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Deep Uncertainties and Climate Change Adaptation: Farmers' Perceptions and Practices in Central Benin

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.....to my lovely son Berger Ariel and my beloved Gillette

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List of acronyms

ASECNA	Agence pour la Sécurité de la Navigation Aérienne en Afrique et à Madagascar" in Benin
CeRPA (ex CARDER)	Regional Centre for agricultural Promotion (Benin)
EU	European Union
FAO	Food and Agriculture Organization of the United Nations (Benin)
FSA/UAC	Faculty of Agriculture Sciences in University of Abomey Calavi
GDP	Gross Domestic Product
IPCC	Intergovernmental Panel on Climate Change
MAEP	Ministry of Agriculture, Animal Breeding and Fishery
MEPN	Ministry of the Environment and Nature Protection
NAPA/Benin	National Adaptation Programme of Action/Benin
NCCC	National Committee on Climate Change
NGO	Non Governmental Organization
PNUD	Programme des Nations Unies pour le Développement
UNFCCC	United Nations Framework Convention on Climate Change
VPA	Visual Problem Appraisal

Glossary

Climate change: Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the UNFCCC, which defines 'climate change' as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods' (IPCC, 2007).

Perception: Peoples' point of view toward a specific issue, which is based on how they interpret their experiences (Pearson et al., 1997).

Adaptation: Adjustment in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts (Smit et al., 2001).

Mal-adaptation: Adaptation to other drivers than climate change what result in an increase vulnerability to climate change. It happens when interventions to cope and adapt to climate conditions are no longer viable or are even more harmful than beneficial.

Adaptive capacity: The potential or capability of a system to a adapt to climatic stimuli, their effect or their impacts (Smit et al., 2001) It can be also understood to be the ability or capability of human social systems (across households, communities, farming systems, and governments) to effectively adjust to changing circumstances. This can be represented both in coping with negative effects as well as taking advantage of new opportunities. Adaptive capacity integrates technical and institutional processes with biophysical circumstances. As such, it is necessarily negotiated through complex social interactions, and is context specific (Gallopín 2006).

Mitigation: An anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks (IPCC, 2007).

Food security: The availability, access, stability of supply and utilization of food (FAO, 2008).

Vulnerability: The extent in which a natural or social system is susceptible to sustaining damage from climate change (Smit et al., 2001).It can be defined also as the degree to which an ecological, social or economic system is susceptible to or unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (Adger, 2006)

Resilience: The ability of a system to absorb and recover from the effects of shocks (i.e. multi-stressors presented by climate variability and change) in a timely and efficient manner, preserving or restoring its essential basic structures, functions and identity (Folke 2006). Note that resilience is not always good, as even dysfunctional or maladaptive systems can have resilient qualities.

Abstract

Climate issues are expected to affect agricultural production in Benin. Agricultural production remains the main source of income for rural communities in Benin. Hence, adaptation of the agricultural sector to climate change is urgent to protect the livelihoods of the farmers and to ensure food security. A better understanding of farmers' perceptions of climate patterns and of their ongoing adaptation practices is important to inform policies aimed at promoting sustainable adaptation strategies for the agricultural sector.

Using focus group discussion, household survey and observation, this study analyzes the farmers' perceptions of climate change and their adaptation strategies developed in the Dame village in Benin to deal with rainfall patterns. Farmers are aware of rainfall change and identify shifts of the rainfall season, unequal distribution of the precipitation, decline of the precipitation, decrease of the number of rainy days, increase of temperatures, erosion and inundation of field and change of droughts frequency as the most destructive climate change factors. Precipitations and temperatures trends from meteorological recorded data compared to survey data show that farmers' perceptions of climate patterns are in concordance with meteorological recorded data. However, singling out climate as the only driver of change is not simple because of some limitations identified in this study. It is also important to notice that the perceptions of the farmers involved in this study may be based on their recent flood event because people's perceptions are often based more on recent, short-term trends rather than long term changes and people's perceptions of climate change are more related to their recent experience.

This research revealed that farmers' understanding of the causes of rainfall patterns is not homogeneous. All the causes reported by farmers do not reach unanimity within the rural communities. There was limited awareness, knowledge and capacity at farmers' level to understand rainfall pattern causes which are necessary to conduct long-term adaptation planning.

Among adaptations made in response to climate patterns, changing the crop calendar to take into account the rainfall changes, sharing experiences and solutions followed by ritual offerings, planting different varieties of the same crop and changing dates of planting, prediction of seasonal rainfall etc. are the most important. Farmers' adaptation strategies are more autonomously than anticipatory and planned. Therefore, there is a need for developing so-called "Innovation system" which can provide an opportunity to catalyze and induce innovation within smallholder farmers for their adaptive capacity towards sustainable adaptation strategies.

Keywords: Benin, climate patterns, farmers' perceptions, adaptation strategies, rainfall, temperatures.

ONE: INTRODUCTION

This chapter presents a background of the research and highlights the information of climate change and variability impacts on agricultural production in the world, in Africa and especially in Benin. It also shows climate issues and the national adaptation framework in Benin. Finally, it explains the problem statement, provides the overall objective of the study and research methodology.

1.1 Climate change

The interest in climate change as discussed in the recent United Nations Climate Change Conference in Copenhagen 2009 is also notable in Benin. This research explores how the rainfall patterns influence agriculture sector and leads to food insecurity. Climate variability affects physical processes in many parts of the world, leading to changes in temperature and rainfall patterns, in wind direction and increased intensity and frequency of extreme events like droughts, floods and cyclones (Trenberth et al., 2007). Adaptation that is adjustments, which moderates harm or exploit beneficial opportunities in response to actual or expected climatic stimuli or their effects is therefore considered as imperative (IPCC, 2007). Because many biological and socio-economic processes such as crop growth and produce prices depend in part on production conditions of which climate is one, changes in climate affect food and livelihood security. It also reverses development achievements. For example, crop failure due to frequent droughts contributes to increased poverty (Speranza, 2010). The clear evidence that climate variability is already a reality calls for action not just to try to slow down the process by reducing the effects of human activity on the global climate but also to assist those affected to cope with the changes taking place. As a result, governments and international bodies started paying more attention to measures aiming at adaptation.

The 4th assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2007) identified Africa, as extremely vulnerable due to the fact that continent economies and livelihoods are highly dependent on natural resources and rain-fed agriculture. According to Niasse et al. (2004), Africa is considered the most vulnerable region in the world in terms of climate risk, because some of its physical and socio-economic characteristic. Therefore, agricultural production and food security in many African countries will be severely compromised by climate variability (IPCC 2007) because Africa is likely to warm across all seasons and its agriculture which depends mainly on rainfall (Boko et al., 2007). Agriculture contributes on average 34% to the GDP of Africa countries and employs 64% of the labor force (World Bank 2007). It accounts for about 40% of exports and provides various ecosystem services. Agriculture and rural development are thus key pillars of the Africa economy. The high dependence of Africa on rainfall agriculture and the weight of this agriculture in its economy mean that the agricultural sector needs important attention in debates about adaptation to climate variability.

Impacts of climate change on agricultural production

Climate change will affect all four dimensions of food security: food availability, food accessibility, food utilization and food systems stability (FAO, 2007).Climate issue is expected to influence crop and livestock production, hydrologic balances, input supplies and other components of agricultural systems. However, the nature of these biophysical effects and the human responses to them are complex and uncertain. For example, crop and livestock yields are directly affected by changes in climatic factors such as temperature and precipitation and the frequency and severity of extreme events like droughts, floods, and wind storms (Adam et al., 1998). It is estimated that climate pattern impacts will contribute to the destruction of forests and thereby promote the emission of greenhouse gases, which in turn will enhance global warming (FAO, 2007). Climate risks will have complex impacts on the bio-physical processes that strengthen agricultural systems. Rising atmospheric CO2

concentration, higher temperatures, changes in annual and seasonal precipitation patterns and in the frequency of extreme events will affect the volume, quality and stability of food production and the natural environment in which agriculture takes place (EU, 2009). According to Schmidhube et al. (2007), climate change affects agriculture and food production in complex ways. It affects food production directly through changes in agro-ecological conditions and indirectly by affecting growth and distribution of incomes, and thus demand for agricultural produce. For FAO (2007) climate impacts can be roughly divided into two groups:

Biophysical impacts:

- physiological effects on crops, pasture, forests and livestock;
- changes in land, soil and water resources;
- increased weed and pest challenges;
- erosion and inundation;
- shifts in spatial and temporal distribution of impacts;

Socio-economic impacts:

- decline in yields and production;
- reduced marginal GDP from agriculture;
- fluctuations in world market prices;
- migration and civil unrest.

As presented above, agricultural sector is under a critical situation which leads farmers to deep uncertainties. Looking at sustainable strategies of adaption should be of serious concern for policy makers as well as international institutes of development. Like many African countries, Benin's economy is heavily dependent on the agricultural sector, which employs approximately 80% of the population. Agriculture provides about 70% of export incomes and 40% of the Gross Domestic Product (FAO, 2007). Despite its high contribution to the overall economy, this sector is challenged by multitudes of factors of which climate related disasters like drought and flood, which often causes famine, are the major ones (Deressa, 2007). In Benin, climate variability is assumed to manifest in rainfall irregularity leading to low crop yield and food security issues. If nothing is done to adapt agriculture to climate risk, yields of principal products such as maize, rice, cotton, peanuts, and cassava, may fall by 6% by 2025 (PNUD,2007). According to Maddison (2006), adaptation to climate variability requires that farmers notice that the climate has changed, and identify useful adaptations strategies and implement them. Many agricultural adaptation options have been suggested in the literature. They include a wide range of scales, stakeholders and types such as micro-level options, market responses, and institutional changes. The technological developments like the development and promotion of new varieties of crop and advances in water management techniques have been also suggested (Smit et al., 2002). Most of these adaptation options represent potential adaptation measures, but there is no evidence that these adaptation options are feasible, realistic, or even likely to occur. Adapting to climate risk requires an understanding of the adaptive capacities and livelihood strategies of the farmers who are directly affected by the impacts of climate variability and who must cope with the realities of multiple pressures. As highlighted by Werners et al. (2010), adaptation involves changes in perception of climate risk, in social practices and in environmental functions to reduce potential damages or to take advantage of new opportunities. But there is very little research on farmers' adaptation to climate variability (Pandey, 2006). It is important for Benin's government and international institutes of development to gain insight or enhance the understanding of perception and coping strategies or local innovations developed by farmers who are faced with climate change damage. This is necessary because policy makers (national and international institutions) need to go beyond traditional forms of

intervention such as top-down" or "bottom-up" approach which are now seen as outdated, paternalistic, inflexible, bureaucratic, inefficient (Rivera et al., 2006) and then less able to cope with the current challenges and the dynamic demands of agriculture. Moving from the "top-down" or "bottom-up" approach of intervention to the "horizontal participatory" or "space for change" approach or strategy seems to be more sustainable in the process of adaptation to climate variability impacts.

Some questions arise from above description, inter alia: why do institutions have this lacks of insight about farmers perception and practices towards adaptation to climate change? And how do increase their understanding?

This study about rainfall pattern aims to contribute the understanding the farmers' practices or local innovations developed to deal with climate patterns in order to identify ways in which those practices or local innovations can be improved by development institutes to achieve the sustainable development in Benin.

1.2 Climate change in Benin

This section gives a general idea on the study country and highlights the climate change issues with focus on changing rainfall patterns and temperature rise.

