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The Double Exposure of Climate Variability and Upstream Dams Development among Fishermen of Bargondaga and Dagawomina in the Inner Niger Delta of Mali

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Abstract:

Like all agricultural sub-sectors fisheries are expected to be highly affected by the variability of climate in Mali and most of the Sahelian states. As a response to climate change and to increase its agricultural productivity, the Malian government intends to develop its hydraulic potential through the construction of large dams, water storage infrastructures and the development of irrigation schemes along the main rivers of the country. The objective of this study was to analyse the impact of climate variability and these dams on the livelihood of fishing communities, as well as to analyse their adaptation strategies. This was done by examining fishermen's awareness of climate variability and the perceived effects of combined climate variability and water development projects. The study was conducted in two villages Bargondaga and Dagawomina located in the Inner Niger Delta of Mali. Data included socio-economic characteristics, fishing type, experience in climate variability and adaptation strategies to climatic risks and the increased water uptake through dams and irrigation schemes. The results reveal that fishing communities in the Inner Niger Delta face a double exposure to climate variability and the ongoing water development projects. The main impact of climate variability and increased water development projects concern the decrease in fish catch, the decrease of the inundated areas, fishing spaces and cultivable land. Among the responsive strategies to reduce these impacts figure income diversification, out-migration, irrigated rice cultivation, as well as the diversification of fishing equipment. Findings show that in order to decrease the vulnerability of inland fisheries to climate variability and large dam development, adaptation policies need to take the socio-economic and environmental situation of fishing communities located downstream of dams into account and to increase their involvement in the decision making process.

Keywords: Climate variability, dams, adaptation strategies, fishermen, Mali.

Résumé:

Comme tous les sous-secteurs agricoles, il est attendu que la pêche soit fortement affectée par la variabilité du climat au Mali aussi bien que dans la plupart des états Sahéliens. Comme réponse au changement du climat et pour augmenter sa productivité agricole, le gouvernement malien prévoit de développer son potentiel hydraulique par la construction de grands barrages, d'ouvrages de retenue d'eau et l'aménagement de terres irrigables le long des principaux fleuves arrosant le pays. L'objectif de cette étude était d'analyser l'impact de la variabilité du climat et de ces barrages sur la vie des communautés de pêche, aussi bien que leurs stratégies d'adaptation. Ceci a été fait en évaluant la perception des pêcheurs sur la variabilité du climat et les effets combinés des aménagements hydro-agricoles. L'étude a été effectuée dans deux villages Bargondaga et Dagawomina situes dans le Delta Intérieur du Niger au Mali. Les données collectées incluent les caractéristiques socio-économiques, le type de pêche, l'expérience de la variabilité du climat et les stratégies d'adaptation face aux risques climatiques et la pression accrue par des barrages et les aménagements hydroagricoles. Les résultats indiquent que les pêcheurs dans le delta intérieur du Niger font face à une double exposition : à la variabilité du climat, et l'impact des projets croissants de mobilisation des ressources en eau. L'impact principal de la variabilité climatique et des nombreux projets de développement des ressources en eau concernent la diminution des captures de poissons, la diminution des zones inondées, des espaces consacrées à la pêche et des terres cultivables. Parmi les stratégies adoptées pour réduire ces impacts, figure la diversification des revenus, la migration, la culture irriguée du riz, aussi bien que la diversification des équipements de pêche. Les résultats prouvent qu'afin de diminuer la vulnérabilité de la pêche continentale à la variabilité du climat et au nombre croissant de barrages, les politiques d'adaptation doivent prendre la situation socio-économique et environnementale des communautés de pêche situées en aval des barrages en considération et accroitre leur participation dans le processus décisionnel.

Mots clés : variabilité climatique, pêcherie, barrages, stratégies d'adaptation, Mali.

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CHAPTER I: INTRODUCTION

Agriculture remains the pillar of the economies of many Sahelian states among which is the Republic of Mali. Indeed, agriculture and its sub-sectors (cultivation, breeding and fishing) are the major sources of income for the Malian population and contribute to 40% to the national GDP (Mali, PRSP; 2013). Most agriculture relies on rainfall and the flow of two major rivers: the Niger and the Senegal rivers. These two rivers have endowed the country with both a huge hydraulic potential and considerable inland fish reserves making the country one of the biggest exporters of fresh water fish in the West African region.

The fishing sector in Mali represents the 3rd most important economic activity in the country and contributes both directly and indirectly to the employment of 500,000 people. The added value of the fishing sector to the Malian GDP averages 30 billions of CFA per year (FAO, 2005). But fisheries like all agricultural sub-sectors, depend highly on rainfall and the flood waters of the Niger River and Senegal River. Furthermore, fish catch vary much with the height of the waters and the variability of the rainfall. Since the 1960s the observations of climatic data for the Sahelian zone has indicated a change in climatic trends. A decrease in the average yearly precipitation and a shift in the isohyets have been confirmed by many researches (Hunt, 2000).

The country has also passed through major environmental crises that were suspected to be the consequences of a highly variable rainfall regime prevailing in the Sahel. These changes in the climate are projected to increase in the future and represent a threat to the ecological balance of Sahelian region (Conway et al; 2009, Salack et al; 2013). According to climate specialists of the country, the agricultural sector will be the most affected by climate change in the Sahelian zone. Fisheries in Mali are also categorized among the sector most exposed to climate variability (GoM; 2007)

As a response to climatic stresses the government of Mali intends to fully exploit its yet untapped hydrologic resources to boost agricultural and hydro energy production (Zwarts et al; 2005). The development of large scale dam is not a new idea and has been much debated in the scientific discussions between pro and cons. However the lack of funds and the low economic development of most Sahelian states have considerably obstructed the development of large dams and irrigation schemes (Barbier et al; 2009) However starting with the era of democratisation and decentralisation and due partially to the effects of climate variability,

many Sahelian states with their economic partners are viewing water resources development as an opportunity to ensure food security and boost agricultural productivity. The increased demographic pressure on water resource and the reliance of national economies on agriculture have once again brought the issue of water resource mobilisation and large scale dams on the table (Kuper et al 2010; Zwarts; 2010).

The National Strategic Framework Document against Poverty (CLSP) is the master policy used as a reference guide for the policies of development and poverty reduction strategies in Mali (GoM; 2002). It emphasizes on the need for the Malian Government to develop its hydro-electric potential of 5,000 GWh/year and its hydro-agricultural potential estimated at 2 million hectares of cultivated land (GoM, 2013). These hydraulic infrastructures divert water and while benefitting agricultural production on the one hand side, may increase the vulnerability of downstream fishing communities and threaten the ecological balance of the whole Inner Niger Delta which depend on the flood water of the river Niger (Beukering, P.J.H.; 2005, Zwarts, L; 2010)

This is the concern of the case of this study which was conducted downstream of major dams and irrigation schemes like the Selingue and Markala Dams at Malian side of the river. Further the construction of two weirs (Talo in 2007 and Djenne in 2010) diverting the water of Niger River for irrigation are also expected to decrease the height of the seasonal flood in the Inner Delta and particularly in the study villages. Most fishing communities live in remote areas accessible by road only during the dry season. A high poverty and illiteracy rate prevail in the fishing communities of Inner Niger Delta. The objective of the study is to assess how decision and policies in water management could decrease the vulnerability of downstream and double exposure of downstream communities through climate variability on the one hand side, and upstream dams in the Inner Niger Delta on the other side.

1.1 Problem Statement

Mali is a vast landlocked country located in the heart of West Africa with a total area of 1,240,192 km². According to the 2009 census, Mali's total population is 14,528,662 (RPGH; 2009). One-fifth of its total land area is located in the Sudano-Sahelian zone with irrigable regions, and partly in the desert or semi-desert zone. The topography is characterized by plains and mountain ranges. The highest point is the Mount Hombori at 1150 m. In general Mali have two main seasons: a dry season divided in a cool period from November to February, with an average temperature of 21°C (72F); and a hot period from March to May, with an

average temperature of 30°C (88F); and a rainy season from June to September or October, with an average temperature of 25°C (80F). There are three agro-climatic zones: Saharan in the north, with an area of approximately 500,000 km² ; tropical between the 17th and 13th parallels, with an area of approximately 200,000 km² ; and Sahelian in the rest of the country.

The Malian economy is highly dependent on agriculture. Weather hazards like droughts and excessive rainfall may create disastrous consequences for the livelihood of farmers. Country-average arable land is only 3.76%, with a mere 0.03% of land area yielding permanent crops. More than 40% of the land is covered by desert and therefore unsuitable for agriculture (WB 2011; FAO 2009). These limitations in agricultural production in Malian increase the economic vulnerability of the country to climatic extremes such as drought and flood. In average years, fish catch can reach 100,000 tons per year. The annual fish production in the Inner Niger Delta averages 85,000 tons per year. Household consumption of fish is estimated to 5.4/year/capita which is much higher than the consumption of meat averaging 4.7/year/capita (MAEP; 2012).

The region of Mopti is a major hub for trade of fish along the Niger River. Fishing is a well-structured sector benefitting from the fishing harbour, the closeness of the market and an increased demand due to population growth within the region. Fresh fish is consumed in Mopti as well as in other towns of the country (Bamako, Segou, Sikasso). Currently, most of the fish is quickly dried or smoked and boxed up in huge cardboard boxes for transport to Bamako, Burkina Faso, Ivory Coast and even to Ghana. High climate variability, increased temperatures, decreased rainfall, isohyetal shift and strong winds are the main evidences of climate change in Mali (Mali PANA; 2007).The mean temperature for Mali have already raised by 0.7°C since 1960 – but there is little agreement between climate models on future patterns of precipitation. Dams, water abstraction and deforestation will combine with rainfall variability and other features of climate change to influence water availability and the viability of different types of livelihoods, yet the nature and degree of future change remains highly uncertain (Goulden et al. 2011). High temperature combined to strong winds are suspected to increase and spread malaria and meningitis in the country (Pana; 2007). A recent study done combining Malian demographic trends and climate projection for Sahel indicates that 6 million could be exposed to malnutrition as a result of climate change and most of whom are children and women (Jankowska et al; 2012). According to the National Action Plan for Adaptation

(NAPA), agriculture, health, fisheries, energy, water resources, forest resources and soil degradation are the sectors that will be severely affected by climate change.

From 1960 to 2009 the Malian population has quadrupled and the growth rate of the population has increased from 2.2 percent to 3.6 percent yearly between 1998 and 2009 (Mali, PRSP; 2013). The rapid population growth is worrisome regarding the availability of resources and the predicted impact of climate change.

To increase its agricultural production and create new jobs, the government of Mali with the contribution of its neighbours and international donors has already established several hydraulic infrastructures and irrigation schemes. The main functional or projected dams' projects on the Malian part of the Niger River are suspected to affect the level of flood in the Inner Niger Delta.

The effects of these dams on flood height in the Inner Niger Delta are also worsened by the water uptake of a number of large irrigation schemes, such as the schemes of *Office du Niger* in Markala, *Office Riz* in Mopti and the Selingue irrigation schemes.

These dams and irrigation schemes have significant impacts on the river flow thus reducing considerably the halieutic production in the Inner Niger Delta (Lae R.; 1994). While contributing to increase the overall agriculture production in the country, these hydraulic infrastructures seem to worsen the living conditions of the fishermen living downstream particularly in the Inner Niger Delta (Zwarts L.; Frerotte J. L.; 2012). Among the negative consequences of the dams figure also the erosion of river banks, pollution of water resources due to use of fertilizers' in the irrigation schemes and a decrease in the spaces devoted to fishing (Bricquet J.P et al;1997).

1.2 Objectives

This study looks at how social vulnerability in the fishing communities is affected by the water uptake of major hydro agriculture schemes in combination with the variable climate. The study looks particularly at how local fishing communities respond to climate variability and the impact of upstream dams and irrigation schemes.

The specific objectives of the study are to:

- explore local climate history and potential climate risks
- assess the socio-economic impacts of climate variability and increased number of hydro-agricultural schemes upstream of the study sites

- understand how communities in the two villages perceive risk, the impacts of climate variability and dams, and how they respond to these impacts
- identify the vulnerable groups and what causes their vulnerability.
- analyse whether and how decision and policies taken at national scale could increase or decrease the vulnerability of small fishing communities

1.3 Research Questions

The main research question guiding this thesis are the following:

- What is the history of local climate and what are the potential risks?
- What are the socio-economic impacts of climate variability and increased number of hydro-agricultural schemes upstream of the study sites?
- How communities in the two village perceive risks, the impact of climate variability and increase number of hydro agricultural schemes and how they respond to these impacts?
- Who are the groups vulnerable to the impacts mentioned above and why are they vulnerable to these changes?
- To investigate whether and how decision and policies at national scale could increase or decrease the vulnerability of small fishing communities?

1. 4 Hypothesis

Given the background to the research problem, the present research is guided by the following working hypotheses:

i. The changing climate and the water uptake of dams and agricultural schemes are increasing the vulnerability of fishing communities in the villages of Bargondaga and Dagawomina.

ii. The frequency and the likely consequences of the climatic risks and decreased flood peaks in the Inner Niger Delta are not new to the fishermen who experienced them in the last decades. Thus fishermen have been constantly reshaping their livelihood systems, mode of adaptation and coping strategies to buffer against climate risks and increased water resources mobilization.

1. 5. Plan of the Thesis

This thesis is structured around five chapter. The first chapter deals with the general introduction, including the problem statement, the research objectives, the research questions and the research hypothesis. The second chapter presents the synthetic review of the critical literature on the topic under the study. The third chapter presents the study areas, the methods and material used in the study for the data collection and the analysis. The fourth chapter presents the results and the findings of the research work. The conclusions and recommendations to the study are presented on the basis of findings and discussion in the fifth chapter. It is followed by references cited and pictures of the research sites.

CHAPTER II: LITERATURE REVIEW

2. 1. Climatic Risk in Mali with Special Focus on the Inner Niger Delta

Climate change is a major challenge for development in Africa and this is compounded by the greater exposure of African economy to climatic variation (Collier, Conway, & Venables; 2008). Tropical convection and the alternation of the monsoons are among the major processes driving climate in Africa. El Niño-southern oscillation of the Pacific Ocean is the third driver, remote but having a greater influence on the first two processes (Conway & College; 2009).The warming trends observed in Africa are likely to increase during the second half of the century(Brown, Hammill, & Mcleman; 2007). Simulations of the regional climate models indicate a prevailing drying tendency over most of sub-Sahara (Paeth et al.; 2011). Temperature indices observed throughout the West African Sahel, point to a general warming trend since 1960 (Ly, Traore, Alhassane, & Sarr; 2013) . Even though rainfall variability is a characteristic of Sahelian climate, some recent studies revealed that the extreme variability in rainfall are induced by intensification of the African Easterly Jets (Bouimetarhan et al.; 2012), coinciding with increased temperatures observed in sea surface temperatures (Salack, Giannini, Diakhaté, Gaye, & Muller; 2013). Since the 1980s, an increasing trend is observed in several locations, indicating that extreme rainfall events have become more frequent in the West African Sahel during the last decade, compared to the 1961–1990 period (Ly et al.; 2013).

These facts further call upon the attention of the Government of Mali. There, the population is poor and depend partly on food aid as a result of the long term drought particularly in the north, central and eastern part of the country. High climate variability is a real challenge for human security and sustainable development in Mali. About 3 500 000 Malians were affected by the drought of 2011-2012 and as a result these populations are presently food insecure (OCHA Mali CAP; 2012)

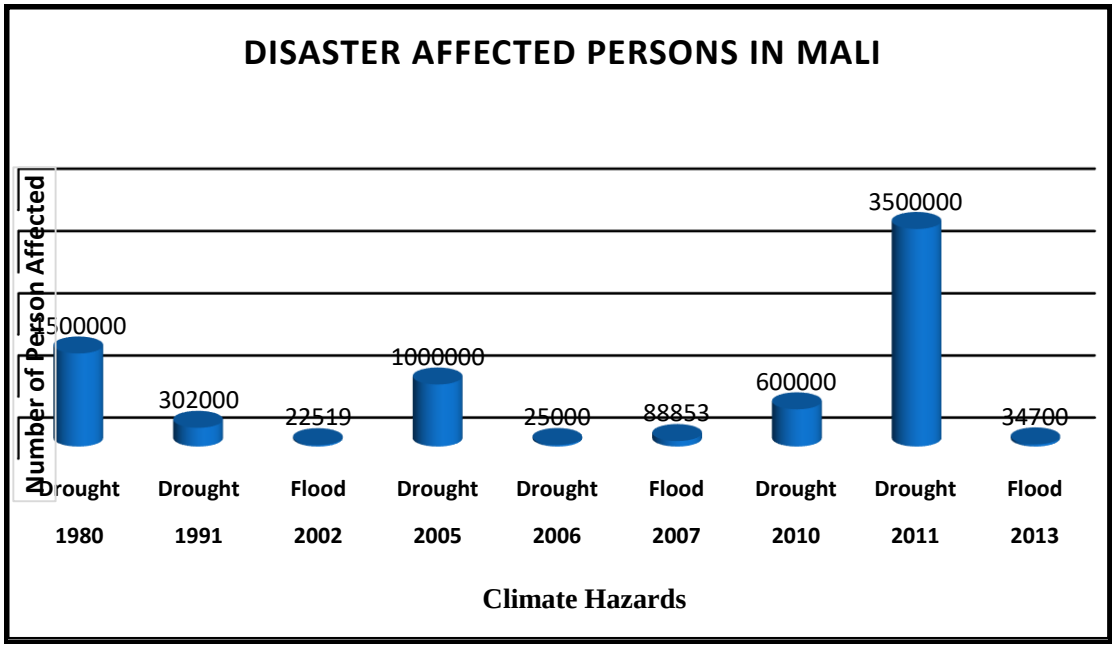

Figure 1 : Natural Disaster Affected Persons in Mali. **Source:** CRED EM_DAT 2014

The resurgence of the Touaregs rebellion in 2011 followed by the occupation of the Northern regions and a greater part of Mopti by Islamist insurgents added to the coup d'état have worsened an already fragile situation by increasing insecurity. The withdrawal of bilateral donors and non-governmental organisations have resulted in a reduction of social services offered. Insecurity, population displacement combined to the drought of 2011-2012 resulted in a major food crisis in the region. While fleeing for their personal safety, the Internally Displaced Persons by the conflict have left behind their most valuable assets: houses, land, and livestock. Getting a new farm in the host community for an internal displaced person is unlikely given the strong pressure already exerted by local population on the scarce land resources. Deficit in critical infrastructures such as road and the residual insecurity slow considerably the delivery of aid.

