

Effects of climate change on the socio-economic activities of fishermen and adaptation strategies in the district of Bamako

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Abstract

The present study aims to analyze the effects of climate change on the socio-economic activities of fishermen in Bamako and their adaptation mechanism based on a survey carried out on 105 households and camp leaders, data analysis climatic and hydrological conditions collected and analyzed. The majority of the population is bozo (48%), and Somono (42%) has experienced the arrival of other ethnic groups as farmers. The main source of income is fishing for 76% of the fishermen, 12% for fishing and gardening, 6% for other activities. The additional activities allow their adaptation to difficult conditions. To explain the changes, the fishermen mentioned the factors that are: the decrease in floods (45%), rainfall (32%), changes in weather (15%), non-compliance with management rules (8%) and the reduction of the size of the catches according to 84% of the fishermen. The analyzes of the climatic data showed a rise in the maximum temperature of 1 ° C, and a decrease of the minimum 1.5 ° C. From 2013, 2014, 2015, the evapotranspiration is above normal, it is up the last three years, these variations explain the change in climate

Keywords: Climate change, socio-economic activities, coping strategies

Introduction

Climate change (CC) and its impacts appear to be one of the greatest challenges for the world, its people, its environment and its economies (IPCC, 2007). But Africa,

and particularly sub-Saharan Africa, appears to be the region of the world most exposed to climate change (Thornton et al., 2008). The IPCC reports (2007) also underline the greatest vulnerability of this region, in particular because the main sectors of the economic

development of the region as well as the resources which ensure the survival of the rural populations are already affected by the CC. The associated risks are increased food insecurity, lack of water, increased migration, or even health problems. The Sahel not only remains an area of aridity, but has experienced major disruptions in its climatic conditions in recent decades (Toure A., 2011). Thus, between the early 1970s and the mid-1990s, the African Sahel experienced one of the longest climate changes ever observed anywhere else in the world during the 20th century (Hulme et al. 2001). In fact, for the past thirty years, there has been a rainfall deficit of around 30% in the Sahel countries, while the flow of certain rivers has dropped dramatically (that of the Niger River has been reduced by 60%).

This period of climatic desiccation was accompanied by a number of very severe droughts, particularly during the 1970s and 1980s, in which thousands of people and millions of animals died.

In Mali, climatic conditions are dominated by a very pronounced alternation between a dry season characterized by dry winds from the Sahara (the harmattan, a hot and dry wind blowing from the North-East to the South-West), the duration of which varies from 6 to 9 months from south to north and a rainy season of 4 to 3 months with humid winds coming from the Gulf of Guinea (the monsoon, humid wind blowing from the South-West to the North-East). The rainfall regime of Mali, of continental intertropical type, is characterized by a regular decrease in rainfall and the duration of the rainy season from south to north (from less than 1200 mm to less than 200 mm), an irregular distribution of precipitation in the region. space coupled with high variability. Annual average temperatures increase slightly from southwest to northeast (from 26 ° C to 29 ° C). The maximum temperature under shelter varies between 34 and 37 ° C and the minimum between 21 and 23 ° C. The maximum temperatures of the year sometimes exceed + 45 ° C and the minimum temperatures are below + 10 ° C.

Mali is one of the leading producers of freshwater fish in inland fisheries in West Africa. National fishery production, estimated at 100,000 tonnes of fish per year under normal hydrology, places Mali third among African countries producing freshwater fish. The gross added value of the fishing industry stands at CFA Franc 90 billion, or more than 4% in the formation of gross domestic product (GDP).

Despite the economic importance of fishery resources, they are faced with the combined effects of anthropogenic, harmful factors (inappropriate exploitation systems, overfishing), and climatic hazards (endemic drought which puts a severe strain on almost all fisheries), the phenomenon of the silting up of the river, the invasion of aquatic plants. This state of affairs has led to a decrease in the resource day by day. Niger, in addition to being a true cultural matrix, constitutes a significant economic resource. It promotes the extraction of construction materials (sand, gravel), agriculture, animal husbandry, but above all fishing.

Thus, fishing like all other activities in this country dependent on agro-meteorological factors are subject to the effect of climate change. Currently, fishing communities live in precariousness and are undoubtedly suffering the effects

of climate change which are perceptible in places (Amoukou, 2009).

Bamako, which is the subject of this study, is an area where the fishing activity is practiced by the local population and which today is subject to the influence of this climatic phenomenon. Due to the worrying pollution in Bamako, the fishing effort is increased (demography, migration), sand extraction; the pressure on the fishery resource is strong and causes a drop in catches. Many fishermen then turn to secondary activities, as do their wives (DRP, 2016). Fishermen in Bamako are grouped together in camps along the Niger River.