The Republic of Benin is located in West Africa, between 6°30 and 12° North Parallels and 1° and 3°40 East Meridians. It is bordered by the Repu blic of Niger to the North, Burkina Faso to the North-East, the Atlantic Ocean to the South, Togo and Ghana to the West and the Federal Republic of Nigeria to the East (figure 3). It covers an area of 112 622 Km2. The population of Benin was estimated at 8 294 941 persons in 2007. The population is unequally distributed on the national territory and is concentrated for more than 35% on the southern part, which only represent 10% of the country area. The Republic of Benin is young (around 50% are below the age of 15 years) and characterized by a high female proportion (around 52%). The population constitutes the main force for agriculture. The Republic of Benin is characterized by a diversity of ethnic groups and religions. The major ethnic groups are Fon, Yoruba and Bariba and the major religions are local tradition, Christianity and Islam. In Benin, the climate is hot and wet. Most certainly, geographical elements such as the stretching of the territory in latitude, the existence of the Atacora Mountain and the orientation of the coastline bring about a slight difference in the climate pattern.

Rainfall issues are one of key components of climate change in Benin (NAPA, 2008). The impacts of climate change will strengthen the variability of Benin's climate regime. An assessment into the climate risks of populations revealed nationally significant risks which are: delayed of cropping season with irregular precipitation following by higher long-term average temperatures, drought, and floods. Other more localized climate risks violent winds and scorching heat in areas, advancing seas and coastal erosion can be very troubling such as health and environmental problems etc. for the government.

In view of the aforementioned climatic risks the following sectors are concerned with vulnerability issues in agriculture, including animal husbandry and fishing, forestry, water resources, coastal areas, human health and energy. In the area of agriculture, climate variability affects crop production behaviours, soil modifications and declines in yield. Regarding aquatic ecosystems, climate issues will potentially affect ecological habitats. The rarity of certain species in catches is already a major indication of the vulnerability to climate events, even if there are several other contributing factors. In northern and central agro-ecological areas, small farm stakeholders, and emerging farm stakeholders are highly exposed to climate risks. In the southern agro-ecological areas, subsistence farming, land, water resources, human health and biodiversity, and small farm stakeholders' and fish harvesters are also highly exposed to climate risks.

The government of Benin has signed and rectified the United Nations Framework Convention on Climate Change respectively on June 1992 and June 1994. The Protocol of Kyoto to the Convention has been also signed and ratified on February 2002 to control actively the national CO2 emissions. According to the government, the integration of climate change in national development strategies depends on Benin's efforts to "green" the Growth Strategy for Poverty Reduction. Furthermore, under the process of decentralization, the government of Benin has developed the national charter on environmental governance. This charter aims to create the necessary condition for strengthening human development and environmental management. The document seeks also to engage competitiveness, foster an enabling national environment for development, facilitate the attainment of Millennium Development Goals and strengthen good governance

To explore changing rainfall patterns and temperature changes, we look at how climate data recorded at meteorological stations has evolved from January 1960 to January 2009. Thus, monthly precipitation and temperature data was obtained from the Agence pour la Sécurité de la Navigation Aérienne en Afrique et à Madagascar in Benin (ASECNA).

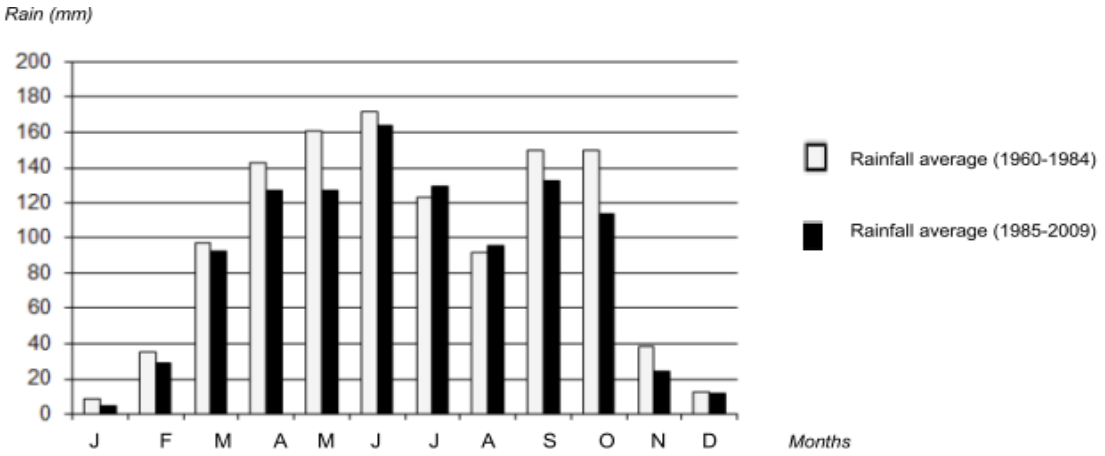

Figure 1: Rhythm of average rainfall during periods 1960-1984 and 1985-2009

Source: ASECNA

Decrease in rainfall is observed from the first period (1960-1984) to second period (1985-2009) in the study area during the months of January, February, March, April, June, September, October, November and December while the rainfall is increased in the rest of the months (July and August). The difference in this rainfall variability is presented in table1. It is important to notice that Central Benin (study area) belongs to the Subequatorial climate with two rainy seasons and two dry seasons coming alternatively. The table below presents the seasons and the difference of rainfall variability between1960-1984 and 1985-2009.

Table 1: Difference of rainfall variability between1960-1984 and 1985-2009

Seasons	Longer rainy season				Short dry season		Short rainy season		Big dry season			
Months	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	Ma
Difference (mm)	-10.8	-20.8	-4.7	+5.2	+4.3	-11.7	-24.1	-37.2	-6.4	-41.1	-18.8	-5.4

Source: ASECNA

The table shows that there is an important variability and modification of precipitation. The analysis of these modifications shows that the short dry season experiences more rains (August). When, we know that this period corresponds to the post harvest activities like

harvesting of yam and drying of Maize (*Zea mays*), there is a risk of decline of yield because of the strong relative humidity which rises from this situation. The short rain season tends to start a little earlier because of the rains from September and stopped also early while the main rain season shows a reduction of the quantity of rains to starting (May and April). This result is an indicator of the climate uncertainties during these two periods: 1960-1984 and 1985-2009. The annual average rainfall was around 1100 mm but from 1971 to 2000 there is 28% of declined with significant variation from one month to another. Maize is the most important annual crop grown in the study zone as well as in the whole country followed by yam and cotton which are actually challenged by 'egussi', beans and cowpea. Maize is the staple food that is grown for both objectives of subsistence and cash crop. It plays an important role in the diet of the study area population. Concerning yam, it is grown for both objectives of subsistence and cash crop and plays a prominent role in people's cultural and social life. It is the single crop on which rituals are performed. Regarding cotton production, it is the only one organized by government in the study area. Nowadays, its importance has decrease but it remains the major cash crop at the national level. It plays an important role in the farming system since farmers are relying on it to get agricultural input like chemical pesticides and mineral fertilizers. This poses a challenge to the agricultural development in the area.

The Meteorological record of temperature data from the periods 1960-1984 and 1985-2009 showed an increasing trend of temperature with the increased mostly in the beginning of longer rainy season.

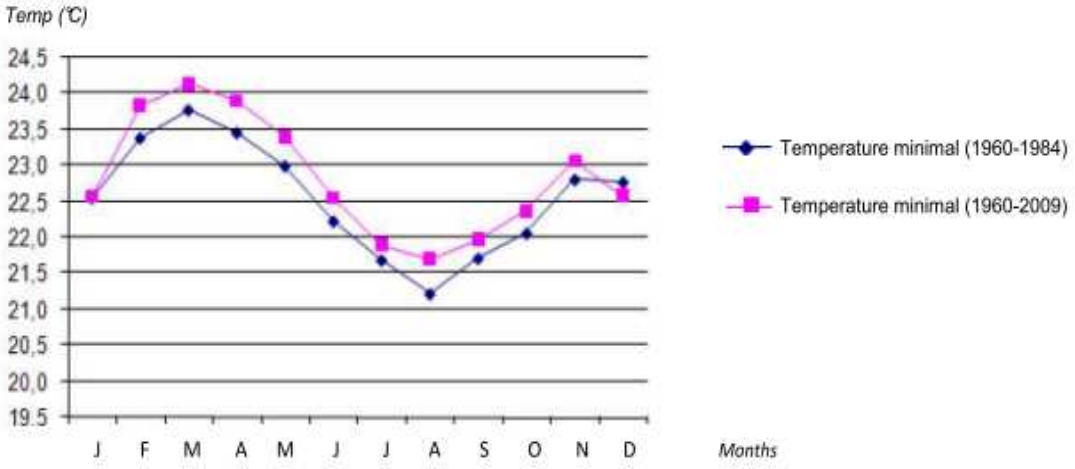

Figure 2: Rhythm of minimal temperatures during periods 1960-1984 and 1985-2009

Source: ASECNA

Increasing temperatures are observed from the first period (1960-1984) to the second period (1985-2009) in the study area during all months of the year excepted January (stable temperatures) and December (temperature became less hot). The difference in the temperature variability is presented in the table 2

Table 2: Difference of temperature variability between1960-1984 and 1985-2009

Seasons	Longer rainy season				Shorter dry season		Shorter rainy season		Longer dry season			
Months	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	Ma
Difference (℃)	+0.5	+0.4	+0.3	+0.2	+0.5	+0.3	+0.3	+0.3	-0.2	+0.0	+0.5	+0.4

Source: Author, August 2010, designed from ASECNA data

Increase of temperature is very remarkable in longer rainy season while the longer dry season starting with less hot temperature. The table 2 above shows the change in temperature of the area, which gives a clear picture of the warming trend in the study area.