The access and uses of water resources are regulated by local customs/traditions and modern laws. Land and all natural resources are the property of the Malian state by law but access and use of natural resources are regulated by local customs/traditions. The plot of land is used by various people at different periods of the year. As an example, the same area cultivated by a farmer during the rainy season becomes a fishing area during a flow recession and a grazing area during the dry season. Access to the natural resources is determined by social status, gender, age and ethnicity. Demographic growth, incoherence between modern and traditional land tenure rights, extensive farming, increased use of fertilizers' and pesticides

have added to the mismanagement of natural resources as well as to the increased competition over natural resources (Benjaminsen, Alinon, Buhaug, & Tove, 2010)

The Great Drought, in the early 1980s, was a major catastrophe for the Sahel population. Rainfall was low, but the decline in river flow was even greater (Zwarts et al.; 2006). Niger River flow variation is determined by rainfall and land use changes (Roudier, Ducharne, & Feyen; 2014). The river flow decline has impacted drastically and directly the livelihoods of fishermen, crop and livestock farmers, and those depending on fluvial transportation.

People rely mostly on the Inner Niger Delta for food production, pasture and fish resources. The Inner Delta is constituted of vast plains flooded seasonally by the Niger River. In the wet 1950's and 1960's, the total flooded surface area was up to 40,000 km². However, due to climate change or variability, the 1970's and 1980's were very dry and although the climate conditions during the last 20 years were comparably wetter, the total flooded surface area did not exceed 21,000 km² (Mahe et al.; 2011 quoted in Liersch et al; 2012). The Inner Delta Niger ecosystem is the largest reservoir of biodiversity in Mali and was classified in 2004 as a world heritage RAMSAR site (Ajayi et al; 2012:6). The Inner Delta is known both for its pasture constituted of *echinocloa stagnina*, "bourgou" in the local language, an aquatic palatable plant and for its fish stocks. Almost 1 million people depend on the natural resources within an area of 50 000 km in the Inner Delta for their livelihoods as fishermen, arable and livestock farmers (Zwarts et al; 2006) The Niger River is also important for its fluvial navigation between Mopti and the Regions of Koulikoro, Segou, Timbuktu and Gao. Fluvial transportation connects the remote villages in the Delta to Mopti.

The inundated area of the Inner Delta has diminished by about 5, 000 km² between 1980 and 2004 because of the decreased rainfall and low flow of the Niger River (Diakite et al 2004 quoted in Samari; 2011:1). The river system is alarmingly threatened by the sand dunes accumulating around its basin.

In the flood plain of the IND[1] farmers usually grow a local floating rice specie (*Oryza glaberrima*) that they harvested using canoes and it requires a well-defined range of water depths between 100–200 cm (Zwarts et al; 2006, Liersch et al; 2012). The consequences of the great droughts and the decrease in the flood level have been disastrous for the farmers in the

[1] IND: Inner Niger Delta

IND who produce in normal years 90 000 tons of rice annually that is to say 40% of Mali's total rice needs (Zwarts et al; 2006). Mismatches in rain timing and the decrease in flood peak and length during the dry period has increased the impoverishment of smallholder farmers in IND. Another consequence of the low flow during the drought years is the reduction of the fish harvest that has increased the impoverishment and livelihood shift of fisher communities in Mopti. The review of the scientific studies done in the area has identified farmers and fishing communities of the IND to be the most vulnerable to yearly variability of rainfall and increased dry tendency over the region (Zwarts; 2006, Bene et al; 2009, Djoudi et al; 2011, Liersch et al; 2012, Morand et al; 2012,)

2. 2. The Impact of Large Dams on Fisheries in the Inner Niger Delta

Another driver of change likely to affect the carrying capacity of the Inner Delta ecosystem is the growing number of dams for water storage and distribution. The construction of dams in West Africa is one of the responses of the governments to the challenges of water management in order to meet the national irrigation needs and electricity supply. Indeed mobilisation and management of water resources constitute a key component of the GoM[2]'s strategic plan to reduce poverty and adapting its production systems to the changing climate. In the Malian part of the Niger Basin, several large dams are operating (Selingue, Markala and Talo) and two are under construction (Djenne, Taoussa). More than 700 smaller dams have been constructed throughout the country with the help of NGO's. Also many projects of water resources mobilisation at local level are underway to increase agricultural production and promote food security. However, their construction often generated socio-economic and environmental impacts significant which require today heavy investments to attenuate them. This threatens the functioning of the wetland ecosystem by reducing the peak discharges (Liersch et al; 2012).

A direct consequence of the growing number of dams is the environmental degradation it creates. According to Lae et al; (2003), the loss of sediment to the Delta via the river has increased the rate of river bank erosion; this is further worsened by the dams constructed on the River during the past three decades (Lae et al; 2003).

Fishing is practiced almost everywhere in the country but the IND remains the main center of fish production in Mali. The national fish production varies from less than 40, 000 tons in dry years like 1984 to more than a 100 tons in normal years like 1994 or humid year

[2] GoM: Government of Mali

like 1970 (Mali RNMVRE; 2006). The growing number of dams and reservoirs has negative impacts on water input downstream of the dams and consequently on fish stock and fish distribution (Lae et al; 2003). The authors argued that the dams disrupted the longitudinal migration of fishes and heightened the impact of the previous droughts on the communities in the Inner Delta and (Lae et al; 2003). Taking together the effects of the planned dam of the Fomi in Guinea and the Taoussa dam in Mali, the loss of inundated area is estimated to reach 6, 200 km² and the situation could potentially increase the vulnerability of fishermen and farmers (Zwarts et al; 2006).

In the actual context of climate change it is worth exploring the impacts large dams and increased water mobilisation have on populations dependent on river ecosystems, especially as disruptions in flow by a dam can mean a disruption in the freshwater goods and services that sustain them (Richter et al; 2010). This is particularly important in the case of Mali, where the indirect effects of hydro-agricultural schemes on downstream beneficiaries of rivers and the consequences of increased low flows on ecosystem functioning during dry periods are still unclear (Zwarts; 2006; Liersch et al; 2012).

A major constraint hindering development in the region of Mopti are land tenure conflicts. The multiplicity of users' rights and their competition to control scarce resources are the sources of current conflicts between fishermen, farmers and herders. Although the conversion of pasture and fishing spaces into farms is beneficial for agricultural development, it heightens these conflicts between land users in the region and may dislocated local customs and production systems that have been efficient when it comes to managing and sustaining natural resources until now (Djik; 1995; 2005, Dicko; 2006, Beeler; 2006, Cotula et al; 2006, Hesse et al; 2013)

Farmers and fishermen have developed various strategies to adapt to their harsh living conditions. These strategies vary from livelihood diversification to temporary migration and total reconversion in a new production sector. Mobility is mostly used by pastoral and fishing communities as strategy to cope with climatic stresses and to manage their fragile ecosystems; the current insecurity compromises pastoral activities and reduces fishermen's mobility. But these capacities to cope and resorb shocks are eroded by decades of high climate variability. In less than ten years, three drought events have been reported in the interval 2001-2013 that affected more than 4 million persons throughout the country (CRED/EM-DAT (2014).

Many researchers warn that climate change could increase the number of forced migrants and environmental refugees (Afifi; 2010; Boano, Zetter, & Morris; 2008; Renaud, Bogardi, Dun, & Warner; 2007; Warner; 2008). Migration is considered as a social capital contributing to the adaptive capacity and resilience of home and host countries (Scheffran, Marmer, & Sow, 2012). Fishing communities in Mali have developed migration as a coping strategy. Migration is seasonal and depends on the level of flood in Inner Niger Delta. Even though the remittances sent by migrants support those left behind and national economies, migration could reduce the labour force and increase food insecurity locally (Lebel; 2008; Ballo; 2009).

The extreme poverty of Malian population remains another threat. 63.8% of Malian population live in extreme poverty. Fishing communities are among the poorest given their location in remote areas only accessible during the dry season by road. The poverty rate is higher in rural areas (75%) and particularly among women. Poverty rate varies from one region to another but Mopti region has the highest poverty rate with more than three quarters of its population living in areas that are below poverty line (Mali PRSP; 2013).

Fishermen have gradually shifted to livestock–based livelihoods, when Lake Faguibine dried out in Northern Mali (Djoudi & Brockhaus, 2013). Hesse and other researchers argue that vulnerability in Sahel is a function of poor governance and a lack of appropriate investment. According to the authors, the top-down approach used in designing inadapted policies and development programs have resulted in disrupting the balance of the ecosystem (Hesse, Anderson, Cotula, Skinner, & Toulmin, 2013). For O'Brien and Lechenko (2000) is shaped by a *double exposure* to climate change and the economic globalisation. They argue that vulnerability analysis should take into account the simultaneous impact of the two global processes because in many regions, sectors, social groups and ecosystems will impacted by both climate change and economic globalisation.

The analysis of the literature on the topic reveals that the social vulnerability of communities to the impact of climate change and the impact of water resources mobilization is a current concern. It is the subject of many studies. The socio-economic and environmental impact of agricultural adaptation and development projects under rapid climate change has been largely discussed in various scientific studies (Lae et al; (1994), Zwarts et al; (2006), Richter et al ; (2001), Russellet al; (2010), Fossi et al; (2012), Barbier et al; (2010)), but the topic is still not totally covered.

The situation is still evolving in the Mali particularly in the study villages located in the Inner Delta, particularly. New development programs involving the realization of many small irrigations schemes and the construction of new dams are underway in the study areas. Thus, it is worth assessing how the livelihood of the fishermen are affected by these changes and the adaptation strategies they have developed to adjust to these changes. Furthermore, this study is principally based on the perceptions of local fishermen who are directly affected by climate variability and the water uptake of dams and irrigation schemes.

2. 3. Adaptation, Vulnerability and Human Security

The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as the process of adjustment to climate change and its effects, in order to moderate harm or exploit beneficial opportunities in human systems or the process of adjustment to actual climate and its effects in natural systems (IPCC SREX, 2012). The definition of the IPCC is focused on climate change and differs slightly from the definition in social sciences and ecology. Adaptation in social sciences is viewed as the process organisms undergo to achieve a beneficial adjustment to a particular environment, which not only leads to biological changes in the organisms but also impacts their environment (Havilland et al; 2005:148). For cultural anthropologists, the survival of all forms of life depends on this dynamic interaction. The particularity of human beings is their ability to produce and reproduce culture enabling them to adapt inventively and continuously to a vast number of environmental constraints. Adaptation is inherent to all human processes. It establishes a moving balance between the needs of a population and the potential of its environment. Agriculture, irrigation and pastoralism are examples of how human systems adapt to their environment.

Manning et al (2011) distinguishes *reactive adaptation* consisting in a response to actual stress or *proactive adaptation* focused on anticipated response to future risk.

The concept of human security was made operational by the United Nations Development Program (UNDP) in the 1994 Human Development Report. Human Security encompasses seven typical priority areas of security: economic security, food security, health security, environmental security, personal/ physical security, security of community life and political security.

According to O'Brien and Lechenko (2007), climate change influences two dimensions of human security: the equity dimension drawing on the fact that communities will be affected differently and the connectivity dimension which emphasize that the security of communities

are linked in space and time. Human security offers an alternative lens for looking at global environmental issues. O'Brien and Barnett argue that environmental change is a social problem with environmental characteristics, rather than an abstract scientific problem(O'Brien & Barnett, 2013).

The Human Security approach is centered on people's needs and freedoms, shifting from the traditional security view. Human security is achieved when and where individuals and communities live with three basic conditions: first, the options necessary to end, mitigate, or adapt to threats to their human, environmental, and social rights; secondly the capacity and freedom to exercise these options; and finally the opportunity to actively participate in attaining these options (Lonergan 1999 adapted from Brklacich et al; 2012)

Since disasters occur in human societies, scientists and policy makers should consider how they will affect natural and human systems.

The concept vulnerability has emerged in social sciences and geography and is increasingly used in the field of climate change. The concept shifts from the traditional engineering view of hazard in natural sciences toward a focus on its human impact.

Since the 1980s the concept is used in the risks hazards literature. Cutter (1996) defines vulnerability as "the likelihood that an individual or group will be exposed to and adversely affected by a hazard. It is the interactions of the hazards of place (risk and mitigation) with the social profile of communities". Cutter distinguished three different approaches to vulnerability. A first approach examines "vulnerability as pre-existing condition" and stresses on exposure or its aspects of potential source of risk. A second group of studies "vulnerability as tempered response" and focuses on coping responses. A third approach perceives "vulnerability as hazard of place". O'Brien and Lechenko; (2000) introduce the concept of double exposure. This school views vulnerability as the product of both climate change and the economic globalization.

Another review of the different conceptual model used in assessing vulnerability was done by Birkman (2006) who notes that the current literature encompasses more than 25 different definitions, concepts and methods to systematise vulnerability. According to Birkman, scientists that are trying to measure vulnerability differ on the same conceptual definition of vulnerability. Birkman distinguishes six main schools of vulnerability summarized in the table below

Table 1: Vulnerability Approaches. Source: Adapted from Birkman (2006)

Vulnerability Approaches	Key Elements
The double structure of vulnerability (Bohle;2001)	Vulnerability has two main sides: • An internal side related to the capacity to anticipate cope, cope with and recover from the impact of a hazard • An external side involving exposure to risks and shocks
The sustainable livelihood framework (DFID;1999)	The framework has two main components: livelihood and sustainability • Livelihoods are viewed as the means of gaining a living, encompassing livelihood capabilities, including tangible and intangible assets. • sustainability is linked to the ability to cope with and recover from stresses and shocks as well as to maintain the natural resource base
The conceptual framework of the disaster community (Davidson; 1997, Bollin et al; 2000)	Views vulnerability as a component of disaster risk and distinguishes four categories of disaster risk: • Hazard • Exposure • Vulnerability • Capacity measures
The pressure and release model (PAR model) (Blaikie et al., 1994; Wisner et al., 2004)	The **PAR** is based on the equation: **Risk = Hazard * Vulnerability** and addresses vulnerability through 3 steps • the root causes • dynamic pressures • unsafe conditions that determine vulnerability
Vulnerability in the global environmental change community (Turner et al., 2003)	Vulnerability is viewed in the context of a join or coupled human–environmental system and encompasses: • Exposure • Sensitivity • Adaptive capacity
The holistic approach to risk and vulnerability assessment (Cardona and Barbat; 2000)	Vulnerability is characterized by four factors: • physical exposure and susceptibility • fragility of the socio-economic system • lack of resilience to cope and recover

This paper mainly stresses on the analytical framework for vulnerability assessment in the global environmental change community.

2. 4. Adopted Vulnerability Model – Framework for this study

The main reason behind the choice of this framework elaborated by Turner et al ;(2003) is its ability to join and couple the human-environment system. The framework also connects global environmental change and the concept of sustainable development. The recent advances in environmental sciences and the causes of global warming have provided scientists worldwide proofs of interaction human-nature. In this particular case the relevance of the sustainable livelihood framework is justified by the fact that we wanted to illustrate both the

human influence and the environmental disturbances outside the study areasss but which interact with the local conditions and undermine the socioeconomic conditions.

Christoplos et al (2009) argue that vulnerability is experienced first at a local level and is affected by factors such as age, gender, culture, local institutions and natural resources tenure regimes. This disproportionate vulnerability is also acknowledged by O. Brown and A. Crawford (2009) who state that vulnerability to climate change varies from an individual to another and from one place to another. The degree of exposure and the sensitivity of the livelihoods and assets of a household determine its level of vulnerability. Households with weak adaptive capacities are bound to experience the highest impact specifically exclusive fishers, farmers, and breeders. Even in the same household vulnerability is felt differently by different household members especially disabled, children, women, and elder (Heltberg, Jorgensen, & Siegel; 2008).

Turner raises a number of questions related to vulnerability "Who and what are vulnerable to the multiple environmental and human changes underway, and where? How are these changes and their consequences attenuated or amplified by different human and environmental conditions? What can be done to reduce vulnerability to change? How can more resilient and adaptive communities and societies be built?*"(*Turner; 2003*).* Before we answer these questions we need a framework which integrates human system in the nature. The selection of the sustainable livelihood framework has been guided by the motivation to apprehend local climatic risks in the socio-environmental context.

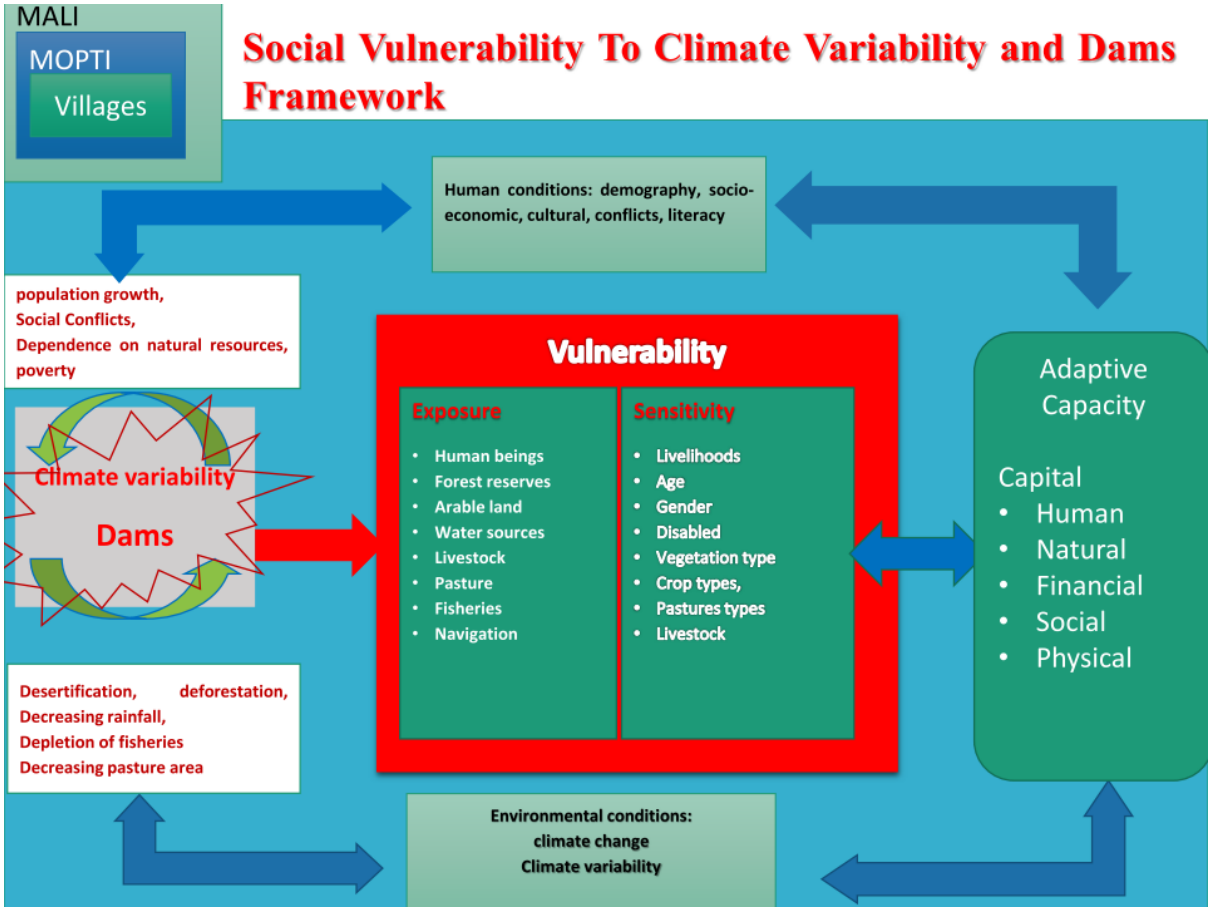

Figure 2 Vulnerability Assessment Framework adopted from Turner et al (2003)

2. 5. Social Vulnerability Indicators

Assessing social vulnerability to climate variability implies developing appropriate indicators to compare the evolution of local condition in time and space after drought and natural shocks. In our case it involves measuring the vulnerability of the communities and the natural resources upon which they depend for a livelihood. In the social sciences there is no universal measure of vulnerability, even though scientists have developed tentative social vulnerability indicators and indexes (Cutter, Carolina, Boruff, & Shirley, 2003)

For each of the components of vulnerability (exposure, sensitivity and adaptive capacity) we choose a set of indicators to inform the index. The chosen indicators will be discussed with local stakeholders and adapted to the local context during the field study.