Despite uncertainties about the exact magnitude of cc at regional scales, an assessment of the possible impacts of cc on fishermen is important for formulating response strategies.

The objective of this study is to analyze the perception of fishermen on the CC in Bamako, to determine the effects of the CC on the variation of the water level in the Niger River in Bamako, and to propose adaptation strategies to fishermen in the face of at CC.

Material and method

The District of Bamako is the location of the study, it stretches 22 km from west to east and 12 km from north to south, on either side of the Niger River. Its area is approximately 267 km². Originally Bamako, was installed on the left bank of the Niger River, in a plain about 4 km wide and sloping towards the river. In 2009, the population, totaling 1,809,106 inhabitants, was distributed among 288,176 households, the average household size being 6.3.

The population of Bamako is made up of 908,895 men or 50.2% and 900,211 women, or 49.8%. In this workforce we observe all the ethnic diversity of Mali: Bambara, Malinké, Peulh, Dogon, Sonraï, Bozo (RGHP, 2009). It therefore exerts a very strong attraction on the commercial activities of the whole country.

The district of Bamako covers 6 communes which group together 21 active fishing camps. It is a secondary fishing area in Mali, located in the southern Sudanian zone. Bamako is the capital of Mali. It stretches from west to east over 22 km and from north to south over 12 km, for an area of 267 km². Its urban growth rate is currently the highest in Africa and the sixth in the world (Pedia-Bamako wiki). The annual average precipitation is greater than 1300 mm sometimes 1500 mm. In this climatic region, a mosaic of savannah and open forests regularly covered by bush fires (Wikipedia).

The following climatic zones can be distinguished: the southern Sudanese zone (rainfall greater than 1300 mm per year), the North Sudanese zone (rainfall between 1300 and 700 mm per year), the Sahelian zone (precipitation between 700 and 200 mm per year) and the south - Saharan zone (rainfall less than 200 mm per year). The annual average temperatures vary from 26 to 30 ° C and the average annual rainfall is 700 mm.

The economy of the District of Bamako is based on three major sectors (primary, secondary, tertiary) and an informal

sector. On the territory of the District of Bamako, the Primary sector is essentially made up of the livestock, agriculture and fishing sub-sectors.

Breeding in the District of Bamako, as for the whole of the country, is recognized as one of the most important activities because of the numerical value of the herd and the primordial place occupied each year in exports.

Agriculture is very active in its three components (market gardening, arboriculture and cereals) and mobilizes a significant portion of the assets of our capital, while making a significant contribution to supplying the city. However, faced with certain problems, in particular those related to town planning, agricultural activity is losing ground in the urban perimeter while peri-urban agriculture is developing, maintained by wealthy city dwellers. adaptation to climate change adopted by households.

The methodology used consisted of the following steps:

- a documentary review made it possible to collect data relating to the effects of climate change
- analyzes of the effects of climate change on the practice of fishing
- a survey carried out among a group of fishermen in charge of camps
- interviews with target groups were organized with the aim of collecting global information on the study area.

The work began a bibliographic review which made it possible to collect as much information as possible through previous work of interest to our study, these are the archives available at the level of the Ministry of Livestock and Fisheries, the National Directorate of Fisheries, the Regional Directorate of Fisheries and the university library, other documentation centers, and through research on interest. The study was carried out on a sample of 105 fishermen, heads or heads of households in the district of Bamako. They are distributed between 8 camps. The data collection tools used are interview guide survey forms.

The household survey carried out made it possible to identify the producer surveyed (sex, age, ethnicity, level of education, household economic profile), the household's knowledge of climate change, the causes, the effects, on their environment. (Social conflicts around fishery

resources and household food security), their activities and the strategies for

an interview guide made it possible to collect more information from the technical services. The questions are centered on the existing relationships between the services and the fishing population. The information collected at the level of the Regional Directorate of Fisheries of the District of Bamako identifies the number of fishing camps and their situation by commune along the Niger River. A guide was used at the level of the National Meteorological Agency of Mali for the explanatory factors of climate change, based on temperature, rainfall and evapotranspiration, the data of which were collected and analyzed.

Results

Characteristics of the climate and hydrology in the district of Bamako

In Bamako, the dry season lasts from November to April and the rainy season from May to October. From 1936 to 1991, the annual number of rainy days ranged from 67 to 100, with an average of 85 days. The monthly variation in the number of rainy days is between 0 and 24 days, with the maximum occurring in August. Annual rainfall varied from 722.6 mm to 1499.5 mm from 1936 to 1991, with an average of 1100 mm. Despite belonging to the North Sudanese zone, Bamako recorded 1499.5 mm of rain in 1967. However, the last decades of desertification have resulted in a decrease in rainfall. The annual average temperature is 27.6 ° C, with extreme averages of 34.8 ° C and 21 ° C.

