POLICY BRIEF

The Importance of Riverine and Floodplain Fisheries for Livelihood Resilience in Africa

2022

AFRICAN DEVELOPMENT BANK GROUP

Africa Natural Resources Management & Investment Center

KEYWORDS
Riverine fisheries, rivers, floodplains, livelihoods, resilience, natural resource governance, nature-based solutions.

KEY MESSAGES

- African river and floodplain fisheries are highly productive social-ecological systems that contribute to the food and nutritional security of many communities. Traditional management and governance of fisheries resources provide essential livelihoods for the most vulnerable people, especially women.

- These systems are not only under increasing threat from climate change, urbanization and infrastructure development, but also from profound changes in natural resource governance frameworks and mechanisms.

- Improved knowledge of these systems is essential to ensure continued development based on the services provided by nature. Governance frameworks for fisheries resources need to be adapted in a regional and *integrated approach to strengthen the resilience of the communities that rely on them.*

ACKNOWLEDGEMENT

This report was prepared by Philippe Tous, Principal Fishery Officer at the Africa Natural Resources Management & Investment Center (ANRC) of the African Development Bank Group. The author is grateful for the insightful comments of Ahmed Khan and Weiwei Wang of the Agriculture and Agribusiness Department (AHAI), Samba Tounkara consultant to the Agricultural Finance and Rural Development Department (AHFR), Linguère Mbaye of the Transition States Coordination Office (RDTS), Léontine Kanziemo, Charles Nyirahuku and Salimata Soumaré (ANRC). The author is particularly grateful to Felix Marttin and John Valbo-Jørgensen of the FAO, Pierre Morand of the Research Institute for Development and Olivier Hamerlynck of the Eduardo Mondlane University in Maputo for valuable exchanges and careful proofreading. Finally, the author thanks Vanessa Ushie for facilitating this work, Fionnuala Tennyson for editing this document and Sadiq Bentum Commey for designing.

DISCLAIMER

Introduction

The livelihoods of rural communities depend primarily on the availability of and access to renewable resources, including water, land and living resources. These resources are components of ecosystems with complex and dynamic relationships. Holling (1973) and Gunderson (2000) have shown that these ecosystems have their own capacity or resilience to adapt to external pressures induced by humans and large-scale environmental changes. This capacity is found in other complex systems, notably in what Ostrom (2009) has called the 'social-ecological system', a concept which integrates resources, their uses and the governance frameworks established by their users. Indeed, resilience appears to be the fundamental mechanism to adjust complex systems on an ongoing basis, which is reflected in the way communities that depend on natural resources develop equally complex and dynamic use strategies. More recently, Quensière et al (2018) have demonstrated how this idea is particularly applicable to artisanal fisheries systems which are subject to a range of environmental, technical, economic, and political pressures.
Most ecosystems are characterized by seasonal and inter-annual variability to a greater or lesser extent depending on the regions and environments concerned. Rivers in particular follow an annual cycle during which they transition from a flood phase to a low water phase, and these extremes can be strongly accentuated according to multi-year cycles which may repeat at ten-year or even a hundred-year intervals. These dynamics contribute to biogeochemical cycles and influence other natural resources, particularly living resources. The adaptation of populations living in these dynamic ecosystems gives them a particular ability to anticipate extreme conditions (like flooding or drought) and to optimize their use of resources. Many communities have thus established implicit rules for risk prevention in terms of land use and settlement and have developed agricultural systems that are particularly well adapted to the cycle of floods and droughts, while integrating a wide range of seasonal food sources based on gathering, hunting or fishing, activities that are highly dependent on the integrity of biodiversity.

Fish are present in all freshwater ecosystems: large and small lakes, main and secondary rivers, permanent and seasonal wetlands. The exploitation of these fisheries resources takes place at scales ranging from capital-intensive fisheries on the Great Lakes of East Africa, to diffuse and occasional exploitation by populations who do not usually even identify as fishers as part of their mixed livelihood strategy.

In particular, river and floodplain fisheries[1] are an essential component of resilient livelihoods for tens of millions of people across the continent.

This paper focuses on the riverine and floodplain fisheries systems in Africa and their contribution to livelihoods. The first part analyzes the resilience factors of these systems, including their considerable, albeit seasonal, productive potential; highly sophisticated traditional forms of low environmental impact use, and pro-poor governance arrangements that integrate other income-generating activities. The second part analyses the threats to these fisheries systems, particularly in relation to demographic pressure, climate change, pollution and infrastructure development, but also reviewing changes in governance and resource management which can drive reductions in resilience. The concluding section identifies ways to address the challenges posed by these threats and makes recommendations to the continent's countries and regional economic communities for preserving this essential element of their natural, social and human capital.

[1] *This note does not deal with fisheries in large lakes*

KEY ELEMENTS OF RESILIENCE IN RIVER FISHERIES SYSTEMS

01 Considerable natural productivity

Seventy per cent of the African continent is covered by watersheds, and the volume of renewable fresh surface water on the continent is estimated at 5,500 km3 per year, with a surface area of 1,330,000 km² (Table 1). According to Lehner and Döll (2004), this surface hydro system consists of rivers (3%), natural lakes[2] (17%), floodplains (52%), flooded forests (14%) and non-permanent wetlands (14%). Each of these categories of ecosystems has its own characteristics in terms of the ecosystem services they provide and their potential contribution to sustainable development objectives, but their distribution across the continent is uneven, ranging from very densely populated areas (such as the Great Lakes, the Nile plain and major deltas) to large areas with low population density (e.g. the northern Congo basin, the upper Zambezi).

TABLE 1: Area of natural freshwater ecosystems in Africa and worldwide (km²)

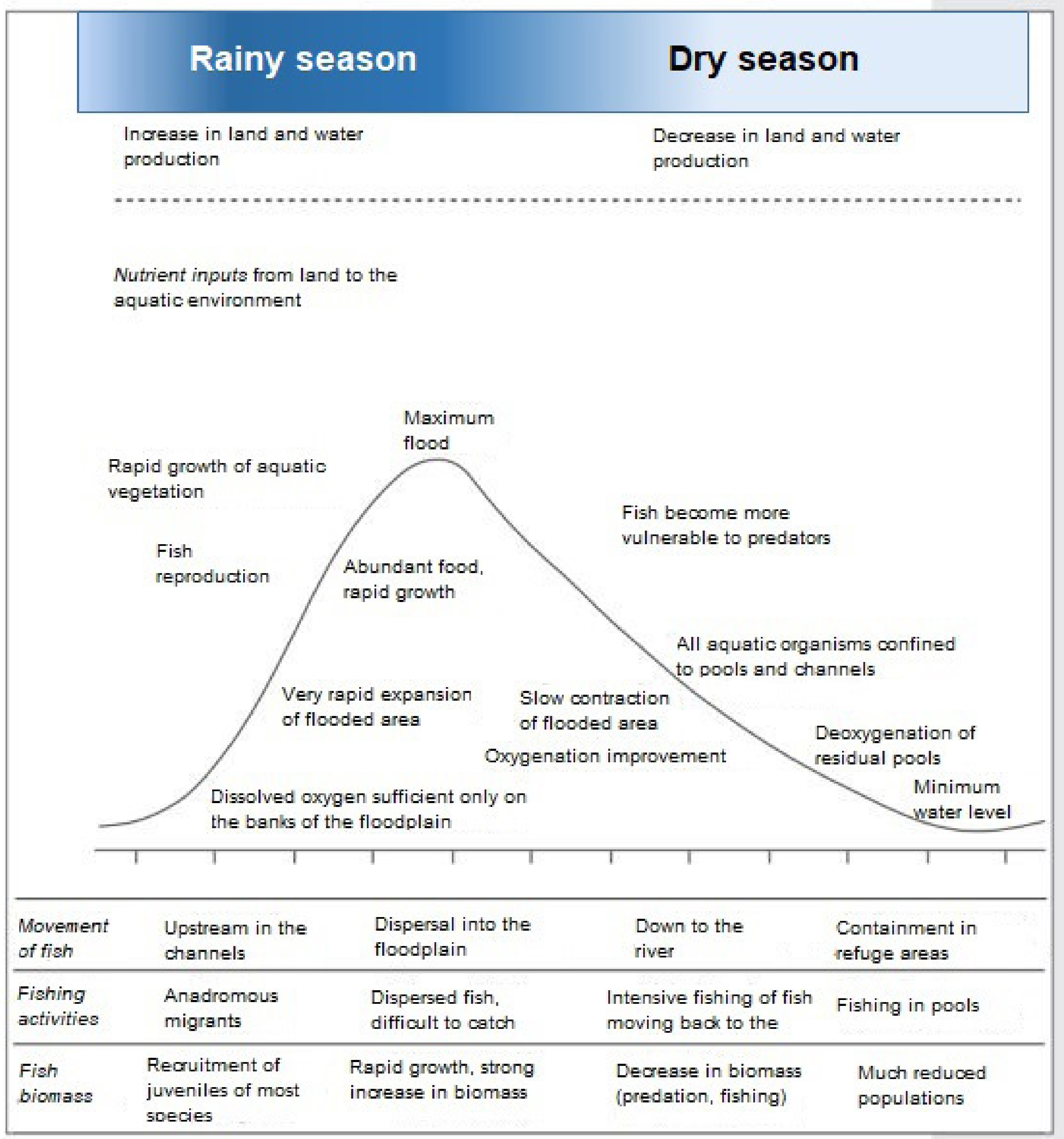
Main types of ecosystems	Africa (km²)	% of freshwater ecosystems in Africa	World (km²)	Share in Africa / World (%)
Lakes	223 000	17%	2 186 000	10%
Rivers	45 000	3%	358 500	13%
Floodplains	694 000	52%	2 485 000	28%
Flood forests and peatlands	180 000	14%	1 862 000	10%
Non-permanent wetlands	187 000	14%	685 400	27%
Total	1 329 000	100%	7 576 900	18%

From De Graaf et al, 2012.

