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Report of the

ADVISORY ROUNDTABLE ON THE ASSESSMENT OF INLAND FISHERIES

Rome, Italy, 8-10 May 2018

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PREPARATION OF THIS DOCUMENT

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ABSTRACT

The two and a half day Advisory Roundtable was convened to contribute to FAO's response to the request by the 32nd Session of the Committee on Fisheries (COFI), to i) advise FAO on its approach to developing a more comprehensive report on methods and data and analytical approach, which could be used to provide a credible, objective and replicable assessment of inland fisheries; and ii) provide guidance on tools that could be provided to member states seeking advice with respect to assessing the status of their inland fisheries (yield/production, threats & drivers), predicting future impacts and how to quantify the effect of mitigation/adaptation measures on fisheries.

The roundtable reviewed and discussed the background that had led up to the meeting to scrutinize the purpose of an assessment and the scope of coverage and how this could be used to determine the status of inland fisheries. It further developed the criteria to conduct such an assessment, and then attempted to apply the approach to a number of basins. This practical exercise was based on concrete examples from countries or basins with which the experts were familiar.

It was concluded by the roundtable, that the use of a dual index approach is the right way to go, and that it can be used to assess fisheries both at the national, basin, regional and global levels although different levels of resolution will be required and may thus have somewhat different data requirements. Adding a valuation element will direct investment towards the fisheries that provides most benefit to society in the context of the priorities set at the national level. At the national level, data may include yields, catches, threats, and measures that can be used to estimate future adaptive capacity. For global level analysis an index approach will be necessary relying on "big" data. Any information system should be useful to serve, first and foremost, the countries that collect/analyse and provide the data. Reports to FAO that could be compiled into a global picture of the state of inland fisheries would be a value-added product of this process. The national reports would also have utility in reporting on progress towards the Sustainable Development Goals/Aichi Targets.

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1. BACKGROUND TO THE ADVISORY ROUNDTABLE

The global population now stands at 7.6 billion and is projected to rise to 9.8 billion people by 2050. Feeding this growing population requires action across the agricultural sector to achieve this in a sustainable manner. FAO's mandate is to support its member countries in their efforts to ensure that people have regular access to enough high-quality food. Growth in the food producing sectors is one of the most effective means of reducing poverty and achieving food security. However, it must be ensured that the increased productivity does not erode the natural resource base upon which it relies.

Fisheries and aquaculture have an important role to play in this global challenge, and FAO is tasked with monitoring the state of global fisheries as a means to track global food production, food security for sustainability and future supplies, and informing management and international and national actions. Inland fisheries, with recorded landings of 11.6 million tonnes in 2016 (13% of total global capture fishery production), deliver accessible and affordable food of high quality to some of the world's most vulnerable populations.

The substantial contributions that inland fisheries provide globally to combat poverty, hunger and malnutrition, as well as inequality and exclusion, are central for the achievement of the Sustainable Development Goals (SDGs). However, while the SDGs have specific objectives, and therefore also indicators, for marine fisheries, no objectives or indicators for inland fisheries have been included. This is partly a result of the lack of recognition that the challenges faced by marine and inland fisheries are distinct, and that the interests of inland fisheries and aquaculture do not always overlap, and are sometimes opposite. This lack of recognition includes also other relevant emerging issues such as climate change adaptation and mitigation.

Inland fisheries are an integral part of the landscape and is, as a result, impacted and changed as countries develop their water and land resources to produce food and provide services for their growing populations. Recognizing the current contribution of inland fisheries is vital, both for their sustained contribution, but also in recognizing that through urbanization, land use changes, irrigation and hydropower energy production we are undermining the very basis of an existing, and often important food production system.

In some cases, we can seek some co-existence or even capture synergies, elsewhere we need to make decisions on trade-offs, but keeping the impacts on livelihoods and food security in mind. The Aichi Biodiversity Targets argue the need for sustainable fisheries, and call for the restoration of healthy ecosystems, pointing out the relationship between healthy ecosystems and the provision of ecosystem services, which include inland fisheries. Countries are expected to develop national plans, and to deliver and report in accordance with this. However, the framework does not provide the necessary indicators to ensure standard reporting.

FAO reports to the Committee on Fisheries (COFI) on the status and trends for 455 marine stocks covering about 80 percent of reported global marine catch. This assessment is based on stocks that are routinely monitored, and indicates only the extent of exploitation against a reference point (i.e. underfished, maximally sustainably exploited, or overfished).

Inland fisheries may be more discrete than marine fisheries, lacking the same degree of connectivity, which is afforded by coastal and oceanic environments, there are therefore far more individual inland fisheries than marine. On the other hand, around 80% of inland fisheries catch comes from just 20 countries or some 50 major basins, but most of these are not routinely monitored, and fish stocks remain to be defined.

Developing assessments and forecasting future sustainability therefore remains complex and tends to be rather localized and FAO has no system to assess the state of inland fisheries comparable to that of the marine equivalent.

The marine assessment does not attempt to assess the underlying ecosystem effects or the state of the system, which sustains the fisheries, nor does it attempt to deal with any drivers other than that of the fishery exploitation. However, any meaningful assessment of inland fisheries, would need to consider a wide diversity of drivers, of which fishing pressure is only one.

For inland fisheries to be considered by policy makers, resource managers and decision-makers have access to data and information in a format that allows comparison with other sectors. The objective assessment of inland fisheries, their vulnerability to threats and externalities, and the extent to which they are capable of adapting to future change will enable more robust policies and actions to be put in place.

The 32nd Session of COFI noted "the difficulties faced in accurately measuring inland fisheries production," and recommended "the development of an effective methodology to monitor and assess the status of inland fisheries, to underpin their valuation, to give them appropriate recognition and to support their management". COFI requested that FAO develop such an assessment methodology, including broader ecosystem considerations that impact inland fisheries.

1.1 SCOPE OF THE ADVISORY ROUNDTABLE

The 2.5 day Advisory Roundtable was convened to contribute to FAO's response to the request by the 32nd Session of COFI, to:

i. Advise FAO on its approach to developing a more comprehensive report on methods and data and analytical approach, which could be used to provide a credible, objective and replicable assessment of inland fisheries.

ii. Provide guidance on tools that could be provided to member states seeking advice with respect to assessing the status of their inland fisheries (yield/production, threats & drivers), predicting future impacts and how to quantify the effect of mitigation/adaptation measures on fisheries.

1.2 SPECIFIC OBJECTIVES OF THE ROUNDTABLE

i. Advise FAO on the development of an effective methodology to routinely monitor and assess the status of inland fisheries, including broader ecosystem considerations that impact inland fisheries.

ii. Identify an index based on the above that would allow for global level analysis.

iii. Identify practical tools that may be used at different scales (national, basin, etc.) in the characterization and assessment of the status of different types of inland fisheries, including approaches for both well-funded/sound science/robust governance frameworks and situations where funding/human capacity is constrained and rigorous science is not possible and mainly qualitative methods would be required. The tools must be simple and methods scalable so they can be applied at national and subnational levels and across regions, and the method should be sufficiently robust as to allow validation and replicability and to compare among countries sharing basins and using transboundary resources.

iv. Provide advice on a standard format for reporting to COFI on the status and trends in inland fisheries.

v. Provide suggestions on how to highlight the contributions of inland fisheries towards achieving the SDGs and the Aichi targets (and link to SSF guidelines)

vi. Identify and prioritize key activities that should be undertaken to promote the assessment.

1.3 PARTICIPATION

Experts with extensive experience from the most important inland fisheries regions around the world, concerned with the work of FAO as it relates to inland fisheries, were invited to the roundtable. Most of the invited experts had participated in the previous workshops and conferences cited above (the list of the participants is available in Annex II).

2. THE PURPOSE OF AN INLAND FISHERIES ASSESSMENT

The roundtable reviewed and discussed the background (Annex III) that had led up to the roundtable meeting to scrutinize the purpose of an assessment and the scope of coverage and how this could be used to determine the status of inland fisheries.

It further developed the criteria to conduct such an assessment, and then attempted to apply the approach to a number of basins. This practical exercise was based on concrete examples from countries or basins with which the experts were familiar (the workshop agenda is available in Annex I).

Assessing the state of the world's inland fisheries has been a long sought-after goal. Unlike the world's most important marine fisheries, which are measured stock-by-stock on an annual basis, inland fisheries have limited assessments of their current status, and little to no understanding of future risks. Development of an approach and appropriate indices that are scalable and encompass the pressures, adaptive capacity and the value of these fisheries would allow governments to track the state of the their inland fisheries resources and provide input to better understanding of global inland fisheries. Further, a standardized assessment approach and index would be repeatable, allowing not only current understanding, but also tracking these fisheries through time.

The creation of a repeatable approach and index to track the status of the world's inland fisheries would permit governments and other interested parties to prioritize various fisheries for investment or management action. Further, the creation of such an index would allow measurement of progress towards various international aspirations, such as the Sustainable Development Goals or the Aichi biodiversity targets.

The ability to track trends in inland fisheries would thus allow countries to better plan for future needs in food security, livelihoods, and recreation, while allowing countries to prioritize limited financial and other resources in support of these fisheries and focus management efforts where most needed. Therefore, a scalable system would further allow countries to use this approach for their own internal planning and investment and provide information.

A country might, for example, choose to prioritize resources on protecting healthy fisheries versus investment in fisheries that have limited ability to respond to management efforts. This follows on the premise that it is generally more cost-effective to protect existing high quality habitats and functioning ecosystems than it is to try to rehabilitate them once they have been degraded. Countries could also design management strategies to promote adaptive capacity, such as increasing the knowledge among fisheries of techniques to control harvest or development of governance structures that create ownership in these inland fisheries, which in turn often make these fisheries more resilient to perturbations.

3. DEVELOPMENT OF AN DUAL-INDEX APPROACH FOR COMPARISON OF STATUS OF INLAND FISHERIES

Developing traditional stock assessment models for inland fisheries is largely impractical for all but a few of the world's more valuable inland fisheries. Inland fisheries, whether recreational, small-scale commercial or artisanal generally are characterized by fishing for multiple species during the same fishing trip, lacking consistent methods to monitor fishing pressure and harvest, and often occur in areas

where there are limited or no information on their extent (including even basic information such as the species composition of the catch). They are also highly dispersed and often remote.

A scalable framework that allows the appraisal of the current status of a fishery, regardless of its nature and with limited data would require a measure of pressures, adaptive capacity, and value or benefit to society. Threats and adaptive capacity essentially give managers a notion of the vulnerability of these fisheries and the determination of value allows each fishery to be compared to other similar fisheries. Such a method could be modified from approaches that have been used to understand climate change vulnerability although IPCC framework is not necessarily applicable to all small-scale fisheries.

The analysis would allow tracking the fisheries by type, environment, watershed, or species both at basin, country, or regional level over time; and could be used to measure progress towards the SDGs. However, given the variable access to and availability of data in different parts of the world, it may not be possible to work at the same level of resolution at national, regional, and global levels.

