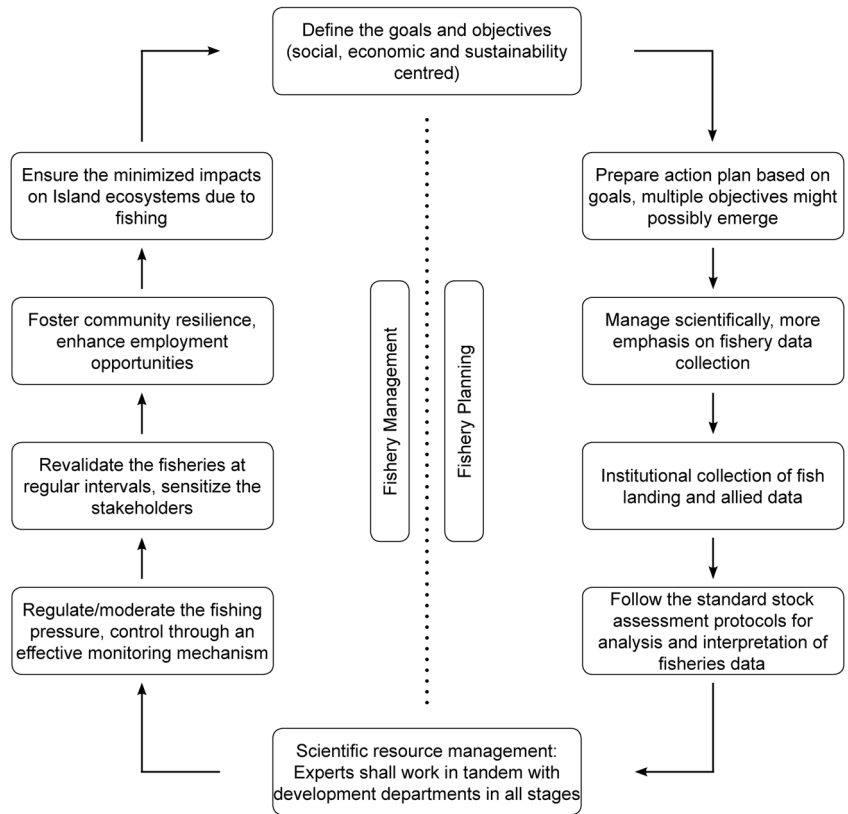
Fishery data collection and monitoring methods	Advantages	Limitations	Suitability in the ANI
Smartphones and Mobile apps	Easy, efficient and time saving. See EFMIS (Enhanced fish market information services) implemented in Kenya and Uganda (Aura et al. 2019) where mobile phones are used in data collection. The use of mobile apps for fishery data is gaining more popularity.	Limited mobile network coverage could be an issue (Jeffers et al. 2019), limited trust and cooperation between fishers and managers (Bradley et al. 2019).	Mobile apps could be a better approach which will be suitable in the Islands as there is a better improvement in networking and internet connectivity in the Islands.
Landing centre surveys	Reliable and efficient method. Can collect biological information on sexes, and length classes. More useful data can be obtained.	Skilled manpower is required to cover larger areas through stratified sampling, could be tedious in case of multi species fishery.	Can be a best option if trained manpower is engaged across the Islands to collect data.
Fish market based information	Could also provide insights on the fishes landed, details on maturity stages can be collected, length and weight data can be obtained	Market samples could provide only limited information as the fish reaches market after selection/size grading etc. High valued fishes will be directly taken by export firms.	The information could supplement the fishery data collected through other methods.
Log books of fishermen	Information on fishing location, depths, catch composition, gears used can be collected.	Fishermen are usually apprehensive on sharing the fishing information and locations of their fishing grounds. Fishermen are also aware of uncertain outcomes that could affect the management decisions in fisheries.	Could be suitable for mechanized fishing vessels, motorized or traditional boats mostly do not use log books
Fisher interviews	Can collect information on fishing location, depth, species caught, catch, effort, discards, by catches, gear used etc. Historic information can also be collected through interviews which could be useful in fishery management decisions.	Fishermen mostly share the data in ranges and broad level and could be inaccurate at times.	Fishermen interviews can supplement more information on fishery data
Information from marine exporters/Airport royalty	Can get the reliable figures on quantity and species exported.	Cooperation of the exporters to share the information	Could be supportive along with other collection methods.
Onboard/ At-sea observers	Designated observers to monitor and verify the catches (Beauchamp et al. 2019), bycatches, discards etc.	Number of observers required for coverage, sampling limitations, costly process (James et al. 2019)	Onboard observations can be encouraged to get first hand information on bycatches, discards etc. Can be explored in larger fleets in the beginning phases for further adoption.
Remote electronic monitoring systems	Can supplement information on catch monitoring programmes using activity sensors and cameras in vessels (Bartholomew et al. 2018; Helmond et al. 2019; Beauchamp et al. 2019).	Cooperation of fishermen groups is crucial, vast nature of fishing fleets could be challenging (Bartholomew et al. 2018), limitations in video based monitoring, maintenance of equipments (James et al. 2019)	Can be considered in future in the case of expansion of industrial fishing activities in the Islands

trained and skilled manpower. The CCRF compliance studies in Andaman and Nicobar Islands should be undertaken and the critical gaps existing and hindering the sustainable fisheries management should be addressed. Policy developments and decision making in the marine fisheries sector should consider evaluating these critical standards to understand the existing compliances to overcome the shortfalls through the coordination of stakeholders.