[3]*Excluded from this inventory are the artificial reservoirs which represent 34,000 km² or 3% of all the surface waters of the continent.*

Among the major freshwater ecosystems, Table 1 illustrates that more than a quarter of the world's floodplains and non-permanent wetlands are located on the African continent. These ecosystems have remarkable characteristics, especially with regard to their productivity.

FIGURE 1: Seasonal cycle of events in a floodplain river (after Lowe-McConnell, 1987)

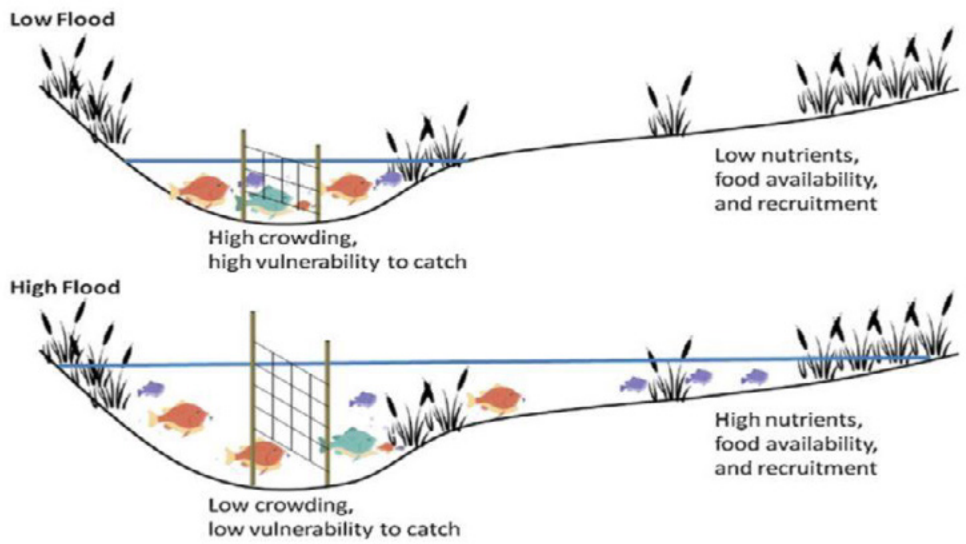


Junk et al (1989) have shown that flood cycles determine the environment's productivity and in particular fish production. Hamerlynck et al (2019) found that floods, despite their negative reputation, are perceived positively by local communities who understand the many ecosystem services they provide, such as groundwater recharge, deposition of fertile silt, fisheries production and the development of pastures that allow wild and domestic herbivores to survive through the dry season.

For fisheries in particular, levels of biomass production of up to several hundred kg/ha/year have been observed in floodplain river systems (Welcomme, 1985). This productivity is all the more remarkable as it is limited to a few months in the year during the period of rising water. Figure 1 explains clearly the processes involved, and in particular the link between biomass production and the extent of flooding, both in terms of extent and duration.

This phenomenon, which has no equivalent in other terrestrial or marine ecosystems, is immediately followed by a phase of intense but not so rapid mortality, linked to the deoxygenation of the water, the reduction of flooded surfaces and the predation of fish on each other as they return to the riverbed (Figure 2). From a fisheries perspective, there is thus a major difference between marine or lake fisheries (where the catch potential is determined by the continuous production of a relatively stable biomass) and floodplain fisheries where the biomass is renewed each year from the tiny fraction of the fish population that has survived the low water period. Jul-Larsen et al (2003) also found that pulsed systems have much higher productivity and resilience than stable systems.

FIGURE 2: Diagram of flooding and parameters determining ecological and fisheries productivity (from Linhoss et al, 2012)



However, the magnitude of the phenomena depends on many factors, such as the river flow cycle (hydrograph), the area and topography of the catchment, and especially the rainfall regime. Table 2 gives an overview of the major floodplain systems in Africa, but there is very little data on their potential productivity or the data are old (Burgis and Symoens, 1987; Welcomme, 1985; Vanden Bossche & Bernacsek, 1991; Crul, 1992). According to Lymer et al (2016), the average productivity of floodplains in Africa is 50 kg/ha/year[3], which corresponds to an annual catch potential of around 3.5 million tonnes of fish, more than the estimated current fishery production of all the Great Lakes and reservoirs of the continent combined. However, because of the difficulty of calibrating models, very few studies have attempted to link rainfall levels or flood strength with a predictive estimate of fish production (Morand et al, 2012; Fluet-Chouinard et al, 2015), with the most successful model being one applied to the Okavango Delta (Linhoss et al, 2012).

TABLE 2: Main river basins in Africa and some fisheries in their floodplains

River basins	Main Floodplains	Surface (km²)	Estimated max Production (t)	Number of fishers
Nile	Sudd	88 300	140-200 000	>100 000
Congo	Cuvette, Kamolondo	142 000	ND	180 000
Lake Chad	Chari - Logone - Yaeres	63 000	>45 000	>40 000
Niger	Inner Delta	43 000	100 000	35 000
Zambezi	Kafue flats + Barotse plain	17 250	15-45 000	>45 000
West African Basins	Senegal	12 000	18-24 000	ND
East African Basin	Kilombero, Rufiji, Tana	8 600	ND	ND
Central African Basins	Okavango	28 000	1 500	3 000

Source: author's calculations

[3] *However, this figure seems very low and the average productivity of African floodplains should be equivalent to those of Asia, at 100-150 kg/ha/year, which corresponds to a potential catch of 7.0 to 10.5 million tonnes (Felix Marttin, Pers. Comm.)*

02 Diversified and often misunderstood modes of exploitation

A surprising and counter-intuitive aspect of African floodplain systems is the lack of correlation between fisheries productivity and the population density exploiting these resources. It appears that some areas have been densely populated for centuries (such as the Inner Niger Delta, Lake Chad, the Zambezi and certainly the Lower Nile Valley), while other areas appear to be almost deserted (such as the Northern Congo Basin, Upper Zambezi, and the Sudd).

However, almost all of these systems offer conditions that allow for a multiple mix of livelihoods through a combination of flood recession agriculture, livestock and fishing (Hamerlynck, 2019). As water is available throughout the year, fishing can be practiced at different times. However, we have seen that during flooding the fish are scattered and therefore more difficult to catch so that only fishers with boats are active during high water. As the water level decreases, the fish gradually become concentrated in the channels and the main riverbed, allowing many people to fish on foot using a wide variety of gear. Finally, during the low-water period, the fish only survive in the main river or are trapped in residual pools where they are condemned to asphyxiate (apart from a few species with special adaptations that allow them to survive in hypoxic environments e.g. by breathing air). This last situation perfectly illustrates the knowledge acquired by the populations of certain flooded areas who then organize collective fishing aimed at "depleting" the resource. These depletion fisheries in residual pools or in flooded forests can be found all over the continent and have been particularly well documented in Guinea (Ferry et al, 2015), Mali (Quensière, 1994), Cameroon (Dounias, 2011), Congo (Comptour et al, 2016) and southern Africa (Paugy et al, 2011).

In an attempt to clarify the diversity of fishing practices in the floodplain, Welcomme (1985) was the first to propose a typology of fishers based on the amount of time spent fishing during the year and distinguishing between occasional, part-time and full-time fishers. In the Inner Niger Delta, Laë and Morand (Quensière, 1994) further categorize fishers according to their seasonal migrations, their technical skills and whether or not they practice other income-generating activities. In the Congo Basin, Béné et al (2008) propose the same categories based on the number of non-fishing activities and the share of income from each activity. Other criteria that have been proposed to categorize riverine fishers include their dependence on fishing for food or as a means of wealth accumulation (Smith et al 2005). These various attempts at classification can be summarized as follows:

A In almost all floodplain systems, there is a category of full-time fishers, i.e. those who do not engage in any other activity throughout the year. These fishers have large boats that are used primarily for migrating to suitable fishing areas during high water. They then settle in camps where they fish using several fishing gears simultaneously, preserve their catch by smoking or drying, and market the processed products at the end of the dry season. These fishers usually make their transhumance accompanied by their families, and the various members of the household participate in fishing or the processing of the fish. The Bozo of Mali is an extreme example of fishers migrating over very long distances and spending more time in their camps than in the villages they come from.

B Fishing is also practiced intensively by another category of fishers for whom agriculture is equally essential. These people are much more sedentary and are actively engaged in farming during high water while they fish during low water. These fisher-farmers have a high degree of technical skill and use several types of fishing gear, some of which require the use of a boat, which is generally smaller than those used by the full-time fishers. If conditions are good, fishing is often a more lucrative activity than farming.

C Among the sedentary populations living in the floodplains, there are also households that fish much less intensively, usually on foot and more frequently during flood recession. Their technical skills are less advanced and the fishing gears are used in a more opportunistic way. These farmer-fishers tend to fish for subsistence, even though they may occasionally market their catches, and always participate in collective fishing, especially depletion fishing at the end of the dry season.