During the Roundtable, a draft framework was developed and tested with several inland fisheries at various spatial and value scales to ascertain whether the framework would allow a reasonable measure of inland fisheries status.

To assess the status and the vulnerability of the fisheries a bubble chart was used (Figure 1): Where a horizontal axis represent the multiple pressures[1], which face inland fisheries and which enable or constrain the supporting ecosystem in any country or region, and the vertical axis represent the adaptive capacity of the fishery[2], i.e. the degree to which the fishery is able to cope or adapt to the pressures - including also governance and institutional/legal dimension and fishery capitals.

The metric for the pressures should be derived from a composite index[3] of pressures facing the fishery (Table 1) and where possible it should be derived from global datasets (although, where more comprehensive, or accurate, data are available at the national level such data could be used for a national assessment). Expert opinion could be used to weight the different pressures according to their specific relevance to the fisheries being assessed in absence of robust information.

Adaptive capacity (Table 2) would also be measured through a composite index; in this case derived from the capacity of the country to accommodate the pressures through management adjustments, regulatory action, adaptations, environmental adjustment, restoration, and economic adjustments, as well as the ecosystem's capacity to respond to management actions. It would look at both current and future vulnerability. Here too, expert opinion or other proxy information can be used when data are scarce.

[1] Pressures act on the fisheries to potentially impact their stability through time, by exposing them to conditions that negatively impact their sustainability growth, or by hitting sensitive components of the system, or both, and include those specific to the fishery (such as exploitation), and others external to the fishery such as habitat modifications, market demands, legal frameworks, land use changes, etc.

[2] Adaptive capacity is the fisheries' ability to absorb pressures or respond to changes caused by pressures, and measures whether the system has the internal resources (whether anthropogenic or natural) to maintain stability or respond effectively to increased pressure. Adaptive capacity can consist of both natural abilities and social measures, but given that governments have the ability to influence social capacity directly through policy choice and regulation to either absorb pressure or respond to change, the focus on social measures is likely to have a greater impact on the current status of inland fisheries.

[3] The major components of the index were identified, however, time did not allow full development of the index during the meeting.

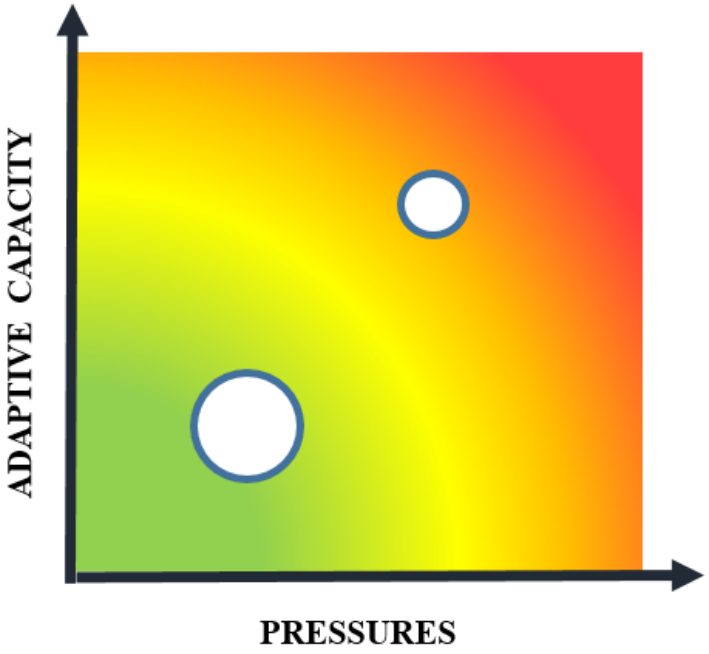

Figure 1: The tool for assessing inland fisheries status and vulnerability developed by the Roundtable. The horizontal axis represents the pressures on the fisheries, the vertical axis the adaptive capacity, and the size of the bubbles the value of the fisheries.

The chart conveys information about the relative vulnerability status of each of the fisheries under scrutiny. Fisheries in the bottom left part of the plot are those which are currently subject to the lowest stressors that negatively impact inland fisheries, but are also the least resilient to pressure; the upper right corner are highly resilient fisheries subject to high levels of stress; the lower right are fisheries under pressure with low adaptive capacity; and upper left with fisheries with high adaptive capacity that are not under pressure. Adding a background with a colour gradient may facilitate interpretation (Table 3).

Table 1: Metrics that could be used to develop the pressures axis (Drivers/outcomes that undermine/compromise the fishery)

PRESSURES ON THE SYSTEM	DRIVER	INDICATOR(S)	WHAT THIS INDICATES	SOURCE OF DATA ASSUMPTIONS-COMMENTS
Resource extraction /fishing pressure				
Total, urban and rural population densities	Demand for fish as food; Demand for fish for recreation Demand for fish as commodity	Population density within xx radius of fishery; % Urbanization of population; % Rural population; Rural population density.	**Proxies for:** Extent of exploitation of fish stocks; Likely dependence on fish for food and employment (vs. recreation); Number of people near to fishing areas that can access the fishery.	**Source:** UN DESA**;** FAOSTAT rural/urban population. **Assumptions:** That a high overall population density mean that all fishable resources will be targeted; That if there is a high percentage of the population living in and around inland fisheries resources, that these will be subject to relatively high fishing effort; That the degree of urbanization is a proxy for overall economic development, and highly urbanized societies may tend to fish for recreation rather than food; Urban populations have less access to wild fishery resources.
Poverty/low level of economic development	Livelihoods heavily based on natural resource extraction or agriculture.	GDP; Poverty index; Number of people without formal employment; Low household incomes; Unemployment.	**Proxies for:** Likely degree of exploitation of fish stocks; Likely dependence on fish for food.	**Source:** World Bank **Assumptions:** That in developing countries there is relatively higher dependence upon extraction of food from the wild; Agricultural populations tend to concentrate around water bodies and courses; Low-income families may fish to supplement food or income in the household.
Fishing pressure	Demand for fish as food; Demand for fish for recreation Demand for fish as commodity	Number of fishers (as percent of population); Fisher density.	**Proxy for:** Extent of exploitation of fish stocks.	**Source**: National survey data; case studies.
		Change/trend in CPUE, catch composition and individual fish size	**Direct measure:** Indication of state of fish stocks (if tracked over time).	**Note:** This is fishery specific and may not be generalized across all inland fisheries in a country.

Table 1: Metrics that could be used to develop the pressures axis (Drivers/outcomes that undermine/compromise the fishery)

PRESSURES ON THE SYSTEM	DRIVER	INDICATOR(S)	WHAT THIS INDICATES	SOURCE OF DATA ASSUMPTIONS-COMMENTS
			Indication of fishing pressure (nets types, fishing regulation)	
Environmental pressures				
Organic and inorganic pollution	Industry, agriculture, mining runoff & waste discharges.	Concentration of heavy metals and toxic chemicals in water, sediments and fish tissue.	**Proxy/direct measure:** Likely impact of inorganic contaminants; Poor water quality for fish; Poor quality of fish as food.	**Source:** Water and sanitation index (Yale) Global Drinking Water Quality Index The global water quality database GEMStat **Note:** If the original data that was used to derive the index can be accessed, it may contain useful information about source water.
	Domestic sanitation & sewage treatment; Cities; Urbanization.	Potential for of untreated sewage entering aquatic ecosystems.	**Proxy for:** Exogenous Nutrients (N/P) Degree of eutrophication of receiving waters; Likely impact of inorganic contaminants.	**Source:** WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation.
	Agriculture and livestock	% of national area under agriculture.	**Proxy for:** Degree of change of natural environment; Deforestation; Farming intensity; Likely nutrient runoff; Possible soil erosion.	**Source:** FAO AQUASTAT **Assumptions:** Agricultural development & intensification all result in higher levels of fertilizer and pesticide use, and this impacts runoff into inland waters. All will generally impact negatively on watersheds, water resources, water quality etc. and thus tend to impact inland fisheries. Low level eutrophication would have a beneficial impact on water fertility and productivity of water bodies, and may be a positive factor for man-made water bodies. However, may lead to changes in species composition.
		Farming intensity.	**Proxy for:** Nutrient levels in water; Degree of eutrophication;	**Sources:** Vörösmarty *et al*. 2005 US EPA may have some global work on nitrogen and phosphorous loads;

Table 1: Metrics that could be used to develop the pressures axis (Drivers/outcomes that undermine/compromise the fishery)

PRESSURES ON THE SYSTEM	DRIVER	INDICATOR(S)	WHAT THIS INDICATES	SOURCE OF DATA ASSUMPTIONS-COMMENTS
			Pesticide concentration in water.	**Assumptions:** Note eutrophication may also drive the fishery and be positive (see explanation above).
		% of farmland irrigated.	**Proxy for:** Intensity of production and water use.	**Sources:** FAO AQUASTAT / FAOSTAT As above- a measure of degree of agricultural intensification and water abstraction.
		Livestock production/livestock density.	**Proxy for:** Possible nutrient loadings; Modification of riparian vegetation and aquatic habitats.	**Sources:** FAOSTAT **Assumptions:** High livestock production will increase manures and wastes, with increased nutrient impacts on water sources; Livestock will need access to water and their owners remove vegetation and the animals will trample brinks and shallow water areas.
	Aquaculture	Aquaculture production; fish farm effluents (nutrients, hormones); escaped fish	**Proxy for:** Nutrients, chemicals; Water quality; Escapees/invasive species; Possible health risks for wild fish (usually the other way around).	**Sources:** National reports on aquaculture; FAO FISHSTAT - Freshwater aquaculture production **Assumptions:** Independent of the amount of production, aquaculture can have high impacts on receiving waters. Even a small production can have a high impact on local/native species and damage a fish population.
Habitat loss and degradation	Changes in land use including draining of wetlands.	Agricultural land use (% of total land area).	**Proxy for:** Degree of land use change (see above) and likely amount of habitat suitable for fish (especially conversion of wetlands, drainage, and flood control).	**Sources**: Agricultural land area: FAOSTAT; Habitat quality: Global ecosystem Restoration Index; Vörösmarty *et al*. 2005. **Assumptions:** Deforestation, land use change and agricultural development/intensification al have generally negative impacts on watersheds, water resources, water quality etc. and thus tend to impact inland fisheries.
		% change in wetland area.	**Proxy for:**	**Sources:** Wetland database.