Table 2 : Drought Risk Assessment Indicators

DROUGHT RISK ASSESSMENT INDICATORS

Component	Subcomponent	Indicator	Scale	Measurement
Exposure	Social	Population	Local	Census, Survey
		Economy	Local	Household Survey
	Ecological	Water	Local	Mapping, Survey
		Fauna	Local	Mapping, Survey
		Flora	local	Mapping, Survey
		Land degradation	Local	Mapping, Survey
Sensitivity	Social	Current livelihood and income • diversity of household • income • Age	Local	Survey
		• Literacy rate	local	Survey, census
		Malnutrition rate	local	Survey, census
		Gender	local	Survey
		Poverty level	local	Survey
	Ecological	Forest	Local	Survey
		Degraded Land %	local	Survey
		Overused land %	local	Survey
Adaptive Capacity		Ability of community to reorganize	Local	Survey
		leadership and governance	Local	Survey
		Equitable access to resources	Local	Survey
		Remittance	Local	Survey
		Migration, Mobility	Local	Survey
		Cereal bank	Local	Survey
		Early Warning System	Local	Survey

CHAPTER III: MATERIAL AND METHODS

3.1. The Study Area

3.1.1 Presentation of Mopti Region

The region of Mopti is located in the central part of Mali and is characterized by lowest social indicators: high poverty rate, high illiteracy rate, highest young mortality rate with one third of the population currently unemployed. The region counts 2 037 330 inhabitants with a growth rate of 3% per year, the population is expected to triple in thirty years. The population of the region is relatively young with 61% of people having less than 25 years (RPGH; 2009).

The fifth administrative region of Mali, Mopti covers an area of 77.800 km² and extends from 5°42' to 0°45' of the western longitude. From the farthest south to the farthest North, it extends from 13°10' to 16°13' of the northern latitude. The region is limited to the North by Gao and Timbuktu region, to the Northwest by Mauritania, to the Southwest by the region of Segou, to the South by Burkina Faso and to the East by the region of Gao.

The region is divided into two climatic zones: a Soudano-sahelian climate in the South and a Sahelian climate in the North. The average annual precipitation varies between 600 to 400 mm in the Soudano-sahelian zone, while it barely reaches 200 mm in the North.

The region is watered by the River Niger and its main affluent the Bani. The yearly rainfall recorded average in Inner Niger Delta and the Dogon plateau gave to these two areas a high agricultural potential.

Mopti is divided into 8 administratives districts: Bandiagara, Bankass, Douentza, Djenne, Mopti, Koro, Teninkou and Youwarou. The main ethnic groups are the Peulh, the Bozo, the Somono, the Dogon, the Bambara, the Malinké and the Songhaï. The main economic activities of the region are farming, breeding, fishing and tourism.

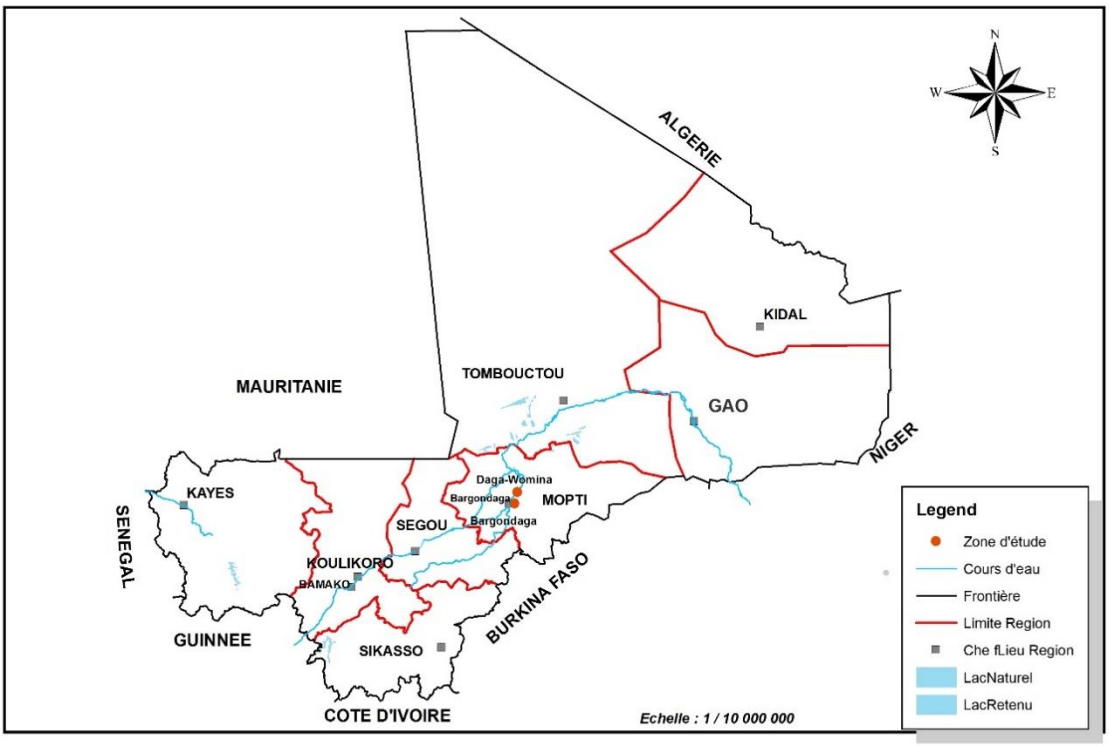

Figure 3: Location of the Study Villages

These natural and biophysical characteristics gave the region a high potential for agricultural activities like farming, breeding and fishing. The freshwater ecosystems have endowed the region of considerable fish resources. The yearly fish catch in the region varies between 70, 000 tons to 120, 000 of fish. 500 000 people rely on the fisheries for their daily expenses.

3.1.1.1. Presentation of the Village of Bargondaga

The village was founded in 1961 by Mory Salamanta who hails from the village of Nabaradaga. Bargondaga means “Where the barrels are”. It was a warehouse where former colonialists store their fuel in barrels. The village is limited to north by Tongorongo, and Nimitongo, to the west by Tirmou, Nantaga, Kobakan. It is limited to the south by Bienville and to the east by Mopti. The village of Bargondaga count 945 inhabitants distributed among 159 households.

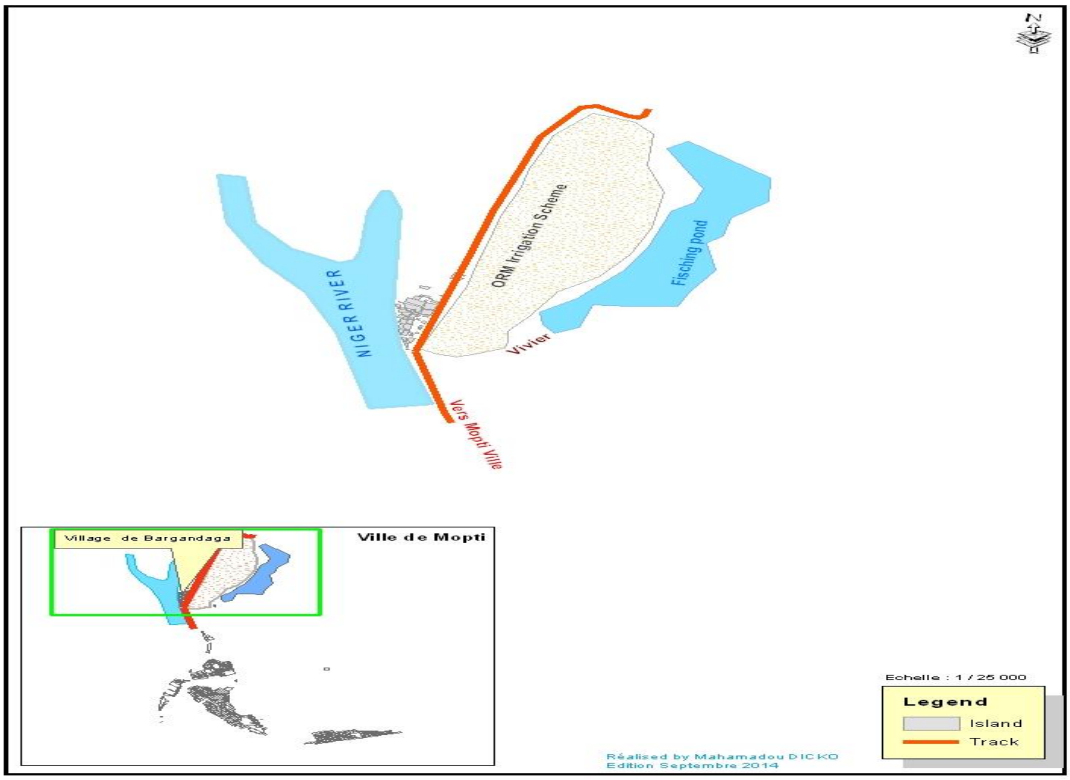

Figure 4: Map of Bargondaga

The main ethnic groups living in the village are the Bozo, the Peulh, the Sonraï, the Dogon, the Somono, the Mossi, the Samogo and the Kelenko (designating the fishermen originating from Ségou region). The common languages spoken in the village are Bozo and Bambara. The economic activities in the village are: fishing, agriculture, trade, breeding (in a least measure) and sand extraction.

The relations with these villages are primarily peaceful and founded on a tradition of alliances and affiliations. Marriages are practiced mainly between the members of the same ethnic group. It is sometimes forbidden but not rare to see a marriage between two members of different ethnic group. The main natural resources of the village are the ponds, the farmlands and the fishing areas. The village is ruled by a village chief. Chiefdom is transmitted from one a generation to the next within the same family. The chief is elected by his brothers, once elected, he will rule the village until his death or his son. When a chief dies, he is replaced by his eldest brother. The chief is in charge of the management of the public life of the village. He appoints the village imam who takes care of the religious matter in the village etc.

3.1.1.2. Presentation of the Village of Dagawomina

This village was founded by Sadakolo Sabé, originating from Mandé. According to the oral tradition, its creation goes back at least to two centuries before the holy wars of Elhadj Omar. The village draws its name from a grass called "Gomina", which was used as food for the cattle. Etymologically "*Dagawomina*" means the place where the grass "*Gomina* is". The village is composed of three hamlets which are Missira (where the Peulh live), Londena and Dagawomina.

Dagawomina is limited to the West by the villages of Sabé, Karba, and Madina; to the East by Treguel, Wourounguiya, and Foussi; to the North by Saya, Komio, Kouana; and finally, finally to the South by Madina and Tongorongo.

The village count 1, 771 inhabitants; 898 of them are women. The main ethnic groups in the village of Dagawomina are the Bozo, the Sonraï, the Dogon, and the Peulh. The spoken language in the village are the Bozo, Bambara and Sonraï.

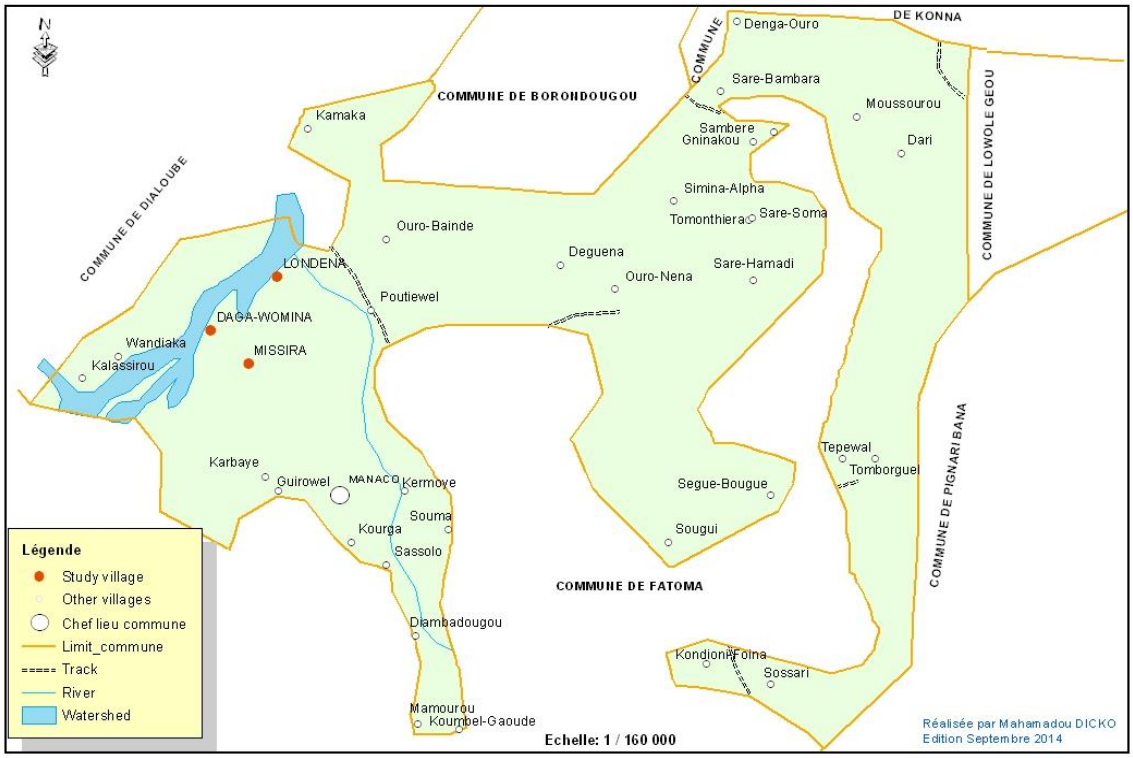

Figure 5: Map of Dagawomina

3. 1. 2. Climate and hydrology

The region of Mopti is divided in 3 climatic zones: the Sahelian climate, the Sudano-Sahelian climate and the fresh water ecosystems of the Inner Niger Delta. These three climatic zones comprise several agro-ecological subfields which can be found in four natural areas: the Inner Niger Delta in the West, the Hombori-Bandiagara plateau in the center and the vast plains of the Eastern part of the region. Our study is focused mostly on the freshwater ecosystems.

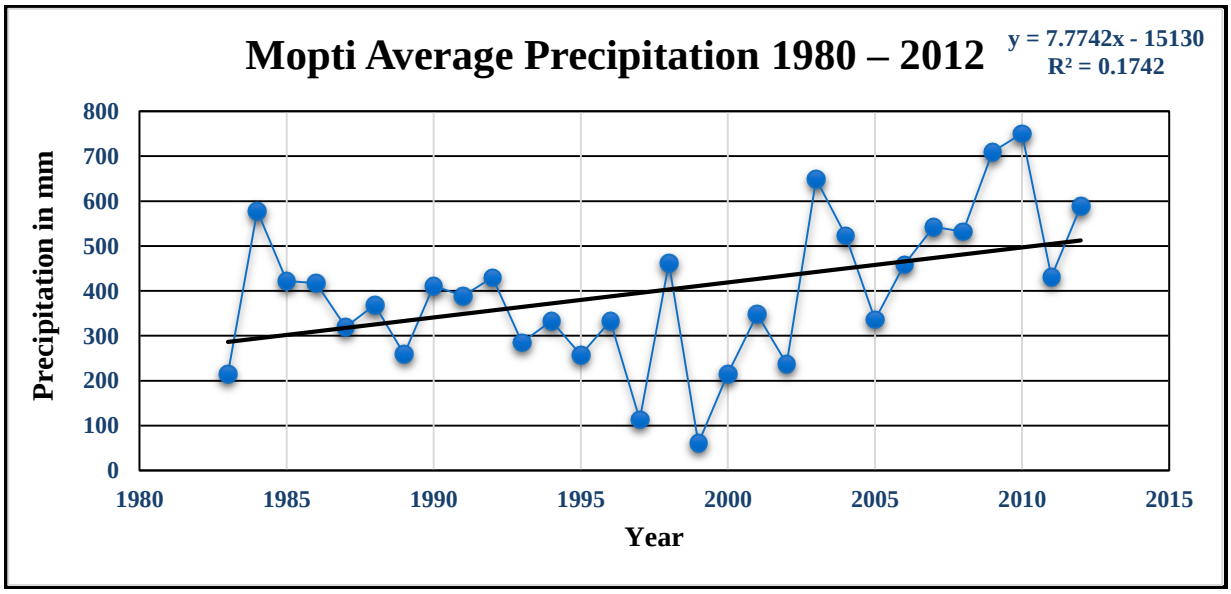

Figure 6: Mopti Average Precipitation 1980 – 2012 (ASECNA, Mali)

The analysis of 30 years of climate data for the station reveal a high variable precipitation trend with a slight decrease. The rainfall pattern in the region is characterized by a high inter annual variability and decreased tendency which is manifested through recurring dry years. This situation threatens the ecological balance of the wetland ecosystem of the Inner Niger Delta by increasing the degradation rate of land and water.