This simplified typology can have various combinations and vary according to the environment and climatic conditions, as highlighted by Mosepele and Ngwenya (2010) for the Okavango Delta. For example, rainfall deficits in the Sahelian zone have modified the itineraries of full-time fishers. Other factors also modify practices, such as having access to modern equipment, which tends to favour the use of certain techniques (nets) to the detriment of traditional methods (trap barriers) and collective fishing (Comptour, 2016).

However, the practice of fishing by the majority of the population remains a constant in most floodplains, and particularly involves women who, in many systems, fish using specific techniques, often small hand nets, traps or pots. This fishing is rarely commercial but contributes to household food security, especially for children.

BOX 1- DIVERSITY OF FISHING METHODS

The technological requirements to successfully exploit the highly fluctuating inland waters of the floodplains have led to the development of many types of fishing gear. In most cases, nets, traps, fences, pots, and the way they are used, have been developed over time to technological perfection (Lohmeyer, 2002).

There are many fairly comprehensive descriptions of fishing techniques in several floodplains. In the Inner Niger Delta, Laë et al (Quensière, 1994) identify six categories of fishing gear: wound fishing gear (spears), cast, raised or pushed nets and seines, passive methods with gill nets, traps and hooked lines. These categories are found in most river basins in Africa and each may include several dozen different gears, adapted to catch a particular type of fish at different times in the hydrological cycle.

Spectacular fishing devices and methods have been developed in some areas:

Luvale fishers on the upper Zambezi River in Angola and Zambia erect barriers dozens of kilometers long in the floodplain. These barriers direct the fish during the floods into traps that can be modified in size to catch particular species or to select the size of the fish (Lohmeyer, 2002).

In Cameroon, the Logone fishing canals are a unique technique developed by Kotoko fishers for at least three centuries, which consist of directing fish from receding water directly to capture sites. Each canal can be several kilometers long and belongs to a community. The free access permitted by the modern administration has led to individual appropriation of the canals and has allowed migrant fishers to settle in the plain and dig their own channels, creating recurrent conflicts (Kolaouna-Labara, 2020).

03 Many unrecorded actors and a largely underestimated production

In marine and lake fisheries, the use of boats is almost the rule. These boats are attached to well-identified ports or landing sites, and it is therefore relatively easy to identify fishers at these sites along the coastline. In contrast, in riverine fisheries systems, including floodplains and deltas, fishing is highly dispersed, with fishers deploying at peak flood levels to follow fish migrations. Full-time fishers and fisher-farmers are then generally absent from the settlement sites for several months and are settled in camps that are inaccessible by land (Quensière, 1994; Lohmeyer, 2002). It is therefore extremely difficult to conduct a rigorous census unless surveys are carried out during periods of reduced fishing activity. However, such surveys must also consider the fact that households are often involved in agricultural activities, which can lead to significant biases, as respondents may indicate fishing as a secondary rather than main activity. The absence of a boat can also leads to households being categorized as farmers rather than fishers. Hamerlynck et al (2019) thus point out that in many floodplains, mixed livelihoods are practiced by groups of people who tend to be invisible in national statistics.

Very few surveys allow for a proper understanding of river and floodplain fishing systems, which would require a household rather than an individual approach and a distinction between housing sites and fishing camps. An exception is the framesurvey carried out in the WAEMU[4] countries between 2013 and 2015 (Chavance and Morand, 2020) which counted 315,000 inland fishers in the eight WAEMU countries (including 145,000 in Mali). Another result from this survey is to show that in inland fisheries the head of the family is systematically assisted by other members of the household in catching, processing and trading activities, which is not typical in marine fisheries where the distinction between the household (social unit) and the production unit (the boat and its crew) is relatively easy to establish. Furthermore, while pluriactivity (agriculture or livestock keeping) only describes a minority (17%) of households in marine fisheries, it involves 74% of households in inland fisheries, which reflects the highly seasonal nature of inland fisheries, which in a good production season is limited to 4-6 months a year on average (Chavance and Morand, 2020).

[4]West African Economic and Monetary Union (also known by its French acronym, UEMOA) members are Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, and Togo.

In order to estimate the scale of river fisheries production, it is necessary to have a seasonal approach and to take into account the geographical spread of fishing operations. Monitoring systems usually set up for marine fisheries and lake fisheries do not work, and this results in very large underestimates in the statistics, especially when these systems rely on observers posted in residential villages where no fish is landed for several months. Approaches adapted to floodplain fisheries have been proposed (Morand and Ferraris, 1998) and validated in a few countries (Chavance and Morand, 2020), but have not been introduced or systematized in most countries. Moreover, such monitoring systems require a large and well-trained staff, which many countries have had to forego in difficult economic contexts.

Welcomme and Lymer (2012) conducted an audit of national declarations for inland fisheries in 43 African countries. Of the 22 major producing countries (producing over 15,000 tonnes per year), only six produced statistics assessed with a high degree of reliability and, apart from Egypt, these were countries where inland fisheries are mainly lake-based (Kenya, Uganda, Ethiopia, Malawi and Tanzania). This audit also noted a systematic deterioration in the reliability of data in 10 countries, and even the abandonment of data production in seven countries, some of which were unfortunately experiencing a simultaneous security crisis in addition to an economic crisis, particularly in the Sahel region. Almost 10 years later, the situation does not seem to have improved in most of the countries concerned (Table 3).

Following this observation, several studies have been undertaken to determine the real scale of inland fisheries catches using different methods, including household consumption and expenditure surveys (Fluet-Chouinard et al, 2018) or household-level pluriactivity surveys (Chavance and Morand, 2020). These studies show that official data are underestimates in a dozen countries, including Zambia (70% of the probable catch), the Democratic Republic of Congo (70% of the catch) and South Sudan (60% of the catch). The real catches of inland fisheries in Africa would therefore be at least one million tonnes higher than the official statistics (see Box 2).

TABLE 3 - Inland fisheries catches (tonnes) - comparison of FAO 2008 and 2019 data with results from the household consumption model (Fluet-Chouinard, 2018)

Country	Survey	FishStatJ 2008 (t)	Results of the model based on the Household Consumption Surveys (t)			FishStatJ 2019 (t)
			Average	Low estimate	High estimate	
Zambia	2002-03	63 000	764 573	668 945	846 685	97 463
Côte d'Ivoire	2002	22 000	155 328	106 285	204 324	31 842
DR Congo	2004-05	231 772	964 636	890 517	1 038 959	230 000
Togo	2006	5 000	20 124	14 054	26 619	6 500
Malawi	2010-11	98 298	392 902	323 944	461 211	154 922
Burkina Faso	2013-14	20 500	77 740	66 586	89 114	24 765
Mozambique	2002-03	17 500	63 411	41 130	91 681	117 430
Sudan	2009	66 000	212 803	185 623	241 149	38 000
Chad	2009	88 000	208 919	171 524	245 076	107 000
Ghana	2006 (WB)	74 500	398 000	97 592	136 434	90 000
Mali	2009	100 000	125 735	114 873	136 503	100 000

BOX 2 – WIDELY UNDERESTIMATED DATA

The Food and Agriculture Organization (FAO) publishes a 'state of the world's fisheries' report every two years (FAO, 2020). For inland fisheries, a specific report is published and updated much less regularly (FAO, 1999; FAO, 2003; Welcomme, 2011; Funge-Smith, 2018). These publications highlight the lack of comprehensive and validated country-level data on inland fisheries and in particular riverine and floodplain fisheries. In the latest of these reports, Funge-Smith (2018) puts the total catch of inland fisheries in Africa for the year 2015 at 2,860,000 tonnes, while stressing the very high probability that this value is underestimated.

The Illuminating Hidden Harvest Programme (2020-2021) is a joint effort between FAO, WorldFish and Duke University to reassess small-scale fisheries data on a global scale. The final report will not be published before 2022, but the lead authors (Funge-Smith, personal communication) indicate that the availability of data from large lakes is much greater than from floodplains and rivers. The amount of data from these ecosystems is therefore lower and the project was unable to obtain satisfactory results on the most dispersed fisheries, which tend not to be recorded by information systems.

04 An underestimated contribution to food security and nutrition and to livelihoods, especially for women

A growing number of studies aim to assess more accurately the discrepancies between the actual and the declared production of inland fisheries. A result common to all these analyses is that the invisible part of these catches corresponds largely to direct consumption by the fishers' households, especially in catches made by fishers who have other activities outside fishing, a profile that is dominant in the floodplains. This observation should lead us to review the way in which the real contribution of fish to food security in the communities living in these environments is measured.

A characteristic of river and floodplain fisheries is their seasonality, which enables the majority of part-time fishers to alternate between farming and fishing. This greatly enhances food availability throughout the year and provides additional livelihood opportunities for the households concerned.

In the Sudd (South Sudan), Fluet-Chouinard et al (2018) show that the average per capita consumption is at least 17 kg of fish per year, three times the national average, and that 1.7 million people are dependent on fishing in the floodplain.

On the Zambezi River, about 250,000 people live in the Barotse Plain of Zambia where 99% of households depend on fishing and consume five times more fish than the national average. Dried small fish is considered the most common animal-based food among the poor because it is widely available at low prices and in small quantities (Kakwasha et al, 2020). For these people, fishery products represent 73% of their monetary income on average (Turpie et al, 1999).

In the Congo Basin, the review of the fisheries sector conducted in 2020 in eight provinces in the Democratic Republic of Congo (DRC, 2021) shows that the majority of fishing households practice an activity other than fishing, but that the income from fish sales dominates all other sources of income.