Table 1: Metrics that could be used to develop the pressures axis (Drivers/outcomes that undermine/compromise the fishery)

PRESSURES ON THE SYSTEM	DRIVER	INDICATOR(S)	WHAT THIS INDICATES	SOURCE OF DATA ASSUMPTIONS-COMMENTS
			Change in the amount of habitat suitable for fish.	**Assumption:** Loss of wetland area will lead to lower fish production and fish catches.
		% of wetland as % of national land area?	**Proxy for:** Amount of habitat suitable for fish.	**Sources:** GLWD; CIFOR Global Wetland database. **Assumption:** Loss of wetland area will lead to lower fish production and fish catches.
		Land cover change index.	**Proxy for:** Change in the amount of habitat suitable for fish.	**Sources:** FAOSTAT agricultural land as a proportion of total land use. **Assumption:** Changes in land use will affect aquatic habitats and translate into changes in fish production.
	Soil erosion and loss of water quality.	Deforestation.	**Direct measure:** % change in forest cover. **Proxy for:** Deteriorated watershed quality; Runoff-water quality; changing water flows	**Sources**: IIASA Global Forest Database; World Bank Forest cover. Normalized Difference Vegetation Index (NDVI). **Assumption:** Deforestation leads to increases in erosion and sediment load in rivers and streams reducing water quality for fish.
		Sediment load.	**Proxy for:** Water quality in clear water systems; Stream bed and habitat quality?	**Sources:** Global river sediment yields database **Note:** This is not always a problem as there are river systems that have naturally high sediment loads (e.g., many tropical large rivers).
	River training	Straightened river channel; unified width and depth; engineered embankments.	**Proxy for:** Change in the amount of habitat suitable for fish; Altered water flow and hydrology	**Source:** **Assumption :** Trained rivers are less suitable as fish habitat and will present less biodiversity and have lower fish production.

Table 1: Metrics that could be used to develop the pressures axis (Drivers/outcomes that undermine/compromise the fishery)

PRESSURES ON THE SYSTEM	DRIVER	INDICATOR(S)	WHAT THIS INDICATES	SOURCE OF DATA ASSUMPTIONS-COMMENTS
Impacts on water **Water stress /amount of water available for ecological flows**	Water stress index.	FAO water stress index; Aqueduct water stress rankings; Number of people per 10^6 cubic meters of water; Regional water vulnerability index: aggregated water use, resource reliability, and socioeconomic coping capacity; Water poverty index.	**Proxy for:** Availability of water for fisheries.	**Sources:** WRI Aqueduct; FAO AQUASTAT; Vörösmarty *et al*. 2005. **Note:** Generally just country level, does not account for local/ regional water stress. 1 700 m^3/capita/year is widely accepted as a threshold below which varying degrees of human-induced water stress are likely to occur. Basic human water requirements (BWR): 50 l/capita/day. Water Poverty Index (WPI): originally the ratio of available resource to water required for BWR and food production to account for food productivity differences in arid and semiarid environments and wastewater recycling. Modified to also incorporate ecosystem condition, community well-being, human health, and economic welfare.
	Abstraction of water for agricultural, urban, industrial purposes.	Total water use as % of total water resources.	**Proxy for:** Availability of water for fisheries.	**Sources:** WRI Aqueduct; FAO AQUASTAT; FAOSTAT.
		Irrigation (% irrigated land).	**Proxy for:** Availability of water for fisheries.	**Sources:** WRI Aqueduct; FAO AQUASTAT**;** FAOSTAT.
		Total area equipped for irrigation. % of total land use?	**Proxy for:** Availability of water for fisheries.	**Sources:** WRI Aqueduct; FAO AQUASTAT; FAOSTAT.
Water regulation, connectivity	Reservoirs	Amount of national/basin storage of water as % of total inflow; Retention time.	**Proxy for:** Extent of water regulation and likely availability of ecological flows;	**Sources:** River Regulation Index (RRI); WRI Aqueduct (based on FAO AQUASTAT); FAO AQUASTAT - total renewable water resources.

Table 1: Metrics that could be used to develop the pressures axis (Drivers/outcomes that undermine/compromise the fishery)

PRESSURES ON THE SYSTEM	DRIVER	INDICATOR(S)	WHAT THIS INDICATES	SOURCE OF DATA ASSUMPTIONS-COMMENTS
		Total reservoir area	Extent of water use for non-fishery purposes.	**Notes:** Difficulty with man-made reservoirs, potentially good habitat for the fish the reservoir now supports, but the original fishery may have disappeared; Runs the risk of suggesting that reservoirs support good fishery, habitat and a good management option, which is not necessarily the case.
	Dams and weirs.	Number and size of dams. Dam density	**Proxy for:** Degree of habitat connectivity for fisheries. Degree of flow regulation	**Sources:** Global Lakes and Waters Database (GLWD), International Commission on Large Dams (ICOLD). **Assumption:** All dams and weirs independent of their height can have negative impacts on biodiversity, fish production and catches.
Loss of longitudinal connectivity	Presence of dams and weirs in critical areas.	Indicator species (e.g., abundance of migratory species).	**Proxy for:** Degree of habitat connectivity.	**Sources:** Species landing data; GLWD.
Loss of lateral connectivity	Irrigation water control structures.	Irrigation (% irrigated land).	**Proxy for:** Degree of habitat connectivity for fisheries.	**Sources:** WRI Aqueduct; FAO AQUASTAT.
	Flood protection; Levees/polders; Flood proof roads.	% Floodplain fragmentation.	**Proxy for:** Degree of habitat connectivity for fisheries.	**Sources:** River Fragmentation Index (RFI).
Biodiversity loss	Many of the other drivers	Number of endangered species	**Proxy for:** Conservation value General threats to fisheries	**Source:** IUCN Redlist **Note:** If species of strong commercial/cultural interest, this should also be captured in the "Value" of the fishery.
Invasive species	Aquaculture	Presence/Abundance of invasive species in aquaculture operations	**Proxy for:** Threats to indigenous species	**Sources:** Global Invasive Species Database (IUCN); FISHBASE and FAO DIAS.

Table 1: Metrics that could be used to develop the pressures axis (Drivers/outcomes that undermine/compromise the fishery)

PRESSURES ON THE SYSTEM	DRIVER	INDICATOR(S)	WHAT THIS INDICATES	SOURCE OF DATA ASSUMPTIONS-COMMENTS
	Stocking with exotic species	Extent of fisheries enhancements.	**Proxy for:** Threat to indigenous target species?	**Sources:** National reports on open water stocking. **Note:** Some discussion in EIFAAC Occasional Paper 50: Aquatic invasive alien species – top issues for their management.
Climate change	Changes in precipitation, evaporation and temperature (flood extent duration and timing); Duration and frequency of extreme events.	Meteorological data; Water stress index; Future water stress; Precipitation change over baseline; Temperature change of baseline.	**Proxy for:** Various water and temperature related stressors. Water availability/water stress.	**Sources:** WRI Aqueduct; National meteorological institutes; IPCC. **Note:** This could be good or bad for target fishery.

Table 2: Adaptive Capacity: Features that indicate potential resilience of the fishery. This covers the intrinsic characteristic of the fish and the fishery

FEATURE	INDICATOR	WHAT THIS INDICATES	SOURCE OF DATA COMMENTS
Fisheries management	Conservation measures (Amount of protected area; Closed areas/spawning grounds) Other effort restrictions	**Direct measure/Proxy for:** Regulation of fishing pressure.	Protected areas may become unavailable to fishers, further reducing fish availability. Could be measured as % fishing area protected or number of days closed for fisheries
Environmental management	Existence of pollution controls/measures to mitigate	**Proxy for:** Water quality,	**Source:** Environmental legislation/policy **Note:** depends upon whether (and to what extent they are enforced. Environmental regulation linked to governance index (capacity to enforce and to implement).
Ecosystem health	Active measures to protect or restore habitat/water resources or directly on fisheries. Stated intention to restore ecological functions for fisheries.	**Proxy for:** Habitat protection and restoration. Restoration of ecological connectivity. Re-establishment or maintenance of e-flows.	**Source:** Fishery, environmental legislation/policy **Note:** The ideal situation would be a fully functional ecosystem with natural processes and flows. In the case of restoration or rehabilitation scoring would be based on the success in restoring these processes.
Productivity	ChlA	**Proxy for:** Water fertility/productivity	**Source**: Method for freshwater lakes described in Sayers *et al*. 2015 **Note:** The indicator is only useful for lentic systems. Flowing waters are often reliant on heterotrophic food chains. The response will be highly variable across environments, and dome shaped.
Capacity to mitigate or evidence of mitigation activity	Habitat enhancement Active mitigation measures	**Direct measure:** Active mitigation/management actions **Proxy for:** Willingness to invest in inland fisheries.	**Source:** Documented policies or active programmes; enforced legislation **Note:** Possibly combine with restoration.
Biological	Stocking/fisheries enhancement.	**Direct measure:** Capacity to sustain a fishery artificially, or restore/create a fishery in impacted waters.	**Source:** official documentation. **Note:** These would not be necessary in a system that has not been impacted/perturbed. However, it is a measure of the

Table 2: Adaptive Capacity: Features that indicate potential resilience of the fishery. This covers the intrinsic characteristic of the fish and the fishery

FEATURE	INDICATOR	WHAT THIS INDICATES	SOURCE OF DATA COMMENTS
			extent to which a system can be assisted if a perturbation occurs, and thus an indication of vulnerability. The success criterion would be whether it has been possible to restore or increase fish harvests beyond the yield from the natural system, and the degree of sustainability.
	Existing aquatic biodiversity. Number of species in the catches.	**Proxy for:** Degree of resilience of the fishery.	**Sources**: FEOW/GBIF databases; Highly diverse multi- species fishery; High biodiversity confers more resilience (https://www.nature.com/articles/sdata2017141) **Note:** This will need to be measured against a baseline of either historic catches or other similar fisheries in the same area. There is a need to be careful because of redundancy of species. There is a question as to how to measure biodiversity as a proxy for resilience and whether to use a composite indicator (e.g. species richness, abundance, proportion threatened etc.)
	Phenology (proportion of r- selected species). Species with vulnerable/resilient life traits/characteristics (those able to respond → not able to respond).	**Proxy for:** Degree of resilience of the fishery.	**Source:** **Note:** Express as proportion of yield. More r-selected species might yield more in good years, but stocks are likely to experience larger fluctuations than more k-selected species. Thus r = more productive but more fluctuating fisheries; k = more stable fisheries but with less rebuilding capacity. The manner of scoring for adaptive capacity will be dependent upon the nature of the system.
	Proportion of periodic species	**Proxy for:** Potential for fishery recover as environmental conditions become favourable	**Source:** **Note:** higher proportion indicates greater potential Apply in those waterbodies where fisheries performance strongly depend on hydrological drivers.