Figure 3: Localisation of Benin

Source: http://www.state.gov/r/pa/ei/bgn/6761.htm

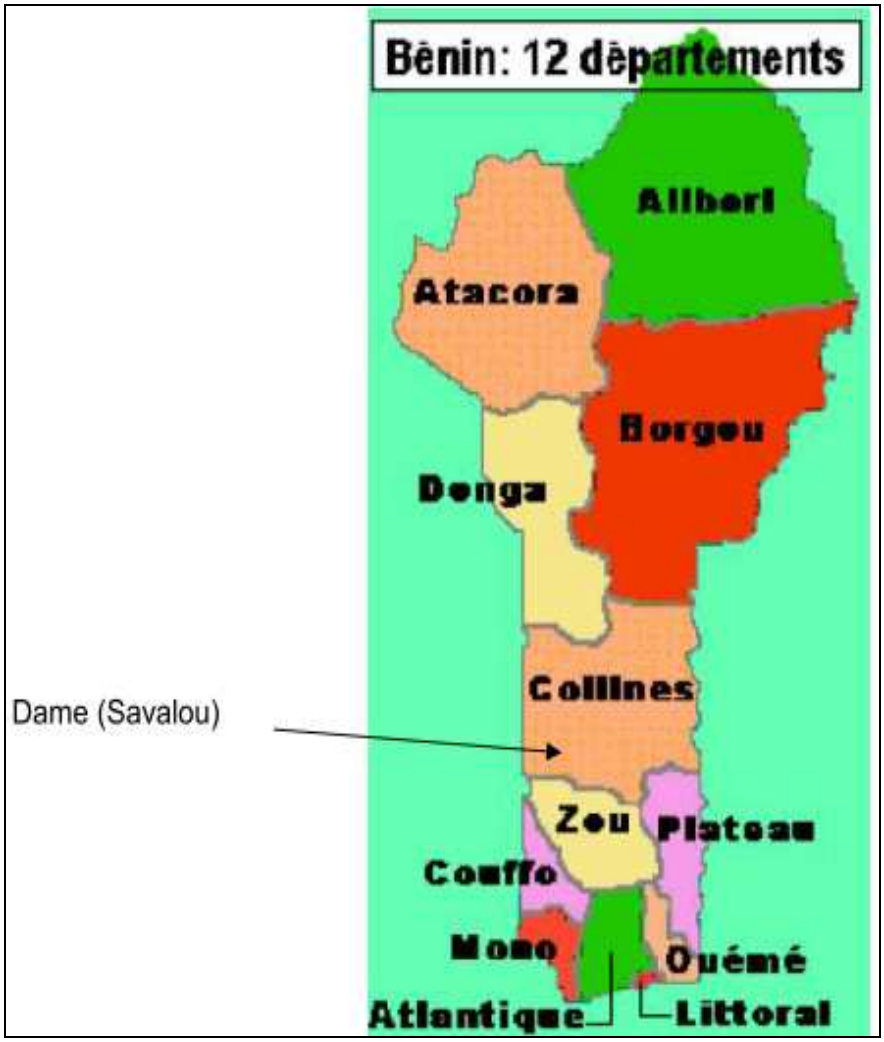

Figure 4: Localization of study area

Source: http://www.state.gov/r/pa/ei/bgn/6761.htm

Livelihood vulnerability, food insecurity and poverty are major problematic issues for the inhabitants of rural areas in Benin. The major activity in the rural areas is rain fed agriculture, which employs approximately 80% of the inhabitants, yet erratic and unreliable precipitation leads to low production. Furthermore, the changing climate pattern is expected to have serious environmental, economic, and social impacts on Benin. It is already noticeable that climate variability affects Beninese agricultural sector. In particular, rural farmers, whose livelihoods depend mostly on agriculture, are likely to bear the brunt of climate impacts. In-depth evaluation into the vulnerability of Beninese populations revealed three significant climates such as drought, late and violent rains, and floods (NAPA, 2008). This situation affects cultivation patterns and decreases in yield.

According to NAPA Benin (2008), the yield of agricultural product in Benin will decrease by approximately 6% between 2008 and 2025 if climate uncertainties impacts are not addressed. This decline will pose a major problem, as cereal product is the country's main staple food and cotton is the country's main source of foreign exchange and provides an income for more than two million producers. From the above discussion we understand or conclude that the rainfall pattern can have a negative impact on agricultural production. Then, there is an urgent need for the government to act face in this dramatic situation.

This research explores how and to what extent farmers perceive rainfall pattern and what kind of practices or local innovation they developed to deal with this rainfall situation. It is important to explore farmers' responses that can contribute to sustainable adaptation strategies in Benin because the problem owner (the government) lacks insights on farmers' perception and practices. Moreover, there is a gap between the wide view and the concrete reality of farmers about adaption to climate pattern.

Adaptation to rainfall changes

IPCC (2007) has defined adaptation as an adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change or take advantage of new opportunities. Adaptation is therefore made up of actions throughout society, by individuals, groups and government (Adger et al. 2005). In essence, adaptation is a complex societal process of activities, actions, decisions and attitudes that reflect existing social norms and processes. Nelson et al. (2007), define adaptation as the decision-making process and the set of actions undertaken to maintain the capacity to deal with future change or perturbations to a social-ecological system without undergoing significant changes in function, structural identity, or feedbacks of that system while maintaining the option to develop.

Several authors classified adaptation to climate risks, by distinguishing between autonomous or "market-driven" and planned or "policy-driven" adaptation. Within policy driven adaptation, a distinguish is made between anticipatory or proactive and responsive or reactive adaptation. According to the IPCC (2007) autonomous adaptation is: "adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems" and planned adaptation is: "adaptation that is the result of a deliberate policy decision based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state". Another important distinction is the one based on the timing of adaptation actions which distinguishes between anticipatory or proactive adaptation and reactive or responsive adaptation. They are defined by the IPCC (2001) as: "adaptation that takes place before and after impacts of climate issue is observed", respectively. There can be circumstances when an anticipatory intervention is less costly and more effective than a reactive action (typical example is that of flood or coastal protection), and this is particularly relevant for planned adaptation. Reactive adaptation is a major characteristic of unmanaged natural system and of autonomous adaptation reactions of social economic systems.

For this research the definition given by Smit et al. (2002) and Adger (2005) has been used, which defines adaptation as a collection of coping strategies, with each strategy focusing on a particular threat. Some of these actions may be taken by autonomous individuals or communities reacting to climate uncertainties as they occur; others may be more planned, depending on their initiation by government policies and institutions. An important issue related to adaptation in agriculture pointed out by Bryant et al. (2000) is how perceptions of climate pattern are translated into agricultural decisions. If farmers learn gradually about the climate uncertainties, Maddison (2006) argues that they will also learn gradually about the best techniques and adaptation options available. According to him, farmers learn about the best adaptation options through three ways: learning by doing, learning by copying, and learning from instruction.

According to Adger et al. (2005), farmers decision whether to adapt to climate pattern or not, is not simplistic because it depend on climatic stimuli as well on other issues, such as their personal, economic and policy motivations. Non-climatic drivers such as financial support can, however, be more important than climatic drivers (Kingwell, 2006). If farmers recognize changes in rainfall, they don't necessarily refer to climate change, because in their view, the

current changes in rainfall can be part of the natural climatic variability. Further, awareness of climate issues doesn't directly mean that farmers will adapt to climate. But farmers can undertake adaptations to climate uncertainties, even when the farmer is not aware of climate issues as those adaptations are in response to other stimuli (Bryant et al., 2000). Connor et al. (2008), therefore suggest that economic incentives are most important trigger for adaptation strategies, and it is hence more important to know how farmers adapt to changes in their farming or environment (Kingwell,2006).

Maddison (2007), found that farmers' awareness of changes in climate attributes (precipitation and temperature) is important for adaptation decision making. Access to the adequate information on rainfall issues is also key elements for farmers' decision making because the availability of better climate and agricultural information help farmers to make comparative decisions among alternative crop management practices and hence choose the ones that enable them to cope better with changes in climate (Jones, 2003). This view is shared by Tizale (2007) who added that extension service can play an important role in the process of adaption of climate issue. However, adaptation to non-climatic drivers can increase the vulnerability to climate pattern, which is referred to as 'mal adaptation' (Adger et al, 2005). On the other word, farmers can adapt to non-climatic drivers, but adapt at the same time to climate issues, which will increase their adaptive capacity.

Nelson et al. (2007) have defined adaptive capacity as ability of individuals, groups, or organizations to adjust to changes and implementing adaptation decisions, i.e., transforming that capacity into action. Adaptive capacity refers to the preconditions that are necessary to enable adaptation and includes social characteristics and physical and economic elements. Adaptive capacity is the potential or ability of a system, region, or community to adapt to the effects or impacts of climate change. Enhancement of adaptive capacity represents a practical means of coping with changes and uncertainties in climate, including variability and extremes. In this way, enhancement of adaptive capacity reduces vulnerabilities and promotes sustainable development (Smit et al., 2000). For this research the definition given by Gallopín (2006) has been used which said that adaptive capacity can be understood to be the ability or capability of human social systems (across households, communities, farming systems, NGO and governments) to effectively adjust to changing circumstances. This can be represented both in coping with negative effects as well as taking advantage of new opportunities. Adaptive capacity integrates technical and institutional processes with biophysical circumstances.

To come up with a sustainable climate patterns adaption, it is important to build people's adaptive capacity by agricultural innovation (World Bank, 2008). For Smit et al., (2000) and Nelson et al. (2007), adaptive capacity can be trigger by social learning and institutional context (policy).

Synthesis of the type of adaption to climate pattern (FAO, 2007)

> Two main types of adaptation are autonomous and planned adaptation.
>
> *Autonomous adaptation* is the reaction of, for example, a farmer to changing precipitation patterns, in that he changes crops or uses different harvest and planting/sowing dates.
>
> *Planned adaptation* measures are conscious policy options or response strategies, often multisectoral in nature, aimed at altering the adaptive capacity of the agricultural system or facilitating specific adaptations. For example, deliberate crops selection and distribution strategies across different agro ecological zones, substitution of new crops for old ones and resource substitution induced by scarcity.

Short-term adjustments are seen as autonomous in the sense that no other sectors (e.g. policy, research etc.) are needed in their development and implementation.

Long-term adaptations are major structural changes to overcome adversity such as changes in land-use to maximize yield under new conditions; application of new technologies; new land management techniques; and water-use efficiency related techniques

Innovation systems

An innovation involves new ways of doing things or 'doing new things' however, doing things differently can only be considered an innovation if the new things work in everyday practice (Leeuwis, 2004). Innovations do not emerge by themselves but may be triggered by a technical novelty, policy initiative or a new social arrangement. Innovation processes should therefore include deliberate efforts to create effective linkages between technological arrangements, people and social-organisational arrangements (Leeuwis, 2004). Innovation system is one of analytical approaches to adaptation to climate uncertainties. In the current fast changing multifunctional agricultural sector, innovation is a central strategy to achieve economic, social and environmental goals (Klerkx et al., 2009).In the agricultural system, the linear view on innovation in which agricultural research and development generates technologies that agricultural extension transfer to farmers for adoption is criticized because it does not take into account the origin, nature and dynamics of innovation (Klerkx et al., 2008).

Therefore, changing from a linear approach to innovation in which public sector, agricultural research and extension delivers new technology in a pipeline configuration, to a systems approach in which innovation is the result of a process of networking, social learning and negotiation among actors is a new challenge (World Bank, 2006; Röling, 2009).In this study, innovation is considered as a process by which social actors create value from knowledge and perception. The theory of innovation systems explains the role of various actors (agricultural entrepreneurs, researchers, consultants, policy makers, supplier and processing industries, retail, customers etc.) in innovation, the nature of their interactions and institutions that structure innovation (Spielman, 2005). World Bank (2007) has defined Innovations System as: "*a network of organizations, enterprises and individuals focused on bringing new products, new processes and new forms of organization into economic use, together with the institutions and policies that affect the way different agents interact, share, access, and exchange and use knowledge*".

This approach is also in line with Roling et al. (1998), who states that innovation can also be seen as an emergent property of a soft system and emerges from the interaction among the social actors. In adopting a soft systems approach to researching innovations in the process of adaptation to climate patterns, is relevant in identifying the factors contributing to innovations for adaption to this climate situation. Various forms of networks and learning processes by individuals and groups of farmers within networks are also relevant in understanding the nature of innovations that are taking in place. Therefore, starts from actors' perception or point of view could play an important role for understanding the nature of innovation. In this case, we focus on farmers' perception in order to explore the nature of innovations which are taking place under the climate patterns.

Farmers Perception

People's perception of the world depend on their environment through a complex network of mental answers learned and kept by cultural factors like cultural code, believes, languages, religion, values etc. and individuals factors such as emotion, self esteem, personal experiences, theoretical knowledge, intuition, prejudice etc. (Vodouhê, 2010). The connection between these elements determines the way people internalize each situation. People's perception refers to the outcome of applying their knowledge to a particular situation (Leeuwis, 2004). In addition, farmers' perception is embedded in the local cultural and social context that is so important in shaping the outcome of environmental changes (Laidler, 2006). Moreover, farmers' perception is linked to their observations that take place at the local scale, which is necessary for sustainable technologies development (Laidler, 2006; van Aalst et al., 2008). Farmers' perception and knowledge can therefore make valuable contributions in gaining a better understanding of climate change. Documenting local perceptions of climate change is also considered important from a policy point of view, since farmers perceptions reflect community concerns (Danielsen et al., 2005) and focus on the actual impacts of climate change on people's lives (Laidler, 2006), which are dependent on local factors and cannot be estimated through models (van Aalst et al., 2008). In addition, farmers perceptions influence their decisions both in deciding whether to act or not (Alessa et al., 2008) and what adaptive measures are taken over both short and long-terms (Berkes et al., 2001). Therefore, farmers' perceptions should be taken into account in efforts to understand climate change, its impacts, adaptation to it, and mitigation of it.