In the Salonga region of DRC, Béné et al (2008) showed that around 20% of the population living in forest areas also engage in fishing on a seasonal basis, and that fishing provides them with 50% of their animal protein needs and 65% of their income on average. Fishing is particularly important for households during the lean season (when agricultural production is lowest) as this period corresponds to the end of the dry season and the low water level of rivers, making fishing easier and more productive.

In the Congolese Cuvette, Comptour (2016) confirms that collective fishing at the end of the flood period is a source of both food and income. Some communities share the fish for consumption and the income from the fish for sale equally among all their members, thus meeting all household expenses during the rest of the year.

In the Okavango Delta in Botswana, Mosepele and Ngwenya (2010) report that while the majority of commercial fishers own agricultural assets, only a few perceive them as a major source of income. All commercial fishers consider fishing as the main source of household income, while other sources of income are lower and are seen as complementary to this major economic activity. The same authors emphasize that the understanding of fishing as a "commercial or men-only" activity denies the role of women who mostly engage in subsistence fishing. Despite the contribution of women, there is no quantitative information on the amount of fish they provide to their households, nor on the amount of fish sold in the local market. Information on fish harvesting is limited to commercial fishers.

In general, women engage in capture fisheries for home consumption or small-scale trading, and their fishing gear are relatively simple, usable only in shallow areas or small bodies of water. However, the quantity of fish they produce is often considerable (Lohmeyer, 2002).

BOX 3 - NUTRITIONAL QUALITY

In sub-Saharan Africa, freshwater fish are an important source of animal protein and micronutrients, especially in poor food-deficit countries. Small fish in particular provide a greater intake of essential minerals (Calcium, Iron, Zinc, Selenium) and vitamins (A, B and D) because they are usually consumed whole, including by children (Funge-Smith, 2018). The nutrient composition of inland fish is not well known for all species, but some have been found to contain very high amounts of omega-3 (DHA). In a recent study, O'Meara et al (2021) confirm that the diets of rural children in Zambia and Malawi are more balanced and diverse among children consuming freshwater fish.

05 A source of animal protein with minimal environmental impact

Another remarkable aspect of river fisheries is their environmental footprint. Unlike marine and lake fisheries, motorized boats are very rarely seen on floodplains. Where they do exist, they are used to transport fishers and their families on seasonal transhumance rather than for fishing, or they are used by fish traders. As a result, in riverine fisheries, the production tool can be considered to be limited to fishing gear and the fisher's labour. According to the World Bank (2012), small-scale fisheries have a significantly higher energy efficiency than any other fishery, and this is particularly true for riverine fisheries in Africa that do not use motorized vessels.

Gephart et al (2021) assessed the global environmental footprint of all capture fisheries and aquaculture products, from production to the different value chains, and found that inland fisheries have the smallest footprint as they do not consume land or water and do not emit any greenhouse gases. The balance could even be strictly positive since, in floodplains, water and seasonally flooded land are used successively for fish production and for flood recession agriculture.

The cost of replacing freshwater fish with other animal or plant proteins has been assessed by Funge-Smith (2018). Overall, replacing freshwater fish with aquaculture fish or other farmed animals would involve very high additional land and water use and CO_2 emissions. These estimates were made only on a global scale and by combining all forms of freshwater fishing. However, the same author concludes that inland fisheries provide important nutritional quality to countries with food deficits caused by poverty and limited access to other forms of quality food. Inland fisheries are therefore an efficient food producer because they have a much smaller footprint in terms of resource use than livestock or other protein-rich foods.

Finally, post-harvest aspects of river and floodplain fisheries need to be more accurately assessed. The literature often suggests the problem of post-harvest losses is considerable, due to the lack of conservation and transport facilities. This issue must be put into perspective because the proportion of self-consumption is high in many river and floodplain fisheries which deliberately target small species and juveniles. However, these small fish can easily be preserved by simple solar drying, especially when fishing takes place at the end of the dry season, which generally corresponds to low water. For large fish, smoking is commonly used as a preservation technique in many fisheries but is more commonly used by fishers in their seasonal camps, in areas where fuel wood is more available than in residential areas.

Finally, from in terms of the impact on biodiversity, riverine and floodplain fisheries are characterized by a balance between the different species caught, ranging from the smallest species to large predators, a remarkable illustration of the concept of balanced harvesting (Kolding et al, 2016). However, the most abundant species in the catches belong to a few groups that are particularly resilient to fishing pressure because of their very high productivity (Alestidae and Cichlidae among others).

06 Traditional pro-poor governance and management

Many authors have analyzed the forms of access rights to fisheries resources in the floodplains of the major African basins, including the Zambezi (Lohmeyer, 2002), the Inner Niger Delta (Quensière, 1994) and the Logone Plain (Ziébé, 2015). These studies show that different forms of free, private and community access rights coexist in all systems. Thomas (1996) explains this coexistence by the nature of the fish resource, which varies in abundance and accessibility. In areas where water is permanent, such as the main riverbed, access is generally open to all but individual fishers can appropriate certain areas, or at least use them in the same way as a piece of land, but some seasonally flooded areas are strictly reserved for the community, especially for collective fishing. For a given area, the access regime may vary over time.

These access rights are generally established by customary authorities on the basis of precise and long-standing knowledge of the environment and allow a share of the resources to be reserved for the most vulnerable members of the community. Management rules are often nested in the mystical relationship that the customary powers have with the natural elements, but they are based on a very detailed knowledge of the hydrology and the behaviour of the fish at different stages of their life cycle (Mosepele, 2010). These traditional management arrangements are flexible and can easily be adapted in the face of major environmental changes, such as intense droughts or the construction of dams. Thomas (1986) argues that access and management rights aim to prioritize social benefits over economic ones in a dynamic context where available resources are variable.

Management measures may also concern fishing techniques, in line with the characteristics of each floodplain. The objective is to optimize the level of catch according to the potential of the resource in the collective interest. Accordingly, Lohmeyer (2002) reports that in Ghana, pond owners, who are often also community leaders, encourage community participation in the annual pond fishing event at the end of the dry season. Restrictions on fishing gear are imposed in order to prolong fishing in the ponds and allow as many people as possible to have access to the fish.

Throughout the floodplains, fishers have developed techniques to catch very small fish, including adults of small species and juveniles of larger species. The gears used to target these fish are often seen as damaging to the resource, while the very functioning of floodplains means that a considerable proportion of these fish do not survive low water (Kolding and Zwieten, 2014). This is well known and integrated into traditional fisheries management systems, such as among the Luvale of the Upper Zambezi, who encourage fishing for young fish trapped in pools that are doomed to dry up, while they prohibit fishing for large spawning fish once they have returned to the large channels.

In conclusion, most fishing systems traditionally include measures to control access to the resources, impose spatial and temporal restrictions that are adaptable to environmental conditions, and place community restrictions on fishing techniques. These systems therefore have the same components as modern management systems (Lohmeyer, 2002) but are based on empirical knowledge, which makes them more resilient. The aim of these management systems is to secure livelihoods for the many rather than the few.

SYSTEMS UNDER MULTIPLE THREATS

African floodplain fisheries production systems face a range of challenges, many of which are interrelated.

Climate change

According to IPCC[5] experts (IPCC, 2021), changes in the Earth's energy balance due to anthropogenic radiative forcings are leading to substantial and widespread changes in the global water cycle. According to the IPCC, the drought that affected the Sahel regions from the 1970s to the 1980s was already a consequence of climate change induced by anthropogenic gas emissions. Predictions of a warmer climate that, on average, makes rainy seasons and events wetter but increases the severity of droughts are made with a high degree of confidence. Seasonality will be more pronounced in the Mediterranean and southern Africa, with less clear trends in the Sahel. The decrease in surface water could disrupt the connectivity between rivers and wetlands.

Climate change will therefore lead to greater uncertainty in fisheries production from wetlands and floodplains in most of the continent's catchments. Only the Congo Basin is expected to be spared these changes in the short- to medium-term. The analysis published by Laraque et al (2020) establishes that the Congo River is marked by its exceptional hydrological regularity over nearly 120 years of observations, with the exception of the Ubangi sub-basin, which has been experiencing a water deficit since the 1970s.

According to Barange et al (2018) increased precipitation may favour the flooding of wetlands and thus increase potential fish production. However, further changes may also affect the capacity of fisheries if sensitive species or life stages encounter water temperatures that exceed their tolerances. In addition, combined agri-fisheries production systems may see a decrease in overall productivity (Morand et al, 2016).

The expected effects of climate change on freshwater fish biodiversity have been assessed at the continental level (Nyboer, 2019). This analysis shows that almost

[5] *Intergovernmental Panel on Climate Change*

40% of the 2,700 freshwater fish species recorded on the African continent are vulnerable to climate change to some degree. However, the groups most affected are not the ones most targeted by fishing. If only the families most exploited by fishing are considered, the rate of species vulnerable to the effects of climate change drops to 27%.

One aspect of climate change that has not been given much attention in the literature is the link between the water cycle and pollution. More intense rainfall patterns and rising water levels around urbanized or industrialized areas could increase the risk of pollution in flood-prone areas through drainage and the spread of inorganic and organic pollutants harmful to fish. The systemic failure to manage waste in general increases the risk to surface waters near large cities along rivers and lakes, but also downstream of mining areas, as for example the 2021 incident in the Kasai basin unfortunately illustrates[6].