Table 2: Adaptive Capacity: Features that indicate potential resilience of the fishery. This covers the intrinsic characteristic of the fish and the fishery

FEATURE	INDICATOR	WHAT THIS INDICATES	SOURCE OF DATA COMMENTS
	Proportion of migratory species	**Proxy for:** Potential vulnerability of fisheries to national and transboundary pressures	**Source:** Note: Apply in those waterbodies where fisheries sustainability strongly depend on migratory species.
	Distribution.	**Proxy for:** The degree of resilience of the species.	**Source:** (FishBase) FEOW proportion of endemic species; **Note:** The more species that have broad distributions indicates resilience (wide-range → narrow-range). Need to decide if endemic for a basin or a country level. If an endemic species with narrow range is lost then that's worse than a wider distribution.
Livelihood portfolio	Human Development Index (HDI).	**Proxy for:** Societies' capacity to adapt to a threat to the fishery.	**Source:** http://hdr.undp.org/en/data
	Fish consumption versus consumption of other sources of protein, nutrients and vitamins.	**Proxy for:** Dependency on fisheries for nutrition – existence of alternatives or high dependence and therefore vulnerability to loss of the fishery.	**Source**: http://www.fao.org/faostat/en/#data/CL
Governance structures	WorldWide Governance Indicators.	**Proxy for:** Capacity to enact laws and enforce regulations, the extent to which rights and needs of stakeholders are supported. Degree of accountability	**Source:** http://info.worldbank.org/governance/wgi/#home **Note:** Covers - Voice and Accountability; Political Stability and Absence of Violence; Government Effectiveness; Regulatory Quality; Rule of Law; Control of Corruption
	Legal/regulatory framework and management measures specific to inland fisheries;	**Proxy for:** Level of consideration given to inland fisheries.	**Source**: http://www.fao.org/faolex/en/ **Note:** covers - National, local, co-management; Extent/effectiveness of enforcement; Spawning area protected, closed seasons? Bag limits?
Degree of isolation	Presence of fish markets; % fish caught that is sold;	**Proxy for:**	**Source**: Maps

Table 2: Adaptive Capacity: Features that indicate potential resilience of the fishery. This covers the intrinsic characteristic of the fish and the fishery

FEATURE	INDICATOR	WHAT THIS INDICATES	SOURCE OF DATA COMMENTS
(fishery accessibility)	Road density.	Susceptibility of the fishery to fishing pressures.	

Table 3: Definition of the terms used in the assessment

PRESSURES	ADAPTIVE CAPACITY
Vulnerable: At greatest risk	
Multiple environmental threats from: Loss of connectivity and flow; periodic flood pulses affected by regulations impacts from sediment, nutrient runoff and pollution; existential threats for invasive species Fish assemblage is not resilient to environmental pressures Large and migratory species threatened/impacted Fishers have lost fishing access and have very limited fishing areas Loss of critical habitats (floodplains)	Ineffective/non-existent management of fishery is resulting in impacts Ineffective governance /regulatory controls unable to address the most important drivers No protection Fishery highly accessible to fishers Limited or low compliance Limited economic capacity to implement mitigation or adaptation measures/actions Low resilience of fishery to fishing pressure and environmental threats Very low human capital to cope with threats Poor legal framework or not developed on an ecosystem-based approach and poor governance process
Persistent: May be at risk from fishing impacts or environmental impacts in the future, but limited capacity to adapt or address these.	
Few/moderate environmental threats Flows and habitat slightly impacted Limited pollution and nutrient runoff No invasive species threats Biodiversity fragile /not resilient to environmental pressures	Fishery management only focused on limited fishery-based regulations Ineffective governance /regulatory controls unable to address the most important drivers Fishery highly accessible and no protection Limited or low compliance Limited economic capacity to implement mitigation or adaptation measures/actions Low resilience of fishery to fishing pressure and environmental threats Stock susceptible to fishing pressures and environmental threats at specific spots, but not at basin/environment scale
Adaptable: May be at risk from environmental pressures but sufficient capacity to address these	
Multiple environmental threats impacting Impacts on water flows, flooding and connectivity Water impacted by pollution nutrient and sediments in runoff	Effective management of fishery Relatively inaccessible or protected fishery resources Sufficient economic capacity to implement mitigation or adaptation measures/actions Effective governance /regulatory environment able to implement mitigation measures High proportion of species resilient to fishery pressure and environmental threats
Resilient: Not currently at risk – few threats and adequate capacity to adapt	
Few environmental threats Flows and habitat not impacted Limited pollution and nutrient runoff No invasive species threats Biodiversity resilient to pressures	Well-developed social, financial and human capitals Effective management of fishery based on ecosystem principles Effective governance /regulatory controls addressing the most important drivers Effective protection Fishery access is managed in accordance with resources Good compliance

PRESSURES	ADAPTIVE CAPACITY
	Sufficient economic capacity to implement mitigation or adaptation measures/actions High proportion of species resilient to fishery pressure and environmental threats

3.1 VALUATION

A third dimension (Table 4) would be the value[4] of the fisheries or the benefits to society, which would be illustrated by the size of the bubbles. Not all inland fisheries have the same level of importance or value to societies, and given the limitations in resources available to effect change in management a measure of value will be necessary to place each fishery in the proper context and help governments determine to which fishery the highest priority for action and investment should be given.

Table 4: Potential indicators for the value of the fishery

Value area	Variable/indicator	Criteria for scoring
Food	Total catch; Per capita consumption; Nutritional value/role (% total protein, micronutrients etc.).	Food/Nutrition (low dependence → high dependence).
Socio-economics	Overall economic value of the fishery (split into export and local economy).	High value to low value; Direct comparison between values.
	Employment (split into primary and secondary services and gender).	Livelihoods (low dependence → high dependence); Human capital (diversity of expertise → few skills within a community).
	Dependency (value of fishing compared with other alternatives – i.e., availability of alternatives if fishery is impacted).	Income (low dependence → high dependence); Social security (high protection → low protection).
Biological	Fishery compared with total number of species (e.g., exploited vs total).	High number of species utilized by the fishery → low number of species.
	Biodiversity.	Biodiversity: High number of species → low number of species.
	Presence of a specific endangered species or unique endemism.	Endangered/endemic species: Low number of species → high number of species.
Cultural value	Yes/no if there is a traditional value; Specific relevance to indigenous peoples.	High cultural significance → low cultural significance.

[4] Value in inland fisheries has been difficult to assess given that most of their value goes beyond traditional market-based economic approaches Traditional market approaches to estimating inland fisheries values have limited applicability outside of a few high-value, export-oriented fisheries (e.g. Nile perch in Lake Victoria, sturgeon caviar fisheries, and ornamental fisheries, whereas a large number of fisheries in large floodplain rivers or remote areas exhibit diffuse commercial chains that are difficult to evaluate.

However, estimation of value for inland fisheries is a complex measurement consisting of not only traditional market based approaches, but also measures of the fishery's food[5], livelihood, nutritional, socio-economical, biological, and cultural[6] contributions (scaling could be based according to Ecosystem Approach requirements).

Each of the value areas should be standardized equally to reduce value bias (e.g. 0 - 3 for each section for a total possible maximum score of 12) and add the total score would constitute the fisheries "value" (it is also possible to use percentage of the maximum score to get a value between 0 and 1). However, the criteria used may be country and context specific and would inter alia depend on national priority setting.

3.2 SOURCE OF DATA/INFORMATION

The metrics, which would be used in the assessment, can be derived from a number of sources. For relatively static, or slow-changing variables (that vary relatively little over a 5-10 year interval), it is possible to extract the values from global data sets. A table of potential data sources is presented in Annex IV.

For small countries, the national data may be a good approximation to the general pressures facing the fisheries within the country.

This relationship will tend to break down in the case of large countries (e.g., Canada, Russian Federation. United States of America, China, India and Brazil) and others where there are significant differences in climate, rainfall, and ecology across the continental scale of these countries. In this case, the pressure data may need to be based on sub-national figures and be specifically relevant to the sub-national basins/geographic areas/fisheries. If such sub-national data are not available, expert opinion may be used to weight the values to account for the variation within the country.

Pre-populating the data for each country based on the global data set could be undertaken to facilitate a country assessment. If specific national data were available, they could be substituted in, and local expert knowledge could be used to weight the figures to improve their relevance. In an ideal scenario, a web portal with the global data would be available and country level managers could input their fishery data, weight the different pressures, and score their fishery values and would then automatically be able to see the relative status of their fishery on the risk matrix and be presented with management options for a fishery with that level of vulnerability.

3.3 ASSESSMENT AT A GLOBAL LEVEL

To make an objective, replicable, and manageable global assessment that would allow also for comparisons across geographic regions, it should draw on global databases for quantifying exposure.

Most of the available indicators do not change over a biennial period, and the fluctuating nature of inland fisheries and their sensitivity to environmental factors such as flow means that inter-annual variability is often very high. In addition, many of the indicators or factors to be measured may only be collected at decadal intervals. This means that only long-term substantive trends can be measured, or data must be averaged across a 3-5-year period.

A global assessment over 5-10-year intervals would be the time scale where a meaningful change could be detected. Such an assessment could also be used to inform progress towards the SDGs.

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[5] "Food provision" cannot be judged exclusively by "tonnes of fish produced" as a "small" production locally can have a great impact on food availability and food provision.

[6] Cultural significance is subjective and hard to assess. It will have to be determined in close cooperation with the relevant local people/communities concerned.

3.4 ASSESSMENT AT THE NATIONAL LEVEL

An assessment of a country's inland fisheries by waterbody (e.g., Lake Kariba or Victoria), environment (e.g., floodplains, small reservoirs, rivers), by type (commercial, subsistence or recreational), by participation/importance and it could be undertaken biennially or at periods of less than five years. Scalable approaches may be preferable – this could assist in prioritization of what to monitor.

The assessment could, for example, cover >75% of the "value" of the fisheries; the valuation should be based on a common set of principles. However, the weighting of the individual elements should be decided by the countries themselves.

A country with adequate financial resources might try to cover all major basins. A country with more limited resources may focus on main food fisheries, major water bodies, or a number of representative fisheries for a diverse set of environments.

In principle, the fisheries monitored should be representative because all fisheries may be important in some way. Small-scale diffuse fisheries could be monitored through a sampling approach and results extrapolated.

- Area-based approaches can be used to upscale harvest estimates from a small number of monitoring sites with similar limnological and climatic features to extrapolate harvest to other comparable environments.
- The countries should ideally state what coverage they have achieved.
- Alternatively, include an estimate of the fisheries areas covered (e.g. countries could submit estimates of coverage, e.g. 100% of large scale commercial, 75% of small scale, 30% subsistence, 10% recreational fisheries).

3.5 PRESENTATION OF THE DATA

The resultant scores, which can be derived using this approach allows the comparison between fisheries, countries, or types of value. This is presented in Figure 2 a-d. The comparisons possible are:

- Comparison between countries based on an aggregate national score of different inland fishery types. Note that this is likely to be quite subjective. In addition, it is possible and even likely that different types of fisheries within the country will have different status and averaging scores will therefore not convey the information needed to do a proper assessment. The value of this for assessment and specific management interventions in many cases is therefore limited (Figure 2a).
- Comparison of the same fishery between time-periods (Figure 2b).
- Comparison between different types of fishery (e.g., reservoirs, riverine, floodplain, natural lakes etc.) within a country (Figure 2c).
- Comparison of food fisheries and recreational fisheries based on value or total (retained) catch fishery (Figure 2d).