Looking at the farmers' perception seems to be an appropriated approach to understand farmers' practices or local innovations developed to cope with climate pattern. The literature on adaptations indicates that perception is a necessary prerequisite for adaptation to climate issues. According FAO (2008), perceptions of climate events are dependent on years spent in farming activities. One would expect that more experienced farmers would be better at distinguishing climate issues from merely inter-annual variation. Alessa et al (2008) reported that older people had a tendency to report more change than younger people. .FAO (2008), argued that farmers' perceptions of rainfall correspond to the evidence of changes provided by climate monitoring stations. One possible way of testing for this could be by comparing the meteorological data with farmers' perception about rainfall pattern or change. For example, Vedwan et al. (2001) evaluate how apple farmers in the western Himalayas of India perceive climatic change. This research is done by comparing the locally idealized traditional weather cycle with climate change as perceived by the farmers of the region using rainfall data to measure the accuracy of perceptions. Another study by Hageback et al. (2005) assess small-scale farmers' perceptions of climate change in the Danagou watershed in China by comparing the local precipitation and temperature data trend with the responses given by farmers to the question "Do you feel any changes in the weather now compared to 20 years?" They conclude that farmers' perceptions of climatic variability correspond with the climatic data records.

Different farmers may have very different ideas about how the uncertainty should be formulated and solved. "Uncertainty or problem perception" is the term used to describe the diverging views which may in the end lead to different problem definitions (Enserink, et al.; 2010). The same authors showed that different problem perceptions will exist if there are different impressions of the existing or expected situation (impacts, causes and possible solutions) and the desired situation (objectives). Enserink, et al. (2010), highlight a number of explanatory variables that exist for differences in perception. These differences are related to such circumstances as:

- The background and history of the actors concerned;
- The position and interests of the actors
- Communication pattern (who talk to whom);

- Individual reference frameworks (selective perception);

According to Leeuwis (2004), perceptions inform people about a particular state of affairs, and constitute information. With the help of information and that related term perception, human beings reduce uncertainty and bring order to the world around them. The same author argues that what farmers do or do not do depend in part on their perceptions of the manifold consequences of certain practices. Thus an important factor that influences farmers' practices or innovations is their perception of whether or not their socio-economic environment is able to support these adequately. The definition given by Pearson et al. (1997) has been used in this study, which defines perception as peoples' point of view towards a specific issue, which is based on how they interpret their experiences. Yet, understanding perceptions of uncertainties in climate contributes to vulnerability assessment. Perceptions can provide new information that complements technical risk assessments because such perceptions may be based on local observations that are too subtle to be reflected in technical risk assessments (Williamson et al. 2010).
According to the United Nations Framework Convention on Climate Change (UNFCC, 1992) the climate pattern is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. Then, insight in farmers' perception will help to understand the role of social learning in the process of adaptation to climate patterns in the local community.

Social learning

In this study, learning in the context of innovation system, refers to dealing with farmers who are confronting with uncertainties where local innovation is required to acclimatize the changing environment. According to Wals (2007), learning is defined as the process of acquiring knowledge, skills, norms, values or understanding through experience, imitation, observation, modeling practice or study by being taught or as the result of collaboration. In social learning processes where people come together as one at some place such as under tree, around a fire etc. to discuss and understand a particular issues or uncertainties. Social learning implies learning from and with a group of different people where each of these people comes with certain 'mental models' and 'frames' to the process (Pahl-Wostl, 2004). Social learning is intended to help improving the quality and wisdom of the decisions we take when faced with uncertainty, complexity and paradox (Leeuwis, 2004). According to Ballard (2005), social learning usually refers to an interactive, participatory, negotiation approach to, or process for, guiding collective problem solving and decision making that incorporates innovation diffusion, system theory and system learning, adaptive management, organizational learning, conflict management and multiple and distributed cognition.

Based on the objective of this study, the definition given by Schusler et al. (2003) has been used, which defines social learning as learning that occurs when people are sharing diverse perspectives and experiences to develop a common framework of understanding and basis for joint action. According to Leeuwis (2004), in learning process, farmers must go through the following aspects:

- Becoming aware: In this case, farmers acquire adequate information and feedback on the uncertainties or problematic field;

- Becoming interested: For example, farmers information regarding personal consequences, opportunities, threats, and the possibility of effectively contributing to problem-solving;

- Becoming involved in active experiential learning and negotiation: When farmers become actively involved in experiential learning and negotiation, different matters become

important, such as information on organizational and technical solutions, and the perspectives and positions of other stakeholders;

- Establishing adapted practices and routines: in this level, farmers may require feedback on the effectiveness of their practices, as well as information on whether or not other stakeholders follow the agreements and arrangements made.

1.3 Study

The main objective of the research is to gain an understanding of farmers' perception and practices or local innovation developed to cope with the rainfall uncertainty. If there is more information available on how farmers are dealing with climate pattern, there will be more insights in how governmental bodies can contribute to this process in Benin.

The above research objective leads to the following research questions:

> What are farmers' perceptions and practices regarding adaptation to rainfall uncertainty?
>
> - How do farmers perceive rainfall pattern?
> - What are farmers concerns regarding agricultural production under the current climate uncertainty?
> - What are the coping strategies developed by farmers to deal with rainfall pattern?
> - What do the farmers perceived as limits to adaptation of rainfall pattern?

The relevance of this research is situated at scientific and social level. The scientific ambition is to contribute to the current debate on climate uncertainties and change that is one of the most pressing global concerns of our time. The social relevance of the study derives from the scientific contribution. The focus of intervention over the last decades was mainly technical without due consideration of social factors. This study which focuses on understanding of farmers' views and practices is of paramount importance to the country in the process of adaptation to climate uncertainties.

The research was carried out in village of Dame in Savalou municipality in Benin during five weeks of fieldwork (July-August). The research area was selected according to the following criteria:

- Savalou is one of the largest agricultural production zones in Central Benin;
- Meteorological station is available for the measurements of precipitation and temperature;
- Savalou belongs to agro ecological area n°4 that is one of the most affected areas by climatic issues in Benin (NAPA,2008);
- Transition area in term of rainfall uncertainties between the southern and northern part in the country;
- Dame village in Savalou is one of village in which the project "Strengthening the Capacity to Adapt to Climate risks in Rural Benin," will be implemented.
- Generally, yields are lower in the study area compared to the national average (MAEP, 2000).
- The researcher speaks the local language. It helps to avoid the use of translator.

The administration division of Benin is constituted in 12 departments (figure 2). The study area is located in the department of Collines (central Benin), in the Soudano-Guinean zone. Mahi and Nago are the major ethnic group. The department of Collines is composed of six municipalities: Dassa, save, Glazoué, Bantè, Savalou and Ouessè (map 2) among them the municipality of Savalou where the studied village (Dame) is located. Dame is 7 km far from its Capital (Savalou). Savalou is 240 km far from Cotonou, the economic capital of Benin. The population of Savalou was estimated at 104 749 persons in 2007 with 50 163 men and 54 586 women. The economic sector in the study area is organized around agriculture, food processing, animal raising, handicrafts, trade and (small scale). Agricultural activities or crop production in the study area is highly diversified. This diversity of crop is locally perceived as a strategy of season risk mitigation since agriculture is depend on climatic condition essentially rainfall.

This thesis report has five chapters. Each chapter focuses on a series of the themes. Chapter one constitutes an introductory part and provides information on the background of the study. It further discusses the research problem, research objectives, and research questions. This chapter deals with literature review and discusses the theoretical and conceptual framework that guided the research and presents the structure of thesis. Chapter two presents research project and focuses on research strategy, provides sampling procedures, data analysis and finally limitation of the study. Chapter three moves the reader to research findings. The fourth chapter focuses on the analysis of the study results which were collected from the focus group discussion and household interview during the field work. Finally chapter five presents conclusions and theoretical reflections with tentative recommendations of the research.

TWO: THE RESEARCH PROJECT

This chapter starts with the research framework, describes the research project and covers four sections. The first section focuses on the research strategy that led to data collection method, the second section covers the sampling procedures used in the study. The third section focuses on data analysis while the last section indicates the limitations of the study.

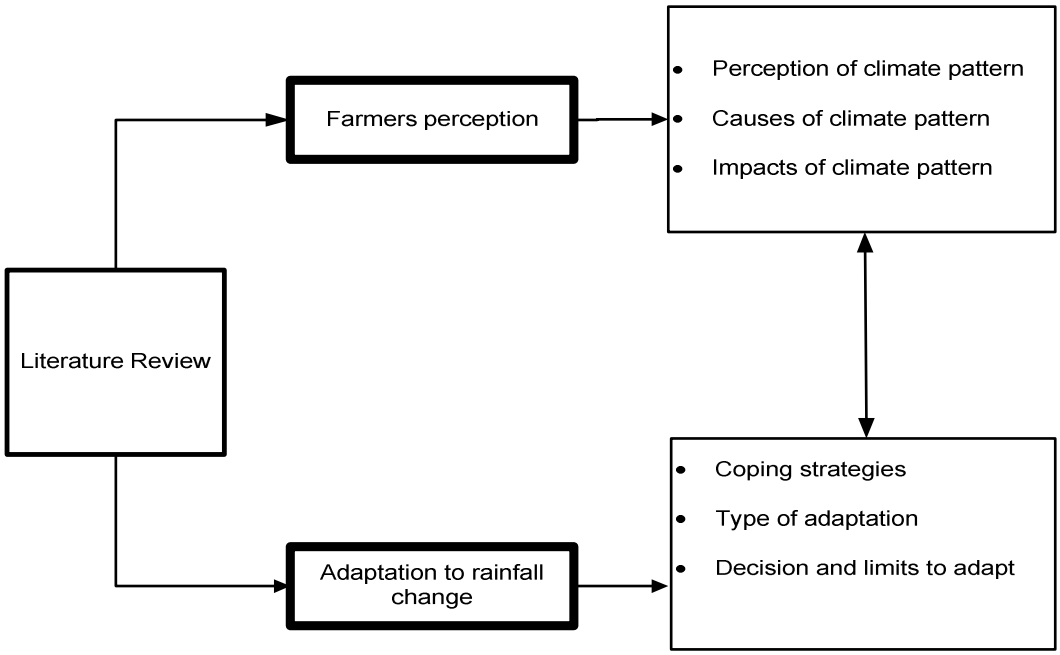

Figure 5: Conceptual framework of the study

2.1 Research strategy

This research was to explore how farmers perceive rainfall pattern and their strategies developed to cope with this changing in rainfall in order to provide insight to policy maker for decision making towards a sustainable development. In the agricultural sector, inclusion of farmers within the identification of adaptation strategies of rainfall pattern can be sustainable if farmers' perceptions on adaptation to climate uncertainties are taken into account. Based on the purpose of this study and in the context of the professional master in VHL University/Wageningen, exploratory research was conducted. This kind of research seeks to find out how people get along in the setting under question, what meanings they give to their actions, and what issues concern them (Schutt, 2009).

Furthermore, in order to gain understanding of famers' perception and practices, a survey approach, based on mainly qualitative evidences was selected because of the explorative character of the study. According to Verschuren et al. (2005), the survey research helps to gain an overall picture of a comprehensive phenomenon spread out over a period of time and space. This may be for example the climate or environmental issue. Regarding the qualitative research methods, it enables the researcher to obtain a more realistic feeling of

the world that cannot be experienced in the numerical data and statistical analysis used in quantitative research (Matveev, 2002). Therefore, farmers' practices or local innovations are often the outcomes of farmers' attitudes, motivations and values, reflected in real-life settings where qualitative evidences can provide a better understanding to such phenomena.