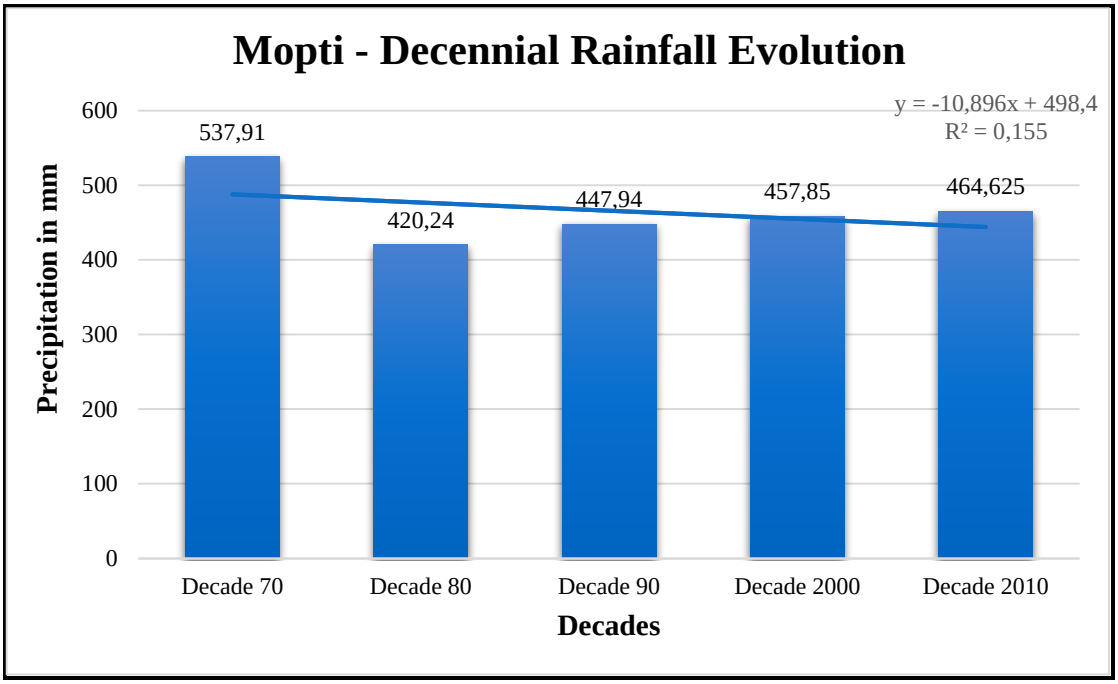

Figure 7: Mopti-Decennial Rainfall Evolution (ASECNA, Mali)

The analysis of the decennial rainfall pattern also reveals a decrease tendency with the decade 80 representing the lowest precipitation recorded. However, an increase in the decennial precipitation trend can be observed on the graph above starting from the decade 90 and continuing.

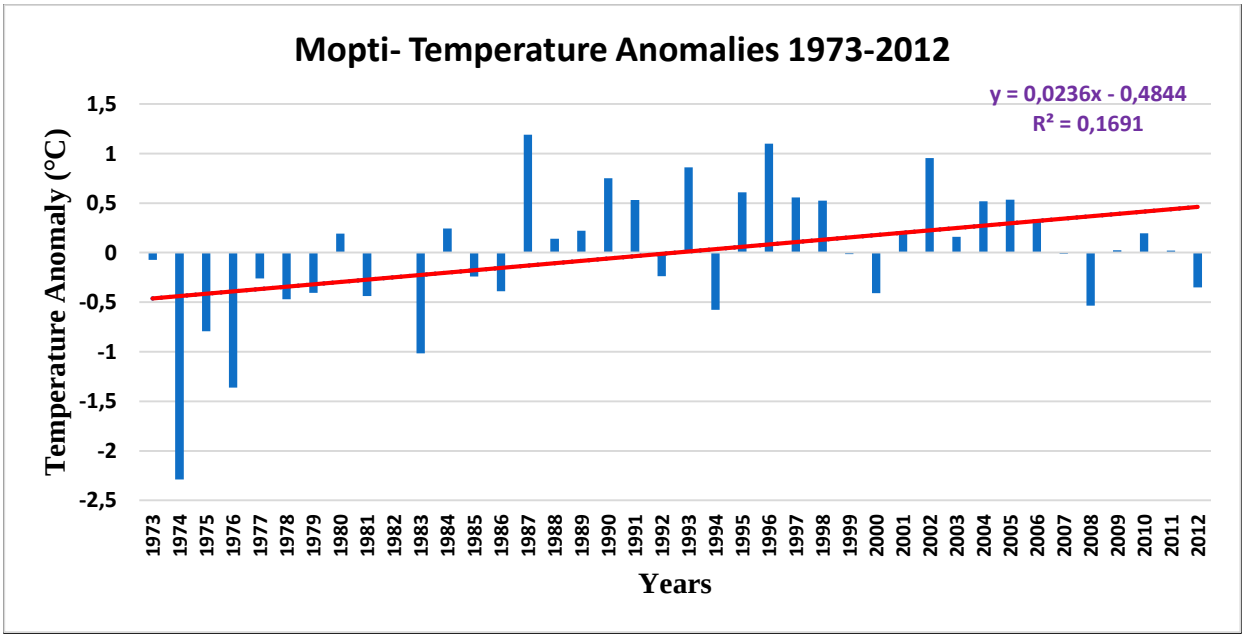

Figure 8: Mopti – Temperature Anomalies 1973-2012 (ASECNA, Mali)

The analysis of temperature observation from 1973 to 2002 reveals an increased trend with high peaks reached in 1987, 1996 and 2012. The temperatures in this area are also characterized by their variability. Combined with the decreased rainfall, these high temperatures will contribute to increase the degradation of the biodiversity in the flooded zone. The relative humidity is lower than 50% during the dry months from November to June. The evapotranspiration varies between 2, 300 mm and 2, 750 mm. the total duration of the insolation per annum is 3200 hours and strong winds blow from February to August with a maximum in June.

Surface water comprises permanent watershed constituted of the Niger and its main affluent Bani added to semi-permanent watersheds that are the main distributaries of the Niger River (Diaka, Koli-Coli, Bara Issa), the lakes (Aougoundou, Debo, Korarou, Niangaye, Walado) and ponds (Antago, Bellal, Dakadjan, Diallo, Sense). The floodwaters of the Delta come primarily from the Niger River, its main tributary the Bani River, and smaller streams that flow down from the Dogon Plateau. The Niger River is the longest river in West Africa and the third longest in Africa.

The river system of the Delta is composed of the minor and major beds of the river, of their semi-permanent extensions which are constitute by the lakes, ponds and inundated plains. The whole system is evolving continuously under the impact of the droughts and climate variability on the short term and tend to shift its course on the long term toward east.

During high flood and low flow, water circulates in a vast and complex network of channels and depressions. The flood plain is very flat with a shallow part where ponds are formed. From the 80s the hydraulic functioning of the River has been modified by the Selingue dam built on the Sankarani of Bamako. The Selingue dam was intended for agricultural and electricity production. The dam also contributes to maintain high the level of flood in the river even during the dry season.

3. 1. 4. Soils

The area of Mopti is characterized by the brittleness of its ecological balances. In the flooded zone, the soils are clayey in the major part of the central delta with alluvial plains and hydromorphic soils where the *bourgou* and other aquatic plants grow.

In addition to the climatic stress several factors contribute to the degradation of soil and water resources. These include the disappearance of fallow system, the continuous culture of cereals, the strong demographic pressure, the use of fertilisers and pesticides as well as wind

and water erosion, among others. This situation is worsened by a weak utilisation of anti-erosive technics.

Mopti presents a large variety of forest systems and facies. Types of vegetation adapted to each ecological zone are found in the area. In the flooded zone, hydrophilic herbaceous and tree are found. The forests of the flooded zone are in strong regression. In 21 years the forest surfaces of the flooded zone regressed about 93%. In 1987, the total surface of the forests was 1 450 000 hectares. But two decades later, in 2007, they were only 451, 114 hectares.

Agriculture represents the first economic activity of the region. Rice farming is the most important culture in terms of household consumption and sales on the markets. The major part of the rice farming is done using traditional cultural methods in the flooded area. In this area the irrigation is done using the flood waters of the River Niger. The sowing is done at the beginning of the rainy season and the irrigation is left to the flood of the river Niger.

3. 2. Methods and Research Design

Both secondary and primary data were utilized to achieve the objective of the study. Secondary data were obtained from government offices, research institutes and NGOs both at national and regional level. Primary data were collected through interviews, focus group discussions, field observations and photography's. Household surveys, key informant interviews, and meeting with officials and local authorities were undertaken both in Mopti and the two study villages during the months of August and September 2014.

3. 2. 1. Selection of the study sites

The research will be focused on the fishing villages of Bargondaga and Dagawomina which are located at the confluence zone of the Niger River and its main affluent the Bani in the Inner Delta of Niger. They are reliant on the river for fishing, rice farming, trade and transportation. The main selection criteria was that fisheries served as major source of income and base of local livelihood. Both communities depend highly on the flood waters of the rivers and face the situation that their inundated areas are diminishing due to the water uptake of operating dams located upstream. The study region is characterized by a highly variable climate. Furthermore, Bargondaga and Dagawomina have been highly affected by the great drought that have occurred in 1973 and 1974 and as a response to these previous climatic stresses the Malian government had implemented of irrigation schemes that are exerting an increasing pressure on areas traditionally devoted to fishing. Finally, the villages are nearby

the major irrigation schemes like the Office Riz Mopti. The regional scale has been selected to facilitate the data collection as the meteorological station of the area is also implanted in the district.

3. 2. 2 Household Survey

The study sample was taken from fishermen of Bargondaga and Dagawomina. Due to time and financial constraints, the sample included a total number of 100 households of fishermen per village. Village chief and his counsellors helped to identify the households that live mainly on fisheries. A combined questionnaire was used to collect household information (see appendix 1).

A short training session in order to familiarise the 5 enumerators with the topic discussed in the questionnaires and to translate the questionnaires into Bambara and Bozo took place in Mopti. After the training session, a short test survey was conducted in a nearby fishing camps which was useful to highlight the uncovered aspects of the topics. After this test, the corrections were incorporated in the questionnaires and the final questionnaire were printed.

To achieve the objective of the study our unit of analysis retained is the household, putting forth the assumption that the household was the relevant unit to study risks and their management thus households are defined in our study as the unit sharing the same cooking pot. As often it is the case in the study areass climate variability frequently induce food shortage and reduce household food consumption. Furthermore. The capacity to cope with shocks depend highly on the equipment level of the households.

Questionnaires have been addressed to head of households practicing fishing as their main economic activity or another member of the household knowledgeable about the activity of each member of the household throughout the year and their livelihoods, major occupation, household equipment level, literacy, sex, gender and age. Questions on the household perception of climate variability and the impacts of water resources mobilisation on fishing activities were included in the household questionnaire. The coping strategies adopted to face these stresses also figure among the questions to fishermen.

3. 2. 3. Key Informant Interview

A particular questionnaire have been addressed to village chiefs, mayor, parliament member, local expert and technicians in agriculture, and fisheries working within rural communities for a better understanding of how climate variability and increased mobilisation

of water resources are managed locally and what are the perspectives for the future (see Appendix 2)

A part of the interviews carried besides NGO's and government representation in French, all the interviews collected in the study villages were done in the local languages: Bozo, Bambara and Songhay. Both the data gathered at the village level and besides NGO's and government offices' were then translated in English. The audio files recorded during focus group discussions were also transcribed in French and translated in English.

3.2.4. Focus Group Discussions

A focus group discussion is a group session moderated by a researcher. It allows an active collaboration among respondents in the production of knowledge. Focus groups were held in each village of study. The groups are consisted of 7 to 10 participants. The discussions were focused on the perceived impact of climate variability and water resources mobilisation. The coping strategies and governmental responses to these various impacts were also treated during the group sessions.

3.2.5. PRA methods

- **Seasonal Calendar:** To assess the period of hazards and stresses we will use a seasonal calendar to understand livelihoods and coping strategies. The seasonal calendar will help us also to analyses changes in seasonal activities. It will allow us to see what are busiest months of the year, the onset of the rainy season and other important details on local livelihoods.
- **Vulnerability-exposure matrix:** this tool will be used to have a broader view of which social groups or livelihoods are most vulnerable to drought. This tool will give us information on how climate variability and water resources mobilisation could impact livelihood activities in the study areas.

3. 2. 6. Social Vulnerability Index

Assessing social vulnerability to climate variability implies developing appropriate indicators to compare the evolution of local conditions in time and space after climate hazards and natural shocks. In our case it involves measuring the vulnerability of the communities and the natural resources upon which they depend for a livelihood.

Vulnerability in our understanding is function of exposure and sensitivity, minus adaptive capacity. For each of the components of vulnerability (exposure, sensitivity and adaptive capacity) we choose a set of indicators to inform the index. To inform exposure to

climate hazards and dams impacts two indicators were selected: the number of household members practicing exclusively fishing, and the annual income of the household heads. Age and Literacy rate were chosen to inform sensitivity to climate risks. For the component adaptive capacity, it was informed by the average income earned through secondary source of income and the level of equipment of the household.

The data collected were normalized using the following equation

$$Ii = (xi - x\min)/(x\max - x\min)$$

Where Ii is the normalized value of indicator i, x is the original value for indicator for individual household, and x max and x min are highest and lowest values of the indicator(Chhinh N.; Cheb H.; 2013)

The indicators obtained where weighted using the equation developed by Iyengar and Sudarshan (1982):

$$wi = \frac{k}{\sqrt{(var(yi)}}\text{ , and k= }\left[\sum_{i=1}^{n}\frac{1}{var(yi)}\right]^{-1}$$

To aggregate the weighted indicators we used the following formula in line with our social vulnerability framework which is as follow

$$\text{V= } \sum wx(s) + \sum wx(s) - \sum wx(ac)$$

3. 2. 7. Field observation and GPS readings

Through direct field observation data collected during household survey and focus group discussions will be validated. Additionally, the geographic coordinates of the limit of villages were collected in order to draw a map of the study villages. Observation is a technique largely used by researcher in social and natural sciences to get a holistic perspective of the complex phenomena or situation they study. Observations' of people's way of life provide us with first-hand information on the daily activities of fishing communities. During our stay we observed also the poor states of the houses built in clay where most of the fishermen interviewed live. As our visit coincided with the farming period we visited fishermen in their rice fields and discussed with them. We also visited the aquaculture scheme in the village and the irrigation schemes closed to the two villages.

3. 2. 8. Secondary Data Sources

Consist of a review and analysis of the relevant literature on climate variability and water resources mobilisation in Mali, the Sahel zone. Secondary data review have been

conducted mostly at the scale of the region of Mopti. The reports of the regional direction of Agriculture and fisheries have been very helpful. Part of the information gathered have been found beside research institutions like the regional station of the Malian Institute of Rural Economy(IER), local development programs like the development programs of fishing in Mopti (Programme d'Appui au Developpement de la Peche a Mopti PADEPECHE), NGO's like Wetland International, CARE. Several actors intervening in the fishing sector were visited and interviewed.

The meteorological data has been collected to the regional station of Mali Meteo during this phase. Part of the secondary has been collected in the Capital Bamako where is located the university and most of the research institutes of the country. The aim was to understand the challenges and opportunities that rural communities in Inner Delta Niger are facing in a context of climate change.

3. 3. Data Handling and Data Analysis

In total 2 villages interview guides, 3 focus group discussion with existing organisations' and 200 household interviews were made during the study. Data were further organised by key questions for the content analysis. This has made it possible to cross check information given by groups and individuals. The consistencies and differences between the answer provided by the participants were then summarized and grouped in key topics.

The quantitative data collected for the needs of the study was composed of two sets of data. The first set of quantitative data is the data gathered during the household surveys concerning mainly the household's demographic data, their equipment level and their main assets.

The second data set is exclusively constituted of the meteorological data gathered between the meteorological stations of Mopti. The two data sets have been processed and analysed using the statistical software SPSS 20.

The validation process cross-referenced the data collected from the household surveys and informant interviews with the rainfall statistics and the documented accounts of previous impacts of climate variability and the water uptake of major dams and irrigation schemes.

3. 4. Limitations of the Study

The complexity of this research has been acknowledged from the outset. Firstly, Niger is a transboundary river. Upstream dams and irrigations schemes in the country and outside the country nations' activities may impose transboundary impacts on downstream villages. In solving such transboundary water resource issues, there are many actors involved. Secondly, climate variability and drought are scientifically very complex entities to handle. Variables are not only multi-dimensional but involve social implication, many of which are not quantifiable. Some of the limitations are expected while others are unexpected. The limitations encountered during the research phase and the solution that were found to overcome these issues are discussed below.

The financial challenges encountered in this research mainly related to the high cost of data, photocopying information materials and transport for the frequent visits to the communities. The payment of research assistants also was a major constraints weighing on the low finances devoted to the study.

The time constraint was a major gap in the realisation of the field surveys and focus groups. Due to the late reception of the research funds, the research activities have been delayed. When the research activities started coincided with the main farming season and fishing activities thus it was quite difficult to gather fishermen in the village during day time.

Transcribing voice recorded interviews realised during village groups discussion was a lengthy task as the interviews have been realised in local languages (Bozo, Bambara). Furthermore, the key informants' interviews were realised in French and their transcription in English took a longer time than expected.

3. 5. Ethical Considerations

This research was guided by the principles guiding ethical research in the social sciences. I undertook to treat the research participants respectfully and not as subjects; not to use the research to disempower them (Creswell, 2003); to respect the communities' cultures and leadership; and not to use the research findings for purposes other than the ones I communicated to the participants. Abiding by the ethic of respecting the traditional leadership in the communities, the village heads and/or councillor were first consulted about my intentions before interviewing the people. Fortunately enough, there was no objection to my requests and this consultation of the traditional leadership became merely symbolic.

Participation in the research was voluntary and no participant was unethically coerced to participate in the research against their will; rather they were informed of the purpose of the research and made their decisions on participation based on that information. The research participants have the right to withdraw at any time, and some requested for the voice recorder to be switched off at certain intervals during the interview, to which I complied. Intentional misinterpretation of data gathered from researches is a violation of ethical research principles, and I have tried to ensure that this was never the case.

CHAPTER IV: RESULTS AND DISCUSSIONS

4.1. Description of the Sample and Fishing Activities

The sample population of the study is distributed between the two villages (Table 4). Respondents were exclusively fishermen. Only 6% of the respondents were females.

Table 3: Repartition of Respondents

Village	Profession	
	Fishermen	
	M	F
Bargondaga	90	11
Dagawomina	98	1

The ethnic composition of the two villages are mostly the same. Half of the of the households were from the Bozo ethnic group followed by the Sonraï ethnic group and the Somono ethnic group (Figure 10) The study of the human settlement of this area put forward an ethno-professional division(Kassibo; 2002)

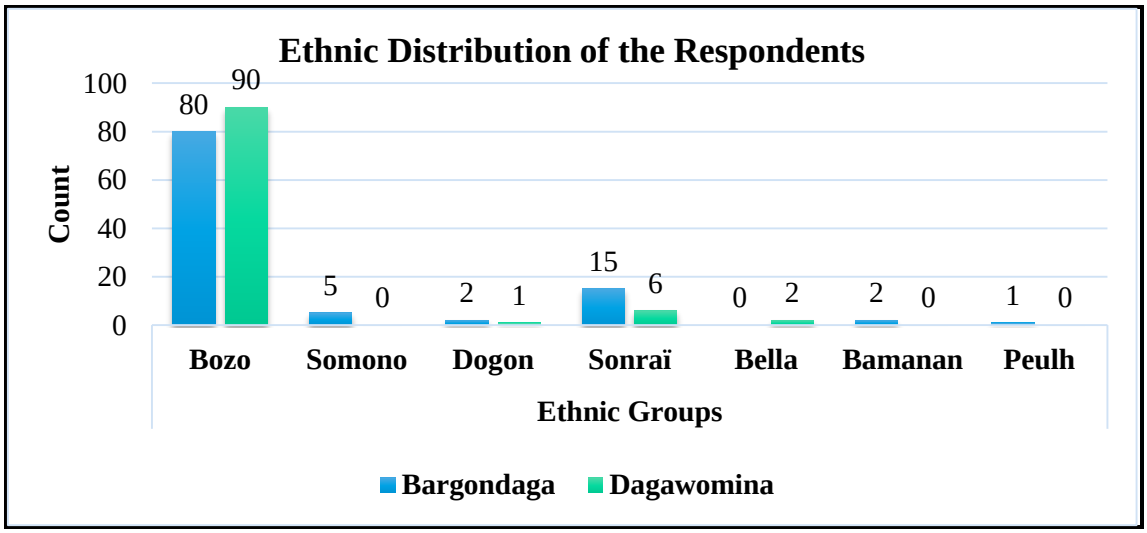

Figure 10: Ethnic Distribution of the Respondents

The major part of the respondents did not receive formal education. A high illiteracy level is observed in the two villages with only 2% of our respondents having received a formal education.