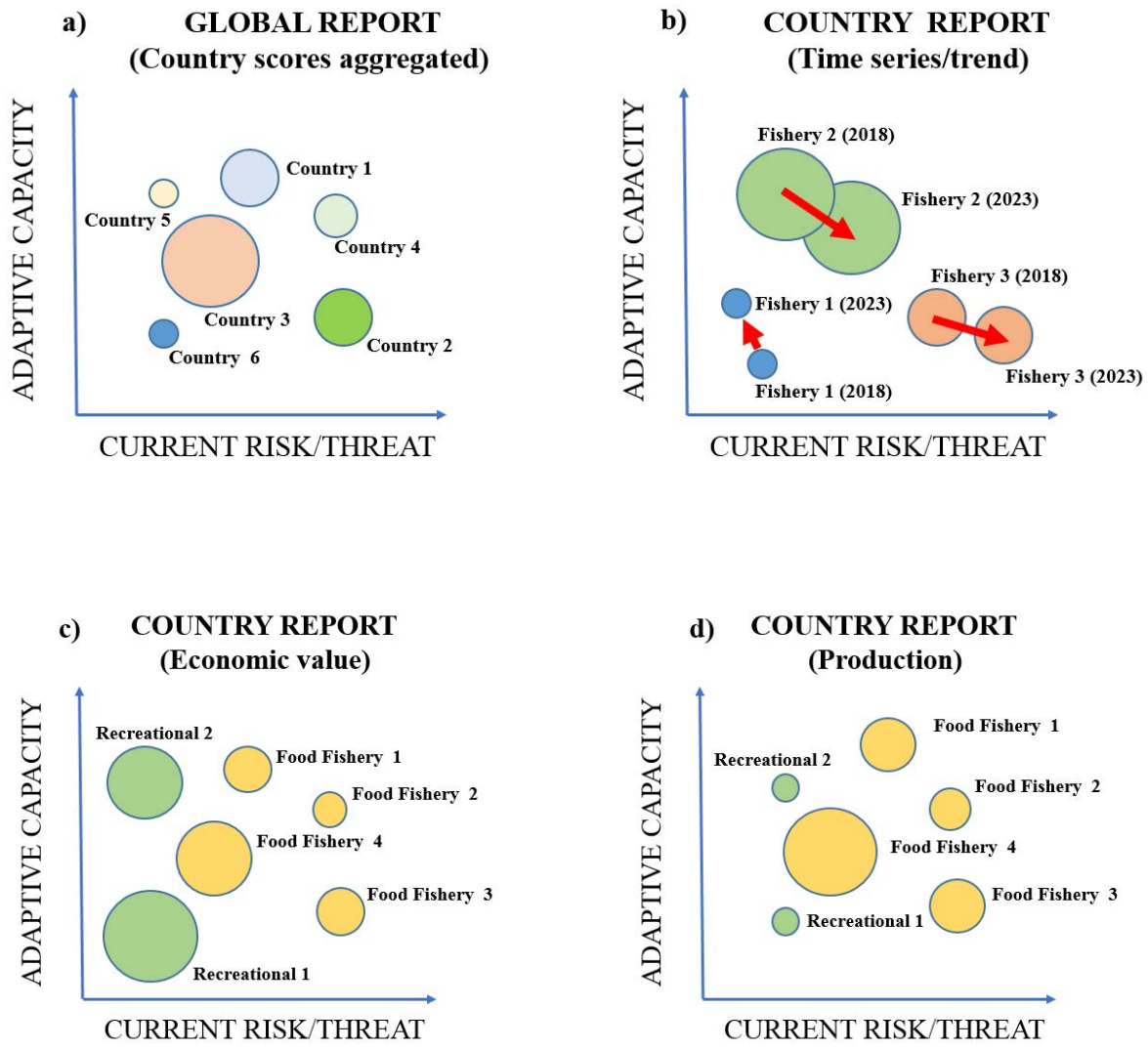


Figure 2: Different ways of presenting the assessment to indicate trends, relative importance of food versus recreation, different types of fishery: a: Comparison between countries, b: Comparison between time-periods, c: Comparison between different types of fishery, d: Comparison of food and recreational fisheries.

To try to validate the approach developed during the workshop, three examples were tested by the group as proof of concept. This was also a means to check the relevance/effectiveness of the different indicators used in the composite indices. These were:

- La Plata Basin fisheries (the fisheries of a major international basin – a mixture of food and recreational fisheries) (Figure 3).
- Zambia inland fisheries (national fisheries – mainly food fisheries) (Figure 4);
- United States Laurentian lake fisheries (a subset of national fisheries – mainly recreational) (Figure 5)

The metric for value was taken simply as the total catch (in tonnes) of the fishery.

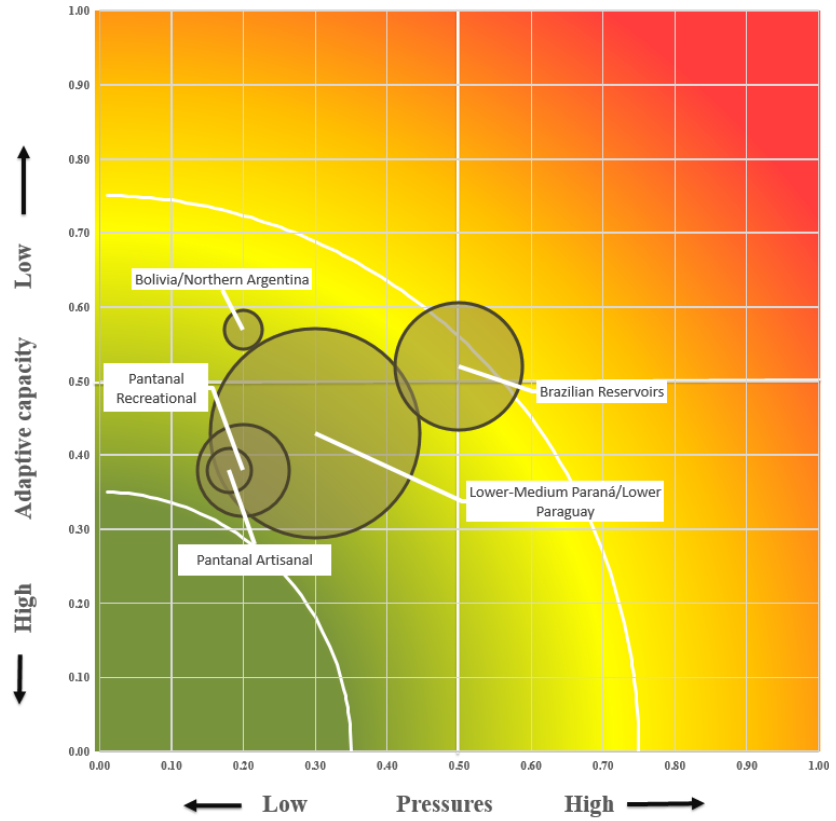


Figure 3: Trial plot of some of the key inland fisheries of the La Plata basin

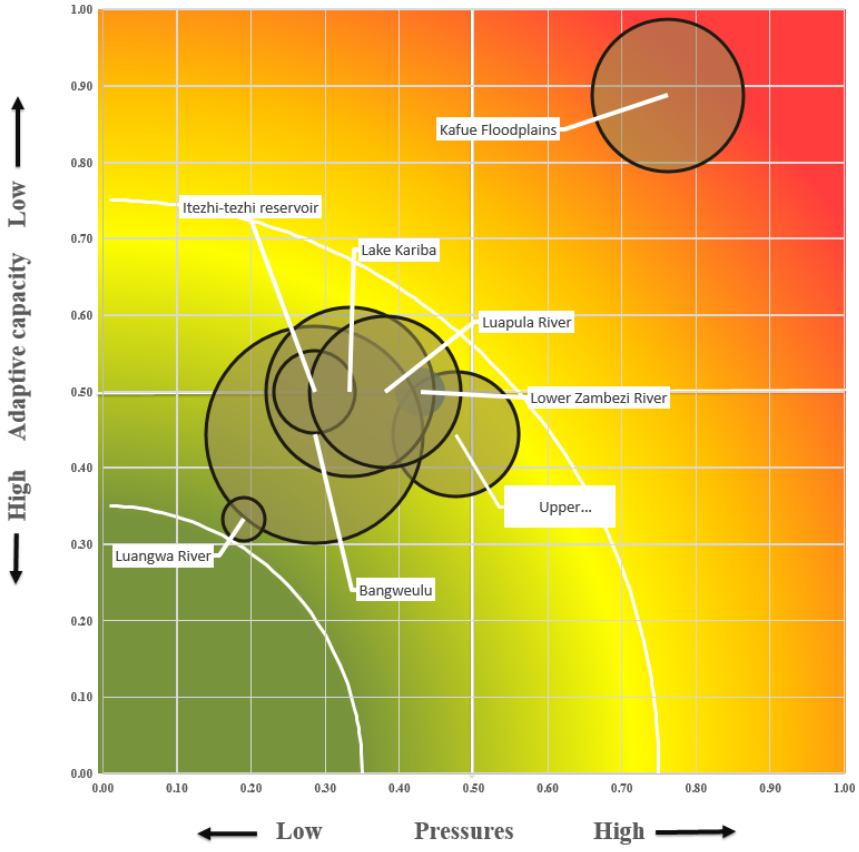


Figure 4: Trial plot of some of the key inland fisheries of Zambia

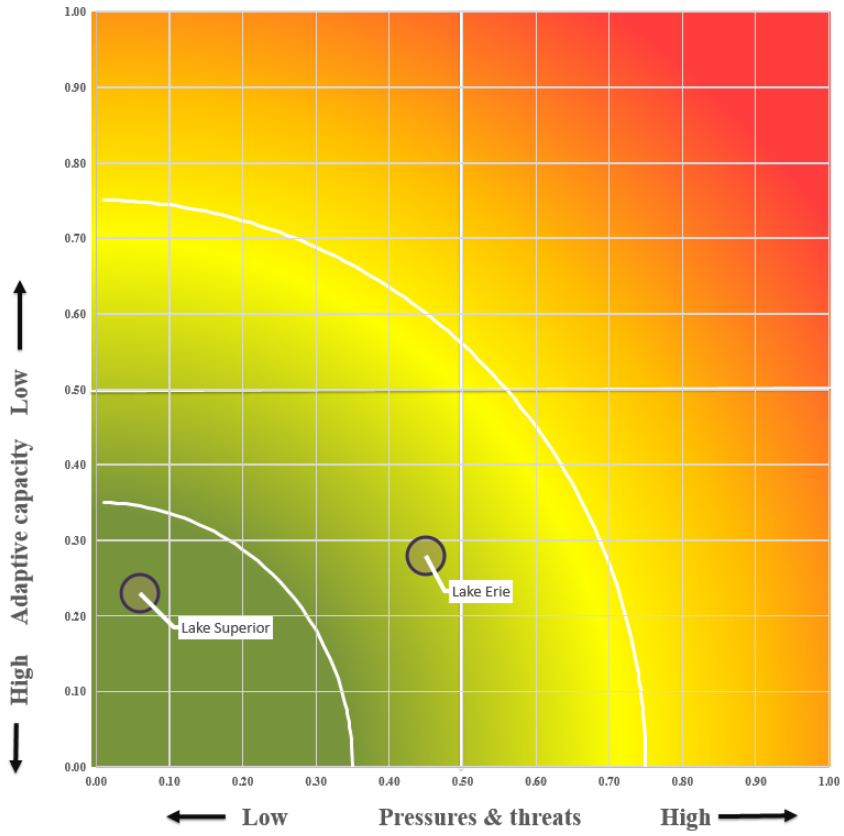


Figure 5: Trial plot of some of the inland fisheries in US waters of the Great Lakes

4. TRIAL OF VALUATION METHOD

Table 4 shows an example for Lake Victoria that was done by the roundtable. In this case, two types of fisheries were recognized, the Nile perch fishery and the fishery for other species.