In 1998, the total precipitation was 974.5mm with four totally dry months (January, March, November and December) and maxima of 324.4mm and 326.3mm recorded in August and September respectively. The annual average temperature was 28.84 ° C with extreme averages of 24.5 ° C and 34.4 ° C recorded in November and April respectively.

Variation in rainfall

Figure 1 shows the variation in rainfall indices in Bamako.

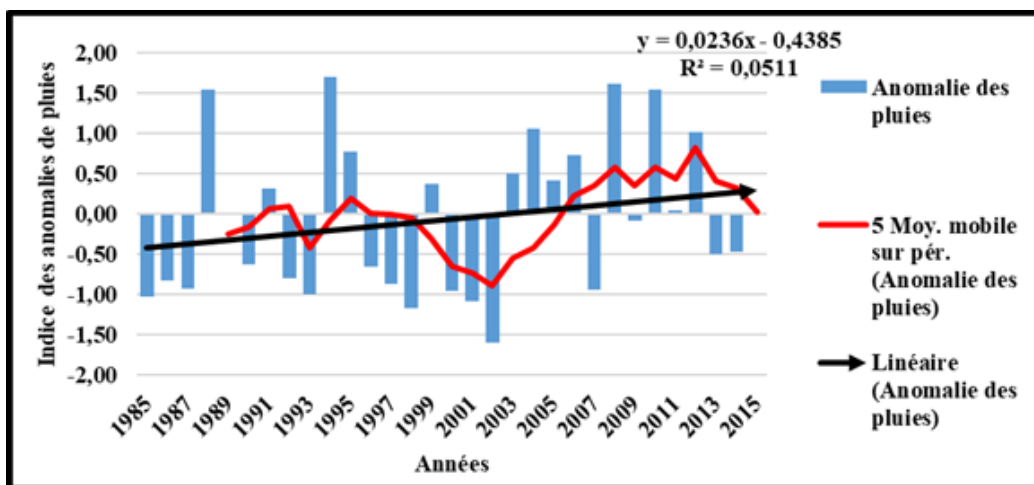


Figure 1: The variability of rainfall indices

Comment: the rainfall anomaly 1985 to 2015 in Figure 1 shows that the rainfall of 1985, 1986, 1987 are lower than normal, against 1988 is higher than normal.

From 1990, 1992, 1993, 1996, 1997, 1998, 2000, 2001, 2002, 2007, 2009, 2013, 2014, 2015 are lower than normal, the other years are higher. Thus, the analysis of the variation in the rainfall anomaly index shows that the rainfall is highly variable in time and space.

Temperature variation

Figure 2 represents the variation of maximum temperatures in Bamako.

Maximum temperature

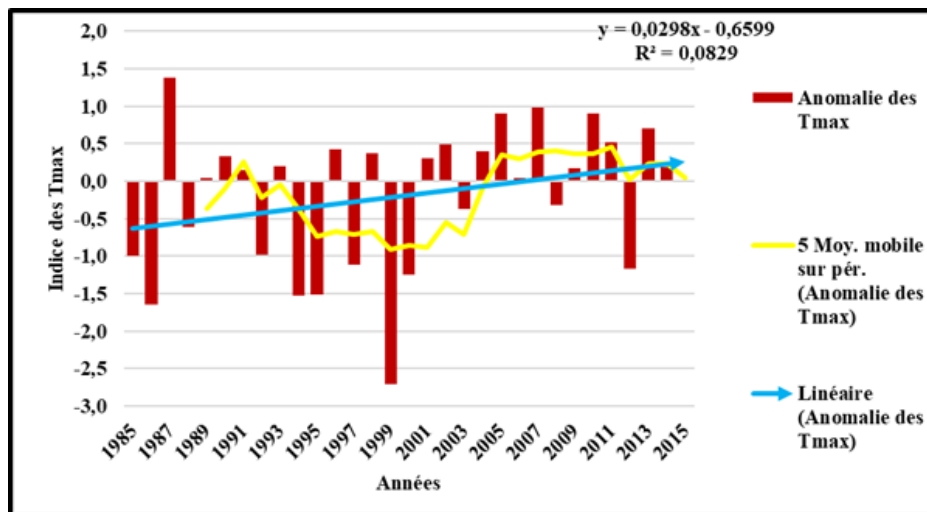


Figure 2: The variability of the maximum temperature

Comment: From 1985 to 1986 the maximum temperature lower than the average against 1987 to normal.