Demographic pressure

Population growth can be expected to have negative effects on aquatic environments in some parts of the continent. According to Harrod et al (2018), agricultural development is likely to lead to large-scale changes in land use, including intensified deforestation at higher elevations and the use of floodplain habitats for agriculture. This in turn will have serious impacts on watershed hydrology (runoff, evapotranspiration) and water quality (sedimentation, agricultural chemicals, eutrophication), affecting the physical, chemical and biological characteristics of surface waters and their ability to maintain food security.

At the level of the Congo Basin, the same authors (Harrod et al 2018) point out that the human population is expected to double by the end of the century, suggesting that the main threats to fisheries will be due to intensified habitat degradation through deforestation for agriculture and increased demand for fish for food. Allison et al (2009) ranked the Democratic Republic of Congo as the second most vulnerable economy in the world to the impacts of climate change on fisheries, mainly due to its current nutritional dependence on fish (where 45% of animal protein is derived from fish) rather than the projected impacts of climate change.

[6] *https://www.nytimes.com/2021/09/03/world/africa/mine-waste-angola-congo.html*

Water management and prioritization of agriculture in food security policies

Bartley et al (2015) remind us that inland fisheries' productivity depends on good management and habitat quality, requiring water in sufficient quantity and quality and flooding at the right time. As the human population grows and competition for freshwater increases, ensuring adequate water and habitat will be a major challenge in the coming decades.

It appears that most national water management policies consider water needs for human consumption, industry and agriculture in a broad sense, but fail to include the water needs to maintain the productivity of riverine fisheries. When analyzing options for irrigation schemes or fish farm development, it is often not possible to assess the impacts on riverine fisheries' productivity because it is largely underestimated.

In addition, water management policies are increasingly taking the risks associated with flooding into account in populated areas or those used for agricultural or industrial purposes. It is not usually the annual floods that cause the most devastation but the ten-year or hundred-year flood events. The frequency of these extreme events may be increasing with climate change. It therefore now seems normal to take measures to mitigate the risks, for example by building dams or protective embankments. In addition to being very costly in terms of investment and maintenance, these measures have obvious limitations since they cannot easily anticipate exceptional floods in a modified climate system. A less costly approach to adaptation could be "nature-based solutions," inspired by the resilient systems developed by communities historically living in floodplains, including cautious land-use, particularly with regard to the location of housing, using seasonal mobility, and favouring flooding in combination with recession agriculture as an alternative to gravity-irrigated agriculture.

In several regions, there has been enormous resistance to floodplain development projects, despite the prospects for job creation and very high returns from irrigated agriculture. An example is the Kafin-Zaki dam project in the Hadejia-Jama'are floodplain in Nigeria, which was partly abandoned due to pressure from communities and local officials, based on a comparison between the presumed economic value of production in future irrigated schemes and the value of the natural production across the floodplain (UNEP, 2006).

Management of hydropower dams

The impacts of dams are very often underestimated, even by the IPCC. Kumar et al (2011) devote only a short paragraph to the subject, stating that the change in the annual flow regime downstream of dams can significantly affect natural aquatic and terrestrial habitats in the river and on the banks. The disappearance of high natural floods through river regulation affects the ecology of floodplains downstream of the structure and impacts organisms that depend on the flood for completion of their life cycles and may in time lead to changes in plant species composition and fish community structure. According to Winemiller (2016), large dams also block the movements that link populations and allow migratory species to complete their life cycle and therefore invariably reduce fish diversity. This can be particularly devastating for tropical river fisheries, where the migrations of many high-value species are linked to the flood cycle. Other effects include the importance of flooding for groundwater recharge and sediment retention that prevents coastal and delta accretion and favours coastal erosion.

In fact, as shown in Figure 1, the productivity of fisheries resources depends on the extent, duration and cyclicity of flooding, to which the area available for feeding and reproduction of fish outside the riverbed is correlated. Fish production is a function of both flood extent and duration and it is not enough to optimize one of these parameters to maximize fish production. However, dam management generally seeks to flatten flood curves by reducing flooding and increasing dry season flows downstream. This results not only in the loss of spawning and nursery areas, but also removes the natural cues that induce fish to migrate to their spawning grounds and lay their eggs. The reproductive success of many species will thus be severely reduced, and other species may also be affected by the lack of food in the lentic environment created by the dam, with juveniles more exposed to predation due to the lack of shelter.

Duvail and Hamerlynck (2007) have shown that in the Rufiji River plain in Tanzania, floods are essential for maintaining the fertility of the floodplains, and thus the agricultural and fisheries system. Floods are in fact seen as a blessing by the people living in the plain, while droughts and the lack of regular floods are perceived as their main threat. Historically, most food shortages in Rufiji District are associated with drought years and the myth of "flood as a plague" only emerged in the late 1960s. In the same region, Duvail et al (2014) demonstrated how involving people in dam management allowed wetlands and temporary lakes to become reconnected with a positive impact on their livelihoods.

A final challenge regarding dams is the idea that fisheries production in floodplains can be compensated for or replaced by fishing or aquaculture in reservoirs. This assumption is untenable for several reasons. Biodiversity in dammed lakes is always lower than in natural systems, with reduced resilience in fish populations to fishing pressure in the medium-term, and because overall productivity in reservoirs is not stable over the long-term. Indeed, all reservoirs undergo eutrophication or sediment accumulation, which reduces fish productivity over the years by increasing fish mortality. Finally, the distribution of benefits will not be as equitable because fishing in reservoirs is often limited whereas fishing in floodplains has unrestricted access.

Inadequate governance and management frameworks

Traditional forms of management are still in place in some areas, but many countries have substituted exogenous systems to maintain open access while regulating it, for example through the issuance of fishing permits. These systems have removed the role of empirical knowledge in management decisions without replacing it on a scientific basis, leading to the influx of fishers from outside the community and, in some cases, the exclusion of the most vulnerable.

There are many examples throughout Africa of modern regulations that are not well adapted to the reality of river and floodplain fisheries, often because they were inspired by the principles of marine fisheries management. These principles are established to consider two characteristics of fisheries resources: the fact that it is possible to exclude (or include) actors from accessing the fisheries, and the fact that, since the resource is limited, each fish caught by a fisher is no longer available to others. The combination of these characteristics is normally used to determine the 'rules of the game' in systems where the resource is known and the factors that determine its abundance are limited to fishing. In river and floodplain systems, however, resource abundance is largely independent of fishing pressure (Kodio et al, 2002), and access rights are determined on social rather than economic grounds (Lohmeyer, 2002). The introduction of access rights in these systems leads to inconsistencies at several levels:

- Controlling access: Free and open access is seen as a cause of overexploitation. Modern management frameworks therefore aim to maintain unrestricted access but at a fee, for example through the issuance of fishing permits. An immediate consequence is the exclusion of the poorest fishers who cannot pay. In addition, open access controlled by a modern centralized administration removes the power of customary authorities and allows the settlement of fishers from outside the community to enter, potentially creating conflicts.

- Control of fishing areas and seasons: modern management frameworks seek to maintain spatial-temporal management measures but on administrative bases (land registry, official calendar) that may be largely incompatible with understanding the intrinsic variability of natural systems. In the absence of fine-grained scientific data to replace the empirical observations of fishers, these management measures are often counterproductive.

- Gear control: Modern legislation is based on theoretical models developed in the 1950s[7] to manage single species marine fisheries, which recommend minimum catch sizes to maximize yields. This principle has been imposed in all fisheries, but does not apply to complex, seasonal, multi-species and multi-gear fisheries, particularly small-scale river fisheries. Under such regulations, catching small fish becomes an offence or misdemeanor, exposing fishers to unjustified penalties (Mosepele, 2014; Kolding, 2019).

In addition to these regulatory problems, there are also challenges related to the mandate of modern administrations. This problem, which also affects marine fisheries, concerns the establishment of protected areas in the context of the objectives of the Convention on Biological Diversity[8]. Inland fisheries are generally administered by a department in charge of fisheries or agriculture, whereas the management of protected areas is the responsibility of the environmental protection or national parks administration. The absence of collaboration between administrations and the lack of consultation with the local communities or traditional authorities leads to the imposition of very restrictive regulations, depriving populations that have depended on fisheries resources for generations of their right of access. The presence of species considered to be threatened in a fisheries system can often be an aggravating factor leading to total bans on access and to fishing being treated as poaching with severe penalties, as for example occurred in the Selous Reserve on the Rufiji River in Tanzania (Paul et al, 2011). Lynch (2017) has pointed out that the diffuse nature of riverine and floodplain fisheries makes centralized management difficult or even unworkable. Unlike marine and lake fisheries, active management of river fisheries through regulation or technical interventions to increase productivity is not always realistic, or even desirable, when open access is so crucial to providing livelihoods for the most vulnerable people. Despite their value, inland fisheries are mostly neglected in governance processes. They face political and economic isolation and invisibility, caused by governance systems in which fishers are poorly represented in decision-making, with limited institutional support for fisheries management, and where other water users take over. The rural and dispersed nature of most river fisheries means that they are often overlooked in discussions about food security and nutrition.

Ngwenya (2012) goes further by analyzing public interventions in the fisheries sector in the Okavango Delta in Botswana, which have tended to exacerbate rather than mitigate gender disparities in access to and control of resources, asset accumulation and employment opportunities. The ecological knowledge, interests and concerns of women fishers have been excluded from the processes defining zoning regulations and temporary fishing closures as well as from co-management structures. The author concludes that development interventions and the current regulatory framework continue to entrench existing gender relations in the sector, which exclude, disempower and marginalize women.

