demolish the fish habitats, ultimately destroying fisheries. Regulations on the use of destructive fishing gears are commonly imposed in the Southeast Asian countries but surveillance remains a big challenge because of the nature of the region's fisheries, which are open access and people are fishing for subsistence.

A substantial challenge in the sustainable development of inland capture fisheries is on the collection and reporting of reliable data on wild-caught fish. There are limited port landing sites for inland capture fisheries and most of the harvested fish is consumed in households without entering the market chain. Therefore, data on inland fish catch are scattered and not well documented by government authorities. Fish catch and effort data are necessary as these are used to determine the total stock of fish in targeted water bodies. Without sufficient reliable data on catch and unit effort, authorities and scientists would not be able to determine the total allowable catch of particular fisheries, which could lead to possible overexploitation. The numbers of fishers and fishing gears are also not well recorded and remain unreported because the majority of inland capture fisheries involve small-scale and subsistence fisheries, while the numbers of on-ground fishery officers are minimal.

Issues and Concerns

In marine fisheries, port landings are crucial facilities as these are used for recording, licensing and monitoring the fishing activities. Data collected from the ports could also contribute to determining the fish stock and total allowable catch, and the development of appropriate policies to protect the fish population and sustain economic development. Expanding port landing sites in inland water bodies equipped with officers and facilities would be important to establish and facilitate capture data documentation. Inland fisheries ports can be designed based on the localities and should be capable of undertaking multi-purpose tasks of not only recording fish catch but also facilitating fishers' ability to sell fish and obtaining fair prices of their catch. While determining the fishing capacity is much easier in marine fisheries, this could also be easily determined in inland fisheries if the fish stocks are well assessed and the catch effort is well documented. Determining fish stocks in inland fisheries so far is mostly based on poor fish catch data which could lead to misrepresentation of the real status of inland fisheries and literally, translate to destruction of the fish population.

Logbook of fish catches and the involvement of observers in industrial marine fishing activities have been known to improve the reliability of the catch data in marine capture fisheries. The same method could also be implemented in inland fisheries by working closely with fishers, especially the permanent fishers who catch fish on a daily basis. The inland fishers themselves can serve as the observers and logbooks could be provided by local fisheries authorities. Trust needs to be established between the fishers and officers, and the governments could consider providing subsidies for fishers who are able to document their fish harvests and catch efforts continuously.

Licensing and registration of marine fishing vessels and fishing gears are not relevant to inland fisheries because inland fisheries are dominated by subsistence and artisanal fishers, and mostly involve the impoverished people with limited capital. However, co-management, local wisdom, and the EAFM concept could be implemented in inland fisheries to monitor the fishing activities. The governments or authorities can work closely with the local people to socialize good fishing practices, instill the importance of sustainable fisheries, and teach fishers how to harvest fish wisely to allow adequate recruitment. Some local wisdom already exist in Indonesia, such as protecting the lubuk or the deepest area in the river during the dry season to allow fish to settle and save them during low water levels and prevent their overexploitation (Dian *et al*., 2016). Promotion of such local wisdom could be strengthened and allowed to be adapted in other areas to protect the fishery resources.

Way forward

There are some key messages that can be implemented to protect inland fisheries and to combat illegal activities that can destroy biotas and habitats. Local communities' engagement would be useful to create trust between the fisheries authorities and local people. As inland fisheries continue to be open access and dispersed, the involvement of local people in data documentation and monitoring of illegal activities is the key. Also, to improve catch data documentation, expanding the numbers of small fish landing ports, either operated by the local community or the government, would be crucial for documenting the catch from fishing activities in inland waters. A good data on catch and effort should be targeted as these are crucial for determining the status of the stocks of commercially important inland water fish species.

6.1.1.7 Application of Innovative Technologies for Combating IUU Fishing

The application of innovations and technologies has been progressing, especially in support of the functions of MCS, for effective fisheries and habitat management, and combating IUU fishing in many countries. The technologies and tools for effective MCS system have been available and have been used (*e.g.* automatic identification system, vessel monitoring system, electronic catch reporting system or e-logbooks, CCTV, drone, satellite imagery, etc.) for monitoring and controlling of fishing activities in land, on ports, and at sea. The technologies have also been improved making them user-friendly, such as mobile applications, offline and what has now evolved into the artificial intelligence and machine learning.

