particularly those at risk of overexploitation, and develop mitigating measures and appropriate conservation and management measures for such impacts through consultative processes that may involve collaboration with regional organizations";

Plan of Action No. 46 to "*Encourage coordinated planning and management on the use of inland water bodies including rivers, floodplains, wetlands, etc. through (i) resource enhancement programs; (ii) inland fisheries management programs; (iii) environmental impact assessment of structures on the aquatic resources; and (iv) restocking of indigenous and/or commercially-important aquatic animals species taking into consideration concerns on genetic diversity; and build/improve the capacity of human resources and institutions in the implementation of such programs*"; and

Plan of Action No. 47 to "*Formulate guidelines to promote the use of practical and simple indicators for inland/floodplain fisheries within the national inland fisheries management framework, to facilitate (i) timely local level fisheries management decisions with due respect to the large number of people/farmers that take part in fishing; (ii) dialogues to ensure that the inter-connectivity of fish migration path is kept as a tool for management/conservation measures; and (iii) adaptation to the effects of climate change within water bodies*"

The AMSs are therefore enjoined to mainstream the abovementioned action plans that were adopted by the authorities of the ASEAN and SEAFDEC, in the respective countries' plans and programs in order that the inland capture fisheries would continue to provide food fish and incomes to the rural fishing communities. Thus, this sub-sector could continue to contribute to food security and poverty alleviation in the AMSs.

2.1.2 Data Collection on Inland Fisheries

Data and information are the basis for proper management, while information on fish and fishers is the essential component of any fisheries. In the case of inland capture fisheries, data collection is usually weak while the compiled data are generally insufficient for generating the kinds of decisions needed. Furthermore, the catch statistics on inland fisheries are fragmented and discontinuous, contributing to the poor picture of the status of the inland fishery resources around the world.

The inland fisheries sub-sector is very complex, comprising many small-scale fishers with catches that vary not only in size but also in species which could be multiple. Meanwhile, fishing gears used are also multiple, and fishing is highly seasonal (Fitzgerald *et al*., 2018; Muthmainnah *et al*., 2020). The majority of activities in inland fisheries are not licensed, operated at semi-commercial or subsistence level, and widely dispersed along with the numerous water bodies (FAO, 2010a). Most of the catches of inland fish are unrecorded as sometimes the catch is bought directly from landing spots or informal local markets. The existence of inland landing sites or major markets is very rare, making it difficult to collect the necessary data and information. Moreover, the importance of inland catch statistics is less valued by most authorities in many countries.

In the Southeast Asian region, some nations have established their national strategies and tools with respect to gathering information on inland capture fisheries, *e.g.* inland fisheries databases had been developed in the Philippines and Indonesia. The National Stock Assessment Program (NSAP) of the Philippines makes use of a standardized method of data collection to come up with science-based policy recommendations for the conservation and management of the fishery resources in the Philippines. While for Indonesia, the One Data Policy (ODP) is the database system used for integrated data compilation. The ODP uses data processors (or enumerators) assigned to visit the respondents and to record and input the data collected (Muthmainnah *et al*., 2017b).

Another issue with regard to the collection of inland capture fisheries data and information is the high cost that could be incurred as this requires people who would be paid for their services, and expenses for the cost of transportation and communication system to be effective (FAO, 1997b). Nevertheless, SEAFDEC/IFRDMD is currently establishing a mobile application known as "Data Collection for Fishery Activities" or DACOFA for short, designed to make sure that fishers or users input the necessary data quickly and efficiently. An android system was chosen considering its convenience and ease of running the application as well as the affordability of the phones. One of the main advantages of using the data collection application is that the data could be gathered easily. The enumerators who are on the go or in a location where internet connection could be unreliable can still input the data. Offline modes would allow the fishers to store a backup of their data on their mobile devices and upload it once an internet connection is available. Automatically, the data will be recorded in the database system. By using this mobile system of data collection compared to paper-based forms, the number of data collected had been enhanced in quality and increased in quantity. This gives the option for the data collectors to use as it suits best their purposes (Muthmainnah *et al*., 2020).

Improving data collection on inland capture fisheries

Strengthening the system of collecting capture fisheries data from inland fisheries has become essential, especially in terms of information on fishery household and production. The availability of complete and valid fisheries data would

facilitate the formulation of policies that benefit the inland fisheries subsector, as policymakers could optimize the utilization of such updated and real-time data in formulating policies that could be appropriately enforced according to the conditions of each inland resource location.

