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COMMITTEE FOR INLAND FISHERIES AND AQUACULTURE OF AFRICA

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CLIMATE CHANGE, INLAND FISHERY AND AQUACULTURE IN AFRICA: BACKGROUND INFORMATION

1. Introduction

The various weather parameters vary within the year and from year to year within a certain range according to the location. Climate is "the average weather" in a particular region based on the statistics of meteorological parameters over long periods (usually 30 years). The climate decides the survival and distributions of species and governs ecosystem processes and productivity. Climate is therefore part of the foundation on which our economies and societies are built.

Throughout geological history, the Earth's climate has undergone short and long-term cycles of change (heating up or cooling down) caused by astronomical and terrestrial phenomena. Various models predict significant temperature rises for the planet in the near future. The extent to which human activities interact with and reinforces these natural trends is the subject of discussion. However, that change is going to happen is no longer a subject of serious debate.

The Intergovernmental Panel on Climate Change (IPCC) has developed a number of scenarios based on climate models describing developments because of climate change. However, the climate models used are relatively crude working on a horizontal spatial resolution of several hundred kilometres, and do not take full account of the topographic, vegetation and land use diversity of the landscape. The reliability of the models thus depends on the scale, the time horizon and the amount and reliability of data available for the area of interest (Conway 2009[1]).

When it concerns Africa, it is important to recognise that Africa's climate is naturally both highly diverse and highly variable. It ranges from the extreme aridity of the Saharan deserts to the extreme humidity of the Congolese rainforest.

According to the existing models, northern and southern Africa are likely to become both much hotter (as much as 4°C or more) and drier (precipitation falling by 15 percent or more) over the next 100 years. In East Africa, including the Horn of Africa, on the other hand, it is believed that average rainfall will increase. Over much of the rest of Africa (including the Sahel), there is considerable uncertainty as to how the rainfall will evolve (Conway 2009, Figure 1).

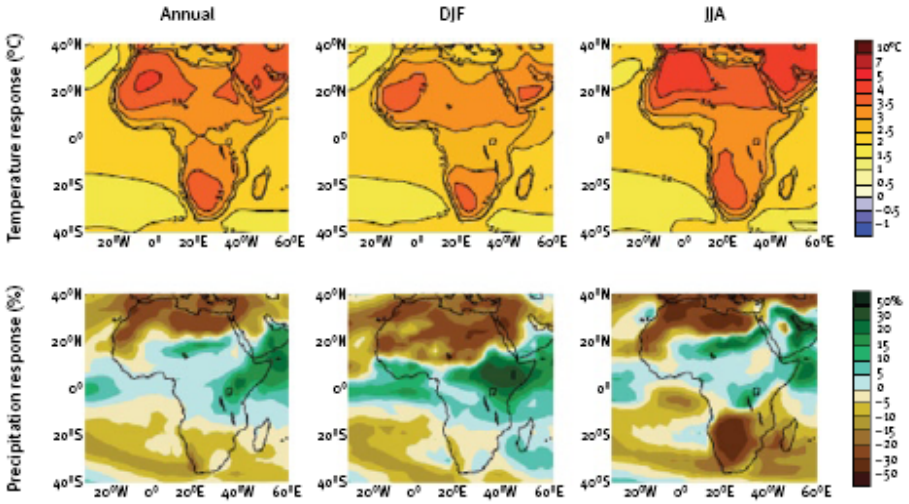

Figure 1 Change in temperature (top row) and rainfall (bottom row) for Africa, between 1980-1999 and 2080-2099 for IPCC scenario A1B, averaged over 21 Atmosphere-Ocean General Circulation Models. DJF – Dec, Jan, Feb; JJA – June, July, Aug. (The A1B scenario assumes a world of very rapid economic growth, a global population that peaks in mid-century and rapid introduction of new and more efficient technologies, with a balance of fossil and non-fossil energy (adapted from Conway 2009).

[1] Conway 2009 The science of climate change in Africa: impacts and adaptation, Discussion paper No 1, Grantham Institute for Climate Change, 24 p.