From 1988, 1992, 1994, 1995, 1999, 2000, 2008, 2012 are below normal, other years are above normal. The maximum temperature is very variable from one year to another this variability can be due to many factors we can mention for example: scarcity of rain, desertification, and emission of

greenhouse gases (CO₂). Thus, the analysis of the variation in the anomaly index from 1985 to 2015 shows a temperature increase of 1 °C.

Figure 3 represents the variation of minimum temperatures in Bamako.

Minimum temperature

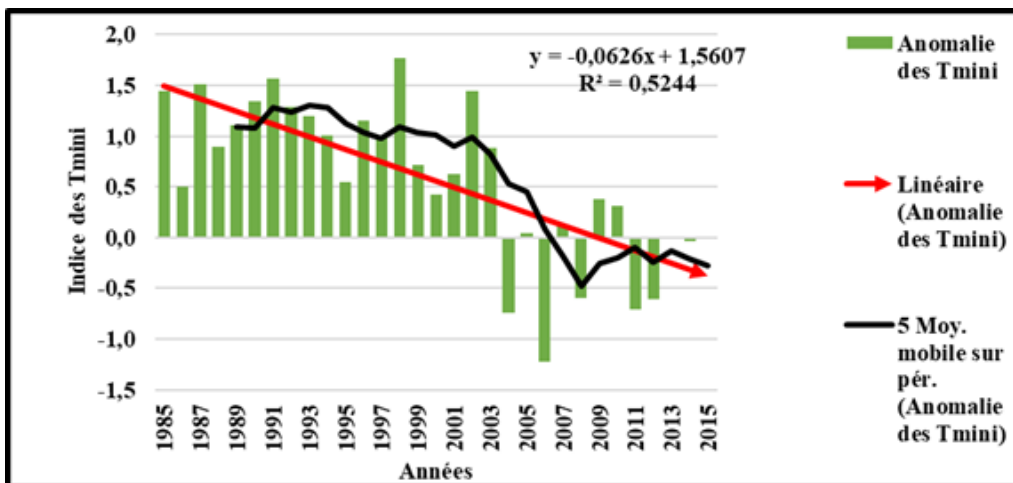


Figure 3: The minimum temperature variability

Comment: From 1985 to 2002 the minimum temperature was higher than normal, against 2003, 2005, 2007, 2011, 2013, 2015 are lower than normal. The years 2004 and 2006 are near par. Thus, the analysis of the variation of the anomaly index shows a drop in the minimum temperature of about 1.5 ° C.

Change in evapotranspiration

Figure 4 shows the variation curve of evapotranspiration increasing the last three

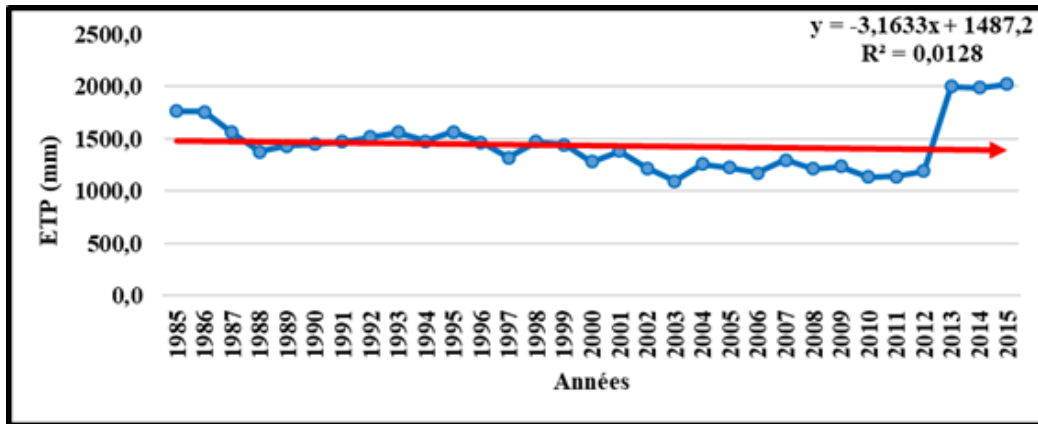


Figure 4: Evapotranspiration variation curve increasing the last three

Comment: Figure 2 shows that 1985, 1986, 1987, in those years there were more evaporations, which explains why the temperature was very high.

- From 1988 to 1999, there was less evaporation during this period. The temperature lower than the average.
- From 2000 to 2012 the ETP was lower than normal and the evaporative value was lower compared to the years previously mentioned.
- From 2013, 2014, 2015, evapotranspiration is higher than normal and very high compared to previous ones. She's up the last three.