A deficit of quantitative information that undermines the sector's recognition and contribution to the SDGs

Inadequate data collection systems in river and floodplain fisheries are a major obstacle to their future development. Obtaining data on catch and fishing effort in African riverine fisheries is problematic, yet such data are needed to illustrate the true value of these fisheries to policy makers. The lack of knowledge about these particular fisheries exacerbates the management dilemma, where managers resort to the conventional marine management approaches in which they were trained. However, these management approaches may not necessarily be easy to implement and enforce or helpful in a riverine context. In addition, the operational costs of management systems based on access and effort control become prohibitive in areas as large and inaccessible as large floodplains (Mosepele, 2014).

[7] *Models by Beverton and Holt, 1957.*
[8] *https://www.cbd.int/*

The lack of information further contributes to the marginalization or even invisibility of this sector in indicators at local, national and regional levels (Mosepele, 2014). Significantly, this relates to food security and nutrition, which is estimated on the basis of apparent availability of fisheries products in relation to the national population, which is often far too imprecise, particularly when it comes to the nutrition of children and women in rural areas. It also concerns employment, which is often estimated on the basis of a declared main activity, whereas some populations practice several income-generating activities on a seasonal basis, particularly the trade in fish products, which is mainly conducted by women. In some contexts, the increasing supply of cheap fish (e.g. tilapia imported from Asia) can drive down prices of local fisheries products in importing countries, further undermining the livelihoods of poor fishing communities (Béné et al, 2016).

The lack of accurate and reliable information on river and floodplain fisheries is also a challenge for land-use planning and natural resource management policies. Africa still has a very high potential for catching fish in rivers and floodplains due to the low population density in some regions, but several floodplains are under heavy pressure, especially in the Sahel. Conflicts of use between livestock keepers, farmers and multi-activity fishers can only be avoided and resolved if there is a detailed understanding of the functioning of these systems. Finally, the lack of information contributes to biased political decisions and strategic choices regarding infrastructure, which should be based on the evaluation of all the costs and benefits, including food production and the livelihoods of the most vulnerable populations.

RECOMMENDATIONS

The safeguarding of river and floodplain fisheries requires a holistic and integrated approach coupled with a strong political will to opt for nature-based solutions (NbS) that respect the knowledge and skills of the people who depend on these resources for their survival. The following recommendations are steps to embark on such an approach.

Improve knowledge and understanding of fisheries systems to assess their real contribution to food security, income and well-being

As a first step, the Regional Member Countries concerned should commit to include in their budgets the implementation of regular surveys to accurately assess the number of households living fully or partly from fishing in rivers, floodplains and deltas. These surveys should be based on a household approach and include all social, economic and environmental dimensions of livelihoods and resilience. Such surveys should, where appropriate, be conducted at the basin level and thus be implemented jointly by several countries[9].

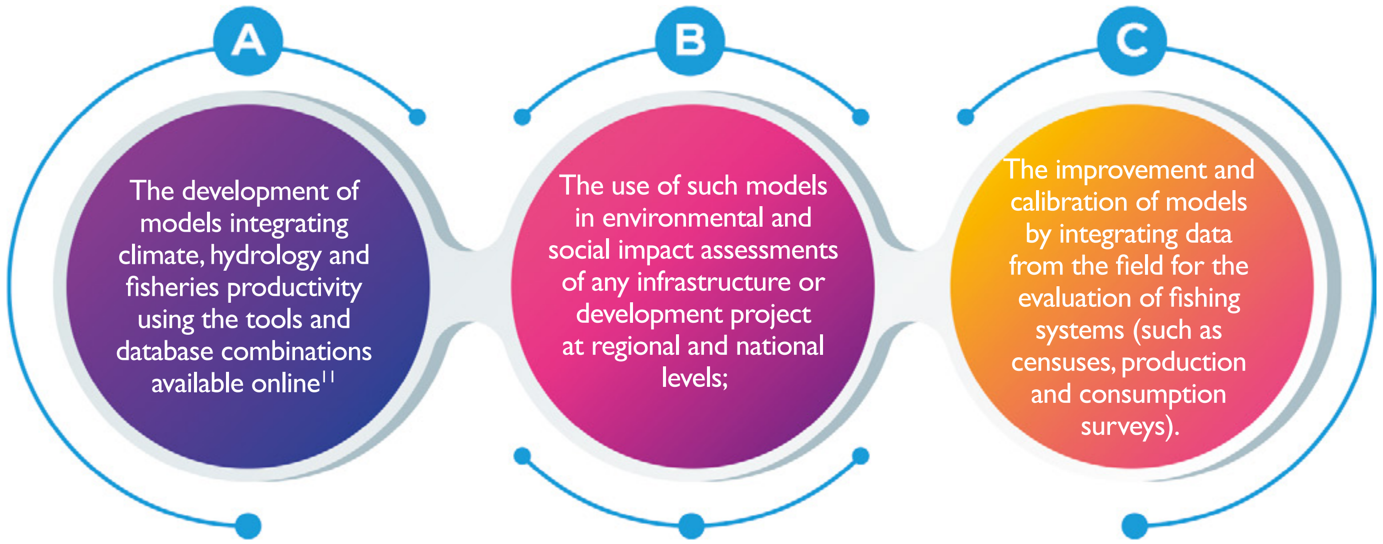
In a second step, RMCs with reliable quantitative data on their riverine and floodplain fisheries should formalize them, through national statistical institutes, so that this sector occupies its rightful place in national statistical aggregates in terms of employment, food security, trade and value added, with disaggregated data on gender.

Basin Organizations should be encouraged to include fisheries in their strategic priorities, along with water, energy and transport, because of the crucial importance of this sector to food security and the livelihoods of the people who depend on it. This approach could be promoted through the African Network of Basin Organizations (ANBO)[10].

[9] *The Lake Albert and Lake Edward surveys in 2019 and 2021 provide an excellent example of collaboration between DRC and Uganda under the LEAF II project funded by the African Development Bank and implemented by the Nile Basin Initiative.*

[10] *https://www.anbo-raob.org/index.php/en.*

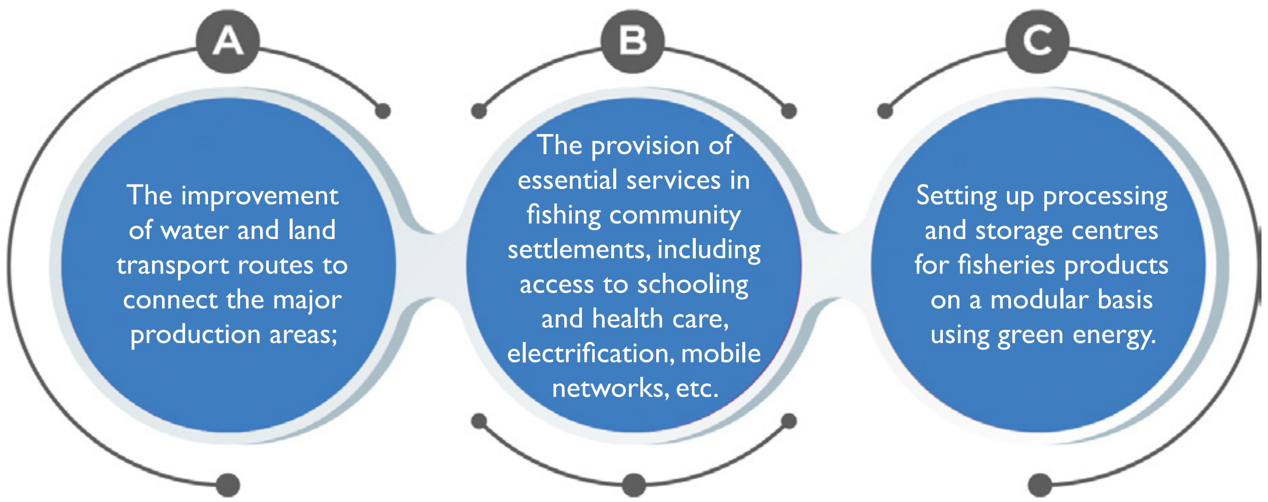
Each organization should be able to develop ambitious knowledge enhancement programmes using the best available technologies, including:



The information could be used to produce an updated atlas of African wetlands and floodplains and their associated fisheries, and thus enable development partners to fund programmes to support conservation and management.

Ensure a balanced development compatible with the dynamics of production systems

Priority development projects should concern the construction of infrastructure adapted to the specific conditions of each area:



Such projects, already identified in several Central African countries (such as DRC, Congo, Angola) should also be subject to in-depth environmental and social impact assessments.

[11] *For example, Google Earth Engine (GEE).*

Preserve the ecosystems concerned and their productivity

It appears to be a priority to extend the recognition of all the continent's wetlands and their inclusion in the list of classified sites under the RAMSAR Convention. Several countries in Africa do not yet recognize the conservation value of any or only a very small part of their wetlands, especially flood plains[12]. Several of these areas are transboundary and an effort must also be made by the Regional Economic Communities and basin organizations to build understanding of their unique contribution.

The preservation of agri-fishery productive systems in floodplains require that the water quality and the seasonal flood cycle be maintained on a basin scale. Where priority is to be given to hydropower production, a comprehensive, detailed and rigorous assessment of the productivity of the whole downstream system should be carried out. Environmental and social safeguards should not be limited to a quick estimate of fish catches but should include all food production (agricultural and livestock) that depends on the flood, as well as all other livelihoods of the people living in the plain.