2. What is at stake in inland fisheries?

With annual landings of about 2.5 million tonnes, African inland fisheries are responsible for about one third of the continents fish production. Twenty two countries account for 95 percent of the catch (Welcomme *in preparation*[2]). Most of the production is concentrated in the large river and lake basins e.g. Lake Victoria (1 000 000 tonnes), Lake Tanganyika (197 000 tonnes), Lake Volta (271 000 tonnes), and Niger River (300,000 tonnes) (De Graaf and Ofori-Danson 1997[3], Mölsä *et al.* 1999[4], Laë *et al.* 2004[5], www.LVFO.org).

The exact number of people involved in inland fisheries is difficult to determine, especially because there are many part-time fishers who combine fishing with farming and other rural activities. However, inland fisheries plays an enormously important role in underpinning the livelihoods of millions of people in remote rural settings where vulnerability to poverty is a serious problem.

Fish contributes on average 21 percent of the daily protein intake for African countries. However, much more fish is obviously consumed in areas with easy access to fish. Inland fish is particularly important for human consumption in countries such as Chad, Uganda, Mali, Congo, Gabon, and Tanzania.

In economic terms, the total first sale value of African inland fisheries production adds up to US$ 1.8 billion. There is no doubt that inland fisheries makes an important contribution to local and regional economies in all the major African river basins, and for several countries including Chad, Mali and Uganda, inland fisheries contributes as much as five to ten percent to GDP.

Trade in freshwater fish products is important for some African countries especially the export of Nile Perch from Lake Victoria (i.e. Tanzania, Kenya and Uganda), which has a value of several hundred million US dollars. There are also well developed, but often informal, national and regional trade networks in inland fish products e.g. the trade in dried fish products in and around the Niger inland delta, and the Lake Chad Basin.

3. What is at stake for Aquaculture?

Aquaculture in the whole African continent amounts to 995 thousand tonnes which is 10.5 percent of the continent's total fish production in 2008. Most of this production (93 percent) takes place in inland waters or under the influence of inland waters (as is the case of aquaculture in Egypt). Aquaculture is dominated by three countries in the region, [Egypt (74 percent); Nigeria (15 percent) and Uganda (6 percent)] and the growth rate of inland aquaculture is very high in several countries; 31 percent in Algeria, 18.7 percent in Nigeria, 16.5 percent in Ghana, 13.6 percent in Kenya. Even though in some of them the production is small, the potential for inland aquaculture is very large. Aquaculture is providing not only good quality food but also jobs.

The emphasis on commercial aquaculture in several countries has created jobs for farm technicians and skilled labour. Furthermore, new industries and financial services in support of aquaculture are also providing employment opportunities in a number of countries. It is estimated that employment by the sector per country range between 18 000-30 000 jobs (Satia *in preparation*).

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[2] R. Welcomme and D. Lymer (in preparation) An Audit of Inland Capture Fishery Statistics – Africa. FAO Fisheries Circular. Rome.

[3] de Graaf GJ, Ofori-Danson PK. (1997). Catch and fish stock assessment in stratum VII of Lake Volta. Integrated Development of Artisanal Fisheries Project technical report 97I. Food and Agriculture Organization, Rome.

[4] Mölsä, H., Reynolds, J.E., Coenen, E.J. and Lindqvist, O.V. 1999. Fisheries research toward resource management on Lake Tanganyika. *Hydrobiologia* 407: 1−24.

[5] Laë, R., Williams, S., Malam Mossou, A. Morand, P. and Mikolasek, O. (2004) Review of the Present State of the Environment, Fish Stocks and Fisheries of the River Niger (West Africa). Pp.199-229. In: Welcomme, R.L. and Petr, T. Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries. Vol.1. FAO and Mekong River Commission. RAP Publication 2004/16.