As for the regional initiatives, SEAFDEC has been supporting and promoting the technologies, tools and measures for the AMSs to apply in combating IUU fishing, *e.g.* RFVR, eACDS (from web-based to mobile application) with support from the Japanese Trust Fund and the SEAFDEC-Sweden Project (2013–2019). SEAFDEC also collaborated with the USAID during 2015–2019 for the implementation of the Project 'Oceans and Fisheries Partnership' also known as the Oceans Project aimed at among others, developing and promoting the electronic catch documentation and traceability systems and initiatives in the region (*e.g.* FAME, PointTrek, TRAFIZ, TraceTales). Such initiative also demonstrated the advancement of technologies and tools that check and connect the marine capture fisheries data throughout the supply chain in the demonstration sites of the AMSs.

SEAFDEC embarked on a questionnaire survey in 2020, to assess the application of innovative technologies for combating IUU fishing. Summarized below are the responses from the AMSs to the questionnaire taking into account the current technologies used in the respective AMSs.

Indonesia and the Global Fishing Watch have shared vessel monitoring system (VMS) data for all Indonesian flagged fishing vessels in a publicly available data platform since 2017. Indonesia's VMS data includes nearly 5,000 medium-sized commercial fishing vessels that are not required to carry AIS, and are therefore not reliably trackable by any other means. In order to improve marine and fisheries resources surveillance to combat IUU fishing, the Indonesian Directorate General (DG) for Surveillance has developed an online application system to monitor VMS transmitters, called SALMON. This application allows the owner of fishing vessels to monitor their vessels' movements, and integrates the functional features such as transmitter activation, monitoring fishing vessels' movement, and e-SKAT (transmitter activation letter) services. This application can be downloaded through Google Play Store. The DG for Surveillance also conducts air surveillance to improve vessel monitoring especially in the areas that are vulnerable to IUU fishing. PoinTrek, a two-way communication Vessel Monitoring System (VMS) and real-time fish catch reporting system, was also introduced in Indonesia through the SEAFDEC-USAID Oceans Project.

In the Philippines, a VMS system developed by Futuristic Aviation and Maritime Enterprises, Inc. (FAME) of the Philippines, is now being installed in large fishing vessels (30 GT and above). Through the Oceans Project, a small-scale vessel tracker and monitoring system has been developed that also serves as communication device, enabling small-scale fishers to participate in electronic Catch Documentation Traceability (eCDT) and establish enhanced communication and safety at-sea. This system has been piloted in the learning site in General Santos City, Philippines in 2018.

Malaysia has imposed the installation of a Mobile Transceiver Unit (MTU) for Malaysian fishing vessels operating in Zone C, C2, and C3. While, all Malaysian fishing vessels operating in zone B, are required to install an Automatic Identification System (AIS) transponder. Moreover, the Malaysian fishing vessels operating at the high seas are required to install CCTV.

Myanmar has implemented Vessel Monitoring System (VMS) since 2019, eACDS (pilot project), and E-licensing for combating IUU fishing. While all Singapore fishing vessels are equipped with AIS transponders for the tracking of vessel movements.

For Thailand, the Department of Fisheries (DOF) of Thailand has developed control and monitoring systems for all operating fishing vessels. Such systems include:

1. Vessel Monitoring System (VMS): a satellite-based monitoring system for licensed commercial fishing vessels (≥ 30 GT) that broadcasts signals at the port and during fishing operations at sea. Together with the VMS, Support Vessel Data and analytical data from AI, support the technical knowledge for the adoption of the VMS technology using computer programs
2. Fishing Info: a port-in and port-out control system, where inspection of fishing vessels is initiated, the information is linked with the Thai Fishing Vessel Database of the Marine Department of Thailand and other relevant authorities
3. Electronic Reporting System/Electronic monitoring (ERS/EM): a surveillance system for Thai fishing vessels operating overseas and transshipment vessels to facilitate submission of reports, *e.g.*, fishing logbook, permitted transshipment status, and showing up real-time photos of suspicious-looking vessels' activities at the Fisheries Monitoring Center (FMC)
4. Machine Learning System: an ongoing development project where the VMS data analysis accessed by AI is automated to build an analytical model of warning system when fishing activities are suspected to be breaking the laws