The river regime is uni modal in its upper part where it experiences an annual flood (Figure 6). The high water period during the rainy season is concentrated over three months, from August to October; while during the rest of the year the level of the river decreases to its low level during the months of February to May. These seasonal variations punctuate the fauna and flora of the river (vegetative cycles, reproduction periods of aquatic species) as well as that of the riparian populations. According to the focus group survey, the fishing populations all along the Niger River in Bamako suffer from flooding with destruction of habitat. This aspect makes these fishermen very vulnerable. They suffer from water-borne diseases (bilharzia and diarrhea).

Hydrological variation

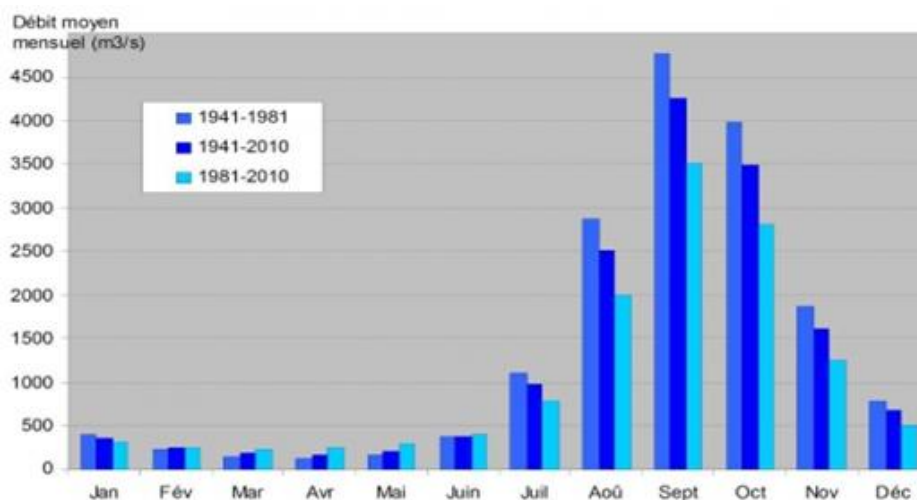


Figure 5: Variation in average monthly flows from Niger to Bamako for various periods between 1941 and 2010 (Source: National Directorate of Hydraulics of Mali, IRD and Luc Ferry. Production: Luc Ferry)

- periods of high hydraulicity from 1922 to 1936 and from 1948 to 1969 (37 years);
- a period of particularly low flow between 1982 and 1993 (12 years);
- “intermediate” periods (55 years), including that observed since 1994.

- the second group, ie 31% of households whose estimated annual income is between 600,000 FCFA and 960,000 FCFA with an average daily expenditure of 2,500 FCFA;
- the third group, ie 38% of households whose estimated annual income is between 200,000 FCFA and 480,000 FCFA with an average daily expenditure of 2,000 FCFA;

Characteristics of fishing camps and activities in Bamako.

The Regional Directorate of Fisheries (DRP) of the District of Bamako has counted 21 fishing camps for an estimated population of 2,511 inhabitants (DRP, 2007). The ichthyofauna of the area is identical to that listed in the DIN, where Daget (1954) lists more than 138 species divided into 62 genera and 26 families but their abundance varies because the biotopes differ. In fact, in the Bamako zone, there is almost no floodplain, the zone is sandy and rocky, fluvial species are therefore more abundant.

A survey carried out among a group of camp managers revealed, according to their estimates, that the groups of species most represented in the landings are: the Labeo (nearly 30%, *L. coubie* and *L. senegalensis*, *L. parvus* less abundant), Cichlidae (nearly 30%, mainly Tilapia: a priori *T. zillii* seems to be in the majority compared to other species), Synodontis (almost 10% mainly represented by *S. schall* largely in the majority then *Hemisynodontis membranaceus*), Mormyrs (7%, various species, *Mormyrus rume*, *Marcusenius senegalensis*, *Mormyrops anguilloides*), Bargridae (more than 5%, *B. filamentosus* and *B. bajad*), Captain (*Lates niloticus*, nearly 4%) then various species mostly Brycinus and Alestes (nearly 4%), *B. nurse*, *B. leucosiscus* especially, a priori *A. baremoze* and *A. dentex*), Chrysichthys (2-3%, *C. auratus* and *C. nigrodigitatus*, small) and *Auchenoglanis* (2%, *A. occidentalis*).