To sum up, the nature of research is exploratory with qualitative approach based on empirical data and various literatures. A survey method was selected to obtained primary data by using participatory diagnostic tools such as focus group discussion, semi structured interview, validation meeting and participant observation. Regarding secondary data, it was obtained by literature review.

2.1.1 Focus group discussion

The purpose of focus group discussion is to draw upon participants' attitudes, feelings, experiences and reactions in a way in which would not be feasible using other methods (Greenbaum, 2000). The purpose of focus group in this research is to map farmers' perception, experiences and adaptation measures about climate pattern and its impacts on farming system. Focus groups generate relevant information during our discussions. Background information was provided to the focus groups in the beginning about the research, purpose of the meeting and expectations from the meeting. The group answers are taken as collective opinions. Precisely, the focus group discussions with farmers were conducted in the local language and took place close to the farmers' farms under a big mango tree where farmers feel comfortable to express their opinions.

The total number of participants for focus groups was 18 farmers who were split up into 2 groups based on characteristics presented in table 3 above. The first focus group discussion involved 8 farmers while the second involved 10. The number of farmer in each focus group respect the principle of Greenbaum (2000), who pointed out that the size for a focus group, is generally between seven (7) and ten (10) people.

Each group discussion took place freely among the participants with assistance or facilitation of researcher and presented their findings at each step of the process of discussion. The discussions were focused and followed more or less in a linear order the following three steps:

- Step 1 Identify the rainfall issues observed by the farmers based on their farming experiences and position of their field.
- Step 2 Identify the impacts of those rainfall uncertainties
- Step 3 Strategies or actions taken by the farmer to deal with rainfall uncertainties and some limits they are facing.

During the focus group discussions, items were listed in French language by researcher on a flipchart as farmers brainstormed on the perception, causes, impacts, adaptations strategies, famer decision and limits to adapt to rainfall pattern. At the same time, researcher was taking notes of some issues that did not make it into the flipchart for various reasons (particularly sensitive issues, such as theft etc).

2.1.2 Semi structured interview

The semi-structured interviews were based on a checklist containing principal topics to be investigated. It gives to the inquired greater possibility of talking about subjects that appear significant to him. Semi-structured interviews were conducted to discuss on the main concepts of the research questions. Semi structured interview helps the researcher to make triangulation of data obtain from the focus group discussion.

Individual households were selected based on purposive sampling and discussion with them was concern their opinions about climate pattern. Researcher entered in any house in the village, established contact by introducing ourselves while presenting the objectives of the study. In each household, we used a checklist to interview the household heads or in their absence, any adult member who has at least 10 years of farming experiences A total of 33 respondents were selected for individual interviews (table 3). The researcher interviewed individuals through face-to-face interaction with the consent of the respondent. Data generated through such interviews focused on farmers' perception and practices towards adaptation to rainfall uncertainties. Most of the discussions were recorded on tape to avoid the loss of certain data. The sound recordings were later transcript for analysis, interpreting and explanation.

2.1.3 Validation meeting

In order to triangulate and validate the results obtained during the focus group discussions and the interviews, a validation meeting was organized with all farmers involved in the research; community leaders, the representative of the project "Strengthening the Capacity to Adapt to Climate risks in Rural Benin" and two communication workers from the public sector (CeRPA) who are involved in extension activities in the village. During this data exchange and validation meeting, our findings were presented and participants were given the opportunity to confirm, clarify or deny some statements. It was also an opportunity to get feedback from development workers. In this way, the reliability of the data was assured.

The validation meeting was also a great opportunity to stimulate and facilitate the communication on rainfall pattern between the community members and the development workers. Figure 6 below showed the data validation meeting.

Figure 6: Data validation meeting

2.1.4 Participant observation

Participant observation was also used to gain a closer understanding of the reality under this study. It enables the researcher to have some ideas concerning the farmers' practices in the process of adaptation to rainfall issues. In a concrete way, after discussion, the researcher joined some farmers in their daily activities related to his domain of research to learn more about some aspects such as erosion and inundation of field etc described by farmers during the focus group discussion and interview.

2.1.5 Secondary Data

The literature review enabled the researcher to understand what work has been done so far in the topic under consideration. The literature review helped the researcher to construct a framework. The sources of literature are basically obtained from text books, websites, and proceedings from workshops, unpublished documents and articles from the journals.

Several libraries have been visited during this research. During the research proposal writing in Netherlands, the WUR library was mainly used. In Benin, the library of Faculty of Agriculture Sciences of University of Abomey Calavi (FSA/UAC), the documentation center of IDID NGO, the library of Ministry of the Environment and Nature Protection (MEPN) and the documentation center of "Agence pour la Sécurité de la Navigation Aérienne en Afrique et à Madagascar" in Benin (ASECNA) were consulted.

The literature review served as both theoretical and empirical base for the analysis of the data collected. It also supplements the information gathered during field work. The following figure 7 presents an overview on the master plan for data collection

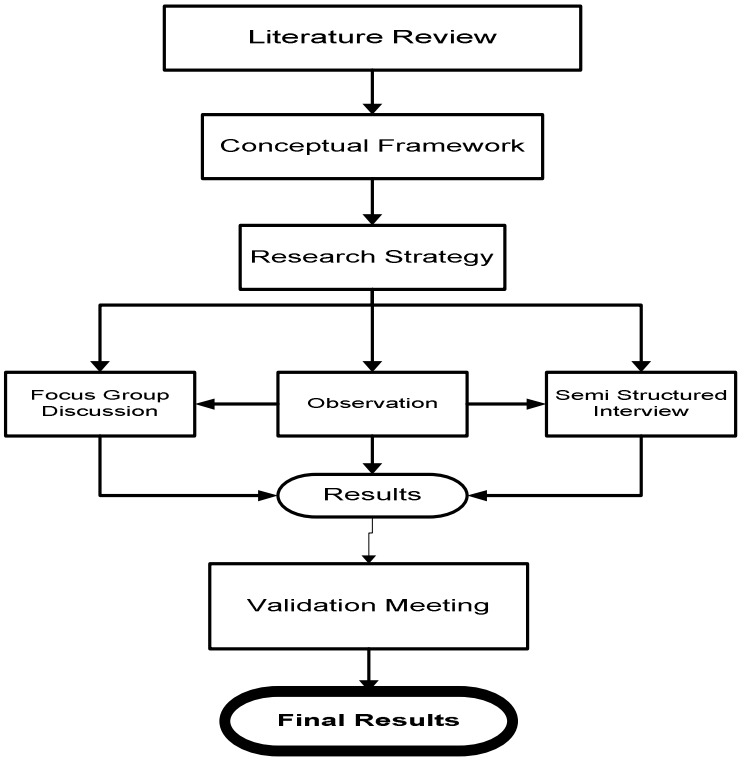

Figure 7: Master plan for data collection

Source: Author, August 2010

2.2 Sampling procedures

The sample size of this research was fifty-one (51) farmers. These farmers were selected and asked for collaboration in this research based on their farming experiences because farmers perceptions of climate events are dependent on years spent in farming activities (Maddison,2006) and their farming position because farmers are differently affected by rainfall issues if their fields are located on the slope or not. Purposive sampling (willingness of farmers to participate in the study) was also used to select those farmers. Table 3 shows characteristics of farmers involved in the study. The research started by a village meeting that was conducted with all community representatives present. The nature of the research was explained to community representative. The other purpose of this village meeting is to understand about climate variability last 20 years from collective memory.

Table 3: Characteristics of farmers involved in the research

Farmers farming position	Focus group discussion		Household interviews (<10 years of farming experiences)	Total
	10 -19 years of farming experiences	+ 20 years of farming experiences		
Sloping plot	4	5	15	24
Bottom of the slope	4	5	18	27
Total	8	10	33	51

Source: Author, August 2010

2.3 Data analysis

Information obtained from focus group discussion, semi structured interview was analyzed using qualitative methods. The analysis of the data was based on the criteria set out in the conceptual framework. The data analysis was mainly focus on comparative analysis between farmers' perceptions of rainfall patterns and meteorological stations' recorded data. It helps to look at how climate data recorded at meteorological stations evolved (variability) and how farmers perceived these changes. For this research we look at how climate data recorded at meteorological stations has evolved during the periods 1960-1984 and 1985-2009 and compared to what farmers have said. Tables and figures were used to present the results.

2.4 Limitations of the study

While conducting the field work, we had to experience some obstacles that we consider as limitations of this study. These are briefly mentioned in following part:

The first difficulty faced was that the farmers felt that the researcher would know a lot about rainfall uncertainties and that he was there to train them on better adaptation practices. Therefore some of the farmers are willing to get such information from the researcher concerning the adaptation strategies instead of describing their own situation. There were others farmers who thought that a researcher is coming from Europe with financial support for his field work and therefore they wanted to receive financial compensation after discussions. Other respondents thought that some kind of aid was coming from government or international donor for them and researcher was conducting the pre-assessment. We could realize that perhaps due to above perception mentioned these respondents to provide us such information that represented their worse condition.

Moreover, other important limitation is about poverty. As the poverty is quite a complex multi -causal issues in rural area in Benin, I'm not always sure if issues mentioned in the study can always be attributed to climate change

THREE: FINDINGS

The primary data presented in this chapter are findings obtained during the field study and mainly result from the focus group discussion and semi structured interviews with farmers. These findings are presented into two sections. The first section is related to the farmers' perception of rainfall situation and the second section focuses on farmers coping strategies of adaptation to rainfall pattern.

3.1 Farmers perception

This section presents the findings concerning on farmers' perception, farmers' expectation of rainfall, causes and impacts of climate pattern as perceived by farmers'.

3.1.1 Perceptions of rainfall pattern

Farmers have different perceptions of rainfall pattern. Table 4 set out farmers' perception about changes in rainfall. In the focus group discussions, farmers observed the frequency of rainfall and described it as "*rainy seasons start late and stop early".* This perception was reported by 100% and 90% of farmers based on respectively farming experiences between 10 to 19 years and with 20 years or more. Almost all farmers were unanimous that the raining seasons start later and stop earlier. This perception was confirmed by household interview by 94%.

The second perception mentioned by farmers was the decreased and unequal distribution of the precipitation. Unequal distribution of precipitation was mainly explained by farmers by the way their observed the rainy season in their environment. According to farmers these changes in rainfall is often manifested by more precipitation on certain location and very less or not all on others place This phenomenon is becoming very frequent and arises a lot of worries among farmers. All farmers with farming experience of 20 years or more involved in this research reported this perception while 87.5% of those who have farming experiences between 10 to 19 years mentioned and confirmed by 97% of farmers in household interview.