Aquaculture is offering opportunities for diversification of sources of livelihoods and farm enterprises, in that it is one of a variety of enterprises comprising the farming system undertaken to diversify production and income, improve resource use and reduce risks of such events as crop or market failure. Examples of fish production systems that offer diversification are culture-based fisheries and integrated farming. Culture-based fisheries offer enormous potential in Sub-Saharan Africa to enhance fish supply, for example in Uganda about 4 000 tonnes of its annual production is from culture-based fisheries (FAO *in preparation*).

4. Impacts of Climate Change

4.1. Physical and Environmental impacts

An expected characteristic of global climate change is a likely increase in the variability of environmental conditions including temperature, precipitation, and wind patterns. There are particular concerns regarding Africa, where temperature is predicted to be higher and rainfall to decrease over large parts of the continent. Wetlands, floodplains and shallow lakes and rivers such as Lake Chad (Figure 2), Niger Inland Delta, the Sudd, Lake Chilwa, Lake Turkana, Kafue Flats and the Okavango delta are all susceptible to changes in temperature and precipitation, and prolonged periods of drought will reduce available fish habitat and they may dry up completely as recently occurred at Lake Chilwa in Malawi and Lake Nakuru in Kenya (Watson *et al.* 1998[6], Allison *et al.* 2007[7]).

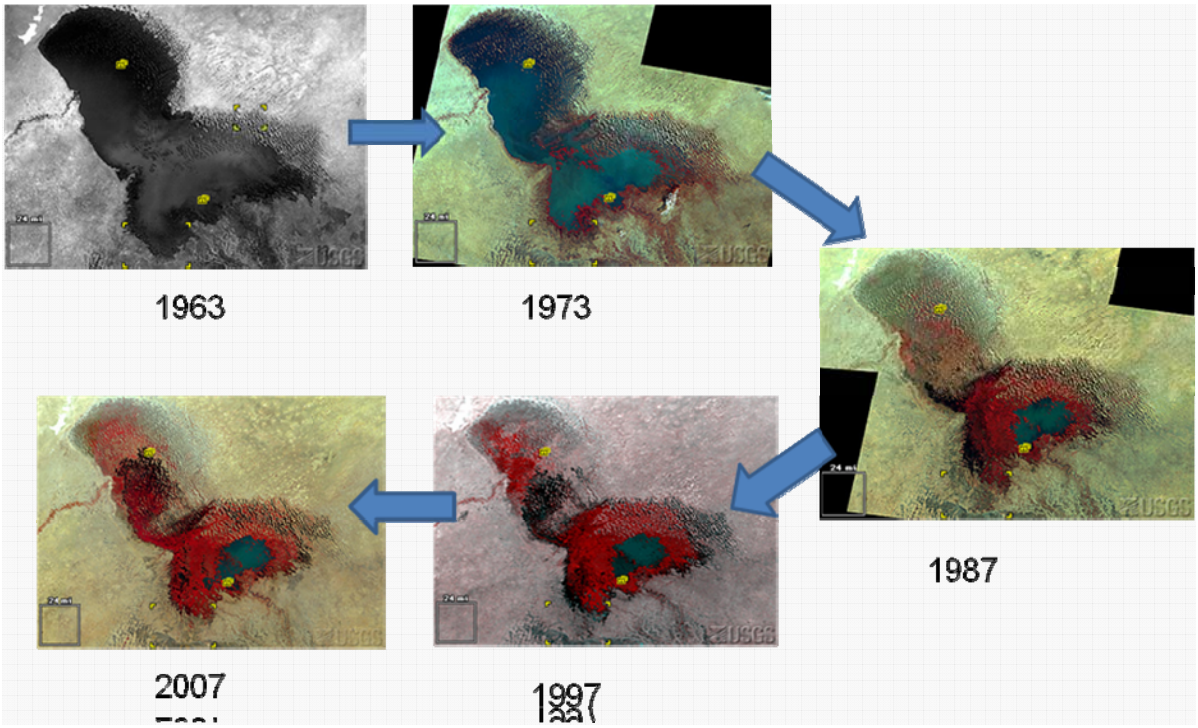

Figure 2 The evolution of Lake Chad 1963-2007 (from Welcomme *in preparation*).