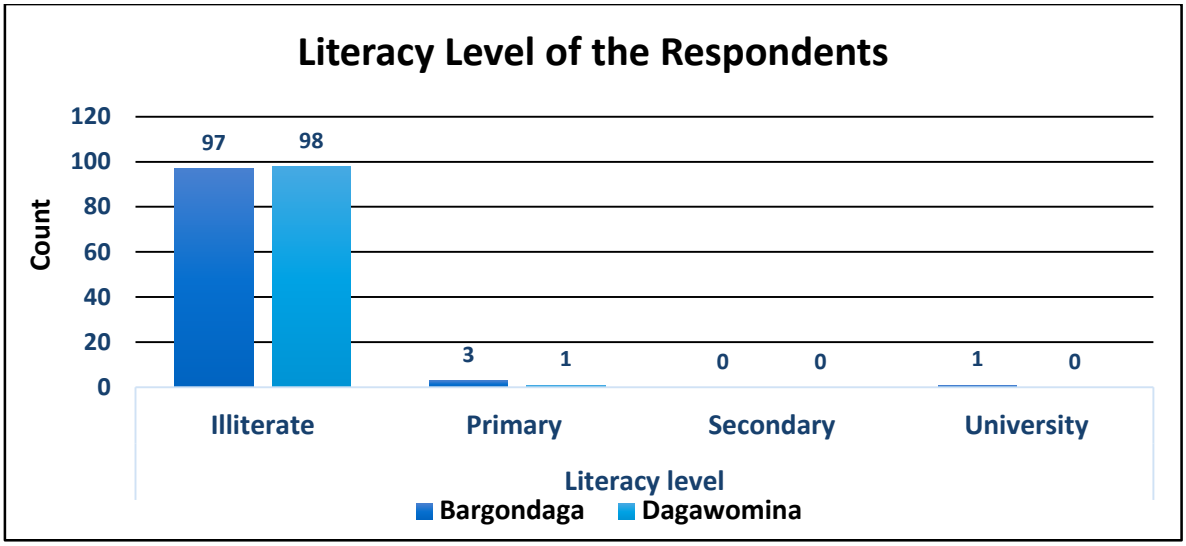

Figure 11: Formal Education among the Respondents

The age of the respondents varied between 18 and 84 years. The average year of the respondents was of 43-44 years. The age group 25 -54 years constituted 76% of the household heads in the survey.

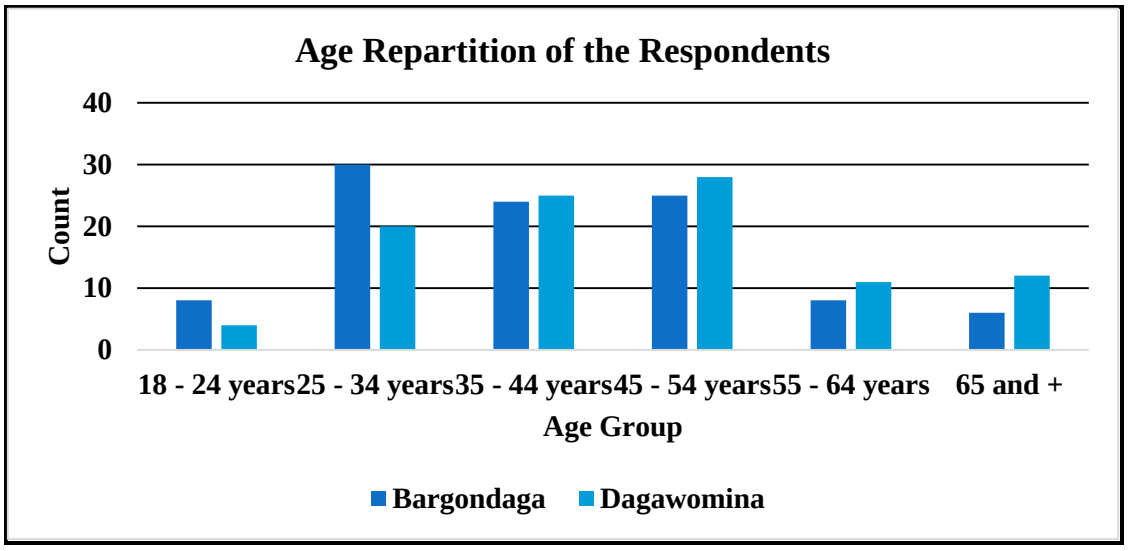

Figure 12: Age Distribution of the Respondents

Because the place of birth influences the access to natural resources in the study areas, the interviewees were asked whether they are native of the village. 65% of the respondents in Bargondaga and 81% of the respondents in Dagawomina were native of their respective village, while 35% in Bargondaga and 19% in Dagawomina had in-migrated from the surrounding villages.

Households' heads were asked about their experience and principal economic activity, including presents and past economic activities. All respondents declared that fishing was their principal economic activity. Most of our respondents affirm that they practice commercial fishing. The product of fishing are directly sold to the market of Mopti. About 10% of the respondents in Bargondaga and 11% of the respondents in Dagawomina were practicing fishing for subsistence. The product of fishing in this case is intended for household use and rarely exceeds household consumption.

Table 4: Type of Fishing

Village	**Fishing Type**	
	Subsistence	Commercial
	%	%
Bargondaga	10	90
Dagawomina	11	88

The average number of household members was 3 persons. 1 active household member to 30 active household members are engaged in fishing. The time devoted to fishing varies according to the villages and according to the type of fishing practiced. In Bargondaga for instance an average of 7 months per year is devoted to subsistence fishing while 9 months is devoted to commercial fishing.

Table 5: Duration of Fishing Activity

Village		**Fishing Type**	
		Subsistence	Commercial
		Mean	Mean
Bargondaga	Duration of Fishing in Month	7	9
Dagawomina	Duration of Fishing in Month	12	11

More time is devoted to both subsistence and commercial fishing in the village of Dagawomina than in the village of Bargondaga. However the time devoted to fishing varies between a minimum of 2 months to twelve months per year in the 2 villages. The mean distance between the village and the fishing areas is 3 km for those practicing subsistence fishing in the village of Bargondaga and 13 km in the village of Dagawomina. The average distance between the residential areas and the fishing areas is close to 13 km for both villages. The distance to the nearest market is 4 km for Bargondaga and 13 km from the village of Dagawomina

In the two sites fishing is practiced using various equipment: canoes, nets, lines and lobster pots. The level of equipment vary according to the type of fishing activity and is nearly the same in the two villages.

Figure 13: Fishing Canoe and Lines in the Study Villages

Figure 14: Fishing Nets and Fishing Traps

In the two villages those practicing commercial fishing are more equipped and own half of the total equipment counted. More than 50% of the respondents in Bargondaga and 60 % of the respondents in the village of Dagawomina own a fishing canoe and a fishing net.

Table 6: Fishing Equipment

Village	Canoe	Nets	Lines	Traps
Bargondaga	51%	78%	1%	3%
Dagawomina	61%	93%		14%

The fish catch depends on the equipment used, the number of active household members engaged in fishing and the type of fishing. The highest production is made by those practicing commercial fishing and they mainly use canoes and fishing nets. For Laë (1994) the use of equipment vary according to the biotope exploited, the species fished and the hydrologic variation.

Table 7: Average Production per Equipment Type

Equipment Type	Bargondaga		Dagawomina	
	Fishing Type		Fishing Type	
	Subsistence	Commercial	Subsistence	Commercial
	Production per year in Tons	Production per year in Tons	Production per year in Tons	Production per year in Tons
	Mean	Mean	Mean	Mean
Canoe		7		7
Net	8	13		10
traps			4	17
Lines	8			

The production depends also on the number of household members engaged in the fishing activity and the distance to fishing areas. The production of commercial fishermen of Dagawomina is higher than the production of Bargondaga.

4. 2. Livelihoods from Fisheries

The fish catch is generally sold to the traders in the town of Mopti. The income made from fishing is majorly intended for household use. The mean distance between the study sites and the market is 4 km for Bargondaga and 14 km for Dagawomina. The revenue earned is spent for food and health expenses. School fees and transportation fees are also important. A limited amount is invested in f0ishing equipment and clothing.

Questioned on the main constraints related to fishing in their villages, fish scarcity and depletion of fish stocks are cited by 30% of the respondents; these are followed by the high cost of fishing equipment. 23% of the respondents in the two villages cite lack of rain as a major constraint. “Now the rains are late, when it rains it is often not enough” observed a participant. For 13% of the respondents the retention of water by the dams of Selingue and Markala decreases the level and the duration of the flood and consist a major handicap for fishing in their areas. For another fishermen “Since the great drought and the construction of the dams, each year water level is decreasing further”

Table 8: Majors Constraints on Fishing Activity

Constraints	Bargondaga	Dagawomina
Depletion of fish stocks/ Fish Scarcity	21%	9%
High Cost of Fishing Equipment	10.5%	14.5%
Lack of Rain	10.5%	13%
Low flood/ Impact of Markala and Selingue dams	3%	10.5%

However the rank of the constraints differ according to the village. 21% of the respondents in Dagawomina found the impact of the dams and irrigation schemes as major stresses on fishing activity against 9% of the respondents in the village of Bargondaga. The constraints are the same in the two villages.

The *Hemichromis fasciatus, Clarias anguillaris, Lates niloticus,* and *Brienomyrus niger* species constitute the lot of fish catch. The abundant fish species fished locally are listed in the table below.

Table 9: Abundant Fish Species

Abundant Fish Species	
Name in Local Language	**Specie**
Baman	*Barbus sp.*
Digi	*Malopterurus electricus*
Fono	*Alestes dentex*
Konko	*Brachysynodontis*
Korokoto	*Auchenoglanus*
Manogo	*Clarias anguillaris*
Nana	*Brienomyrus niger*
Ntebe	*Hemichromis fasciatus*
Saale	*Lates niloticus*
Samu	*Auchenoglanus*
Tineni	*Brycinus leuciscus*
Wondo	*Protopterus annectens*
Wulu jɛgɛ	*Hydrocynus brevis*

According to our respondents, several fish species have disappeared among which *Heterotis niloticus, Polypterus senegalus senegalus, Gymnarchus niloticus,* and *Citharinus citharus species.*

Income diversification is a strategy used in both villages. 80% of the respondents in Bargondaga and 78 % in Dagawomina declare that they have a secondary source of income. Mostly all interviewees said that fishing alone is not enough to feed their family. Fossi et al (2012) acknowledge that fishermen have diversified their income generating activities to adapt to the decreasing flood level and climatic changes.

Agriculture particularly rice farming in the irrigation schemes is the secondary source of income. Trade comes behind agriculture and is followed by daily wages labour. An average of six members per household are engaged in the secondary activity. According to the interviewees, the most profitable of these activities is rice farming follow by trade. The revenue made from the secondary source of income is mostly used to cover the household expenses. Fossi et al (2012) estimated that 40% of the fishermen have been converted to farmers and Poncet (2000) asserted that 93% of the fishermen in the Inner Delta are practicing agriculture.

However, around 20% of the respondents did not have any other source of income, fishing is their only source of income. The reasons behind this is the lack of financial means or human resources necessary to operate a second activity.

4. 3. Climate Variability and Fisheries

More than 90% answered that climate has changed during the last decades. An increase in the temperature and a high variable rainfall are the main observations indicating climate change. The causes of climate change vary and the main causes cited by the respondents as inducing climate change is the scarcity rain and the reduction of the vegetation cover. Around 5% of the interviewees view climate change as an act of god and several think it is the result of immoral behaviours of human beings.

The respondents in Bargondaga as well as in Dagawomina indicate that the vegetation decreased in the last decade. According to them, the trees have completely disappeared in their areas, living the place to new species of grass which did not grow there in the past. Due to the increased number of irrigation schemes, the *bourgoutiere*s have decreased and new invasive plants have appeared in the river reported fishermen.

During the last two decades temperature have increased in the areas according to 95% of the interviewees. They also asserted that wind velocity has increased considerably the last decades. Winds are becoming drier and hotter the last years. “The wind storms are strong and so dark that you cannot even see your fingers in front of you” reported an old fisherman who affirmed that this type of wind was rare during their childhood

Compared to the fish catch of the past decade, 80% of the fishermen in Bargondaga and 50% of the fishermen in Dagawomina found that their fish production of the last season is acceptable, while only 1% of the fishermen found the last season catch better than the seasons of the past decades.

Among the causes that have influenced the fish production of the last season the most frequent answers are rainfall scarcity(35%), followed by other causes such as the low flood induced by the impact of dams (30%), short duration of flooding (15%), the increased demographic pressure (11%) and the depletion of fish resources(9%).

The fishing season of the last 3 years (2011, 2012, and 2013) have been highly affected by climate variability. More than 80% of our informants declare that their fishing activities were affected during these seasons in the two villages. 80% of our respondents recognise that the fish catch have decreased as a result of the variability of climate and the low flood level of the Niger. The decrease in fish catch per unit of efforts have already been mentioned by Lae R. and Mahe G; (2002) who reported that the fish catch has decrease in size and in quantity.

More than 90 % of fishermen interviewed estimated that there are vulnerable to climate variability and its changes. They explain this by their high reliance on the flood waters of River Niger and their lack of resources to face the extreme climate events as droughts and floods. The lack of fishing equipment's, and their high cost are also cited.

Questioned on the groups of people that are most vulnerable to climate variability, most of respondents say that the elders are the most vulnerable to climate variability. The elders are vulnerable because their age does not allow them to work and also because of the poverty they are already living in. Women and children are the second and third groups that are most vulnerable to the variability of climate. Women and children are vulnerable because they lack either the financial resources or the physical strength to take care of themselves. Furthermore women have a limited access to natural resources. Sick persons and persons living with disabilities are also considered as vulnerable groups to climate variability.

Table 10: Vulnerable Groups

Village	Groups Vulnerable to Climate Variability				
	Elders'	Women	Children	Sick Persons	Disabled Persons
Bargondaga	59	15	14	10	2
Dagawomina	64	11	13	10	2

The degree of vulnerability of the different groups are perceived differently from one village to the next. For example, in the table above we could see that respondents in Bargondaga consider women more vulnerable to climate change than children, while people in Dagawomina think the opposite.

The most frequent climatic hazards reported by the interviewees are drought and flood. Storms and violent winds represent the third hazard cited in the study villages.

Table 11: Households Vulnerability to Climate Hazards

Hazards	Frequency	%	Valid %	Cumulative %
Drought	108	54	54	54
Flood	58	29	29	83
Storm/Wind	34	17	17	100
Sum	200	100	100	

17% of interviewees admit that violent winds and storms constitute a threat to fishing communities and their occurrence are increasing accidents during fishing and decrease their fish catch. 76% of the fishermen surveyed reported that climate hazards are more and more severe due particularly to their frequencies and the reliance of households on climate sensitive resources.

Table 12: Severity level of Climate Hazards

Hazards	Severity		
	High	Medium	Low
Drought			

Flood			
Wind Storms			

For 72% of the fishermen surveyed, the frequency and the severity of climate hazards are impacting negatively the livelihoods and the economic activities while 5% of the respondents reported that the negative impacts of these hazards on their household is low. Questioned on the ability of their households to face climate hazards, 73.5% of the fishermen said that it is very difficult for their households to face severe and frequent climate hazards, while 20.5% found it difficult and 6% affirmed that it is not difficult for their households to face climate hazards.

Table 13: Ability of Households to face Climate Hazards

Ability	Frequency	%	Valid %	Cumulative %
Very Difficult	147	73.5	73.5	73.5
Difficult	41	20.5	20.5	94
Not Difficult	12	6	6	**100**
Total	**200**	**100**	**100**	

More than 60% of the fishermen in the study sites answered that they have access to meteorological information against 39% who reported that they did not use meteorological information in their fishing activities.

Table 14: Access and Use of Meteorological Information

Answer	Frequency	%	Valid %	Cumulative %
Yes	121	60.5	60.5	60.5
No	79	39.5	39.5	100
Total	200	100	100	

94% of the respondents who access meteorological and climate information receive it from government sources and 6% receive information from NGOs. The information is broadcast on government radio and local radio. The main meteorological information forecast are related to the maximum and minimum daily temperature, precipitations, wind direction and velocity. Fishermen who have used meteorological information in their fishing activities find

that the information prevents from having accidents during fishing; the information is equally useful for farming.

11% of the fishermen who did not use climate information blame the unreliability of meteorological information, while several fishermen declare that climate information is useless. However, 86% of the interviewees express that they need more access to meteorological information particularly seasonal forecast and precipitation trends. 6% respond that they did not need meteorological information because the information provided are not reliable.

4. 4. Impact of Upstream Dams and Irrigation Schemes

The fishermen of Bargondaga and Dagawomina reported that the major dams and irrigation schemes located nearby the study areas are the irrigation scheme of the Office Riz Mopti, the Talo Dam and the Dam of Djenne.

Table 15: Hydro-agricultural schemes

Dam/Irrigation Scheme	Frequency	%	Valid %	Cumulative %
ORM Irrigation Scheme	142	71	71	71
Talo	47	23.5	23.5	94.5
Djenne	11	5.5	5.5	100
	200	**100**	**100**	

According to 33% % of the interviewee's they have been associated to the realization of the irrigation scheme of the Office Riz Mopti (ORM) even though they were not associated to the realization of the Dams. Wymenga et al (2012) argue that the water uptake of Talo will reduce the flow of the Bani at Mopti. When interrogated on which dams are impacting their fishing activities, villagers cite mostly the dams of Markala and Selingue. Though remote, those dams are having considerable impacts on the fisheries of the Inner Delta. According to the fishermen of Dagawomina, the inopportune and untimely release of flood waters by the Dams of Markala and Selingue during years of high waters threatens their village and is causing flood from time to time. Van Beukering et al (2005) warn that the increased number of dams may induce a significant reduction of the income per capita in the Inner Niger Delta and they further assert that dams may transfer the benefits to upstream communities while increasing the vulnerability of downstream communities.