Increase of temperatures appears as the third perception mentioned by all farmers involved in this research. According to the farmers, temperatures became more and more warm, and they indicate that even under trees the heat is unbearable. The fading of the crop plants in the fields is shown as the consequence of strong and persistent heat during the cropping season. For the farmers, cloudy times dropped with the detriment of very sunny times. "*We could work under the sun before, but now it is not possible any more*» is one of the remarks which the farmers make to explain the increase of the temperature. Farmers' perception of increase of temperature was explained by one the respondents as:

The heat during the dry season from January to April is oppressive. The air is so hot making it difficult to have respite in any place, either under the tree during the daytime or in the room (day and night). This situation causes us to sleep outdoor at night when that period comes. Even the plants suffer from it as they are scorched on field

(Quote 1: Female, 48 years old, Dame)

Change of droughts frequency, inundation and erosion of field were also reported by farmers. Farmers' explanation about change of droughts frequency was linked to the serious delay of rainy season they observed last years. According to the farmers, after a long time of delay, the rainy season starts with a high intensity of rainfall leading to erosion and inundation of field, but this period of rainy is often very short with lot damage to crop. Furthermore, all respondents highlighted that 5 years ago there was a terrible flood in the village which affected gravely farmers' livelihood and created lot of homeless in the community. This situation was confirmed by validation meeting

Table 4: Synthesis of farmers' perception of rainfall patterns (% of respondents)

Perceptions	Focus group discussion based on years of farming experiences		Households interviews
	10-19 years (N=8)	+ 20 years (N=10)	(N=33)
Rainy seasons start late and stop early	100	90	94
Decreased and unequal distribution of the precipitation	87.5	100	97
Increased of temperatures	75	80	84.84
Change of droughts frequency	62.5	70	75.75
Inundation of field	62.5	60	45.45
Erosion of field	50	40	15.15
Increased of precipitation	12.5	0	0
No change in precipitation	0	0	0
Decreased of temperatures	0	0	0
No change in temperature	0	0	0

Source: Author, August 2010

Before the onset of the rains cropping season, the weather became a growing concern for the farmers in Dame, the rest of Savalou municipality and even most of Benin. The delayed start of the cropping or rainy season was a good entry point to discuss rainfall issues with farmers in the village and sometimes within farmers in the neighbouring villages. In general farmers did not complain about the amount of rainfall, rather they complained about the timing of the rains. According to farmers, their area has medium rainfall because the rains in a normal year are sufficient to assure them of a good harvest. However, the farmers felt that the yield could increase if there would be more rainfall with less wind.

The quote below describes farmer perception of cropping season

Since the period I have started tilling in the sixties until recently, I always begin my farm activities during the 7th month of the agricultural calendar (which is February). But these last years, I don't understand the pattern anymore. There is no longer rain in that month. We now record the first rain of the major growing season only at the end of the 8th month (March) or at the beginning of the ninth (April). The first rains are violent and abundant. They become irregular and turn out to be abundant again at harvest time. This situation is very disturbing and is not in our best interest.
(Quote 2: Male, 72 years old, Dame)

Farmers in Dame use local names to describe the rains in relation to cropping season: *Zofin kploji, Xwé sin, Gboja ji and Nugblé ji:* Below these rains are described by a 61 year old farmer:

Zofin kploji is the first rain which comes after the dry season. This rain announces the major rainy season. Literally, the word used for that rain in local language means "rain which clears out the black ashes deposited upon the soil by the dry season bush fire which turns the vegetation or animals into charred product and dust". It can be inferred from that name that it is a heavy rain which cleans the charred trashes and scraps. In the past, this rain used to come at the beginning of March at night. To avoid that the rain came with heavy winds, the old person of the village offered some sacrifices to "Hê viosso" (god of heaven and thunder) and things were going well. There was no damage. But at the present time, not only that rain comes very late since the 1980s but also is followed by violent winds. The delay is so great that the rain is now coming in April or even in Mai.

Xwé sin that is the water of the year, It is the very first rain after the Zofin kploji. This rain launches the beginning of the rainy season. It gives the green light i.e. it announces the start of the major rainy season. It is a heavy and abundant rain. It always comes at night. Its arrival is characterized by a silent, calm and light wind. When it rains at that night, somebody who is at 12 km of the village knows that the rain of happiness has come. The first tillage and seeding operations are carried out after that rain. But since the first visit of the pope John-Paul II in Benin (1982), this rain has disappeared and has given place to another type of rain called Gboja ji.

Gboja jit is. a rain which chooses the area it will humidify. It falls selectively in the area (it can fall in one village and not at all in the next or vice-versa). Rain can fall in an area located at less than 1km from the village and not in the village itself. It is a real spectacle, a pure paradox and we have no answer to it. This rain which falls selectively at different location and time has tremendous consequences such as different seeding periods from a village to another or from a plot to another plot of the same land (according to the pattern of the phenomenon). The major rainy season delays so much that we are now heading to a single rainy season pattern. As a matter of fact, the rainy season starts in May and one can no longer make a clear demarcation between the small rainy season and the major one. That is the problem we are facing now.

Nugblé jj is a rain which used to fall in December (during the second half of the month: 18-20 December). The name means a "rain of havoc". In fact, his arrival coincided with the period of the drying of groundnut on ridges. These plants of groundnut were the ones which had already come to maturity and had been harvested during the small rainy season. This type of rain was intense and came frequently. As a result, it led to the rotting of the groundnut pods because of lack of oxygen and sunray. In the meantime, that rain was beneficial for the cassava crop. It enabled a proper growth and development of the cassava allowing it to stand throughout the major dry season. It was also an appropriate period for farmers who were late to make ridges and nursery plantation. That rains is no longer falling nowadays. (Quote 3: Male, 61 years old, Dame)

3.1.2 Farmers' perceptions of causes of rainfall pattern

The rainfall variability and uncertainties is recognized by all farmers who are involved in this study, but the causes which are allotted to it are variable within farmers. Table 5 presents the main causes of the rainfall issues evoked by the farmers.

Table 5: Farmers perceptions of causes of rainfall pattern

Farmers perceptions of causes of rainfall issues	Percentage (%) of farmers who mentioned causes of rainfall issues based on field position	
	Sloping field (N=24)	Field on bottom of the slope (N=27)
Lack of respect of divinities and social norms	45.83	48.15
Don't know	33.33	40.74
Deforestation (tree cutting)	20.83	11.11
Total	100	100

Source: Author, August 2010

The lack of respect of divinities and social norms was the mainly cause of rainfall issues mentioned by both categories of farmers (farmers with field on slope 45.83% and farmers with field on bottom of the slope 48.15%) and shown on the table 5. Indeed, in the municipality of Savalou which is a zone where the beliefs are very strong, people associate the rainfall issues with a work of God. Farmers thought that the rainfall issue is the divine punishment and the manifestations of the prophesied end of the world. Thus, instabilities of rainfall would be the consequences of the lack of respect of the God laws while the rainfall stability would be a standardization of the bonds which bind the human ones to God. Other farmers make a link between the climatic modifications and the lack of respect of the social interdicts. This is perceived as a disobedience to the divinities. It is strongly perceived that the divinities guarantee a good cropping season. The lack of respect of divinities and social norms was mainly mentioned by farmers who have their field on bottom of the slope. Another cause of the rainfall issues discuss during focus group by some farmers as social interdicts is the bad faith of certain men who claim makers of rains. Indeed, these "lords of the rain" according to a popular name would have the control of the space time distribution of the rain during the seasons. Satisfaction of the requirements (financial and/or material) of these makers of rains depends on the quality cropping season.

It is important to notice that 40.74 percent of respondents who have their field on bottom of the slope don't have any idea about rainfall issues causes. This answer is confirmed by 33.33 percent of respondents who have they field on the slope.

Deforestation is also mentioned as a cause of rainfall issues. Among the category of farmers who reported the deforestation as cause were 20.83 and 11.11 percent respectively of farmers who have their field on slope and the bottom of the slope.

3.1.3 Farmers' perception of impacts of rainfall pattern

Discussing the impact of climate patterns the damage to crop and decline of yield were mentioned by all categories of respondents. Indeed, the environment of growth and development of the plants is mentioned as strongly disturbed these last years and does not support any more a good production. The damage to crop, crop failure, low productivity etc due to the speed of wind, the inundation and erosion of field were mainly revealed by household interviews. Figure 8 shows the farmers perception of impacts of rainfall pattern.

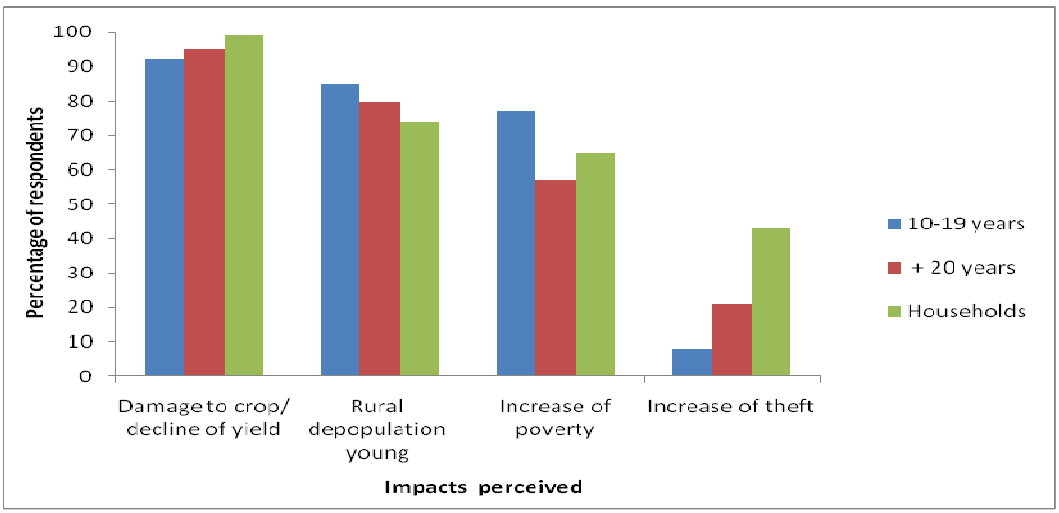

Figure 8: Farmers' perception of impacts of rainfall pattern

Source: Author, August 2010

Impact of rainfall patterns observed by farmers pertained to agricultural production. Most of farmers complained that there is very difficult for them to plan agricultural activities ahead of time due to frequent variability of rainfall last years.

The figures below exemplify some damages of crop.

Figure 9: Erosion of cotton on sloping plot

Figure 10: Inundation of cotton on bottom slope

Yam and maize constitute the principal staple foods in the study village and are selected to exemplify farmers' perception about impact of rainfall pattern.

The yam production was formerly an art made up of a succession of standardized operation in this village.

The first operation which is called the « Fan sinsan » used to start in June. The "Fan sinsan" it means the realization of small ridge for yam by burying weeds into the soil. The sizes of the ridges were increased in July, one month after leaving them at << rest>>. This period of time was necessary for the rotting of the weeds previously buried. Next, we chopped down some trees which would serve later as prop to the future yam plant. Because the leaves of these big trees were abundant, they were used as green manure to the soil.The second farm operation was carried out from July to August. It consisted in the cultivation of other crops on the area previously prepared and allocated to yam production. In fact, crop such as groundnut or Bambara beans were put on the ridges formerly realized (during the small rainy season). The yam planting followed after harvest of the latter crops. The Farmer might also decide to sow some maize around the yam ridges in August. If that case, the ridges were enlarged at 40 days after sowing to offer better support to the growth of the maize. The yam plants were definitively settled in December-January or even in February according to the availability of the farmer. The third operation concerned the care for the young yam plants. It was mainly about weeding activities which start 4 months after plantation. They are then repeated three times at the frequency of one weeding operation per month. Nowadays, with the change in rain pattern, one cannot trust the rain calendar anymore. Therefore, we produce a lot of cultures to manage the uncertainty related to climate change. Consequently, time fails us to carry out all the operations required to yam production. This is how we now proceed for yam production: we carry out weeding with machetes in August-September and we directly realize the ridges in September. There is therefore no spare time after weeding operation. The « fan sinsan » operation has disappeared with all the subsequent steps. Tillage operations are hardly deep, considering the structure of the soil after weeding. We are no longer producing yams because we independently of our will violate the rules embedded in the art.
(Quote 4: Male, 55 years old, Dame)

Everyone cultivates maize in this village and the production is adversely affected by the uncertainty related to the rain pattern. Maize has difficulty in coping with the delay or break in rain as well as its excess. In fact, factors such as lack of water, high temperature, pouring due to wind, loss at harvest, disruption in agricultural calendar and excess of water bring about loss in yield at harvest. These factors affect the maize crop differently according to topo sequential situation of the plot. On the plots located on the top of a slope, the factors responsible for the decrease in yield are mainly the insufficiency of water, high temperature, overturning of crop due to wind, loss at harvest, disturbance in agricultural schedule. On the other hand, the plots situated in the middle or at the lower part of a slope are primarily affected by the excess of water followed by flood, pouring effect of wind and the disruption in agricultural calendar which are the major factors. These climatic phenomenon causes loss at harvest, lower quality of product and even greater loss during storage.
(Quote 5: Female, 53 years old, Dame)

The second impact of climate pattern perceived by all categories of respondents is related to social transformation like rural depopulation of young people. This type of impact was mainly mentioned by category of respondents that we can call "young people" because of their experiences in farming activities. Faced of climate uncertainties, farmers and especially young people are discouraged to engage in farming activities in which they are not sure to earn a living. Then, most of them decided to go out of the community in seeking for job.