While the important roles of data in various aspects of fisheries, from planning, policy formulation to evaluation are recognized, the insufficiency of data on inland capture fisheries makes it difficult for policymakers to give due recognition on the importance of this sub-sector. Furthermore, when the data on the importance and socioeconomic value of inland fisheries is unrecorded or under-reported, decision-makers would have the tendency to value more the other water uses with known value to the economy over the inland fisheries sub-sector. Therefore, strengthening data collection and compilation should form part of an important component in policy formulations as good data could be used as a basis for policy-making in every program and activity. Moreover, this would also require the identification of appropriate indicators and compilation of local/indigenous knowledge to back up the information on the status of inland fishery resources. It is also a challenge to come up with novel methods of data collection, analysis, and dissemination, including the use of mobile applications for data collection, as these would make data collection more convenient.

2.1.3 Impact and Mitigation of Impacts of Water Barrier Construction on Inland Fisheries

The role of the inland fisheries sub-sector as a significant contributor to the economic development of many countries, alleviating poverty and ensuring food security in rural communities, has recently been well-recognized. Nonetheless, the sustainability of inland fisheries is dependent on the quality of the freshwater resources, aquatic habitats, and the ecosystem. In attaining such sustainability, strategies are necessary to strike a balance between maintaining the quality of the freshwater fishery resources and aquatic habitats, and utilization of the water resources by the non-fisheries sectors.

One of the important developments that have resulted in drastic impacts on the inland aquatic habitats and ecosystems is the construction of infrastructures along rivers and other bodies of water for economic development, which includes dams and weirs. Large-scale water construction projects such as hydropower structures could promote progress and development such as road construction, deforestation, mining, and urban development in the surrounding areas, but the impacts of such construction on the aquatic biodiversity of the inland water environments should also be taken into consideration (Arantes *et al*., 2019). Environment and socioeconomic impacts are generally assessed only in some areas near the infrastructure projects, *e.g.* hydropower structures, but not in the upstream and downstream areas where many people are dependent on the whole river ecosystem for their livelihoods. Dams and weirs are the main structures that could greatly improve the performance of an irrigation system as they help retain water in catchment areas during the rainy season and store water for utilization throughout the entire year for irrigating the agricultural lands. Constructing dams and weirs in rivers could therefore contribute to economic growth, poverty alleviation, crop productivity, water availability, and electricity generation. However, these water infrastructures could also cause depletion of the inland fishes because as water barriers, they could cause interruptions of the fish migration routes to complete their life cycles. When the fish route is blocked by such barriers, fishes are unable to access their habitats to complete the critical stages of their life cycle. Although species with short life cycles may be able to adapt to such conditions, but as a consequence, other fish populations in the upstream and downstream waters could be severely affected, especially in terms of their genetic makeup. Dams fragment the aquatic ecosystems by blocking the fish migration routes, sediments, nutrients, wood debris, and aquatic organisms in general (Zielinski & Freiburger, 2020). The impact of such ecosystem fragmentation generally affects not only the migratory fish species but also the non-migratory aquatic species as well.

Strategies should therefore be developed and promoted to mitigate such impacts of ecosystem fragmentation, especially through the construction of fish passage that allows the upstream waters of rivers to reconnect with the downstream waters. Fish passage or fishway facilitates fish migration from downstream to upstream or vice-versa. Fish that swim from downstream can enter the fishway inlet located downstream of a dam. Knowledge of fish passage construction has been used globally to maintain river connectivity. However, the appropriate design of fish passage must be based on the local fish that inhabit the particular water systems.

According to Bunt *et al*. (2012), the efficiency of fishways consists of attraction and passage efficiencies and constitutes the proportion of a fish stock present downstream that enters and successfully passes through the fishway with minimal delay. Effective fishway design requires extensive integration of biological and hydraulic data (Castro-Santos *et al*., 2009). As the variation of fish morphology is large among species, the hydraulic structure should consider the morphology of the fish in producing a selective passage. Several morphological characters such as body length, body shape, and structure of fins affect the fish swimming functions and performance. To be effective, a fishway must allow target fish to successfully pass, this implies that good knowledge of the swimming capabilities of the target fish is crucial for an effective and efficient fishway design (Katopodis *et al*., 2019).

Research should therefore be undertaken with the collaboration of fish passage biologists and engineers, emphasizing on the ecohydraulic concepts that consider