Table 4: A test with valuation scoring for Lake Victoria fisheries - higher scores indicate more 'value'.

Indicator	Nile Perch	SCORE	Other species	SCORE
Production	230 000 tonnes	3	670 000 tonnes	3
Consumption	Exported	0	50% ASF	2
Value	USD 250 million	3	USD 1 million	1
Employment M	30% primary	1	70% primary	2
Employment F	10% secondary	1	90% secondary	3
Dependency	The groups engaging in this activity have no other alternatives	3	The groups engaging in this activity have no other alternatives	3
Richness	The species richness in the lake ecosystem is high. Although these fishers tend to only exploit one species.	3	The species richness in the lake ecosystem is high. Some fishers may specialize for example in	3

			small pelagics, others may target multiple species.	
Endemic	The species targeted has been introduced and may even suppress native species. So has no biodiversity value. However, it has subsequently formed the basis of a large commercial fishery	2	Most of the species targeted are native. Many are endemic.	3
Endangered	The target species is not threatened with extinction.	0	Some species have become very rare.	3
Cultural / traditional	Since the fishery is based on an introduced species, it is not a traditional fishery.	0	Since most species caught are indigenous the fishery is part of the cultural heritage.	3
TOTAL		**16**		**26**

5. LESSONS LEARNED FROM THE PILOT EXERCISE

Most indicators are likely to be scored based on expert opinion, rather than based on data with absolute cut-offs. It will be necessary to develop clear guidance on cut offs/limits or indicators to inform the scoring. This guidance is necessary to ensure that assessments are based within a common frame, to ensure consistent application of scoring.

Increasing the number of indicators that are based on actual values will strengthen the analysis.

Where scoring has been used, including level of confidence or a measure of uncertainty will help.

The guidance could be provided as a training exercise, video/narrated Youtube presentation with instructional notes, and even an advisory group of people with experience in doing an assessment. The assessments should involve both government agencies and other actors working on social, economic and fisheries issues.

5.1 PRESSURES ON THE FISHERY

Habitat pressures: There are several measures of habitat availability and quality. It will be necessary to evaluate if these parameters are independent (e.g. river connectivity/fragmentation and water regulation are both related to water management structures and their operation).

Water regulation: Retention time might be a better metric for water regulation than amount of stored water, but there is a need to define better how this will work in the case of natural lakes.

Not all metrics apply to all environments: For example: How do water storage, retention time, flood protection, irrigation and other services apply in the case of natural lakes? How does erosion and sediment load apply in rivers that naturally carry large amount of sediments?

Agricultural pressures: There is a need to distinguish between intensive agriculture and small-scale subsistence agriculture, the former is a source of nutrients and chemicals, while the latter has relatively little impact except where it is linked to soil erosion.

Fishing pressures: It is difficult to find the right way to measure the impact of the level of exploitation. This is because different ecosystems and stocks will respond differently to fishing pressure. Heavy fishing pressure may lead to the collapse one fisheries/stock, but in another region, the pressure may result in increased productivity (e.g. via predator-removal effects). Fishing pressure and overfishing are therefore not necessarily related. One potential metric could be the reduction or disappearance of larger, late maturing species from the catches. There was no answer as to the optimal balance for large versus small species as it depends on the type and structure of the environment.

Presence of invasive species: Whilst the presence of invasive species, is generally assumed to be a threat to a fishery and undesirable in many open waters, it is not an absolute case. This is a complex topic since many fisheries (particularly in man-made water bodies/reservoirs) are driven by exotic species that under certain conditions may become invasive. Fisheries for stocked fish and naturally recruited fishes will probably need to be split, and given separate treatment in the analysis. Although the alien species that are considered to be a threat are normally fish species, inland fisheries can be impacted by other invasive species such as water plants.

Reservoir fisheries: Where riverine and floodplain fisheries based on native species are disappearing new fisheries in man-made reservoirs frequently emerge. In these cases, reservoirs are potentially good habitats for the fish the reservoir now supports. Treating the two types of fishery equally runs the risk of suggesting that establishing reservoirs is good for inland fisheries.

Declining fertility from nutrients in reservoirs as they become older was not addressed. One solution could be to use a decision tree that will guide the evaluator through a stepwise process when doing the assessment so that different scores are applied when dealing with different types of fisheries.

Social economic indicators proved complex to work with: GDP and poverty index were not useful at the sub-national level. Population density was an indicator, however, it might be better to use relative population density inside the country or to use rural population density to avoid confounding this with urban populations within a particular area. Cities constitute a possible source of alternative incomes but on the other hand large urban areas have the potential for large impact on fish and riverine habitats

5.2 ADAPTIVE CAPACITY

National capacity: The fact that a country scores high with respect to capacity to address problems does not mean that this capacity is actually used for this purpose.

Defining "good" habitat/species composition: The habitat/species composition that would support the highest "value" would score highest. Man-made or perturbed environments, may therefore score positively where some capacity for rehabilitation or stocking exists.

Resilience of the resource: There was some discussion about which species traits to measure and their validity as indicators, and how to measure them (e.g., maximum size, families of fish in the fishery, phenology, abundance or distribution) and what should be done in the case of mixed fisheries, but no conclusion was reached.

Tolerant versus less tolerant species: This can indicate the extent to which a fishery is resilient and therefore able to cope with the pressures it faces. It is not a measure of the quality of the fishery, as there may be a range of highly vulnerable species which require more effective management to ensure that they are not impacted. The lack of resilience is therefore not a negative feature, it is an indication of the need for greater precautions.

Urbanization: Urban settlers are more resilient because there is more employment available outside the fisheries/agriculture sector and they have less dependency on fisheries.

Governance: Weak governance and bigger problems are found where there are multiscale fisheries and multiple actors.

Fisheries management: This can be highly subjective and scoring may need to reflect this. The ideal scoring method would be the degree to which the fishery is sustainably managed under conventional or traditional measures. There are examples where conventional management measures do not actually result in the best outcome (or are simply ignored because they are unable to deliver an acceptable outcome), and equally situations where fishery may be exploited under customary or traditional measures which result in sustainable levels of exploitation. (e.g. in the Barotse floodplain, where fisheries are not managed in a classical sense, because there is no effective enforcement of regulations. However, there are rights allocation and effort limitation through traditional measures which means that the pans are harvested at times when yields peak).

Additional factors: Other issues that might be influencing the adaptive capacity of the fishery include: Civil strife/Conflict, Lack of communication, education, common management, alternative livelihoods; Perverse or inappropriate subsidies and Tourism.

5.3 VALUATION

Scoring less tangible values: Unique or special biodiversity or cultural significance are quite subjective in the case of cultural importance and would be the decision of the country completing the assessment.

Heterogeneous fisheries: It will be necessary to break down into the different types of fishery within the basin/country in concern: large/small man made reservoirs, floodplains, natural lakes, and rivers. A particular challenge arises where food and recreational fisheries occur in the same place; also conservation value is not easily compatible with fisheries value. The group did not find a way to combine these into a single value index. One solution could be to plot them separately giving them different colour codes (according to their particular characteristics).

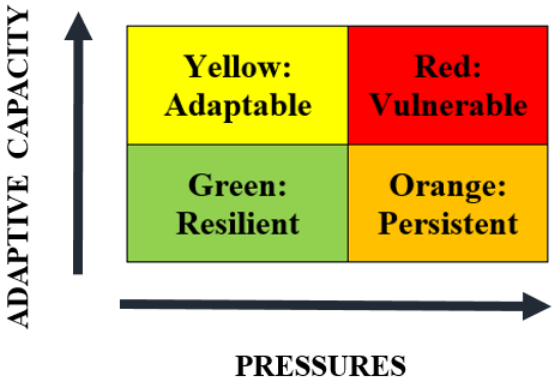
Economic value versus societal benefits: Using production alone indicates just the size of the fishery, which does not necessarily reflect societal benefits. Per capita production for the locality may be a better indicator of nutrition/livelihood value. Employment in primary and secondary services broken down by gender can reveal livelihood importance. Economic value is a useful measure for recreational fisheries.

Endemic versus invasive: The valuing of high degrees of endemism in a fishery makes sense where this is high, and there may be some threats from alien invasive species. However, it is redundant in a fishery that has been established based on non-endemic species (e.g. the tilapia fisheries of the tanks and reservoirs of Sri Lanka). This can help to value biodiversity hotspots, but should not penalize countries that have well established fisheries based on native species, unless these are continuing to suppress or impact endemic fisheries.

Time: Valuation will need to consider both historic and current situation (e.g., current and future recreational demand).

5.4 INTERPRETATION OF THE ASSESSMENT PLOTS

There is a need to go beyond the fully exploited, over-exploited, sustainably exploited concepts used in the assessments of marine fisheries as this only covers the impact of fishing and therefore implies that this is the overriding driver of the state of the fishery. Therefore such classification is not suitable for inland fisheries and other classification criteria should be used. Based on the plots (Figure 3-5), which are derived from the pilot assessments done by the roundtable, the fisheries can be categorized into four categories or types. For example: Green: Resilient, Yellow: Adaptable, Orange: Persistent, and Red: Vulnerable.



It would also be possible to establish a composite score between 0 and 1 for the risk (vulnerability vs. exposure). The typical cut off for this score would be >0.75 for high-risk fisheries (e.g., multiple threats and very little adaptive capacity) 0.35-0.75 medium-risk and adaptive capacity less than 0.35 for low-risk fisheries (e.g., low pressures and high adaptive capacity). Some fine-tuning may be required to avoid clustering of the fisheries in the centre of the chart or provide higher sensitivity for fisheries classification. However, this will only be possible once several more fisheries have been assessed - including more fisheries under significant pressure.

6. CONCLUSIONS

The roundtable concluded that the use of an index approach is a promising way forward, and that it can be further explored to assess fisheries both at the national, basin, regional, and global levels although different levels of resolution will be necessary and may thus have somewhat different data requirements.

It would be worthwhile for a working group to repeat the exercise with actual data.

It will be essential to define who in the countries should produce the report, and that indicators are interpreted in a harmonised and consistent framework. As most of the countries may lack of appropriate information or data local experts will play a critical role in the assessment and therefore is very important to choose them properly. It will be necessary to keep the assessment simple and transparent and allow for validation and reproducibility. With time, it will be possible to track trends and where possible it would be useful to analyse the historic situation.

Any information system should be useful to first and foremost serve the countries that collect/analyse and provide the data. Reports to FAO that could be compiled into a global picture of the state of inland fisheries would be a value-added product of this process. The national reports would also have utility in reporting on progress towards the SDGs/Aichi Targets.

6.1 NEXT STEPS AFTER THE ROUNDTABLE

The roundtable discussed follow-up actions, which would enable further elaboration of the assessment approach developed.