A major constraint is the conversion of fishing areas to agricultural schemes. According to the fishermen surveyed, most of the fishing ponds of Bargondaga and

Dagawomina have been converted in rice farms by the ORM. Furthermore the setting of grills and gates to retain water are also decreasing their fish catch.

Table 16: Impact of Hydro-Agriculture Schemes

Impact	Bargondaga	Dagawomina
	%	%
Decrease fish catch	43	11
Flooding	17	45
Conversion of Fishing areas	19	15
Water Erosion	21	29
Total	100	100

The impact of the major dams like Talo, Djenne and Markala are translated into a low level of flood in their villages; this decreases fish catch and increases poverty level and unemployment in the village. Dagawomina is also flooded by the untimely water release from the Dam of Markala and Selingue. The inopportune water release of Selingue hinder fishing by scattering fish stocks. This is caused by the abrupt arrival of the artificial flood which increase the river level (Laë; 1992).

Even though both villages are affected by the dams and irrigation schemes, the impact varies and the risks are not the same in the 2 study villages. Due to its geographical location, the village of Dagawomina is more exposed to flood and water erosion due to the impact of inopportune water release of the dams of Markala and Selingue. The social, economic, and environmental impact of major dams and irrigation schemes varies from one village to the next and from an individual to another. Morand et al (2009) confirm that the dams built on the river basin have often been disastrous for the fishing activities of communities living downstream.

As a result of the conversion of fishing areas into irrigation schemes, fishermen have to change their fishing place. They have to go far from their habitual fishing space, making fishing accessible only to owners of canoes and those who are well equipped. This is to say that poor households lacking adapted equipment and sufficient human resources are the loser of this system.

57% of the fishermen surveyed expect the impact of dams and irrigation schemes to be heightened by the changing climate. For the respondents, if the decrease in rain persists the level of the flood will decrease in their areas, thus reducing fish catch and increasing poverty. Among the detrimental side effects caused by the water uptake of upstream dams and irrigation schemes figure the alteration of the natural ecologic systems downstream (Morand et al; 2009)

4. 5. Informal and Formal Support in Case of Disaster

82.5% of our respondents declare that they did not receive a support of any kind during the previous climatic stresses that have occurred in the study villages while 17% of the respondents have received a form of support. 17% of the interviewees who have received a form of support during the past crises got it from social networks, mainly from relative living outside of the community, 73% received a support from NGO's and 20% received a support from governmental agencies. The support received during natural disasters consists of food aid (60%), fishing equipment (10%); cash transfers (15%) and capacity strengthening in aquaculture (13%).

4. 6. Socio-Economic Organisation of Fishing Communities of Bargondaga and Dagawomina

Until now the social organisation in the villages of Bargondaga and Dagawomina is still a traditional type based on gerontocracy which is still very powerful in the management of natural resources and matters related to the daily life of the study villages. Gallais; (2003) highlighted the important role devoted to traditional management of fisheries which enabled local communities to sustain their fishing activities by using for each biotope the adequate fishing equipment. In the past, the economic organisation relies mostly on fishing which was practiced during six months out of twelve. Fishing is still a male activity in the two villages, while the transformation and the trade of fish production is the domain of women, generally.

The inhabitants of the two localities are mostly semi-nomad bozo, Sonraï and Somono fishermen whose livelihood are based principally on fishing followed by rice farming and trade. The economic activity are still related to ethnic provenance. Most of the fishermen are from the Bozo and the Somono ethnic groups.

The main fishing season extends from October to November and depends on the level of flood in Inner Niger Delta. It is followed by the second fishing season extending from April to August during which the catch is minimum. The trade activity is at its maximum in the fishing period and is mainly based on the trade of fish products. Farm activities start in April with the preparation of land and end with the harvest in the month November to December.

The main fishing season is followed by a lean period extending from May to September during which to avoid food scarcity, the poor households of fishermen take loans besides cereal sellers to feed their family. These loans are usually deducted from their fish catch during the main fishing season. For Morand et al (2009), though fishing and farming are separated, they

are complementary. Whereas fishing bring back money and proteins, farming provide the grain necessary for the household.

Even though the inhabitants of the 2 villages are mostly fishermen, fish contributes only to a small portion of their food consumption. The consumption of fish represents only 8% of household needs. The households depend highly on the cereal available in local markets and the cereal production of the neighboring villages. For poor households in the 2 villages it is not unusual to exchange fish against cereal.

The ownership of fishing nets, canoes and the number of household members engaged in the fishing activity are the main factors determining wealth in the study villages. The fishing nets of the medium and well – off classes are numerous, longer and are a better quality than those owned by the poor fishermen households. Fishing canoes are an important asset for fishing and trade. Poor fishermen also resort to the rent of canoes and fishing nets with big traders mainly outside the community.

Well-off and medium households draw their income principally from fish, rice farming in the irrigation schemes and trade. Women play an essential role in the trade of fish products and cereal grain trade. Canoes or carts to bring their products to the market of Mopti and surroundings.

The fresh fish being a very perishable food product, the fishermen must have means of transport fast and effective techniques to preserve or process fish in order to reduce the losses to the minimum (Fossi et al.; 2012). Fishermen live mostly with the surplus of fish production that is smoked or dried and sold on the nearby market of Mopti. Nowadays and particularly due to the combined effects of climate change and major hydraulic infrastructures built upstream, fishing efforts have considerably increased after the big droughts of 1973 and 1984.

The old age of fishing activity in this zone and the particular nature of fish resources (invisible and mobile) have pushed communities to set gradually a set of rules to share fish resources and fishing spaces between the different ethnic groups practicing fishing as a livelihood (Kassibo,1994). Common law regulating the access and management of halieutic resources have been continuously evolving in the quest of compromises related to socio-economic aspects of fishing (Breuil, 1996).

The known oldest organization was founded on a pact tied and renewed with the divinities of water. The ethnic groups had each one their technical speciality corresponding

to one or more particular biotopes. Persons in charge for various types Master of waters, heads of clans) allocate exploitation rights of fish resources.

The fisheries in the study area were managed locally by communities themselves until the accession of the country to the independence. Fisheries in the two villages are managed by a Master of Water called "*Djitou*" or "*Djitiguiw*" in the local languages. The "*Djitou*" controls the access of the fisheries and they perceive royalties for this task even though the amount paid is usually symbolic. The access to the resources differs according to the origin of the fishermen. For natives, the access to resources are generally free while migrant fishermen have to pay an amount of 1,000 CFA to the "*Djitou*" if he intends to exploit local fish resources.

In common agreement with the village chief, the Master of the Water decides on the time best suited for collective fishing. Collective fishing is mostly practiced in the most abundant ponds during the dry hot season where the flood waters of the River Niger receded. This fishing activity gathers together exclusive fishermen and agro-fishermen of nearby villages and is accessible even to women, children and to migrant fishermen without any form of payment. The main role of the "*Djitou*" is to manage rationally the fish resources. To achieve the rational management of the resources, fishermen must comply with a certain number of rules

- No fishing in restricted areas so that the depleted fish could replenish;
- Fishermen should not dam the main passage of fish so that the reproduction of fish could continue freely;
- Respect of rights of other fishermen on the resources.

A committee constituted of the young men of the village is in charge of enforcing these rules. All the contraveners to these rules are brought to the chief of the village and are fined in function of the damage they have caused. Today the "water masters" are no longer involved in the administrative decisions regarding the management of water resources and even less in conflict management of fisheries. Its roles and powers were transferred in their majority to mayors (Wymenga et al (2012).

4. 7. Main Constraints Encountered by Fishing Communities in the Study Areas

In 1949, at the time of the first studies of Daget in the Inner Niger Delta, the number of fishermen was relatively few and the fish resources were abundant. At that time, fishing was a profitable activity, the incomes of Bozo, Sonraï and Somono fishermen were then three times

higher than those of exclusive farmers (*Laë* et al; 1994). After this period of fast development which had led to a doubling of the production between the 1940s and the 1960s, the deltaic fisheries underwent a crisis between 1973 and 1994. This resulted in the reduction of the fish catch, the reduction in the sizes of the captures, even the disappearance of certain species. This situation created serious conflicts between groups of fishermen (Quensière; 2002). "Several species fished by our senior are no longer existing" say many fishermen during the interviews and before these days the fish catch are bigger than now". Today the living conditions of the fishermen are still hard, the production is the conflicts related to the exploitation of natural resources have increased.

In the Fifties, the annual production was about 45, 000 tons in the IND. From 1950 to 1970, the development of fishing activities involves an improvement of the production of fish which passes thus from 45, 000 to 90, 000 tons per annum (Laë et al; 1994). The halieutic potential having varied probably little, Fay (1989) estimates that the increase in production results mainly from the extension of the fishing zones and the intensification of fishing activities by migrant fishermen. But from the 1970s, and until 1993, the fish production and marketing strongly fell, reaching a minimum in 1984-1985.

The ichtyological productivity is thus very strongly dependent on the hydrological conditions of the catchment basin of IND and particularly of the height of flood waters. The low floods lead to a reduction in the number and size of fish and to less profitable fishing campaign.

A low level of flood in the IND means that the high plains furthest away from the minor bed will not be flooded. They cannot be used as spawning grounds nor as nurseries for the alevins and the young fishes. "Since the building of the dykes and the irrigation system the fish remain blocked in the rice farms due to grills and dykes obstructing the passage during flood recession" have observed the communities. Moreover, because the duration of the flood in the lowest zones remains shorter than in period of high waters, the fish do not have time to grow under good conditions. On the contrary, if the flood level is high, the conditions are favourable to a prolonged spawning time, which, for many species can lead to repeated eggs laying.

Laë (1992) relate the annual catches and the flow of the Niger River at Koulikoro to the maximum surface flooded of IND. Zwarts and Diallo (2005) also demonstrate it by comparing the annual catches in IND between 1966 and 2003 with the variation of the maximum flood level observed at Akka hydrological station.

These modifications of the hydrological characteristics of the IND would be caused by two main factors:

• The droughts and the climatic change which reduced the power of the flood

• The management of water of the dam *Markala* and the dam *Sélingué.*

Precipitations during the rainy season have considerably decreased between 1973 and 1974. The flow of the River Niger at Koulikoro naturally decreased. Mahé et al; (2002) calculated that between the two periods 1907-1969 and 1970-1995, the reduction in the river contributions to the delta was approximately 48%. The plains flooded from July to December then passed from 25 000 km² in 1966 to 7 500 km² in 1989 (Laë and al; 1994).

All the scientists agreed that the dry periods of 1970 is the principal factor behind the reduction in the height of the flood and thus of the reduction in the halieutic production in the Inner Niger Delta.

The effects of climate variability in the study villages are compounded by the impact of hydraulic infrastructures realised upstream of the Inner Niger Delta.

In 1947, the start-up of a water reservoir at Markala (www.fao.org) allowed a significant development of agriculture. The dam realized made it possible to maintain the water level upstream at a coast close to that of high waters in order to be able to irrigate by gravity the vast depression located at the North-East. Intended for the culture of cotton at the origin, this agricultural zone currently produces rice and sugar cane (Laë; 1994).

In 1982, the construction of a dam was completed in Sélingué on Sankarani, the main tributary of Niger located upstream of the town of Bamako. The dam supplies part of the electricity need of Mali (*Laë,* 1994). It also makes it possible to irrigate cultures. The reservoir of the Selingue dam is much more significant than that of Markala (Wymenga et al; 2012).

The development of dams and hydro agricultural schemes on the Niger River and its affluent have many consequences on the communities in the study areass: the decrease of flood peak, the decrease of the flooded area, the decrease of fishing spaces and fish catch.

According to fishermen the realization of these two hydraulic infrastructures got many consequences on their livelihoods. The inundated areas have decreased recalled, most of our respondents. The chief of Dagawomina recalled that before the dams, they use canoes to go from one fishermen family to another during the yearly peak of flood but now the peak flood hardly reaches the village.

Before the realization of the dams, fishermen reported that they could fill 3 to 4 canoes of fish per night during the main fishing season when the flood peak was high. But now they can hardly fill 1 canoe due to the decrease in flood peak. The decrease in flood height decrease the inundated area and fishing area, thus decrease fish catch and spawning grounds. The

duration of the inundation has also shortened, decreasing the fish catch and the duration of fishing season. Furthermore, fishermen in Dagawomina reported that the inopportune release of water have eroded and broke the main protection dyke of their village. As a result the village have been flooded many times.

These impacts observed by communities are the same expected by scientists who feared that dams and irrigation schemes on the Niger River would transfer the economic benefits to upstream communities and would increase poverty among downstream communities.

Another consequence of the agricultural schemes is the high prevalence of malaria in the villages of study. This further concerning as the Circle of Mopti were is located the study sites shelters the majority of the irrigation schemes developed in the region. The irrigation schemes cover more than 28, 972 hectares. The degradation of water resources and the increase of invasive plant species are among the consequences of the fertilizer used in irrigation schemes.

4. 9. Community Exposure and Sensitivity Analysis to Climatic Hazards

To understand the climatic risks to which the study villages are exposed, a group exercise was conducted in the two villages including the village chief and its councillors, the young and the women. Participants were first asked to list the most frequent climatic hazards occurring in their village. Participants were asked to rank their degree of exposure to climate hazards (drought, flood, wind storm) between 1 to 0.25 and the probability or likelihood of impact of these hazards. The score of 1 representing the highest degree of exposure to climate hazards and 0.25 the lowest score. The participants were also asked to rank the possible adverse consequences of these hazards on their lives and their assets. A score comprised between 1 and 0.25 was given to each category susceptible to be impacted by the listed climate hazards. The score of 1 representing very severe consequences and 0.25 representing the lowest consequences. The highest the score indicated the most sensitive groups and activities to climatic risks.The results are presented below (table 18).

Table 18: Climate Sensitivity Matrix

Risks/Effects	Drought		Flood		Wind Storm		
	Exposure	Sensitivity	Exposure	Sentivity	Exposure	Sensitivity	Risks Rating

Who/What will be affected?	Probability or likelihood of impact	Possible Adverse Consequences (Expected losses)	Probability or likelihood of impact	Possible Adverse Consequences (Expected losses)	Probability or likelihood of impact	Possible Adverse Consequences (Expected losses)	
People Groups							
Elders	1	1	1	1	1	0.5	5.5
Women	1	1	1	1	0.5	0.25	4.75
Children	1	1	1	1	0.75	0.5	5.25
Resources							
fish	1	1	0.25	0.25	0.25	0.25	3
water	1	1	0.25	0.25	0.75	0.25	3.5
Economic Activities							
fishing	1	1	0.5	0.25	1	0.75	4.5
farming	1	1	0.75	0.75	0.5	0.25	4.25
trade	0.75	0.5	0.25	0.5	0.5	0.5	3
Physical							
Houses	1	0.25	1	0.5	0.25	0.25	3.25
Fishing equipment	0.25	0.25	0.25	0.25	1	0.75	2.75
Others							0

The analysis reveals that the most common climatic hazards in the study areas are drought, flood and wind storm. The most exposed groups of people to the consequences of these hazards are elders, women, and children. These groups according to the respondents are the more at risk and are suspected to be highly impacted in case of disasters due to their socio-physical conditions. Fishing and farming are the most exposed to the adverse impacts of drought, flood and wind storms followed by trade. The houses and fishing equipment are also at risks from the climatic hazards like flood and storm wind in the study areas.

4. 10 Social Vulnerability Analysis

The result of the social vulnerability of fishermen households to climate variability and increased water uptake were mapped using the households coordinates collected during the household survey.

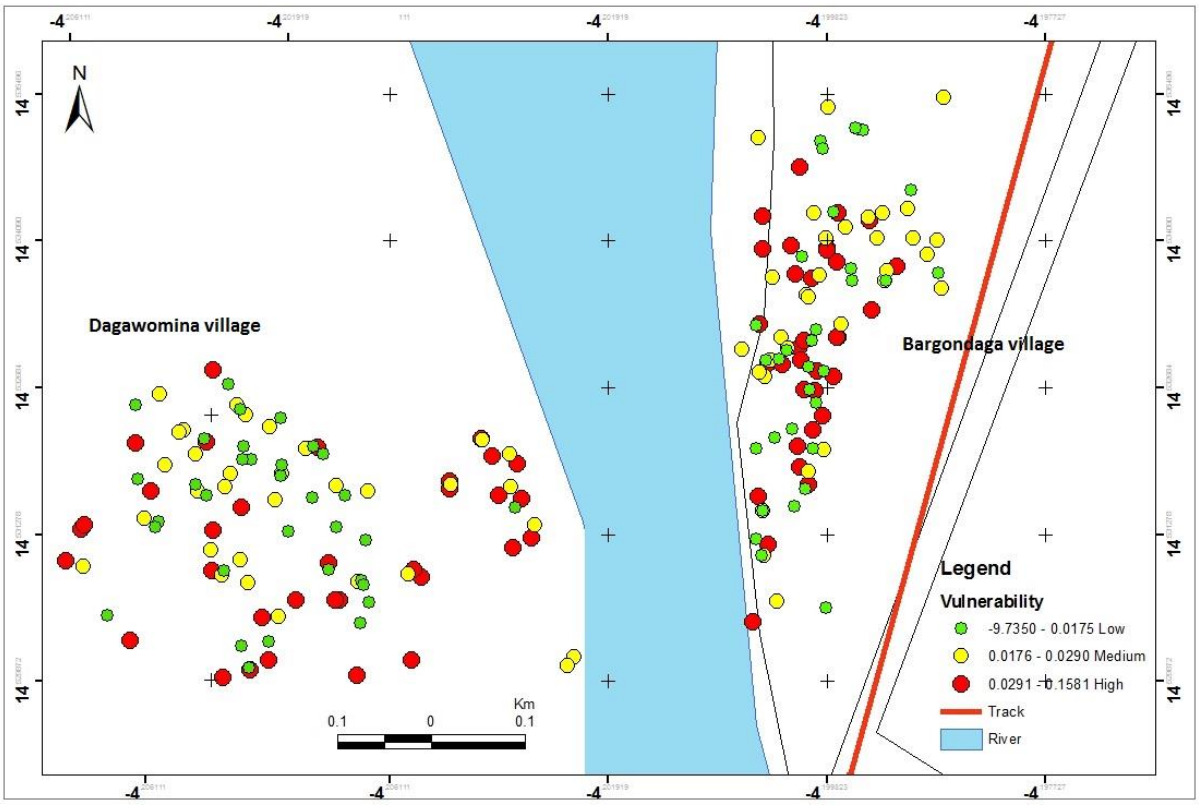

Figure 15: Social Vulnerability Index Map

The results of the overall vulnerability scores are distributed between 3 classes of vulnerability using the near neighbour methods: low, medium and high. The results reveal that 55 % of the fishermen households surveyed are highly vulnerable to climate hazards. The reasons behind this are their low adaptive capacity and the great exposure of their livelihoods to climate variability and increased water uptake of hydro-agricultural schemes while 30%. The most vulnerable are women and children. The households practicing only fishing and under equipped are among the most vulnerable to climate hasards. 25% of the households are moderately affected by climate variability and dams impacts because of the diversification of their sources of income. In this case households depend partially on fishing and farming but in most of the cases, they are poorly equipped. The households with a low vulnerability to climate variability represent only 10% of the fishermen surveyed. This group is well equipped and practice both fishing and farming in addition to many other sources of income practiced by the households.