In large lakes and reservoirs variations in temperature and wind could affect stratification of water bodies and circulation of water masses and lead to changes in productivity and cause shifts in the relative abundances of species throughout the food chains and deoxygenation in bottom layers. Evidence for a shallower oxygenated water column has for example been found in Lake Tanganyika

[6] Watson, R.T., Zinyoera, M.C., and Moss, R.H. 1998. *The Regional Impacts of Climate Change: An Assessment of Vulnerability*. A Special Report of IPCC Working Group II, Cambridge: Cambridge University Press.
[7] Allison, E.H.; Andrew, N.L.; Oliver, J. 2007. Enhancing the resilience of inland fisheries and aquaculture systems to climate change. *Journal of SAT Agricultural Research* **4,** 35 p.
http://dspace.icrisat.ac.in/dspace/bitstream/123456789/1006/1/Enhancing_the_resilience.pdf

(Verburg *et al.* 2003[8]). The surface temperatures in the three great East African lakes: Lake Tanganyika, Lake Malawi, and Lake Victoria are expected to increase with 1.3-1.4° C over the next 50 years (FAO *in preparation*).

4.2. Ecosystem impacts

Climate change whether natural or human induced has the potential of becoming the most important driver of change to inland aquatic ecosystems on the global scale.

Variations in river flows will lead to disturbances in flood patterns including extent, timing, and duration. Smaller lakes may dry up and streams may cease flowing during the dry season allowing only the hardiest species to survive. The Orange River, the fifth largest river in Africa, is for example likely to be severely affected. The river has run dry in the past and has experienced very low flows in recent years. On the other hand, rivers in eastern Africa may experience increased drainage density because of the higher predicted rainfall. The flow of the Nile is difficult to assess and current models vary considerably in their predictions, but while some of the headwaters may experience greater rainfall, coastal lagoons in the Nile Delta will be severely affected by sea level rise (Conway 2009).

In rivers with reduced discharge, up to 75 percent of local fish biodiversity could be heading toward extinction by 2070 because of combined changes in climate and water consumption and most of the species loss will occur in poor countries (Xenopoulous 2005[9]). Flash floods may wash eggs and fry out of their normal habitats thereby increasing chances that they will die from starvation or predation.

Increased water temperatures will affect fish physiological processes and thus their ecological fitness. As opposed to the marine environment where many species can move to more suitable water conditions, many inland fish species are constrained by physical boundaries that would prevent them changing their distribution. Species raised in aquaculture facilities would be similarly confined. There could also be an increased risk of species invasions and the spread of vector-borne diseases.

Small pelagic fish species (e.g. dagaa and kapenta) form the basis for very important fisheries in many of the largest lakes and reservoirs in Africa (e.g Lake Kariba, Cahora Bassa, Lake Tanganyika, Lake Victoria etc). The populations of these fish are controlled by pulses of nutrients washed out by the rain in the basin and arriving with inflowing water from tributaries, and upwelling of bottom water because of wind induced mixing of the water column. A more stable water column because of higher water temperature could therefore affect pelagic fish. Stronger winds could have the opposite effect by increasing mixing of water layers depending on their direction and the exposure of the waterbody. Stronger winds from directions that differ from what prevails today could shift upwelling and thus fish stocks to new areas.

Apart from the direct impacts of climate change on aquatic ecosystems, indirect impacts arising from the attempts by other sectors to mitigate the impacts could be significant, and may even overshadow the direct impacts. Examples of that may include the establishment of new or expanding existing reservoirs, irrigation schemes, hydropower dams, and flood protection leading to habitat degradation and loss of connectivity. Intensification of agriculture – i.e. more intensive use of fertilizer and pesticides - can also be expected with negative consequences for water quality.