Recommendation	Actions
Develop a guidance note to describe the methodology	This would require some additional research work to finalize a realistic (workable) set of indicators; work out which are important and which are not (maybe regionally relevant); identify indicators, which are duplicative/redundant and could be excluded or merged; Address the balance between rivers, and lakes/reservoirs/wetlands;

	Look to the biodiversity indicators partnership (CBD/CITES/CMS/CITEs/FAO partnership) for possible indicators (also BioDiscovery).
As part of the above activity, look for funding for a postdoctoral researcher/FAO Fellowship to:	Work on generating country data and (if possible) downscaled basin/sub-national data; Pre-populate the global pressures data set as the first cut for the assessment; Try to test the approach retrospectively (i.e., use old/historic information), to see if the approach can show if/how the test fisheries has changed over time (in terms of their position in the pressures/adaptive capacity and their importance).
Try to get a few trials done during some workshops	e.g., World SSF Congress.
Identify funding for a global workshop in early/mid-2019	Ideas are: Royal Society; NATO; philanthropic donors; or pull together a hybrid using funds of a group of like-minded institutions (USGS, FAO, MSU others?).
Convene a global workshop to validate the method and develop first iteration of a global assessment of inland fisheries	Attended by ~20 inland fishery researchers to bring their country assessments; Participants would be regionally representative - and would also cover a substantial amount of the world's inland fisheries; Validate the method and develop first iteration of a global assessment of inland fisheries; This would then be used by country correspondents to develop their country assessment; Send this out to them prior to the workshop and bring their assessment with them; Develop a video "how to use the framework" to assist the respondents.
The assessment could be put online to aid respondents	This could be a survey or dynamic pdf (even better if the fishery is plotted when the results are entered; Ideally responses would be done by a team; A national correspondent could be identified (from research?) to coordinate the assessment; The InFish network could also try to do this for individual fisheries; The FAO RFBs may be able to assist with this to undertake regional workshops; These national assessments could then be collated into a global picture.
Resource mobilization will be key	Link the assessment to food security/nutrition; Link to SDG; Limited donor engagement in the sector; Global environmental NGOs may be interested, however this may tend to drive the assessment towards a biodiversity assessment rather than inland fishery assessment; Consider approaching FINNIDA, GIZ, CIDA and Danida for interest in funding this.
Outcomes would be targeted at COFI 2020	SOFIA section; Working paper for COFI 2020 Propose a side event at COFI 2020

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ANNEX I: ROUNDTABLE AGENDA

Tuesday 8 May

TIME	SUBJECT	PRESENTER
13:00	Welcome and presentation of participants	
	Introduction and objectives of the meeting	
Analysis of assessment methodologies		
14:00	Presentation & discussion of assessment methods	
	Estimation/valuation and trend • Catch/value; nutrition; dependency • Characterizing large and small scale fisheries (matrix approach) Fishery approaches • Fishery monitoring (indicator fisheries) System level approaches • Risk/adaptation assessment • Current-future threats • Basin assessment approach • Complex index Objective Measurement of change	
15.00-17.00	Analysis: Strengths Weaknesses Opportunities by method	

Wednesday 9 May

TIME	SUBJECT	PRESENTER
Developing a routine methodology for inland fishery assessment		
9:00-9:30	Introduction	
9:30 -12:00	Develop an assessment format: Who is it for; what scale to operate at; can this be used to develop a global picture?	
12:00-14:00	Lunch	
14:00 –17:00	Select a pilot country/basin to work with as a thought model	
	Identify likely data needs/data sets available/data sources-collection methods Try to populate the information into the format	

Thursday 10 May

TIME	SUBJECT	PRESENTER
9:00-11:00	Continue on assessment approach	
Recommendations		
11:00-12:00	Review earlier efforts by FAO and others (e.g. InFish, USGS, EU, WorldFish) – clarify what the assessment can, and cannot provide What has/has not been implemented so far? Why?	
12:00-14:00	Lunch	
14.00-15.00	What can be done to accelerate implementation? And what is FAO and other partners' role in this? Can an assessment provide supporting information for the measurement of progress against SDGs/Aichi?	
15:00-17:00	Which activities should FAO prioritize in the biennium 2018-2019.	
	Identify potential partners/funding.	

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ANNEX III: BACKGROUND TO FAO'S PREVIOUS WORK TO IMPROVE INLAND FISHERY ASSESSMENT

There has been a long history of FAO's work to characterize and described fisheries prior to this, however, this work did not generally provide a comparable assessment of the status of the fisheries under consideration. Over the past 15 years, FAO has worked on ways to improve assessment of inland fisheries. This work focussed on addressing the primary issue of weak statistics, under-reporting and undervaluing of inland fisheries. Overall, there has been relatively less attention paid to assessing the status of inland fisheries (as opposed to the biological status of a fishery stock).

Region/ country	Title	Year
Africa	Welcomme, R.L. (Comp.) (1979). *The inland fisheries of Africa*. CIFA Occas.Pap., (7): 69 p.	1979
Africa	Vanden Bossche, J.-P.; Bernacsek, G.M. 1990. *Source book for the inland fishery resources of Africa*: 1. CIFA Technical Paper. No. 18.1. Rome, FAO. 240p.	1990
Africa	Crul, R.C.M. 1992. *Database on the inland fishery resources of Africa (DIFRA). A description. Description d'une base de données portant sur les ressources halieutiques des eaux intérieures de l'Afrique (DIFRA)*. CIFA Occasional Paper/Document occasionnel du CPCA. No. 24. Rome, FAO. 1992. 21p.	1992
Africa	Welcomme, R., Lymer, D. 2012. *An audit of inland capture fishery statistics – Africa*. FAO Fisheries and Aquaculture Circular No. 1051. Rome, FAO. 61 pp.	2012
Africa	de Graaf, G. & Garibaldi, L. 2014. *The value of African fisheries*. FAO Fisheries and Aquaculture Circular. No. 1093. Rome, FAO. 76 pp.	2014
Asia	Coates, D. 2002. *Inland capture fishery statistics of Southeast Asia: Current status and information needs*. Asia-Pacific Fishery Commission, Bangkok, Thailand. RAP Publication No. 2002/11, 114 p.	2002
Asia	Lymer D. & S. Funge-Smith (2009). *An analysis of historical national reports of inland capture fisheries statistics in the Asia-Pacific region (1950-2007)*. FAO Regional Office for Asia and Pacific. RAP Publication 2009/18, 18 pp.	2009
Europe	Dill, W.A. 1990. *Inland fisheries of Europe*. EIFAC Technical Paper. No. 52. Rome, FAO. 471 p.	1990
Europe	Mitchell, M., Vanberg, J. & Sipponen, M. 2010. *Commercial inland fishing in member countries of the European Inland Fisheries Advisory Commission (EIFAC): Operational environments, property rights regimes and socio-economic indicators. Country Profiles*. EIFAC Ad Hoc Working Party on Socio-Economic Aspects of Inland Fisheries.	2010
South America	FAO/FishCode. 2004. Seminar on responsible fisheries management in large rivers and reservoirs of Latin America. FAO/FishCode Review. No. 5 (En). Rome, FAO. 72p.	2004
Country	Various FAO Fishery Technical Papers on specific countries or waterbodies.	
Regional	RFB reports/working documents – e.g. CIFAA and EIFAAC.	
Global	FAO Inland Water Resources and Aquaculture Service, Fishery Resources Division. 1999. Review of the state of world fishery resources: inland fisheries. FAO Fisheries Circular. No. 942. Rome, FAO. 53p.	1999
Global	FAO Inland Water Resources and Aquaculture Service, Fishery Resources Division. 2003. Review of the state of world fishery resources: inland fisheries. FAO Fisheries Circular. No. 942, Rev.1. Rome, FAO. 60p.	2003

A summary of some FAO's key work on developing methods to improve information, statistics and assessment of inland fisheries over the last 15 years is provided here:

FAO REGIONAL CONSULTATION (2003)

FAO. 2003. New Approaches for the improvement of inland capture fishery statistics in the Mekong Basin. Ad-hoc expert consultation Udon Thani, Thailand 2 to 5 September 2002.

This consultation reconfirmed that basic information is needed to manage and develop the sector, but that the quality of the information needs to be improved although significant progress can be made by working with information that is already available in project reports, government offices, NGOs and IGOs.

It was concluded that focused studies can provide information on particular fisheries or habitats and these results can then be extrapolated to a wider area. However, fisheries officers appear to lack understanding of the purpose of collecting fisheries statistics and there is need to create capacity and increase the status of fisheries officers working on inland fisheries.

Data collection and interpretation must take into account how habitats, production and human activity change in response to the changing environmental conditions in the basin. It will be crucial for policy makers and managers of the inland fishery sector to form partnerships with stakeholders in other sectors e.g. ministries controlling hydrology, water resource management and hydroelectric development. There was a call for a comprehensive valuation to provide inland fishery managers and policy makers with ammunition to convince national governments, donors and the international community to commit adequate financial and human resources to the sector. The countries in the Mekong Basin were encouraged to submit data on inland fishery yield, species, effort and consumption to FAO.

ADVISORY COMMITTEE ON FISHERIES RESEARCH (2006)

FAO 2006. *Report of the sixth session of the Advisory Committee on Fisheries Research (ACFR)*. Rome, 17-20 October 2006, FAO Fisheries Report. No. 812. Rome, FAO. 2007. 21p.

The ACFR strongly supported the update of information on the different capture fisheries subsectors (The PROFISH Big numbers project was published as the World Bank 2012 "Hidden Harvest") and welcomed the inclusion of inland fisheries to the analysis and underlined that the creation of capacity and raising awareness of the need for this type of information in the future were essential. The ACFR recommended that FAO undertake in-depth studies of the contributions of culture-based and inland capture fisheries to world fish production. Culture-based fisheries are particularly important in many inland water bodies.

FAO should consider strengthening its involvement in work on inland fisheries, which provide livelihood for millions of people in rural communities and often provide an affordable source of animal protein. The FishCode-STF Project was recommended to be expanded to include inland fisheries. FAO to raise the awareness of the importance of fisheries in integrated management in inland watersheds, particularly rehabilitation of rivers, lakes and reservoirs for fish.

FAO INTERNATIONAL WORKSHOP (2010)

FAO International workshop on: Ecosystem approach to inland fisheries: data needs and implementation strategies, Vientiane, Lao PDR, 2010.

Subsequently published as: Beard *et al*. 2011. Ecosystem approach to inland fisheries: research needs and implementation strategies (*Biol. Lett.* **7**: 481–483).

The workshop reached consensus on the preparation of a suitable policy framework manuscript for publication in an international journal. Group discussions were held on the possible contents of the manuscript. The main aim of the said manuscript would be to increase the profile of the inland fisheries sector among public and especially among policy makers.

FAO EXPERT WORKSHOP (2012)

FAO. 2012. Report of the Workshop to Develop an FAO Strategy for Assessing the State of Inland Capture Fishery Resources, Rome, 7-9 December 2011. FAO Fisheries and Aquaculture Report No. 1016. Rome. 37 pp.