In both villages the lack of social infrastructures (health center, market, and roads) also increase the vulnerability of the fishermen. Furthermore the closeness of irrigations schemes and stagnant waters increase considerably vector-borne disease such as malaria. To sum up,

fishermen of Bargondaga and Dagawomina are vulnerable to the impacts of climate change and increased mobilisation of water resources. This vunlnerability is caused by the increases in the frequency and the severity of climatic hazards (drought, flood) and their low adaptive capacity.

CHAPTER V: CONCLUSION AND POLICY RECOMMENDATION

This study assesses how fishing communities of Bargondaga and Dagawomina located in the Inner Niger Delta are affected by the double impact of climate variability and the increased number of dams and irrigation schemes developed on the Niger River and it's affluent.

The results of this study show that fishing communities in the region of Mopti are aware of climatic changes and have a clear perception of the decreased flood level in their areas even if they can't dissociate the climatic impacts from the impacts of dams. The main changes observed are related to the decrease in the amount of rainfall, the increase of the temperature, and the increase in the aridity of wind and its velocity. The late onset of the rainy season and its shortening are reported by most of the respondents in the two villages. These changes are confirmed by the analysis of the climatic data gathered from the regional meteorological station of Mopti.

To reduce their vulnerability to both climatic risks and the impact of increased water resource development projects, fishermen implemented a series of measures enabling them to cope with these stresses based on their traditional know-how and their socio-environmental conditions. These measures include rice farming in the irrigation schemes, practice of extensive aquaculture, migration to artificial lakes and other abundant fishing spaces, trade and daily wages labour. Some have entirely give up fishing for more profitable jobs as the manufacture of canoes while some fishing communities have settled near the irrigation schemes and artificial lakes.

The groups of people that were found to be the most vulnerable to the impact of climate variability include the elders', the women, the children and the sick persons. The household with only one active member are also vulnerable as they lack sufficient human resources to operate fishing activity. The lack of equipment and their high cost a factor increasing vulnerability to climate variability and increased number of dams and irrigation schemes.

The government and the NGO's intervening locally have implemented many measures to increase the resilience of fishing communities through the management of irrigation schemes and the promotion of aquaculture. These measures have indeed improve the conditions of communities through the availability of food and the creation of new jobs. However due to the financial high cost to operate these schemes and the double exposure of both fishing and farming to climatic disturbance and the water uptake of dams and irrigation schemes, these measures may not be viable in the long term.

Government policies aiming at promoting rice farming also aggravated the living conditions of fishing communities. The consequences of these policies are the conversion of fishing grounds into rice farms, the decrease of flood peak and the decrease of the inundated areas. The decrease in the inundated area also reduces the availability of cultivable lands. Furthermore, the practice of rice monoculture and the use of fertilizers in the irrigation schemes are contributing to the degradation of water and land resources materialised the reduction of fertility and the acidity of soils. This state of fact increases poverty and vulnerability among fishing communities.

The study reveals that communities of fishermen of Bargondaga and Dagawomina rely heavily the wetland system of the Inner Niger Delta for fishing and farming. But the impact of climate variability and the increased number of dams and irrigation schemes degraded the land and water resources and may disrupt the ecological systems. This situation threatens the livelihoods of communities already affected by climatic shocks. Achieving sustainable development in the study areas and preserving the biodiversity must pass through the implementation of a series of measures including:

- Implementing participative and integrated management of fisheries and water resources;
- Increasing the participation of local communities in the management and decision making-process by using a bottom-up approach;
- Introducing adaptation technologies preserving the biodiversity of the wetland ecologic systems upon which depends the livelihoods of local communities;
- Strengthening the capacity of local communities in terms of access and use of meteorological information in their economic activities; and
- Increasing the access of fishermen households to microfinance and income generating activities.

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VI Appendix

6. 1 Questionnaire Menage

Nom et Prenom Enqueteur : _____Date :_____/_____/2014

Village :_____Commune :_____Cercle :_____

I. Identification de l'enquêté

Nom_____ Prénom(s)_____Age_____

Statut Matrimonial : Marie/__/ Divorce /__/ Célibataire /__/ Veuf (ve) /_ /

Sex_____Profession_____Ethnie_____Religion___
_____Niveau de formation : _____Tel_____

II. Expérience

1- Quelle est votre principale occupation ? _____

2- Combien de temps avez-vous pratiqué cette activité_____

3- Avez-vous exerce d'autres occupations par le passe ? _____
_____

4- Combien de temps avez-exerce cette profession ?_____

5- Pourquoi avez-vous- changé d'occupation ? _____

6- Etes-vous Originaire de ce village : Oui /__/ Non/__/

7- Si Non depuis combien temps habitez-vous ce village ? /_____/

8- Combien de Membres du Menage sont âgés de 0-12 ans /_____/ 60 ans +/_____/

9- Nombre de personnes handicapees dans le menage /____ /

III- Type, taille et envergure de l'exploitation de pêche

Type de Pêcherie	Nombre de Membres du Ménage Exerçants l'activité	Temps consacre à la pêche par an	Quantité Produite par an
Domestique/Traditionnel			
Commercial			
Saisonnière			
Autres (à préciser)			

a- Quelle est la distance entre votre activité de pêches et votre résidence /_____/km

b- Quels types d'Equipment de pêches possédez-vous ?

Equipment	Type	Nombre	Nombre de personnes utilisant l'équipement	Production moyenne annuelle par type d'Equipment(en Kg/Tonnes de poissons)
Canot/Pirogue				
Filet				
Nasses				
Lignes				
Autres (à préciser)				

Revenus Moyen par an /_____/FCFA

IV- Situation économique

1) Quelle utilisation faites-vous des revenus tirés de la pêche

a- Achat de moyen de déplacement Oui ☐ Non ☐

b- Scolarisation des enfants Oui ☐ Non ☐

c- Construction/Réfection de logement Oui ☐ Non ☐

d- Position sociale Oui ☐ Non ☐

e- Faire face aux dépenses de la santé Oui ☐ Non ☐

f- Faire face aux dépenses alimentaires Oui ☐ Non ☐

g- Assure la sécurité alimentaire Oui ☐ Non ☐

i) autres à préciser_____

_____

4) Existe-t-il un marché dans votre village ? Oui ☐ Non ☐

5) Si Non à quelle distance se trouve le marché le plus proche ?_____km

V- **Identification des contraintes**

1) Quels sont les contraintes liées à votre activité de pêches :

   Expliquez-

   vous_____

   _____

   _____

VI- Connaissances Ecologiques et Etat des Ressources Piscicoles

a- Quels sont les types de poisson pêchés dans vos eaux ?

Especes de poisson	Etat de la ressource (Abondant, Rare, Disparus)

VII- Diversification des activités économiques au sein du ménage ?

a- Exercez-vous ou un autre membre du ménage exerce-t-il une autre activité rémunératrice ? Oui /_/ Non /_/ (si oui renseigner le tableau ci-dessous

Activité	Membre du Ménage exerçant l'activité	Rémunération moyenne (FCFA/An)	Utilisation de la rémunération

Si Non Pourquoi _____

_____

VIII- Perception des changements climatiques

1) Pensez-vous que le climat à changer? Oui ☐ Non ☐

2) Si Oui quels sont les changements que vous avez constatés?

_____

_____

_____

_____

3) Selon vous qu'est-ce qui est à l'origine de ces changements?

_____

_____

_____

_____

_____

4) Selon vous le couver végétale à t-il évoluer? Oui ☐ Non ☐

5) Si Oui à t-il diminuer ou Augmenter dans les 10 ou 20 années passé?

Augmenté ☐ Diminué ☐

6) Selon vous la température à telle changée? Oui ☐ Non ☐

7) Si Oui a-t-elle diminué ou Augmenter dans les 10 ou 20 années passé?

Augmenté ☐ Diminué ☐

8) Selon vous est-ce que la vitesse et la force du vent sont-elles changée ?

Oui ☐ Non ☐

9) Si Oui Ont- elles augmentées ? ☐ diminuées ? ☐

a- Comment évaluer vous votre production de pêche de l'année passée par rapport au 10 derrières années?

Passable ☐ Moyen ☐ Bien ☐

b- Pourquoi la production était à ce niveau l'année dernière ?

Expliquez _____

_____

_____

_____

_____

c- Lesquelles des saisons de pêche suivantes ont été affectées par la variabilité climatique ?

1999 ☐ 2000 ☐ 2001 ☐ 2002 ☐ 2003 ☐ 2004 ☐

2005 ☐ 2006 ☐ 2007 ☐ 2008 ☐ 2009 ☐ 2010 ☐

2011 ☐ 2012 ☐ 2013 ☐

d- la variabilité climatique a-t-elle influencée vos activités de pêches?

Oui ☐ Non ☐

e- selon vous quelle était la cause de la variabilité climatique que vous avez vécue?

_____

_____

_____

_____

f- pensez-vous être vulnérable à la variabilité climatique ? Oui ☐ Non ☐

Pourquoi?_____

_____

_____

_____

g- Selon vous Quels groupes dans la communauté sont particulièrement vulnérables à la variabilité de climat?

Vieux ☐ Malade ☐ Handicapé ☐ Enfants ☐ Femmes ☐

Pour quoi? _____

_____

IX- Vulnérabilité des ménages aux aléas climatiques

Aléas évènement climatiques	Lequel de ces évènements climatiques vous ou les membres de votre ménage ont vécu	A quelle fréquence ces évènements se produisent-ils ? 3= Très fréquent, 2 = Peu fréquent,	Quelle est la sévérité de ces évènements? 3= Très sévère, 2 = peu sévère ,	A quel degré ces évènements affectent ils négativement votre ménage? 3 =Elevé 2 = moyen,	Quelle est le degré de difficulté pour vous et votre famille à faire face à ce type d'évènements?	Somme Total de la vulnérabilité du Ménage (Somme des colonnes de A jusque D)

	au cours des 20 années passes (Cochez les bonnes réponses Svp)	1= Rare **A**	1= pas du tout sévère **B**	1= faible **C**	3 = Très Difficile, 2 = Difficile, 1 = Pas difficile **D**	
Inondation						
Sècheresse						
Vents forts, Orages						
Autres (préciser)						

X- Accès et Utilisation des informations Météorologiques et Climatiques

1) Utilisez- vous les informations climatiques dans vos activités de pêche ?

Oui ☐ Non ☐

a- Si Oui Qui vous fournit ces informations climatiques ?

Gouvernement? ☐ ONG? ☐ Autres ? ☐

a.1 Si Oui ces informations vous sont-elles été utile? Oui ☐ Non ☐

a.2 Si Oui comment ? _____

_____

_____

a.3 Si Non Pourquoi ? _____

_____

_____

2) Souhaiteriez-vous avoir du soutien du service des informations climatique pour l'amélioration de vos activités de pêche ? Oui ☐ Non ☐

a- Si Oui de quel type ?

_____

_____

_____

_____

b- Si Non Pourquoi ?

XI- Impact des Aménagements Hydro-agricoles :

1- Quels sont les principaux barrages/ponts existants ou en construction dans votre zone ?

_____

_____

_____

2- Votre communauté a-t-elle été associée à cet aménagement hydro-agricole ? Oui /__/ Non /__/

3- Quels sont les impacts de ces aménagements sur

Vos activités de pêche ?_____

_____

_____

_____

Sur le village ?_____

_

4- Comment faites –vous face aux impacts négatifs de ces aménagements ?

_____

_____

_____

5- Croyez-vous que les changements climatiques puissent aggraver les conséquences négatives de ces aménagements ?

Expliquez_____

_____

6- Quelles solutions préconisez-vous pour atténuer ces conséquences ?

_____

_____

_____

XII- Assistance et Mesures d'adaptation aux catastrophes et aléas Climatiques

1) Recevez-vous d'aide en cas de catastrophes et aléas Climatiques de la part de:

ONG? Oui ☐ Non ☐

Gouvernement? Oui ☐ Non ☐

Réseaux sociaux? Oui ☐ Non ☐

3) Si Oui quel type d'aide?

ONG

_____

_____

_____

Gouvernement

_____

Réseaux sociaux

_____

4) Si non quel appui attendez-vous en cas de sécheresse de la part de:

ONG

_____

Gouvernement

_____

Resaux sociale

_____

_____

6. 2. Guide d'entretien Village

Enquêteur : _____ Date : _____/_____/2014

Village : _____Commune_____

Cercle : _____Région :_____

Nombre de Participants : Femmes /_____/ Hommes /_____/ Total /_____/

I- Histoire du Village

1- Qui a fondé le village ? D'où venait-il ? de quand date la fondation du village ?

_____
_____
_____
_____
_____
_____

2- Quelles sont les principales ethnies ? Les langues parlées couramment ?

_____
_____

3- Quels sont les villages limitrophes ? Quelles sont les relations avec les villages voisins ?

_____
_____
_____

4- Quelles sont les activités économiques pratiquées dans le village ?

_____
_____
_____

5- Comment accède-t-on à la chefferie du village ? Quels sont les rôles et les responsabilités du Chef de village ? Des conseillers du village ?

_____
_____
_____

II- Organisation Sociale

1- Quelles sont les principales organisations villageoises ?

_____

2- Quelles sont les conditions d'accès à ces organisations ?

_____
_____

3- Quels bénéfices peut- on- tirer à faire partir de ces organisation ?

_____
_____

4- Quel est le rôle de ces organisations dans la gestion des ressources naturelles ?

_____
_____

III- Accès et Gestion des Ressources Naturelles

1- Quels sont les principales ressources naturelles du village ?

_____
_____

2- Qui est charge au sein du village de la gestion

a- Des terres ?

_____
_____

b- De la gestion des ressources en eau ?_____
_____

c- Des ressources ligneuses _____
_____

3- Quels sont les modalités d'accès pour les autochtones aux

a- Terres ? _____

_____

b- Au ressources en eau ?_____

_____

c- Des ressources ligneuses ?_____

_____
_____

4- Quelles sont les modalités d'accès des migrants et étrangers aux

a- Terres ? _____

_____

b- Au ressources en eau ?_____

_____

c- Des ressources ligneuses ?_____
_____
_____

IV- Accès et Gestion des pêcheries villageoises

1- Qui est charge au sein du village de la gestion et de l'accès aux pêcheries ?

_____
_____
_____

2- Comment et où la pêche se faisait-elle traditionnellement ?

_____
_____

3- Comment et où se font les activités de pêche de nos jours ?

_____
_____

4- Quels sont les groupes ethniques et groupes sociaux pratiquant la pêche ?

_____
_____
_____

5- Quelles sont les conditions d'accès des pécheurs autochtones au pêcherie du village ?

_____
_____
_____

6- Quels sont les conditions d'accès des pécheurs migrants et étrangers aux pêcheries du village ?

_____
_____
_____
_____

7- Quelle est l'évolution des ressources piscicoles du village au cours des 10 -20 dernières années ?

_____
_____
_____
_____
_____

V- Changement et Variabilité Climatiques

1- Quels changements avez-vous observées au cours de ces 20 dernières années dans
   a- La quantité des pluies tombées ?

_____
_____
_____

   b- Le début et la durée de la saison des pluies ?

_____
_____
_____
_____

c- La repartition des pluies durant la saison pluvieuse ?

d- Les températures ?

e- La vitesse et la force des vents ?

f- Le couvert végétal ?

g- Les eaux de surfaces ?

2- Comment ces changements ont-ils affectes
a- Les activités et le pouvoir d'achat des pécheurs dans ce village ?

b- Les activités économiques des autres groupes socio-professionnels du village ?

c- Quelles mesures avez-vous adoptée pour faire face ?

VI- Impact des aménagements hydro-agricoles

1- Quels sont les barrages et aménagements hydro-agricoles existants ou en cours de construction dans votre zone ?

_____
_____
_____
_____

2- Votre village a-t-il été associé ou consultée lors de la réalisation de ces ouvrages ?

_____
_____
_____
_____

3- Quel a été l'impact de la réalisation de ces ouvrages hydro-agricoles
   a- Sur les activités de pêche ?

_____
_____

   b- Sur les activités des autres groupes socio-professionnels du village ?

_____
_____

4- Quelles mesures avez-vous adoptées pour atténuer les impacts socio-économiques négatifs de ces ouvrages ?

_____
_____

5- Pensez-vous que les changements observés dans le climat peuvent accroitre les impacts socio-économiques négatifs de ces ouvrages ?

_____
_____

6- Avez-vous bénéficié d'une assistance pour atténuer ces changements négatifs ?
   a- Si oui précisez la nature et qui a fourni cette assistance

_____
_____
_____
_____
_____

   b- Si non, quel type d'appuis souhaiteriez-vous avoir ?

_____
_____

Merci de votre patience

6. 3. Focus Groups Checklist

Facilitateurs : _____

_____

_____

Village : _____ Commune _____ Cercle_____

Région _____Nombre de Participants /_____/ H /_/F/__/M/__/

Date :

I – Histoire du Village :

A. Fondateur du village, historique de la fondation, activité économique exercée par le fondateur ?

_____
_____

II- Perception et Connaissance sur le Changement et la Variabilité Climatique

A. Quels sont les changements que vous avez observés dans le climat au cours de ces dernières années?

_____
_____
_____

B. Quelle est la cause de ces changements ?

_____
_____
_____

C. Quel est l'impact de ces changement sur
   - Les pecheurs ?

_____
_____

   - Les autres groupes socio-professionnels du village ?

_____
_____

   - Les ressources naturelles villageoises ?