4.3. Socioeconomic impacts

Climate change will affect societies and economies, and increase pressures on all livelihoods and food supplies. However, people's vulnerability will be determined not only by their exposure to the

[8] Verburg, P., Hecky, R.E. and Kling, H. (2003) Ecological consequences of a century of warming in Lake Tanganyika. *Science* **301:** 505–507.

[9] Xenopoulos, M.A. Lodge, D.M. Alcamo, J. Marker, M. Schulze, K. & Van Vuuren, D.P. 2005. Scenarios of freshwater fish extinctions from climate change and water withdrawal. *Global Change* Biology 11: 1557–64.

specific change, but equally on their sensitivity to that change, and their ability to respond to impacts or take advantage of new opportunities.

Increased vulnerability may result from less stable livelihoods, decreases in availability or quality of fish for food, feeds for aquaculture, water for aquaculture and safety risks due to fishing in harsher weather conditions and further from their landing sites. Damage to property and assets is also a concern for both fisheries and aquaculture

The crucial role fish has as a key supplier of animal protein implies that the lack of a stable supply of fish will have a direct and very important impact on people's livelihoods. Supply will depend not only on changes happening within the fisheries sector itself but will be the result of dynamic interactions with other sectors such as supply and price developments for substitute food products. Trade may increase to provide fish to areas where they formerly existed, as long as trade and infrastructure exist.

5. Impacts of climate change on inland fisheries and aquaculture

Though precise consequences cannot yet be defined for Africa, where the availability of information is reduced, three main pathways of climate change impact can be outlined, affecting fisheries and aquaculture, their dependent communities and their economic activities (Cochrane *et al*., 2009)[10]:

- Direct physical (e.g. flooding, storm impacts, severe droughts);
- biological and ecological (e.g. productivity of lakes and rivers, species abundance, ecosystem stability, stock locations, pathogen levels and impacts); and
- indirect wider social and economic (e.g. fresh water use conflicts affect all food production systems, adaptation and mitigation strategies in other sectors impacts either the aquatic systems in general or the fisheries and aquaculture sector directly).

6. Specific impacts on inland fisheries

How climate change is going to impact on the fisheries depends not only on the capacity of the ecosystem to adapt to change, but also on how the fishers will be able to respond to these changes. The impacts of physical and biological changes on fisheries communities will be as varied as the changes themselves. Both negative and positive impacts could be foreseen. Thus, while climate change almost certainly will influence inland fisheries in significant ways, the exact nature of these changes cannot be easily established.
Impacts would be felt through changes in capture, production, and marketing costs, changes in sales prices, and possible increases in risks of damage or loss of infrastructure, fishing tools and housing. Higher fuel prices will increase costs of fishing (although in most African inland fisheries this impact will be low due to low levels of mechanization in the sector) and distribution of fishery products.

Inland fisheries stocks – and thus also fisheries – are controlled by environmental processes and factors, such as natural fluctuations in climate or flood patterns. Often, the yields track intra-annual and inter-annual variations in nutrient inputs decided by precipitation and land use in the basin. In years when rain is plentiful and flooding extensive nutrients are released in the flood plains leading to explosive population growth at all levels in the food chain, although response times in terms of fisheries yield depend on the life cycle of the fish which the fishery is targeting.

Unfortunately, the level of detail and quality of statistics and information is often not adequate to monitor these processes. In many African countries, it appears that statistics have deteriorated since the 1990s. One example is the Sahel fisheries, which, in spite of being a climatically unstable region, comprehend some of the richest fisheries on the continent including the Niger, Senegal, Chari and

[10] Cochrane, K.; De Young, C.; Soto, D.; Bahri, T. (eds). Climate change implications for fisheries and aquaculture. Overview of current scientific knowledge. *FAO Fisheries and Aquaculture Technical Paper*. No. 530. Rome, FAO. 2009. 212 p.

Logone River systems, as well as Lake Chad. Catches reflect the rainfall until the middle of the 1990s implying that it is a good indicator of trends in yields to that date. However, recent records of sustained high catches in spite of continued low precipitation are not consistent with that and possibly indicate a change in or a breakdown in data collection and reporting (Welcomme *in preparation*).