The restoration of ecosystems should aim to promote rehabilitating conditions of optimal productivity, in particular by restoring plant cover throughout the basin. Engineering prospects for supplying water to Lake Chad, for example, seem to present costs and risks that are difficult for the countries concerned to bear. Nature-based Solution (NBS) restoration programmes could present a more appropriate approach and offer greater long-term resilience.

Pollution prevention and response should be the subject of ambitious strategies at the level of basin organizations. This particularly concerns industrial sources, for which control measures must be applied during their operation, closure and restoration. It also concerns agricultural and urban pollution, for which public policies must be coordinated, including at a local level in the framework of urban development plans.

[12] *https://rsis.ramsar.org/fr/ris-search/?f%5B0%5D=regionCountry_fr_ss%3AAfrique*

Adapting fisheries governance and management to the realities of production systems

Policy frameworks for fisheries management must give priority to food security, and therefore the greatest importance to the subsistence forms of fishing practiced by women and the most vulnerable. This priority should lead to a revision of management frameworks that have been imposed for decades in some countries and whose effectiveness is inversely proportional to their cost (issuing fishing permits, controlling gear, collecting taxes, etc.).

Traditional management systems should be preserved wherever they exist and are still operating effectively. By continuing to prohibit the catching of small fish, the use of small-mesh nets or collective depletion fisheries in residual pools, regulations based on the conventional approach to fisheries management do not optimize the use of floodplain fisheries resources and could lead to hardship and increase food insecurity.

Given the difficulty of accounting for fishers' activity and quantifying their production in floodplains, it would be preferable to focus on the level of satisfaction of the basic needs of these populations, by conducting appropriate socio-economic surveys rather than censuses or catch monitoring (De Graaf et al, 2015).

It seems particularly desirable to rehabilitate traditional management methods in situations where precariousness is aggravated, for example by the arrival of refugee populations, since these systems make it possible to support a seasonal fishing pressure adapted to the abundance of the resource, and by allowing people without means of production to meet their needs. In the same spirit, basin organizations should integrate fisheries into their resource management policies in order to facilitate the transhumance of fishers across national borders when floodplains are shared by several countries.

These changes cannot be made abruptly or in an authoritarian manner. Hamerlynck et al (2019) recommend that governance inspired by traditional systems, with the strong involvement of users at all stages of planning and management, will facilitate development trajectories adapted to the local context, promoting gradual but deeper and more lasting change.

References

Allison, E.H.; A.L. Perry; M.C. Badjeck; W.N. Adger; K. Brown; D. Conway; A.S. Halls; G.M. Pilling; J.D. Reynolds; N.L. Andrew; N.K. Dulvy. 2009. Vulnerability of national economies to the impacts of climate change on fisheries. Fish and Fisheries, 2009, 10, 173–196. https://doi.org/10.1111/j.1467-2979.2008.00310.x

Barange, M.; T. Bahri; M.C.M. Beveridge; K.L. Cochrane; S. Funge-Smith & F. Poulain. (eds.). 2018. Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options. FAO Fisheries and Aquaculture Technical Paper No. 627. Rome, FAO. 628 pp.

Bartley, D.M.; G. de Graaf and J. Valbo-Jørgensen. 2015. Commercial inland capture fisheries. In Freshwater Fisheries Ecology, J.F. Craig (Ed.). https://doi.org/10.1002/9781118394380.ch35

Béné, C.; E. Steel; B. Kambala-Luadia and A. Gordon. 2009. Fish as the "bank in the water" – Evidence from chronic-poor communities in Congo. Food Policy 34 (2009) 108–118

Béné, C.; R. Arthur; H. Norbury; E.H. Allison; M. Beveridge; S.R. Bush; L. Campling; W. Leschen; D. Little; D. Squires; S.H. Thilsted; M. Troell & M. Williams. 2016. Contribution of Fisheries and Aquaculture to Food Security and Poverty Reduction: Assessing the Current Evidence. World Development, 79, 177-196. https://doi.org/10.1016/j.worlddev.2015.11.007

Burgis, M. J. & J.J. Symoens (eds.). 1987. Directory of African wetlands and shallow water bodies. 654 pp. Edition ORSTOM. Travaux et document n°211. Paris

Chavance, P. et P. Morand (Eds). 2021. Atlas des pêches et pêcheurs d'Afrique de l'Ouest - États membres de l'UEMOA : Bénin, Burkina Faso, Côte d'Ivoire, Guinée-Bissau, Mali, Niger, Sénégal, Togo. IRD Editions / UEMOA. Marseille, Ouagadougou, 2020.

Comptour, M.; S. Caillon and D. McKey. 2016. Pond fishing in the Congolese cuvette: a story of fishers, animals, and water spirits. Revue d'ethnoécologie. http://journals.openedition.org/ethnoecologie/2795. https://doi.org/10.4000/ethnoecologie.2795

Crul, R.C.M. 1992. Modèles pour l'estimation des rendements potentiels en poisson des eaux intérieures africaines. Document occasionnel du CPCA. No. 16. Rome, FAO. 1992. 23p.

De Graaf, G.; D. Bartley; J. Jorgensen and G. Marmulla. 2015. The scale of inland fisheries, can we do better? Alternative approaches for assessment. Fisheries Management and Ecology, 2015, 22, 64–70. https://doi.org/10.1111/j.1365-2400.2011.00844.x

Duvail, S. and O. Hamerlynck. 2007. The Rufiji River flood: plague or blessing? Int. J. Biometeorol. 52, 33–42 (2007). https://doi.org/10.1007/s00484-007-0105-8
Duvail, S.; A.B. Mwakalinga; A. Eijkelenburg; O. Hamerlynck; K. Kindinda and A. Majule. 2014. Jointly thinking the post-dam future: exchange of local and scientific knowledge on the lakes of the Lower Rufiji, Tanzania. Hydrological Sciences Journal, 59 (3–4), 713–730.

FAO. 1999. Review of the state of world fishery resources: inland fisheries. FAO Fisheries Circular. No. 942. FAO Inland Water Resources and Aquaculture Service, Fishery Resources Division. Rome. 53 pp.

FAO. 2003. Review of the state of world fishery resources: inland fisheries. FAO Fisheries Circular. No. 942, Rev.1. Rome. 60 pp.

FAO. 2017. Workshop on improving our knowledge on small-scale fisheries: data needs and methodologies. Workshop proceedings, 27–29 June 2017, Rome, Italy. FAO Fisheries and Aquaculture Proceedings No. 55. Rome, Italy.

FAO. 2020. The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome. https://doi.org/10.4060/ca9229en

Ferry, L. ; M. Mietton ; A. Renard-Toumi ; D. Martin ; M.A. Barry et N. Muther. 2015. Plaine alluviale du Niger supérieur et mare de Baro (Guinée) : Fonctionnement hydrologique, gestion traditionnelle des ressources et perspectives après-barrage. Territoire en mouvement, Revue de géographie et aménagement 25-26, 2015. https://doi.org/10.4000/tem.2786

Fluet-Chouinard, E.; B. Lehner; L.-M. Rebelo; F. Papa and S.K. Hamilton. 2015. Development of a global inundation map at high spatial resolution from topographic downscaling of coarse-scale remote sensing data. Remote Sensing of Environment 158 (2015) 348–361.

Fluet-Chouinard, E.; S. Funge-Smith and P.B. McIntyre. 2018. Global hidden harvest of freshwater fish revealed by household surveys. www.pnas.org/cgi/doi/10.1073/pnas.1721097115

Funge-Smith, S.J. 2018. Review of the state of world fishery resources: inland fisheries. FAO Fisheries and Aquaculture Circular No. C942 Rev.3, Rome. 397 pp.

Gephart, J.A.; P.J.G. Henriksson; R.W.R. Parker et al. 2021. Environmental performance of blue foods. Nature 597, 360–365 (2021). https://doi.org/10.1038/s41586-021-03889-2

Gunderson, L.H. 2000. Ecological resilience - in theory and application. Annual Review of Ecology and Systematics 31:425-439

Hamerlynck O.; D.W. Nyingi; J.-L. Paul & S. Duvail. 2019. The fish-based farming systems: maintaining ecosystem health and flexible livelihood portfolios. In Dixon et al. (eds) Farming systems and food security in Africa: Priorities for Science and Policy under Global Change. Routledge, Earthscan, 640 p.

Harrod, C.; A. Ramírez; J. Valbo-Jørgensen and S. Funge-Smith. 2018. Current anthropogenic stress and projected effect of climate change on global inland fisheries. Chapitre 19. In Barange et al. (eds.) 2018. Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options. FAO Fisheries and Aquaculture Technical Paper No. 627. Rome

Holling, C. S., 1973. Resilience and Stability of Ecological Systems. Annual Review of Ecology and Systematics 4:1-23.

IPCC. 2021. Sixth Assessment Report. Working Group I Contribution. Chapter 8: Water Cycle Changes.https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter_08.pdf

Jul-Larsen, E.; J. Kolding; R. Overå; J. Raakjær Nielsen; P.A.M. van Zwieten. 2003. Management, co-management or no management? Major dilemmas in southern African freshwater fisheries. 1. Synthesis report. FAO Fisheries Technical Paper. No. 426/1. Rome, FAO. 2003. 127p

Junk, W.J.; P.B. Bayley and R.E. Sparks. 1989. The flood pulse concept in river–floodplain systems. In: D.P. Dodge, ed. Proceedings of the International Rivers Symposium. Canadian Special Publication of Fisheries and Aquatic Sciences., 106, 110–127.