### Setting fishery standards

Eco-labeling and certification programmes have become an important part of seafood trade (Lallemand et al. 2016; Tsantiris et al. 2018; Ramachandran and Parappurathu 2020). Fishery certification programmes could improve the performance and sustainability (Parkes et al. 2016; Arton et al. 2018). Some of the international certification programmes such as Marine

**Fig. 4** Management steps recommended for effective fisheries governance in the Islands

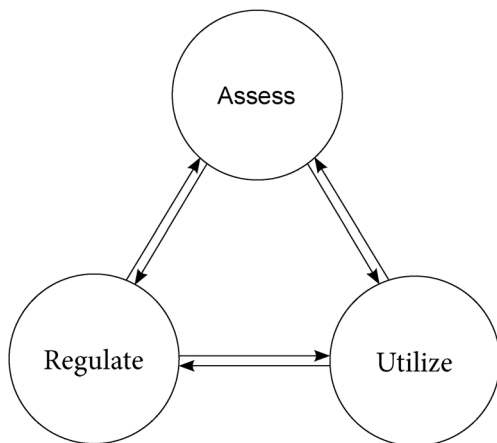


Stewardship Council (MSC) recognize well-managed capture fisheries through regular structured assessments (Hilborn et al. 2015; Lallemand et al. 2016; Opitz et al. 2016; Parkes et al. 2016). Pole and line fisheries for skipjack tuna in Lakshadweep Islands of India have also moved towards MSC certification (Cadamin 2017) whereas Kerala’s Ashtamudi estuary short neck clam fisheries have received India’s first MSC certification (WWF India 2014). Other than MSC certification, Friend of the Sea (FOS) fishery certification programme is also gaining attention in the Asian seafood market (Seafoodsource 2014). Besides these international certification programmes, government can also promote self-certification programmes by setting

appropriate standards in the seafood industry based on the sustainability of marine fishery resources as suggested by Ramachandran and Parappurathu (2020).

**Active networking of scientists-administrators-stakeholders**

Coordination between resource users and decision-makers is essential for fishery monitoring programmes (Andrade and Schiavetti 2015; Dorner et al. 2015; Sampedro et al. 2017; Kiruba-Sankar et al. 2019; Michalena et al. 2020). The importance of networking between scientists, administrators and stakeholders are discussed in Kiruba-Sankar et al. (2019). Coordinated efforts are required to meet the desired objectives of fishery management in an efficient manner. Discussions aimed towards participatory fishery management approach have often led to hostile relationships between fishermen and the managers or scientists. Bailey et al. (2017) suggest building a good relationship with the local people by sharing ideas and participating along with them in their field activities which could build an active linkage. Peterman (2004) outlines the real challenge for scientists lies in communicating complex and technical results to the decision-makers and the public. A mechanism to integrate the opinions of stakeholders along with scientists and managers or administrators should be explored productively for engaging the stakeholders in effective fishery management programmes. Encouraging face-



**Fig. 5** The approach recommended for sustainable fishery management



to-face interactions between the fishermen and the fishery managers at regular intervals could help to formulate better decisions in fishery management through a coordinated approach. Such interactions can foster a healthy relationship among the stakeholders and could assist the fishery managers in the collection and monitoring of fishery data since these programmes require the support and cooperation of the fishermen for successful implementation.

## Conclusions

Lack of organized fishery data and resource assessment protocols remains the most crucial issue in the Island fisheries sector. Developmental programmes are taken up based on the available estimates on fishery potential and fish landings however, decisions based on unrealistic fishery data can threaten the sustainability of marine resources. Natural calamities and extreme events are adversely impacting the coastal ecosystems and the associated fishery resources of the Islands. Livelihood and food security of small-scale fishers depending on these ecosystems are at stake due to these events. Ensuring the sustainability of small-scale fishers should be the top priority. Alternative sector development through industrial fishing activities should be promoted through proper monitoring, control and surveillance (MCS). At-sea observing and electronic monitoring systems as discussed in Table 1 are important components of MCS (Sylvia et al. 2016) which could be adopted in future for monitoring the fisheries in ANI. Developing a stakeholder interface platform could promote participatory, transparent and science-based management of fisheries resources. Building closer linkages are to be encouraged between the fishery managers and the fishermen that could help in building constructive policies with guiding principles. Scientists should actively involve with fishery management agencies directly to resolve issues (Purcell and Pomeroy 2015). The issues highlighted could be integrated in the policy development plans for sustainable fishery management. The opinions provided in the article could assist the administrators and policymakers towards the planning and management of fishery resources. Operative trade links and logistical developments along with robust fisheries governance could provide larger benefits to the stakeholders of the Islands in providing livelihood, income generation and employment opportunities in a sustainable manner.

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## Compliance with Ethical Standards

**Competing interests** The authors declare that they have no competing interests.

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