The most common ethnic groups are: Bozos, Somono and others consisting of Bambara, Sonrhäi, and Peulh. The majority of this population is over 50 years old, so 6% are between 30 and 40 years old, 11% are between 40 and 50 years old, 46% are between 50 and 60 years old, 37% are between 60 and over. In addition, a minimum of 40 years is required to be selected so that the respondent can speak about climate change. The population is divided into Bozos (46%), followed by Somono (40%) and other ethnic minority groups 14% including the Bambara, Songhāi, Peulh.

The 76% of the fishermen surveyed declared their source of income only from fishing activities, 12% in fishing and market gardening, 6% in marabout activities and 6% in bovine fishing and fattening.

The surveyed fishermen's households are divided into three groups:

- the first group, ie 31% of households whose estimated annual income is between 1,200,000 FCFA and 2,160,000 FCFA with an average daily expenditure of 3,500 FCFA;

In relation to the various material goods that constitute physical capital (equipment used for production), the respondents declared:

- 37% have Pirogue and Motorcycles;
- 25% have Pirogue and land for housing;
- 20% have canoes, bicycles and refrigerators;
- 18% have Pirogue, Motorcycles, and nets and refrigerators;

None of the fishermen surveyed have savings, and all say they do not have access to credit due to a lack of collateral.

In conclusion, the populations of the households surveyed live below the poverty line. Thus, this situation affects the whole country, of which in 2010, more than half of the population (51%) lived under the poverty line of 1.25 dollars per day (625 FCFA). Since then, drought and war have worsened poverty, which however is much less prevalent in urban areas (14%). In the absence of reliable estimates, it is imperative to improve methods of measuring well-being and data collection, in order to better analyze the livelihoods of poor households.

Effects of climate change on the practice of fishing

In the past, the fishing activity only interested certain categories of social classes and ethnicities. Nowadays, this activity has seen an increase in able-bodied arms coming from all the corporations and all the ethnic groups. Fishing is moving from a subsistence activity to a very attractive economic activity given the volume and speed of earnings at a lower cost.

Surveys show that: 98% of fishermen practice fishing more than 30 years ago and the 2% less than 30 years. 64% say they practice this activity by tradition from father to son, 20% by necessity and for 16% fishing is a hobby.

From these analyzes, two major observations emerge: firstly, the fishing activity which was practiced by tradition from father to son and reserved for a few Bozo and Somono ethnic groups becomes an activity out of necessity for other new fishermen from other ethnic groups.

Social, economic, political, ecological developments have contributed to the modification of social behavior and the reduction of the income of fishermen. The changes observed in the practice of fishing can be grouped into several factors:

- a dazzling increase in the number of fishermen from all professions and ethnicities formerly hostile to

fishing. Of all of our respondents who practice fishing, 48% are Bozo, 42% Somonos, 15% other ethnic groups;

- the increased use of children and women in the fish industry has increased due to the decrease in fish production and the strong demand for the product;
- failure to comply with legislative and regulatory texts for fisheries management. Today's fishermen use all means and techniques of catching fish to increase their income, including the technique of placing tree branches in water in the form of traps, small mesh nets, etc.

According to the fishermen, the reasons for these changes are due to four factors which are: The decrease in floods (45%), that of rainfall (32%), changes in weather (15%), non-compliance with the rules of fishery resources management (8% of opinions).

The releases of water from the Sélingué dam contribute to the reduction of catches by increasing the volume of water in the river.

Compared to the fishing periods and seasons, in the opinion of fishermen, the fishing season began in November and ended in July around the 1950s. During this period, fishermen migrate according to the rhythm of the catches and the fishing grounds. Nowadays with the variation of the climate the winter season is shorter and the dry season long. Fishermen claim that in some years they have trouble recognizing even the 3 seasons. BS, said on this subject *"Before it rained a lot, it can rain several days in a row. Our rivers were full of water, all activities were carried out in peace"*. The fishing seasons and the changes observed in the fishing seasons.

The adverse effects of cc that have occurred in recent decades have changed the rotation of the fishing system in our study area. The changes observed relate to the duration of the fishing season, the reduction in rainfall levels and the floods recorded, the reduction in the size of catches and the number of fish species, the rate of recession, reduction of the fishing, the use of fishing techniques and very harmful gear. Failure to comply with texts on fisheries management, temperature rise, more time devoted to fishing activity with little yield are other changes that were stated by respondents.

A fisherman from the Daga Palace told us "the most important modification in our country is that nowadays, for reasons of survival, we use small mesh n ° 3, n ° 2 for example".

The current fishing season in our study area occurs in two distinct periods: from June to August, and from October to January, it is during these periods that the fishing activity is intense.