The interpretation of overall trends in Africa is further complicated by the failure to report yields for individual water bodies. This means it is impossible to track the history of catches by major river basin, lake, or reservoir - a problem that is intensified in the case of international water bodies (Welcomme *in preparation*).

Case studies have also demonstrated significant changes in species composition because of hydrological events. This has for example been clearly demonstrated in Lake Chad where hardy swamp species such as *Clarias*, Tilapiine cichlids and *Heterotis* spp. replaced open water species *Lates*, *Hydrocynus*, *Labeo* and *Distichodus* during times of low water, high temperature, and low dissolved oxygen. Changes in species composition are automatically accompanied by changes in fishing gears and methods in order to maximize the catches (Neiland *et al.* 2002). However unfortunately, landings are usually not reported by species or species group and with sufficient resolution to follow these trends.

In many parts of Africa, fishers traditionally move between several fishing grounds according to the availability of fish. Access to fish will be granted according to the relationship with the local communities. These are often long established arrangements that may fall apart if the fish move to different areas, and migrant fishers would have to establish new relationships. Existing approaches to fisheries management usually focus on limiting access, which tends to exclude non-residents from fishing. It can therefore be difficult for the fisheries manager to accept that migration is a legitimate and sustainable strategy to maximize benefits from a fluctuating resource. However, this factor needs to be taken into account in the design of any community-based management scheme (Allison *et al.* 2007).

Increased risks of species invasions and vector-borne diseases with consequences for both fisheries and aquaculture are a concern. For example, the epizootic ulcerative syndrome (EUS) is a disease currently affecting wild fish in a large area of the Zambezi River basin[11], and it may be susceptible to climate change as temperature and rainfall are critical ecological factors for its expansion.

Inland fisheries play an important role in providing livelihood opportunities for surplus labour during lean times. Fish stocks will come under increasing pressure from new people entering the sector because of lack of employment. This trend will be enforced by the displacement of aquatic resources causing fishers to migrate in pursuit of new fishing grounds. Increased competition for access to resources is likely to cause conflict. On the other hand, rigid access regulations may reduce the mobility of fishers and their capacity to adjust to fluctuations in stock distribution and abundance.

6. Specific Impacts on aquaculture

Aquaculture is providing increasing livelihood opportunities and diversification options also involving women, but climate change may imperil some of these options.

Captured-based aquaculture where seeds and juveniles harvested from the wild is raised extensively in captivity is important in some parts of Africa; e.g. *Clarias* catfishes. Such fish farming depend on the status of the wild stocks and is therefore strongly connected with inland fisheries.

Farmed fish cannot relocate themselves and look for better living conditions. Therefore, farmers have to be aware that the living conditions for their fish may deteriorate (or improve in some cases).

[11] FAO. 2009. Report of the International Emergency Disease Investigation Task Force on a Serious Finfish Disease in Southern Africa, 18-26 May 2007. Rome, FAO. 2009. 70p.

However, where fish are farmed below their optimal temperature a higher temperature could also increase the growth rate, and hence resulting in a positive effect. However, warmer water can also accelerate decomposition of organic material and thus lead to hypoxia or even anoxic conditions that can cause mortality to farmed and wild fish. Climate change can also exacerbate the sensitivity of farmed fish to diseases, but it can also facilitate the spread of new disease and parasites thus increasing the exposure of aquaculture.

Climate change can also affect the availability and costs of feeds for aquaculture, for example through shortages of fishmeal and other feed components; this can be a main obstacle in Africa.

As explained above, variations in river flows will lead to disturbances in flood patterns including extent, timing, and duration. Flooding can affect and destroy fishponds while severe droughts can leave the ponds without water or with less than acceptable water quality.

Sea level rise can be a major threat for the freshwater (and brackish) aquaculture of tilapia and other species in the Nile Delta in Egypt therefore affecting the largest aquaculture production today in the region.