Kakwasha, K.; F.A. Simmance; P.J. Cohen; L. Muzungaire; H. Phiri; M. Mbewe; E. Mutanuka; B. Nankwenya; J. Wesana; K. Byrd; L. Pincus; J. de Bruyn; C.Y. Chan; D. Mills and V. Siamudaala. 2020. Strengthening small-scale fisheries for food and nutrition security, human well-being and environmental health in Zambia. Penang, Malaysia: WorldFish. Program Brief: 2020-41

Kodio, A. ; P. Morand ; K. Dienepo et R. Laë. 2002. La dynamique de la pêcherie du delta intérieur du Niger revisitée à la lumière des données récentes. Implications en termes de gestion. pp. 431-453 in Orange D. ; R. Arfi ; M. Kuper ; P. Morand et Y. Poncet (eds. sc.). 2002. Gestion Intégrée des Ressources naturelles en Zone Inondable Tropicale. Editions IRD . coll. Colloques et Séminaires Kolaouna Labara, B. ; A. Djaowe ; D. Tajo ; S. Chouto ; F.X. Chendjou & R. Tagne. 2020. La pêche artisanale par canaux dans la plaine du Logone : une rentabilité source de conflits entre pêcheurs. BSGLg, 75, 2020, 83-100

Kolding, J. & P.A.M. van Zwieten. 2014. Sustainable fishing of inland waters. J. Limnol., 2014; 73(s1): 132-148 DOI: 10.4081/jlimnol.2014.818

Kolding, J.; N.S. Jacobsen; K.H. Andersen and P.A.M. van Zwieten. 2016. Maximizing fisheries yields while maintaining community structure. Can. J. Fish. Aquat. Sci. 73: 644–655. dx.doi.org/10.1139/cjfas-2015-0098

Kumar, A.; T. Schei; A. Ahenkorah; R. Caceres Rodriguez; J.-M. Devernay; M. Freitas; D. Hall; Å. Killingtveit; Z. Liu. 2011. Hydropower. In IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, C. von Stechow (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

Laraque, A.; G.D. Moukandi N'kaya; D. Orange; R. Tshimanga; J.M. Tshitenge; G. Mahé; C.R. Nguimalet; M.A. Trigg; S. Yepez; G. Gulemvuga. 2020. Recent Budget of Hydroclimatology and Hydrosedimentology of the Congo River in Central Africa. Water 2020, 12, 2613. https://doi.org/10.3390/w12092613

Lehner, B. and P. Döll. 2004. Development and validation of a global database of lakes, reservoirs and wetlands. Journal of Hydrology 296 (2004) 1–22

Linhoss, A.C.; R. Muñoz-Carpena; M.S. Allen; K. Kiker and K. Mosepele. 2012. A flood pulse driven fish population model for the Okavango Delta, Botswana. Ecological Modelling Volume 228, 10 March 2012, Pages 27-38. https://doi.org/10.1016/j.ecolmodel.2011.12.022

Lohmeyer, U. 2002. Traditional Inland Fisheries Management and Enhancement Systems in Sub-Saharan Africa and their Potential for Development. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ).

Lowe-McConnell, R.H. 1987. Ecological Studies in Tropical Fish Communities. Cambridge University Press.

Lymer, D.; F. Marttin; G. Marmulla & D. Bartley. 2016. A global estimate of theoretical annual inland capture fisheries harvest

Lynch, A. J.; I.G. Cowx; E. Fluet-Chouinard; S.M. Glaser; S.C. Phang; T.D. Beard; S.D. Bower; J.L. Brooks; D.B. Bunnell; J.E. Claussen; S.J. Cooke; Y.-C. Kao; K. Lorenzen; B.J.E. Myers; A.J. Reid; J.J. Taylor & S.Youn. 2017. Inland fisheries – Invisible but integral to the UN Sustainable Development Agenda for ending poverty by 2030. Global Environmental Change, 47, 167–173. https://doi.org/10.1016/j.gloenvcha.2017.10.005

Morand, P. et J. Ferraris. 1998. L'évolution des systèmes d'enquête des pêches artisanales en Afrique de l'Ouest, entre questions halieutiques et solutions méthodologiques. https://www.researchgate.net/publication/282169299

Morand, P.; A. Kodio; N. Andrew; F. Sinaba; J. Lemoalle and C. Béné. 2012. Vulnerability and adaptation of African rural populations to hydro-climate change: experience from fishing communities in the Inner Niger Delta (Mali). Climatic Change, 115: 463-483. Mosepele, K. and B.N. Ngwenya. 2010. Socio-Economic Survey of Commercial Fishing in the Okavango Delta, Botswana. Okavango Report Series No.7

Mosepele, K. 2014. Classical Fisheries Theory and Inland (Floodplain) Fisheries Management; Is there Need for a Paradigm Shift? Lessons from the Okavango Delta, Botswana . Fish Aquac J 5: 101. doi:10.4172/ 2150-3508.1000101.

Ngwenya, B.N.; K.K. Mosepele; L. Magole. 2012. A case for gender equity in governance of the Okavango Delta fisheries in Botswana. Natural Resources Forum 36 (2012) 109–122. https://doi.org/10.1111/j.1477-8947.2012.001450.x

Nyboer, E. A.; Ch. Liang; L. J. Chapman. 2019. Assessing the vulnerability of Africa's freshwater fishes to climate change: A continent-wide trait-based analysis. Biological Conservation 236 (2019) 505–520

O'Meara, L.; P.J. Cohen; F. Simmance; P. Marinda; J. Nagoli; S.J. Teoh; S. Funge-Smith; D.J. Mills; S.H. Thilsted; K.A. Byrd. 2021. Inland fisheries critical for the diet quality of young children in sub-Saharan Africa. Global Food Security 28 (2021) 100483. https://doi.org/10.1016/j.gfs.2020.100483

Ostrom, E. 2009. A General Framework for Analyzing Sustainability of Social-Ecological Systems. Science. 24 July 2009 Vol 325, Issue 5939 pp. 419-422. DOI: 10.1126/science.1172133

Pasqualino, M.; G. Kennedy; K. Longley & S.H. Thilsted. 2016. Food and Nutrition Security in the Barotse Floodplain System. CGIAR Research Program on Aquatic Agricultural Systems (AAS)

Paul, J.L. ; S. Duvail et O. Hamerlynck. 2011. Appropriation des ressources naturelles et criminalisation des communautés paysannes. Civilisations. DOI : 10.4000/civilisations.2806

Quensière, J. (ed.) 1994. La pêche dans le delta central du Niger : Approche pluridisciplinaire d'un système de production halieutique. Orstom / Karthala, 1994.

Quensière, J. ; S.B. Tounkara et A. Kane. 2018. La résilience perdue des pêcheries du Delta Central du Niger : une illustration de la nature systémique complexe de la résilience. Éditions de la Sorbonne, Revue internationale des études du développement, 2018/3 N° 235, p. 29-59. DOI 10.3917/ried.235.0029

RDC. 2021. Plan Prioritaire de Relance de la Pêche en République Démocratique du Congo 2021–2030. Ministère de la Pêche et de l'Élevage

Smith, E.D.L.; S. Nguyen Khoa and K. Lorenzen. 2005. Livelihood functions of inland fisheries: policy implications in developing countries. Water Policy 7 (2005) 359–383

Thomas, D.H.L. 1996. Fisheries Tenure in an African Floodplain Village and the Implications for Management. Human Ecology, Vol. 24, No. 3, 1996

Turpie, J.; B. Smith; L. Emerton and J. Barnes. 1999. Economic Valuation of the Zambezi Basin Wetlands, IUCN – Regional Office, Harare.

UNEP. 2006. Africa's Lakes: Atlas of Our Changing Environment. Division of Early Warning and Assessment (DEWA) United Nations Environment Programme (UNEP) Nairobi, Kenya

UNEP: 2010. Africa Water Atlas

Vanden Bossche, J.-P.; G.M. Bernacsek. 1991. Source book for the inland fishery resources of Africa (SIFRA) vol. 1, 2 & 3. CIFA Technical Paper. No. 18. Rome, FAO. 1990.

Welcomme, R.L. 1985. River Fisheries. FAO Fish (1985) Tech. Paper (262) 330pp.

Welcomme, R. 2011. Review of the state of world fishery resources: Inland Fisheries. FAO Fisheries and Aquaculture Circular No. 942, Rev. 2. Rome. 97 pp

Welcomme, R.; D. Lymer. 2012. An audit of inland capture fishery statistics – Africa. FAO Fisheries and Aquaculture Circular No. 1051. Rome, FAO. 2012. 61 pp.

Winemiller, K.O. ; P.B. McIntyre ; L. Castello ; E. Fluet-Chouinard et al. 2016. Balancing hydropower and biodiversity in the Amazon, Congo, and Mekong. Science 351 (6269), 128-129. DOI: 10.1126/science.aac7082

World Bank. 2012. Hidden Harvest: The Global Contribution of Capture Fisheries. Report N°66469-GLB.

Ziébé, R. 2015. Fisheries in the Waza Logone Floodplain : an analysis of the status of the fisheries sector and mitigation of conflicts within the sector in North Cameroon. University of Leiden.

AFRICAN DEVELOPMENT BANK GROUP

Africa Natural Resources Management &
Investment Center

Avenue Jean-Paul II -01BP 1387,
Abidjan - Côte d'Ivoire

ecnr_info@afdb.org
www.afdb.org