In sum, 62% of respondents think there has been a change in the fishing seasons, 34% say that the seasons have not changed, 4% do not know. The riparian populations are more aware of the shortening of the rainy season, which, according to them, has caused the extension

of the dry season in both the cold season and the rainy season. So the dry season can last up to 5 months.

Indeed, the prolongation of the dry season had an impact on the duration of the flood. The good rainfall, well distributed in time and space, meant that the flood period lasted 4 months, but today it hardly reaches 3 months.

Indeed, climate change has greatly disrupted the fishing schedule, which all depended on traditional management activities of fishery resources. Also, the fishermen have found that changes such as an increase in temperature or a decrease in the amount of rain have had and will always have an impact on their fishing activity.

- In relation to catches

In the study area, the modification of the living conditions of the fish due to climate change had effects on the fish. Effects which will mainly result from changes in temperature (temperature rise), water levels (drop floods).

Household surveys have shown that the average size of catches has decreased considerably according to 84% of fishermen over the past 30 years, 13% believe that they have not experienced any modification in the catches and 3% do not know if there has been a change.

Climate change has had adverse effects on fish populations and the sustainability of fisheries. According to household surveys, climate change has influenced not only fish production, which is declining, but also the size of fish, which is only decreasing.

According to OS a fisherman from Torokorobougou said that "the size of the fish has decreased considerably 30 years ago, you could catch fish over 1m in size, and nowadays it is rare to catch a fish of this size".

- Compared to fishing gear

Fishing gear used during the year:

- **Flood:** hawk, sleeping nets, gillnets
- **Decline:** Longlines, traps, sleeping nets, hawks
- **Low water level:** hawk, two-handed net, sleeping nets

In the past, the materials were designed based on dah, but nowadays with the introduction of nylon poly filament (mainly seines) and monofilament rubber (gillnets, dormant nets) less expensive and invisible in water the pressure on the resource has become very strong.

The slicks thus introduced are invisible in the water and are more resistant to the striking force of large fish. In the 1990s, this change in the netting helped to lower the purchase prices of the nets and make them more accessible to fishermen.

In the study area, 26% of respondents claim to make no change in fishing practices, on the other hand 74% claim that they have made changes to fishing gear, in particular

the introduction of iron fencing, Tamani, Doura Koro, Nèkègoa.

The fishing techniques in our study are diverse. It should be noted that with climate change, fishermen have increasingly resorted to novice techniques which are the deposit of tree branches in the water, poisons to put fish to sleep and the use of small nets and mesh size.

Among the changes in fishing techniques is the mobility from one fishery to another. The introduction of fish farming in ponds and floating cages.

Perceptions of fishermen on climate change

In the study area, climate variability and change are manifested by phenomena caused by the disturbance of certain climatic parameters such as temperature and rainfall. Regarding the causes, they are linked to human activities for some and for others they are natural and / or divine. Different reasons were cited:

❖ Human activities

They are among the factors which, according to household surveys (78%), affirm that before independence and especially the construction of large dams on the river (Sélingué in 1982), the flood level was very high. On the other hand, the construction of dams on the river (Sélingué) today, fishermen have observed an increasingly precocious decline, which means that the flood rarely exceeds three months.

The construction of dams constitutes, according to most of the people interviewed, an obstacle to the good practice of fishing with on the one hand, the retention of the quantities of water; on the other hand, by the untimely releases of water that cause poisons to "flee" with each intervention.

Indeed, they claim that the dams retain a large part of the water or divert it towards the delta mer (Office du Niger zone). This is why the floods no longer manage to reach their level (before the construction of the dams) while a good flood rhymes according to the fishermen with an abundance of poison in the river.

❖ The reduction in rainfall

According to household surveys (6%) one of the determining factors of the CC is the reduction in the amount of rainfall. According to most fishermen, before independence, the rain was abundant. At that time, the wintering started in June and ended in October.

❖ The rise in temperature

It is a factor of climate change according to the fishermen in our study area, 6% of the fishermen interviewed think that the rise in temperatures is at the base of the drop in water level with early recession. By the way, they claim that before

the 1973 drought, temperatures were not as high as they are today.

❖ The divine factors

The majority of the populations surveyed are Muslims. This is felt in fishermen's perception of climate change. Indeed, 10% of surveyed fishermen firmly believe that climate change is a fact of God and therefore comes from the will of God. They explain this fact by the will of God to punish men by their selfishness, and their dishonesty. They find that climate change can only be solved when man returns to God.

Climate change and conflicts

There are no social conflicts around the management of the fishery resource in the district, but some cases of opposition can arise between fishermen. Usually these are acts taken by some, going against the interests of those with whom they share the fisheries, such as the use of arrows, water beating by the metal chain, or the permanent laying of nets.