Way forward

Novel technologies are important for the authorities to support the implementation of MCS and improve the effectiveness of fisheries management for the sustainability of the fishery resources. Such technologies (*e.g.* VMS, AIS) would help support the countries' efforts toward monitoring and surveillance of fishing activities, traceability of fish catch throughout the supply chain, as well as regional/sub-regional networks for sharing and exchange of information. The concerns raised with respect to the applicability of the technologies should be considered, such as making these

user-friendly and enhancing their capability of providing real time data. It has also become necessary that the availability of offline records, internet, improved capacity of data storage, and data security, should be ensured at lower costs. The fast evolution of such technologies in the fisheries sector over the past years, *e.g.* machine learning and use of robot, sensors or Artificial Intelligence (AI), had been happening. Although these had already been introduced and tested in MCS and for combating IUU fishing in the region, some of the new technologies are still beyond the limit of human knowledge to be able to efficiently use them, and it is in these aspects that SEAFDEC and the AMSs have been monitoring the changes and developments.

For example, the human observers' onboard program might still be useful, while adjustments are being made with regard to the use of onboard digital cameras and recorders which still requires humans to review the footage of the information collected in the form of video clips. Nevertheless, with huge amount of data, the AI could be useful in compiling and analyzing the data. Such technology is therefore useful for improving effective fisheries management.

Many countries had been affected by the COVID-19 crisis in 2020–2021. Nevertheless, the countries continued to develop and implement their respective national measures, especially those that concern the health of laborers or crew onboard fishing vessels. As a result, the relevant national agencies had also adjusted the modes of work of fishers but also making sure that IUU fishing activities are prevented from occurring during this critical time. The use of the aforementioned novel technologies and innovations should therefore be promoted as these could be useful tools for remote monitoring and control of fishing activities at sea, and thus, support the governments' efforts in maintaining the fish stocks and in combating IUU fishing in their respective waters amidst the present crisis.

6.1.2 Management Concepts and Approaches

6.1.2.1 Ecosystem Approach to Fisheries Management (EAFm) and Ecosystem Approach to Aquaculture (EAA)

Ecological approach in fisheries (EAF) is a strategy that aims for the promotion of sustainable development, and the application of an ecosystem approach balances the fulfillment of the three objectives of the Convention on Biological Diversity (CBD): conservation, sustainable use, and fair and equitable sharing of the benefits arising from the utilization of genetic resources (Staples & Funge-Smith, 2009). The EAF was therefore devised as a tool to support the implementation of the FAO Code of Conduct for Responsible Fisheries (CCRF) with respect to the sustainable exploitation of fishery resources worldwide.

Ecosystem Approach to Fisheries Management

Ecosystem Approach to Fisheries Management or EAFM is one of the approaches currently being used in fisheries management (Jaya & Zulbainarni, 2015; Kusnandar & Mulyani, 2015). Applicable not only for the sustainable management of marine and coastal fisheries but also for inland fisheries and aquaculture, the EAFM approach is aimed at achieving an integrated, comprehensive, and sustainable fisheries management while balancing the socioeconomic aspects, knowledge, information, and the uncertainties about abiotic-biotic components and human interactions in the ecosystem.

Thus, EAFM has been used as an approach to improve fisheries management that has already existed but might had been conventionally applied by focusing on the target aquatic species (commodities or economic components) without looking at the interactions and relationships among the various aspects of the ecosystem. Several things had led to this paradigm change and could include increased understanding of the strong interaction among the fishery resources, and interaction of the fishery resources with the environment; of the ecosystem services for human life that need to be maintained and cared for to be sustainable; as well as of the ecosystem functions for humans and the environment—awareness of the many factors of uncertainties about the functions and dynamics of the ecosystems.

The application of the EAFM has already been globally accepted and endorsed in many international fora and countries. The approach, which represents a move away from the usual fisheries management systems that focused only on the sustainable harvest of target species, anchors toward systems and decision-making processes that balance environmental well-being with human and social well-being, within improved governance frameworks. The EAFM helps to manage fisheries more holistically; reduce user group conflicts; help unlock financial resources; enhance cooperative work with other stakeholders, and better resolve fisheries issues and challenges. The EAFM is not only applicable for marine and coastal fisheries management, but its concept and principles could also be used and applied to inland fisheries management, *i.e.* the Ecosystem Approach to Inland Fisheries or EAFm, as well as to aquaculture or the Ecosystem Approach to Aquaculture (EAA). Together with EAFm and EAA, EAFM is a strategy for the integration of the fisheries and aquaculture activities within the wider ecosystem in order that the promotion of sustainable development, equity, and resilience of interlinked social-ecological systems, is in place.