Increase of rural poverty was the third impact of rainfall pattern perceived by farmers who are involved in this study. Framers income depends mainly on agricultural production which is affected by climate patterns. This situation leads to increase of poverty because the level of poverty is very high in rural community compared to city center in Benin. We noticed that increase of poverty as impact of rainfall pattern was reported by young category of respondents and confirmed by household interview.

Increase of theft was the last impact of rainfall variability perceived by some respondents in this study. During the focus group discussion the theft as impact was not mentioned into the flipchart because of its sensitive character. 21 percent of respondents of old category (< 20 years of farming experiences) highlighted it and confirmed by 43 percent of respondents in household interview while 8 percent only of young category mentioned (10-19 years of farming experiences). According to household discussion, due to climate uncertainties, some lazy farmers give up completely on farming activities and started to steal in the village.

The impact of rainfall variability on the human capital of the households is considerable. Indeed, from informal discussion, certain farmers affirm to have removed from school at least a child these five last years for financial reasons. We noticed also some cases of "placements of children" as impact of rainfall uncertainties. In addition, the destroyed room in figure 11 was shown me by farmers as an example of the impact of intensity of rains accompanied by violent wind.

Figure 11: Destroyed room by rains accompanied by violent wind

3.2 Adaptation towards rainfall pattern

3.2.1 Adaptation strategies

- **Change the crop calendar and crop rotation**

Changing the crop calendar to take into account the rainfall changes was adaptation strategies mentioned by a large number of farmers to deal with climate variability. As set out on the table 6, this kind of adaptation strategies was reported by 40.75 and 37.5 percent of farmers who have respectively their field on the bottom of the slope and on the slope while the rest of farmers in both categories focused on 6 other types of coping strategies. According to farmers, they have changed the crop calendar and start sowings from the second decade of April (previously, it was done at the end of March). Indeed, the farmers who started sowing from April would have a strong probability to get a good yield contrary to those who carried out very early.

The change of crop rotation is also one of the local innovations developed by farmers to deal with climate pattern. This change of crop rotation intervened after the introduction of soya and rice into the farming system and the abandonment of others. So, the rotations of maize – beans, maize-groundnut, etc., gave way to other types of rotation as maize-soya. With the previous situation, there was a relay culture of the maize by the cotton: maize at the beginning of season and cotton in the maize before its harvest. But currently, each speculation has its own plot due to the short of rainy.

During the focus group discussion with farmers, some of them especially the old persons said that they have changed their planting decisions which were based on improved hybrid seed for greater productivity advice by extension workers to focus on endogenous varieties of crop. They recognize that endogenous varieties of crop are less productive but are more resistant of rainfall variability. As said by one of the farmers *"for me, the change of rainfall pattern that we observe nowadays and that affect our livelihood is a great thing come from God to save the heritage left by our ancestors. To survive, we have to go back and be aware of our endogenous realities and take care of our endogenous seed and crop which are becoming extinct".*

- **Sowing same crop in different date and re sowing**

Sowing the same crop in different dates is also farmers practice in the climate risk management. This practice is called "spread out sowings". It consists in sowing the same crop on two different plots of land or even on a single plot of land in different dates. Farmers said they are doing this by hoping that the rhythm is going to correspond to the phases of growth of one at least cultures with regard to their date of sowing. Re-sowing is also developed by farmers as a strategy towards adaptation to changing climate patterns. Indeed, when precipitations start with delay or stop in growing phase of crop, the crops become yellow and dry especially when the drought or the rupture of the rains is prolonged. In case of resumption of rains, the farmers proceed to the "re sowing". This re sowing consists of a replacement of the"roasted" seedlings by other seeds. This practice is often observed in cotton and maize production because they are generally planted starting the first rains of season.

Sowing same crop in different date and re sowing was the second local innovation reported by 20.83 percent of farmers who have their field on the slope. At the same time this practice constituted the fourth local innovations mentioned by 14.81 percent of farmers who have their field on the bottom of the slope.

- **Livelihood diversification and migration**

In the study area, livelihood diversification is one of adaptive strategies focused on off-farm activities that are not depend on rainfall such as setting up small businesses (tea kiosks, market stalls, firewood, charcoal, craft industry etc.). These activities are more carried out by men. As far as women concerned, they pointed to the need to create value added products and want to engage in cassava processing because whatever the rainfall season cassava tree survive but they highlighted the need for equipment and capital. Crushing of the stones and hills was also mentioned as livelihood diversification activities carried out especially by women (mothers assisted by their children).

Due to rainfall uncertainties and its impacts on farmers' livelihoods that lead to lack of daily food, and the money to buy it, farmers found the way of migration. Thus, migration of farmers' especially young people to the surrounding towns has become popular in the village. Young people migrate to towns such as Savalou, Glazoué, Dassa, Bantè and sometimes Cotonou (economic capital of Benin) in searching of jobs. Some of them are engaged in motorcycle taxi that called "Zémidjan" in Benin, in petrol selling around the roads, in security guards activities etc. Some of these young people return to village very sick because of living condition they are facing in their adventure and became a serious worry for their families and the community as well.

Livelihood diversification activities and migration as practices of adaptation to rainfall change were reported by 20.33 percent of farmers who have their field on the slope and 18.51 percent of farmers who have their field on the bottom of the slope.

- **Social learning, ritual offering and prayer**

The need to put together adaptive capacity to climate risk into Dame village is becoming a core worry for farmers who are more affected by impacts of rainfall variability. Face on stressors, farmers complaints and a deep climate uncertainty, the village leader organizes the first community meeting on 15th August 2008 in order to discuss about climate issues. During this social learning meeting that brought together men and women as well as young and elder persons, lot information was sharing and enhancing farmers understanding on climate variability. According to farmers, the social learning gave them a great opportunity to:

  - Become aware of rainfall pattern: In this case, farmers acquire information and feedback on their concern;
  - Become interested of adaptation to rainfall pattern: Farmers are interested and motivated to learn about information regarding their peers personal experiences, practices, knowledge used in farming system in order to reduce the impacts of damage of crop;
  - Become involved in active experiential learning: Farmers become actively engaged in experiential learning like planting of panicum C1 against erosion in the field.

In the process of social learning in this community, farmers said that they don't have formal planning to get together for discussion and information sharing but they meet often through other canal as market place, church, funeral ceremony etc.

Ritual offering and prayer are also part of farmers' local innovation or practice towards adaptation to rainfall pattern in the study area because farmers thought that lack of respect of divinities and social norms were the mainly cause of rainfall pattern. Under the responsibility of rain makers, farmers are offering sacrifice to ancestral spirits, to "vodoun Xêbiosso" that is

the god of thunder and harvest and controls the rain. For the older farmers, ancestral ceremonies are a time to discuss serious issues like rainfall pattern affecting both the individuals and the community at large. Prayers are also organized in the different churches by farmers who are not involved in the traditional religion for imploring God forgiveness.

Ritual offering and prayer were the third local innovation reported by 16.16 percent and fourth in ranking of farmers who have their field on the slope. At the same time this practice constituted the second local innovations mentioned by 18.52 percent of farmers who have their field on the bottom of the slope.

Table 6: Farmers adaptation strategies to rainfall pattern (% of respondents)

Farmers adaptations coping strategies	Percentage of farmers who mentioned adaptation strategies based on field position	
	Sloping field (N=24)	Field at the bottom of slope (N=27)
Change the crop calendar to take into account the rainfall changes and crop rotation,	37.5	40.75
sowing same crop in different date, different land and re sowing	20.83	14.81
Livelihood diversification (development of off-farm activities)	20.33	18.51
Ritual offerings and prayer	16.16	18.52
Predicting of rainfall	4.17	3.7
No adaptation	0	3.7

Source: Author, August 2010

- **Predicting of rainfall**

Some farmers of our study village have several ways of reading the signs or indicators of a good cropping year (Table 7). Several traditional ways of forecasting were mentioned by farmers. Understanding the indicators or the signs was often considered by the farmers who did not have this knowledge as an endogenous practice known and practiced by the old and wise persons. The farmers called “local forecasters” who use the signs as rain predictors are often rain makers. They recognize that sometimes the signs give incorrect indications like meteorological prediction and only God knows the good cropping season According to farmers and based on their every day experience, baobab trees are more predictable than others. In the same time, farmers believe that trees are less predictable than stars because stars “live” with God.

Table 7: Synthesis of farmers' indicators for predicting rainy seasons

Indicators or signs	Prediction about cropping seasons
Baobab tree (*Adansonia digitata*)	Good season: • A lot of flowers and leaves on baobab tree in the beginning of rainy season; • Flowers of baobab are opened and staying for long time on tree in the beginning of rainy season.
Cashew tree (*Anacardium occidentalis*)	Good season: A lot of flowers on cashew tree in the beginning of rainy season
Direction of the first rains in the season	Good season: First rains in the season are coming from the east Bad season: First rains in the season are come from west
Stars	Good season: Huge star is visible in the west around 5 p.m. to 8 p.m. in certain period in dry season
Dew	Bad season: dew with a lot water in the beginning of rainy season

Source: Author, August 2010

Figure 12: Baobab tree showing signs of a good cropping season

3.2.2 Type of adaptation

According to farmers, they do not receive any information from the government even the local government and NGO about rainfall pattern. All farmers who are involved in the study were unanimous in this finding. Farmers recognized the presence of some Non Government Organizations (NGO) and extension workers (public sector) which are working with them in the village, but any of these institutions have not advised them on rainfall issue. Farmers frequently receive advice on some crops production, especially cotton and rice. For farmers, the extension workers also complained about rainfall situation. Farmers coping strategies of adaptation to climate pattern are mainly based on local innovation.

It is important to notice that very few farmers said to learn from radio that planting of trees could help them in mitigation of rainfall issue. That is the only information get from "outsider" focusing on rainfall pattern.

3.2.3 Decision and limits to adapt to rainfall pattern

According to farmers, their decision making under this change of rainfall is determined by some factors. Thus, farmer production strategies seek to manage uncertainties and reduce losses by diversifying field locations and cropping systems. Therefore, at the onset of the rainy season, farmers make decisions about what, when, and where to plant. The second level farmers' decision making focused on:

- Availability of wetland: farmers who have some wetland available are less worry about rainfall compare to those who do not. Whatever the rainfall season, farmer who has planted on wetland get "*something to feed his fa*mily" at the end of the day.
- Rainfall prediction: Although some farmers do not believe of local indicators of rainfall because of they may not always coincide with outcomes, it plays an important role in farmers decision under this climatic issues.
- Availability of short cycle of varieties of crops and labor force: farmers concern here is related to money. As agriculture is under rainfall pattern, it is not easier for farmer to get production loan that is determinant in input supply and labor force getting.