_____
_____
_____

6. 4 Social Vulnerability Index

Village	Latitude	Longitude	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Bargodaga	14.53124	-4.2005	0.002913	0	0.003886587	-0.00097356
Bargodaga	14.53515	-4.19948	0.005826	0	0.003323261	0.002502794
Bargodaga	14.53433	-4.20044	0.008838	0.108195	0.030022742	0.087010214
Bargodaga	14.53402	-4.20044	0.002913	0.059979	0.018277933	0.044614415
Bargodaga	14.53394	-4.20007	0.000113	0.014859	0.004154076	0.010818046
Bargodaga	14.53403	-4.19982	0.000233	0.063075	0.003323261	0.059984678
Bargodaga	14.53423	-4.19964	0.018138	0.015478	0.009153141	0.024462271
Bargodaga	14.53458	-4.19902	0.002913	0.015478	0.015813837	0.002577068
Bargodaga	14.53517	-4.19955	0.000873	0.015478	0.015011371	0.001339603
Bargodaga	14.53296	-4.20028	0.000485	0.015478	0.00166163	0.014301301
Bargodaga	14.53306	-4.20064	9.7E-05	0.063694	0.045329951	0.018461071
Bargodaga	14.53283	-4.20047	0.005826	0.016716	0.003323261	0.019218902
Bargodaga	14.53329	-4.20047	0.043695	0.016716	0.003323261	0.057088259
Bargodaga	14.53189	-4.2	0.014552	0.017335	0.004154076	0.027732751
Bargodaga	14.53151	-4.20044	0.005826	0.017335	0.004154076	0.019007202
Bargodaga	14.53151	-4.20044	0.007777	0.017335	0.031627674	-0.006515355
Bargodaga	14.53108	-4.20045	0.005826	0.017335	0.009138967	0.014022311
Bargodaga	14.53045	-4.20053	0.019402	0.017954	0.000830815	0.036525661
Bargodaga	14.53171	-4.20003	0.005826	0.017954	0.011392273	0.01238812
Bargodaga	14.53155	-4.20013	0.000728	0.017954	0.018024619	0.000657299
Bargodaga	14.5321	-4.19996	0.014552	0.018573	0.028571902	0.004553155
Bargodaga	14.53229	-4.20015	0.002913	0.018573	0.018277933	0.003208547

O

Bargodaga	14.5328	-4.20042	0.004089	0.018573	0.003323261	0.019339258
Bargodaga	14.53284	-4.19985	0.002267	0.018573	0.00416825	0.016672395
Bargodaga	14.53064	-4.20031	0.004534	0.018573	0.003886587	0.01922125
Bargodaga	14.53058	-4.19983	0.006802	0.018573	0.014448045	0.010926984
Bargodaga	14.53221	-4.20032	0.001191	0.018573	0.021333705	-0.001569453
Bargodaga	14.53212	-4.2001	0.018349	0.018573	0.005815706	0.031106873
Bargodaga	14.53254	-4.19993	0.00388	0.018573	0.012758065	0.009695816
Bargodaga	14.53266	-4.19999	0.005826	0.018573	0.016616303	0.007783205
Bargodaga	14.53288	-4.2	0.000243	0.018573	0.00166163	0.01715435
Bargodaga	14.53305	-4.2002	0.000146	0.018573	0.00166163	0.017057474
Bargodaga	14.53295	-4.20037	0.000388	0.018573	0.000830815	0.018130681
Bargodaga	14.5331	-4.41998	0.009069	0.020431	0.051145657	-0.021646092
Bargodaga	14.53295	-4.20041	0.007016	0.020431	0.024924455	0.002521971
Bargodaga	14.53317	-4.20026	0.005826	0.021669	0.004435739	0.023059345
Bargodaga	14.5321	-4.2005	0.000227	0.021669	0.012786414	0.009109334
Bargodaga	14.53107	-4.20042	0.001455	0.021669	0.00166163	0.021462559
Bargodaga	14.53307	-4.20019	0.00291	0.021669	0.00221787	0.02236148
Bargodaga	14.53379	-4.19876	0.001363	0.022288	0.025572829	-0.001921663
Bargodaga	14.53412	-4.19899	0.005826	0.022907	0.006497368	0.022235946
Bargodaga	14.5344	-4.19905	0.002913	0.023526	0.006379033	0.020060369
Bargodaga	14.53505	-4.19989	0.00233	0.023526	0.008308152	0.017548644
Bargodaga	14.53537	-4.19981	0.005252	0.023526	0.004154076	0.024623868
Bargodaga	14.53508	-4.20048	0.004851	0.023526	0.00166163	0.026715278
Bargodaga	14.5348	-4.20008	0.005826	0.024765	0.000830815	0.029759844
Bargodaga	14.53436	-4.19995	0.005826	0.024765	0.00166163	0.028929029
Bargodaga	14.53437	-4.19976	0.01363	0.024765	0.095644793	-0.057249971
Bargodaga	14.53497	-4.19987	0.004677	0.024765	0.024924455	0.004517234

Bargodaga	14.53547	-4.1987	0	0.024765	0	0.024764604
Bargodaga	14.53517	-4.19953	0.000194	0.024765	0.010533108	0.014425923
Bargodaga	14.53432	-4.19943	0.000292	0.024765	0.00166163	0.023394615
Bargodaga	14.53436	-4.19929	0.005826	0.024765	0.00166163	0.028929029
Bargodaga	14.53412	-4.19934	0.006802	0.025384	0.007209848	0.024975447
Bargodaga	14.53371	-4.19926	0.005826	0.025384	0.014419695	0.016790079
Bargodaga	14.53385	-4.19915	0.01363	0.026622	0.006646521	0.033605646
Bargodaga	14.53396	-4.19886	0.023331	0.027241	0.027352794	0.023219558
Bargodaga	14.5341	-4.19876	0.002267	0.02786	0.005815706	0.024311665
Bargodaga	14.59406	-4.19864	0.002425	0.02786	0.00166163	0.028623817
Bargodaga	14.53381	-4.19924	0.000388	0.02786	0.008308152	0.019940071
Bargodaga	14.53371	-4.19927	0.006802	0.02786	0.014448045	0.02021371
Bargodaga	14.53364	-4.19873	0.009701	0.02786	0.010547283	0.027013966
Bargodaga	14.53325	-4.19993	0.000156	0.02786	0.026586085	0.001429637
Bargodaga	14.53355	-4.2	0.011652	0.028479	0.011638499	0.028492905
Bargodaga	14.53376	-4.1999	0.005826	0.028479	0.005273641	0.029031708
Bargodaga	14.53389	-4.19973	0.009701	0.028479	0.003323261	0.034857103
Bargodaga	14.534	-4.19983	0.008739	0.029718	0.004984891	0.033471716
Bargodaga	14.53374	-4.20034	0.008739	0.029718	0.009969782	0.028486826
Bargodaga	14.53371	-4.19958	0.00291	0.029718	0.029374368	0.003253478
Bargodaga	14.53295	-4.20007	0.002425	0.029718	0.000830815	0.031311977
Bargodaga	14.53317	-4.19973	0.009701	0.030956	0.008336501	0.032320324
Bargodaga	14.53343	-4.1994	0.002913	0.030956	0.003323261	0.030545522
Bargodaga	14.5333	-4.19968	0.003889	0.030956	0.009998131	0.024846172
Bargodaga	14.53317	-4.19972	0.004851	0.030956	0.00166163	0.034144659
Bargodaga	14.53313	-4.20004	0.003889	0.030956	0.005548217	0.029296086

Bargodaga	14.53292	-4.20039	0.001529	0.030956	0.003323261	0.029161588
Bargodaga	14.53306	-4.20009	0.004851	0.030956	0.00166163	0.034144659
Bargodaga	14.53377	-4.20012	0.005252	0.031575	0.003323261	0.033503179
Bargodaga	14.53374	-4.19997	0.019402	0.032194	0.006942359	0.044653764
Bargodaga	14.53383	-4.1996	0.001944	0.033432	0.02216452	0.013211969
Bargodaga	14.53405	-4.20016	0.001457	0.033432	0.004717402	0.030171327
Bargodaga	14.53314	-4.19997	0.005833	0.034051	0.025572829	0.014311324
Bargodaga	14.53291	-4.20025	0.000113	0.034051	0.004984891	0.029179799
Bargodaga	14.53265	-4.19994	0.01363	0.03467	0.017771305	0.030529359
Bargodaga	14.53284	-4.19992	0.005826	0.03467	0.004717402	0.035779098
Bargodaga	14.53279	-4.19976	0.001363	0.035909	0.005815706	0.031455992
Bargodaga	14.53266	-4.20005	0.009701	0.037147	0.004984891	0.041863084
Bargodaga	14.53229	-4.19996	0.000679	0.037147	0.001943294	0.035882688
Bargodaga	14.53209	-4.19985	0.000146	0.037147	0.008308152	0.028984406
Bargodaga	14.53193	-4.20009	0.000453	0.040242	0.000830815	0.039865105
Bargodaga	14.53176	-4.2	0.011652	0.040862	0.008885653	0.043628054
Bargodaga	14.53164	-4.20048	0.007299	0.0421	0.007477336	0.041921977
Bargodaga	14.53241	-4.19986	0.022672	0.0421	0.011631412	0.053140333
Bargodaga	14.53118	-4.20038	0.000227	0.043338	0.002492445	0.041072331
Bargodaga	14.53429	-4.19941	0.001748	0.043338	0.009138967	0.035946907
Bargodaga	14.53436	-4.19972	0.11336	0.046434	0.00166163	0.158131592
Bargodaga	14.53412	-4.19983	0.001944	0.046434	0.020827077	0.02755083
Bargodaga	14.53328	-4.2005	0.004089	0.046434	0.036049239	0.01447346
Bargodaga	14.53357	-4.20002	0.011652	0.047672	0.030557719	0.028766253
Bargodaga	14.52804	-4.20959	0.004851	0.049529	0.085573961	-0.031194218

Bargodaga	14.52826	-4.20971	0.009701	0.050767	0.003886587	0.05658192
Dagawomina	14.52803	-4.20976	0.002267	0.011144	0.008308152	0.005103112
Dagawomina	14528231	-4.21009	0.002097	0.011144	0.004154076	0.009087376
Dagawomina	14.5282	-4.20993	0.002913	0.013001	0.002492445	0.013421999
Dagawomina	14.52823	-4.21013	0.003589	0.013621	0.000830815	0.016379113
Dagawomina	14.5285	-4.21015	0.001455	0.015478	0.004154076	0.012778962
Dagawomina	14.5283	-4.20976	0.000233	0.015478	0.011631412	0.004079508
Dagawomina	14.5281	-4.21038	0.008107	0.015478	0.019432935	0.004151723
Dagawomina	14.52758	-4.21011	0.009701	0.015478	0.014448045	0.010730902
Dagawomina	14.52765	-4.20968	0.019402	0.015478	0.004154076	0.03072594
Dagawomina	14.52736	-4.20951	0.004851	0.015478	0.004984891	0.015343521
Dagawomina	14.52813	-4.21069	0.001814	0.016097	0.003323261	0.014587486
Dagawomina	14.52837	-4.21047	0.002726	0.016097	0.000830815	0.017992221
Dagawomina	14.52852	-4.2107	0.011652	0.018573	0.006646521	0.023579042
Dagawomina	14.5274	-4.21085	0.00105	0.018573	0.003323261	0.016300506
Dagawomina	14.52787	-4.20964	0.007777	0.018573	0.003323261	0.023027288
Dagawomina	14.52847	-4.21012	0.00233	0.018573	0.003323261	0.017580614
Dagawomina	14.52759	-4.20951	0.019402	0.018573	0.005815706	0.032159885
Dagawomina	14.52726	-4.21	0.024253	0.018573	0.02575527	0.017070856
Dagawomina	14.52834	-4.21034	0.006802	0.018573	0.009138967	0.016236062
Dagawomina	14.52815	-4.20993	0.009701	0.018573	0.009138967	0.019135555
Dagawomina	14.52747	-4.20947	0.014552	0.018573	0.009138967	0.02398609
Dagawomina	14.52762	-4.21024	0.00388	0.019193	0.000830815	0.022242181
Dagawomina	14.5279	-4.21058	0.011336	0.019812	0.004717402	0.02643024
Dagawomina	14.52749	-4.20985	0.002425	0.019812	0.000830815	0.021406135
Dagawomina	14.5284	-4.20999	0.021827	0.021669	0.00166163	0.041834804
Dagawomina	14.52764	-4.21024	0.014552	0.021669	0.003323261	0.032897372
Dagawomina	14.52739	-4.21003	0.000291	0.021669	0.00166163	0.020298701

Dagawomina	14.52768	4.209598	0.029103	0.021669	0.005815706	0.04495653
Dagawomina	14.52767	-4.21098	0.007777	0.021669	0.004154076	0.025292049
Dagawomina	14.52787	-4.2106	0.014552	0.021669	0.004154076	0.032066556
Dagawomina	14.52713	-4.2101	0.008739	0.021669	0.009969782	0.020438329
Dagawomina	14.52762	-4.20926	0.00194	0.022288	0.003323261	0.020905097
Dagawomina	14.52712	-4.2101	0.004864	0.022907	0.003323261	0.024448067
Dagawomina	14.5283	-4.21013	0.016214	0.022907	0.00166163	0.03745919
Dagawomina	14.52863	-4.21021	0.008739	0.022907	0.01860212	0.013044221
Dagawomina	14.52806	-4.21062	0.00194	0.023526	0.003323261	0.022143327
Dagawomina	14.52785	-4.20989	0.162136	0.023526	0.02100458	0.164657404
Dagawomina	14.52757	-4.20949	0.002913	0.023526	0.021657892	0.004781509
Dagawomina	14.5278	-4.20948	0.00194	0.023526	0.045329951	-0.019863363
Dagawomina	14.52727	-4.21073	0.006802	0.023526	0.008308152	0.022019798
Dagawomina	14.52775	-4.2103	0.048505	0.024765	0.003886587	0.069383362
Dagawomina	14.52764	-4.2103	0.000388	0.024765	0.001943294	0.023209353
Dagawomina	14.5274	-4.20994	0.011336	0.024765	0.00166163	0.034438933
Dagawomina	14.52814	-4.20993	0.007777	0.024765	0.00166163	0.03088007
Dagawomina	14.52806	-4.20947	0.009728	0.024765	0.017236328	0.017256413
Dagawomina	14.52809	-4.20964	0.004851	0.024765	0.000830815	0.028784324
Dagawomina	14.52806	-4.21037	0.005826	0.025384	0.003055772	0.028154002
Dagawomina	14.52826	-4.21038	0.011652	0.026003	0.005815706	0.031839238
Dagawomina	14.52792	-4.21066	0.005826	0.02786	0.003323261	0.030362974
Dagawomina	14.52748	-4.20965	0.008739	0.02786	0.008308152	0.028291111
Dagawomina	14.52804	-4.21033	0.022672	0.02786	0.006942359	0.043589738
Dagawomina	14.5277	-4.21015	0.006306	0.02786	0.083081515	-0.048915641
Dagawomina	14.52724	-4.21014	0.00126	0.02786	0.004154076	0.024966481
Dagawomina	14.5276	-4.20919	0.011652	0.02786	0.016616303	0.022895986

Dagawomina	14.52758	-4.20952	0.019402	0.02786	0.00166163	0.045600687
Dagawomina	14.52839	-4.21045	0.00388	0.02786	0.008308152	0.023432456
Dagawomina	14.5282	-4.21055	0.005826	0.02786	0.004717402	0.028968832
Dagawomina	14.52808	-4.21023	0.004534	0.02786	0.000830815	0.031563748
Dagawomina	14.52831	-4.2107	0.009701	0.02786	0.009998131	0.027563118
Dagawomina	14.52802	-4.20996	0.009701	0.02786	0.002492445	0.035068803
Dagawomina	14.5301	-4.20434	0.008731	0.02786	0.002492445	0.034098696
Dagawomina	14.53002	-4.20441	0.009701	0.02786	0.004984891	0.032576358
Dagawomina	14.53125	-4.20475	0.004851	0.029718	0.002492445	0.032075614
Dagawomina	14.53138	-4.20472	0.004851	0.030337	0.000830815	0.034356359
Dagawomina	14.53154	-4.20491	0.008739	0.030337	0.009138967	0.029936756
Dagawomina	14.53162	-4.20484	0.00291	0.030956	0.012462227	0.021403849
Dagawomina	14.53165	-4.20507	0.009701	0.030956	0.001943294	0.038713531
Dagawomina	14.53174	-4.20495	0.009701	0.030956	0.000830815	0.039826009
Dagawomina	14.53176	-4.20552	0.004534	0.030956	0.00166163	0.033828508
Dagawomina	14.53195	-4.20489	0.005826	0.030956	0.002492445	0.034289365
Dagawomina	14.53205	-4.20496	0.014552	0.030956	0.009138967	0.036368392
Dagawomina	14.53203	-4.20513	0.011652	0.030956	0.009138967	0.033468898
Dagawomina	14.53219	-4.20522	0.014552	0.079172	0.017447118	0.076276375
Dagawomina	14.53172	-4.20554	0.020391	0.030956	0.025572829	0.025774119
Dagawomina	14.53178	-4.20553	0.006802	0.032813	0.000830815	0.038783861
Dagawomina	14.53219	-4.20523	0.014565	0.033432	0.002492445	0.045504907
Dagawomina	14.53116	-4.20493	0.006628	0.034051	0.003323261	0.037356195
Dagawomina	14.52858	-4.21058	0.014552	0.034051	0.00166163	0.046941304
Dagawomina	14.52832	-4.21032	0.002913	0.034051	0.002774109	0.034190249
Dagawomina	14.52852	-4.21017	0.00194	0.03467	0.00166163	0.034949029

Dagawomina	14.52845	-4.20993	0.006802	0.03467	0.008308152	0.03316387
Dagawomina	14.52829	-4.20974	0.00109	0.037147	0.030557719	0.007679604
Dagawomina	14.52769	-4.21107	0.011336	0.037147	0.004717402	0.043765463
Dagawomina	14.52788	-4.21098	0.013603	0.037147	0.012786414	0.037963643
Dagawomina	14.52829	-4.2098	0.00292	0.037147	0.003323261	0.03674344
Dagawomina	14.52764	-4.20923	0.005826	0.037147	0.009138967	0.033833994
Dagawomina	14.52717	-4.20924	0.004851	0.038385	0.008308152	0.034927519
Dagawomina	14.52768	-4.20968	0.005826	0.040242	0.009445435	0.036623101
Dagawomina	14.52797	-4.21014	0.00291	0.040242	0.000830815	0.042321987
Dagawomina	14.52785	-4.21029	0.006802	0.041481	0.003323261	0.044959027
Dagawomina	14.52815	-4.2102	0.00102	0.043338	0.002774109	0.041584185
Dagawomina	14.52786	-4.21099	0.008753	0.043338	0.023319523	0.028771151
Dagawomina	14.5287	-4.21029	0.002156	0.043957	0.002492445	0.043620367
Dagawomina	14.52707	-4.21024	0.029103	0.046434	0.021066217	0.054470623
Dagawomina	14.52717	-4.21	0.003821	0.047053	0.009167316	0.041706227
Dagawomina	14.52749	-4.20962	0.15943	0.047672	0.003323261	0.203779065
Dagawomina	14.52709	-4.20953	0.000243	0.047672	0.000830815	0.047083575
Dagawomina	14.52709	-4.20953	0.014552	0.048291	0.00166163	0.061180951
Dagawomina	14.52709	-4.20953	0.019402	0.052006	0.008308152	0.063099655