This workshop was convened to develop a strategy to improve the state of information on the status of inland fisheries. Following from the observation by the 28th Session of the FAO Committee on Fisheries that:

> "*Data and statistics on small-scale fisheries, especially in inland waters, were not always comprehensive, resulting in underestimating their economic, social and nutritional benefits and contribution to livelihoods and food security. The underestimation of the importance of inland fisheries can lead to policies and practices that further degrade resources and endanger food security*."

Compared with the FAO biennial review of the status of marine fish stocks, which covers 455 stocks and about 80 percent of reported global marine catch, there is no equivalent information set for inland fisheries on which to make assessments. For marine fisheries, the state of exploitation is the principal driver determining their status, and FAO uses this as the main indicator of management performance for global assessment. The status of inland fisheries is also determined by rates of exploitation, but other influences that affect habitat quality and quantity are often more important.

The Workshop identified ecosystem services provided by inland fisheries and some potential indicators and information that could be used for the assessment of inland capture fisheries including also social and economic aspects of a fishery and environmental and production aspects, and efforts were made to establish a composite indicator.

The elements of a strategy to assess inland fisheries were not completely defined by the Workshop and further work is needed to determine the usefulness of the indicators and composite indicator.

FAO/MSU/AFS GLOBAL CONFERENCE "FRESHWATER, FISH AND THE FUTURE"

Convened FAO Headquarters, Rome, Italy, 26-28 January 2015.

Taylor, W. W., D. M. Bartley, C. I. Goddard, N. J. Leonard, and R. Welcomme, editors. 2016. *Freshwater, fish and the future: proceedings of the global cross-sectoral conference*. Food and Agriculture Organization of the United Nations, Rome; Michigan State University, East Lansing; American Fisheries Society, Bethesda, Maryland. The Global conference issued "The Rome Declaration: Ten Steps to Responsible Inland Fisheries".

This declaration covered several areas, which are strongly pertinent to the assessment issues related to inland fisheries, specifically:

Improve the assessment of biological production to enable science-based management: Establish a minimum set of data requirements that would be practical for countries to collect and that would allow cross-sectoral comparisons. Accurate and complete information about fishery production from inland waters is lacking at local, national and global levels. Governments often lack the resources or capacity to collect such information due to the diverse and dispersed nature of many inland fisheries. There is

much scope for developing and refining biological assessment tools to facilitate science-based management.

Correctly value inland aquatic ecosystems: The true economic and social values of healthy, productive inland aquatic ecosystems are often overlooked, underestimated and not taken into account in decision-making related to land and water use. Economic and social assessment is often difficult and valuation often limited. In most cases, especially in the developing world, inland fisheries are part of the informal or local economy, so their economic impact is not accurately measured in official government statistics. Ecosystem services should be valued along the entire value chain.

Promote the nutritional value of inland fisheries: The relative contribution of inland fisheries to food security and nutrition is higher in poor food-insecure regions of the world than in many developed countries that have alternate sources of food. Good nutrition is especially critical in early childhood development (i.e., the first 1,000 days). Loss of inland fishery production will undermine food security, especially in children, in these areas and put further pressure on other food producing sectors.

Develop and improve science-based approaches to fishery management: Many inland waterbodies do not have fishery or resource management arrangements that can adequately address sustainable use of resources. Where management arrangements exist, compliance and enforcement are often minimal or non-existent. This may result in excessive fishing pressure, decreased catch per unit effort, and conflicts between fishers, as well as changes in the productivity of fishery resources. In some areas, reductions in fishing capacity will be required. To facilitate fishery management, it will be important to improve access to and promote better sharing of data and information about inland fisheries supporting the assessment management cycle.

Implement an Ecosystem Approach to Inland Fisheries.

Modify or establish fishery and resource management arrangements to protect the productive capacity of inland waters and the livelihoods of communities dependent on the resource.

Develop collaborative approaches to cross-sectoral integration in development agendas: Water-resource development and management discussions very often marginalize or overlook inland fisheries. Therefore, trade-offs between economically and socially important water-resource sectors and ecosystem services from inland water systems often ignore inland fisheries and fishers. Development goals based on common needs, e.g., clean water and flood control, can yield mutually beneficial outcomes across water resource sectors. Incorporate inland fish and fisheries into the post-2015 sustainability development goals on water issues and include all ecosystem services provided by inland aquatic ecosystems.

ANNEX IV: POSSIBLE DATA SOURCES

Productivity	
Chlorophyll a productivity	Sayers *et al.* 2015. A new method to generate a high-resolution global distribution map of lake chlorophyll.
FAO FISHSTAT fishery and aquaculture statistics	http://www.fao.org/fishery/statistics/en and http://www.fao.org/fishery/statistics/software/fishstatj/en
Land use/land cover	
Freshwater Ecoregions of the World, (FEOW)	http://www.feow.org/
Total Land Area, Arable and Permanent Cropland, Irrigated agriculture area; Permanent Pasture, Forest and Woodland, and Other Land	Food and Agriculture Organization of the United Nations (FAO), FAOSTAT, FAO, Rome. http://www.fao.org/faostat/en/#home
Global Lakes and Wetlands Database (GLWD)	https://www.worldwildlife.org/pages/global-lakes-and-wetlands-database
CIFOR Global Wetlands	https://www.cifor.org/global-wetlands/
Wetland Extent Trend Index	https://www.bipindicators.net/indicators/wetland-extent-trends-index
Normalized difference vegetation index (NDVI)	http://www.un-spider.org/links-and-resources/data-sources/daotm/daotm-vegetation
IIASA Global Forest Database	http://www.iiasa.ac.at/web/home/research/researchPrograms/EcosystemsServicesandManagement/GlobalForestDB.en.html
World Bank forest cover	https://data.worldbank.org/indicator/AG.LND.FRST.ZS
IIASA Global Forest Database	http://www.iiasa.ac.at/web/home/research/researchPrograms/EcosystemsServicesandManagement/GlobalForestDB.en.html
Water connectivity	
Commercial Hydroelectric Consumption	United Nations Statistical Division (UNSTAT), Energy Statistics Yearbook, UNSTAT, New York. https://unstats.un.org/Unsd/energy/yearbook/default.htm
Dams current and future	GRanD database (Lehner *et al.* 2011) http://www.gwsp.org/products/grand-database.html
	Zarfl *et al.* 2015. A global boom in hydropower dam construction
	Dams - State of the world's rivers (IRN) http://tryse.net/googleearth/irivers-dev3/
International Commission on Large Dams	http://www.icold-cigb.net/
River Regulation Index (RRI) River Fragmentation Index (RFI)	Grill *et al.* 2015. An index-based framework for assessing patterns and trends in river fragmentation and flow regulation by global dams at multiple scales.
	GRID Arendal http://www.grida.no/resources/5633
	Nilsson *et al.* 2005. Fragmentation and flow regulation of the world's large river systems
Water quantity and quality	

FAO AQUASTAT	http://www.fao.org/nr/water/aquastat/main/index.stm
FAOSTAT	http://www.fao.org/faostat/en/#home
WRI Aqueduct: Water Resources per Capita, Domestic Annual Withdrawals, Industry Annual Withdrawals, Agriculture Annual Withdrawals, Irrigation area, water storage	http://www.wri.org/our-work/project/aqueduct Data compiled by the World Resources Institute
Global Drinking Water Quality Index	http://www.un.org/waterforlifedecade/pdf/global_drinking_water_quality_index.pdf
Global water quality database GEMStat	https://gemstat.org/about/
Global river sediment yields database	http://www.fao.org/nr/water/aquastat/sediment/index.stm
Water and sanitation index (Yale)	https://epi.envirocenter.yale.edu/2018-epi-report/water-and-sanitation https://epi.envirocenter.yale.edu/epi-downloads
WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation	http://www.wssinfo.org/
Water security and water threats	Vörösmarty *et al.* 2010. Global threats to human water security and river biodiversity.
	Vörösmarty *et al.* 2000. Global water resources: vulnerability from climate change and population growth.
Biodiversity	
FISHBASE	http://www.fishbase.org
Global Biodiversity Information Facility (GBIF)	https://www.gbif.org/
IUCN Redlist	http://www.iucnredlist.org/
Species introductions	
FAO DIAS	http://www.fao.org/fishery/topic/14786/en (DEAD)
Global Invasive Species Database	http://www.iucngisd.org/gisd/
Ecosystem restoration	
Global Ecosystem Restoration Index (used by IPBES)	Fernandez *et al.* 2015. Global Ecosystem Restoration Index http://www.ipbes.net/sites/default/files/Metadata_GEO_BON_iDiv_Global_Ecosystem_Restoration_Index.pdf
Climate change	
IPCC Temperature and precipitation projections	https://www.ipcc.ch/
Demography	
Total Population, Current Population Density, and Projected Population Density	UN DESA, United Nations Population Division, Annual Populations, United Nations, New York http://www.un.org/en/development/desa/population/
Total Urban Population	United Nations (U.N.) Population Division, Urban and Rural Areas, 1950-2025, New York http://www.un.org/en/development/desa/population/theme/urbanization/index.shtml

Urban Population in Coastal Cities	UN Statistical Office, UN Office for Ocean Affairs and the Law of the Sea, Offshore Magazine, and other sources.
Economy, development and governance	
GDP from Agriculture, GDP from Industry, GDP from Services, and GDP Annual Growth Rate	World Bank, Washington, D.C. https://data.worldbank.org/
GDP per Capita in Constant PPP	The Penn World Tables 6.1 http://dc1.chass.utoronto.ca/pwt61/
Agricultural Labour Force, Total Labour Force.	Food and Agriculture Organization of the United Nations (FAO), FAOSTAT, FAO, Rome http://www.fao.org/faostat/en/#home
World Bank development indicators	https://data.worldbank.org/products/wdi Most of these are aggregated from other sources (e.g FAO statistics)
WorldBank World Wide Governance Indicators	http://info.worldbank.org/governance/wgi/#home

The two and a half day Advisory Roundtable was convened to contribute to FAO's response to the request by the 32nd Session of the Committee on Fisheries (COFI), to: i) Advise FAO on its approach to developing a more comprehensive report on methods and data and analytical approach, which could be used to provide a credible, objective and replicable assessment of inland fisheries; and ii) Provide guidance on tools that could be provided to member states seeking advice with respect to assessing the status of their inland fisheries (yield/production, threats & drivers), predicting future impacts and how to quantify the effect of mitigation/adaptation measures on fisheries.

The roundtable reviewed and discussed the background that had led up to the meeting to scrutinize the purpose of an assessment and the scope of coverage and how this could be used to determine the status of inland fisheries. It further developed the criteria to conduct such an assessment, and then attempted to apply the approach to a number of basins. It was concluded by the roundtable, that the use of a dual index approach is the right way to go, and that it can be used to assess fisheries both at the national, basin, regional and global levels although different levels of resolution will be required and may thus have somewhat different data requirements. Adding a valuation element will direct investment towards the fisheries that provides most benefit to society in the context of the priorities set at the national level.

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