Fishermen have a tradition of arranging certain places where they deposit bran to attract fish. Operation of these places without the permission of the purported owner can create conflict between them. Sometimes these cases reach the police, otherwise most cases are resolved amicably at the request of the camp elders.

Climate change adaptation strategies

According to the United Nations Framework Convention on Climate Change (UNFCCC. 1992) "adaptation refers to any adjustment in natural systems or in human activities, in response to the effects of actual and predicted climate change, adjustments allowing for mitigate the negative effects or exploit the beneficial opportunities.

To cope with the adverse effects of climate change, populations have developed various strategies to strengthen their resilience in order to contribute to food security. In addition to fishing, fishermen have diversified the activities among others we have: market gardening and agriculture, masonry, petty trade, extraction of building materials (sand, gravel), sewing, workers in factories local, and migration, the activities of marabout or charlatan.

Contrary to the diversification of activities, other fishermen have chosen to adapt to the profession, that is to say the intensification of the fishing effort, which can prove to be dangerous in the long term for management. sustainable fishery resources in so far as in the event of a bad flood.

The intensification of the fishing effort for them means taking longer to fish and especially with small mesh nets. This could in the long term pose a problem of stock renewal for the following campaign.

Discussion

The District of Bamako is located in the Sudanian zone straddling the Niger River. It is a very urbanized area, and crossed only by the Niger River, which is subject to a regime of significant floods. The productivity of the river is linked to this seasonal variation, which is linked to rainfall. Annual catches and discharge are strongly correlated ($R^2 = 0.73$ in the DIN, Quensières et al. 1994), because they depend on the flooded area (especially in the central delta). The flood begins in July to reach a maximum around September to decrease until January, or the water levels remain low until the next rains, the interannual variations can be important. The ecosystems in the monitoring area are very different from those found in the Central Delta area, so it is not possible to extrapolate data from one area to another. Indeed, there are hardly any floodplains around Bamako whereas in the DIN, the ecosystem operates according to a floodplain model. The potential production of our monitoring area is therefore much lower than the yields of the DIN, because the flood plains are very important food sources for the growth of fish fauna. Around Bamako, the river is less rich in nutrients and its productivity is therefore low. The waters of the minor bed are in fact poor in dissolved substances and the very abundant sand forms sterile banks that do not contain any food resources (Quesnière et al., 1994). The river bed is narrower in the monitoring area, includes more rapids and rocky. Following the global analysis of the answers to the various questions, the results obtained showed that the fishery resource in the District is under pressure from various factors which hinder its sustainable exploitation; it is about climate change, and human actions. According to Bekaye, 2015 the final period of fish reproduction corresponds to the laying of baited traps which attract juveniles. The density of the traps is such that the stock has difficulty rebuilding itself (3215 traps for the 105 fishermen surveyed) to this must be added the arrival of wastewater from the collectors which flow into the river and the solid waste carried by the wind, and the operations of direct dumping of pollutants such as: tanneries, dyers and trucks which unload in the bed during low water.

The proposed strategies for restoration, preservation and compensation are consistent well with the national resource and environmental management policy, in particular laws and regulations as well as projects and programs in favor of fishing. However very little effort is made for sustainable fishing in Bamako.

Conclusion

Changes in climate are attributed directly or indirectly to human activity altering the composition of the global atmosphere and which adds to the natural variability of the climate observed over comparable periods. An analysis of climatic and hydrological data showed a maximum temperature increase of 1°C , and a decrease of the minimum 1.5°C . From 2013, 2014, 2015. Evapotranspiration is above normal, it has been increasing for the past three years. In fact: the increase in extreme weather events: increasing periods of droughts, floods and storms suggests that the climate.

Climate changes have had the following effects: silting up, siltation is caused by the collapse of the banks and by the mud carried by runoff water during the rainy season, the invasion and development of aquatic plants, changes in fish distribution. To explain the changes, the fishermen mentioned the factors which are: the decrease in floods (45%), variations in the level of the river play an important role in the fish reproduction process. That of rainfall (32%), changes in weather (15%), non-compliance with the rules for the management of fishery resources (8%). This state of affairs is believed to be the cause of the reduction in the average size of the catches which has considerably decreased for 84% of fishermen in the catches over the past 30 years, 13% believe that they have not experienced any changes. in the holds and 3% do not know if there has been a change.

Fishing is still the main activity of water communities today. Fishermen face enormous difficulties. These changes are not in themselves negative, as they sometimes lead to new possibilities for fishing activities. But their indirect effects on the fragile balance of ecosystems, and on the current species that inhabit them, are not yet well understood. Therefore, permanent vigilance is required.

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