Farmers' access to rural services, such as extension and credit influence their behavior on adaptation to rainfall pattern. Table below set out what farmers perceived as limits to adaptation.

Table 8: Farmers perceptions of limits of adaptation to rainfall pattern

Farmers perceptions of barriers of adaptation to rainfall change	Percentage (%) of farmers of based on field position	
	Sloping field (N=24)	Field on bottom of the slope (N=27)
Lack of cooperation with research institutes and development workers in climatic issues	45.83	55.56
Lack of credit and government support	20.83	26.63
Lack of water	29.17	14.81
No limits or barriers	4.17	0
Total	100	100

Source: Author, August 2010

FOUR: ANALYSIS AND DISCUSSION

This chapter presents analysis and discussion of the main findings. In order to adapt to rainfall pattern, farmers must perceive that changes are taking place in their environment and especially in their farming system.

4.1 Farmers perception

Looking at the farmers' perception on climate pattern is important for institutional policy for supporting rural development and especially agricultural production. The literature on adaptations also makes it clear that understanding farmers' perceptions is a necessary prerequisite for policy maker to address climate issues. There is a need to understand how farmers who are directly affected by the impacts of climate pattern perceive this situation. The analyses of the findings of the field research with farmers of Dame village as presented in the previous chapter are analyzed. Farmers in the Dame village are strongly aware of the climate uncertainties and have clear views on climate pattern, especially in precipitations patterns (rainy seasons start late and stop early, decreased and unequal distribution of the precipitation, change of droughts frequency, inundation of field, erosion of field) and the intensity of temperature (.increased of temperatures)

The way farmers expressed the frequency of rainy seasons seemed that they are living in deep uncertainties and are very anxious about the future because their livelihood depends on agriculture that is reliant entirely on rainfall. The second most important perception mentioned by farmers was the decreased and unequal distribution of the precipitation followed by increased of temperatures.

Farmers' perceptions of rainfall pattern

There was no major variation in farmers' perceptions of rainfall pattern in areas of 10 to 19 years of farming experience and < 20 years of farming experience (Table 4). A large number of all farmers who are involved in this research perceive changes in rainfall patterns (changes in the timing and distribution of rainfall, etc) and temperature has been increasing over time (Table 4). Farmers' perceptions of rainfall pattern appear to reflect precipitation and temperature data obtained from Agency for the Security of Air Navigation in Africa and Madagascar in Benin (ASECNA), which show a decreasing trend in precipitation and an increasing trend in temperature between 1960 and 2009 (figure 1 and 2; table 1 and 2). Farmer's perceptions of rainfall pattern appear to be in line with meteorological record data. These finding corresponds with literature from FAO (2008) which argued that farmers' perceptions of rainfall correspond to the evidence of changes provided by climate monitoring stations. This method of comparing is supported by Vedwan et al. (2001), and Hageback et al. (2005) who argued that one possible way of testing farmers' perception is by comparing the meteorological data with farmers' perception on rainfall pattern.

However, singling out climate as only driver of change is not simple because of some limitations identified in this study. There is also important to notice that perceptions of farmers who are involved in this study may be based on their recent flood event because people perceptions are often based more on recent, short-term trends rather than long term changes and people perceptions of climate change are more related to their recent experience (Deressa, 2007). This view is also shared by Smit et al. (1997) who said that while farmers report to be observing climate variability; their perceptions of climate variability are more related to recent experience. Furthermore, Hansen et al. (2004), said that farmers' memory of past climatic variability may be distorted in systematic ways, reflecting wishful thinking by distortions consistent with decision goals as well as being shaped by personality characteristics and preexisting beliefs. Therefore, the flood event there was 5 years ago and

the last drought situation reported by respondents could be determinant factors which influence farmers' perception.

But, based on the way farmers expressed their perception highlighted the past experience and showed erratic rainfall patterns, increasing warming days, ecological variability, biological change and their adverse effects on human beings. This is corroborated by research carried out in four other regions of Benin with different climatic profiles have shown producers' perceptions on climatic risks and revealed that farmers are perceived irregular rainfalls, shortening of cultivation season, occurrence of violent winds and a increase of temperatures (Guibert et al. 2010).

Above discussions seem to suggest that climate variability has become reality and farmers in the study area are aware of this climate variability. Maddison (2007) found that farmers' awareness of changes in climate attributes (precipitation and temperature) is very important for adaptation decision making. In his address to the High Level Event on Climate issues on 24 September 2007, the Secretary General of the United Nations , Mr Ban Ki Moon, stated "*I am convinced that climate variability, and what we do about it, will define us, our era, and ultimately the global legacy we leave for future generations*. Today, the time for doubt has passed". There is no doubt about significance of studying farmers' perception of rainfall pattern.

Farmers' perceptions of causes of rainfall issues

The cause of rainfall pattern points to significant differences in the ways framers and scientists understand cause. Most of respondents reported that the lack of respect of divinities and social norms are the major cause, excepted only 20.83% and 11.11% of farmers who have respectively their field located on slope and bottom of field. This finding contrary United Nations Framework Convention on Climate Change (UNFCC, 1992). According to the UNFCC (1992), the climate pattern is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

It is clear that farmers have different perception of real causes of rainfall pattern. Only very few of them recognize deforestation as causes of this situation. Though deforestation is reported as cause of climate issues, this awareness does not mean that farmers are willing to stop cutting or to start planting trees. It is also necessary to notice that far from being convinced of this cause, these farmers said deforestation because they would have learned it by media (Radio).

Farmers' perception of impacts of rainfall pattern

Among impacts of rainfall pattern, the most mentioned by all categories of respondents was the damage to crop and decline of yield as shown in figure 8. Respondents agree the environment of growth and development of the plants is strongly disturbed these last years and does not support any more a good production. Climate variability not being the only determining factor the yield or output, other determinants of the output like soil fertility, quality of the seeds, diseases and pest also strongly take part in this fall of the yield perceived by farmers. It is important to notice that damage to crop, crop failure, low productivity etc due to the speed of wind, the inundation and erosion of field were mainly revealed by household interviews. This could mean that the households are more affected by impacts of rainfall pattern than individual farming level.

The second most important impact of climate pattern perceived by all categories of respondents is related to social transformation like rural depopulation of young people. This situation could create famine because young people constituted a major part in agriculture

activities. Moreover, in rural area the labor force is often constituted by young people, therefore they depopulation will affect and lead to lack of food. Impact of rainfall patterns observed by farmers pertained mostly to agricultural production. The finding for impacts shows a similar perception of farmers living in other areas in Benin. According to Guibert et al. (2010) and NAPA (2008), the impacts of rainfall pattern is more expressed by farmers in term of decline of yield, destruction of crops, erosion and inundation which lead to difficulties to pay back credit and incapability of farmers to support their children schooling. The fact to remove children from school due to decline of agriculture production is a critical situation for the country because poverty reduction depend big part on education. As shown by Waithaka et al. (2006), improving access to education is highlighted as an effective way of improving livelihood security, but formal education alone is not sufficient to move people out of poverty. If the formal education is at risk, what will happen to non formal education?

Considering all categories of respondents, there was no noticeable difference between their perceptions in term of impacts.

4.2 Adaptation towards rainfall pattern

4.2.1 Adaptation strategies

- **Change the crop calendar and crop rotation**

Changing the crop calendar and crop rotation is the first important coping strategy developed by farmers. As set out on the table 6, all categories of respondents (farmers in sloping field and farmers in bottom of slope field) revealed this coping strategy of adaptation. This result is shared by Deressa (2007) who highlighted that the common coping strategies of adaptation to climate risks in agriculture include the use of changing planting dates, rotation of crop and new crop varieties that are more suited to drier conditions, irrigation, crop diversification, mixed crop livestock farming systems. However, the changing in crop calendar to take into account the rainfall changes suppose that farmers have some indicators for detecting the starting of rain season in order to prepare the field.

With the previous situation of crop rotation, there was a relay culture of the maize by the cotton: maize at the beginning of season and cotton in the maize field before the maize harvest. But currently, each speculation has its own plot due to the short of rainy. This situation leads to the increase of the production loads because farmers need more labor force (financial support) in this circumstance. The rainfall situation leads also farmers to go back to endogenous crops which are recognized less productive but are more resistant of rainfall variability. One of the questions that could arise from this coping farmer's strategy is how to bridge endogenous knowledge to scientific knowledge in the process of adaptation to rainfall pattern.

- **Sowing same crop in different date and re sowing**

Sowing the same crop in different dates and re sowing as adaptation strategy confirmed the real uncertainties in which are living. Farmers are doing this practice by hoping that the rhythm of season is going to correspond to the phases of growth of one at least cultures with regard to their date of sowing. The sowing same crop in different date and re sowing appears as the second most important coping strategy for farmers who have their field on the slope. At the same time this practice constituted the fourth coping strategy of farmers who have their field on the bottom of the slope. This difference could mean that a field on bottom of the slope is less appropriate for this strategy.

- **Livelihood diversification and migration**

Farmers' livelihood diversification as adaptive strategies focused mostly on off-farm activities that are not depend on rainfall such as setting up small businesses. These finding corresponds to the Maddison (2006), who argued that livelihood diversification is the most research findings on adaptation to climate risk in Africa. Thus, livelihood diversification received the greatest number (and percentage) of mentions in most finding but in this study, only 20.33 percent of farmers who have their field on the slope and 18.51 percent of farmers who have their field on the bottom of the slope mentioned. This fact could mean that livelihood diversification depends on farmers' financial capacity, new skills or market driver.

Due to rainfall uncertainties and its impacts on farmers' livelihoods that lead to lack of daily food, and the money to buy it, farmers found the way of migration. This view is also shared by Arendse et al. (2010). According them, the transformation of social structures and social practices is sometimes more difficult to directly link to climate risks. However, inasmuch as climate pattern leads to greater uncertainty and livelihood insecurity, such transformations are inevitable. Temporary migration is a classic example of a social adaptation to climate variability.

- **Social learning, ritual offering and prayer**

The need to put together adaptive capacity to climate risk into Dame village is becoming a core worry for farmers who are more affected by impacts of rainfall variability. The social learning, ritual offering and prayer is the most important second coping strategy for farmers who have their field on bottom of field while it constituted the fourth for the farmers who have their field on slope. It is important to notice that farmers learning process follow the social learning theory developed by Leeuwis in his book communication for rural innovation, rethinking agricultural extension (2004). Furthermore, in the social sciences there are two ways in which learning can be considered social. The first is about individual learning that is conditioned by its social environment (farming transformation due to change in rainfall) and the second is about the social collectives such as community organizations that can learn in their own right because they are interested in adaptation of climate risk (Jarvis et al, 1998).

Farmers' awareness of rainfall change and through their social learning leading to collective action can contribute to the formation of local network with surrounding villages or communities. According to Thomas et al. (2005), more than any one specific piece of technology, a community's ability to pool collective resources and facilitate the transfer of knowledge and technology may be the most effective mode to combat climate extremes. The strengthening of this local network could be a good point of entry to create space for innovation towards adaptation to climate pattern. Even, farmers reported differently the impacts of rainfall change, it is clear that this change of rainfall affects them collectively. Therefore, find out strategies that call for collective action could be one solution because it is often easier to build capacity and introduce a new adaptation strategy or technology through an organized group of farmers (Thomas et al. 2005; Adger, 2003). Smit et al (2001) argued that effort should be made to build adaptive capacity through social learning, which creates the ability of farmers to cope with climate-related risks and allows for local assessment and more tailored responses.

- **Predicting of rainfall**

Rainfall prediction is one of farmers' strategies towards adaptation to rainfall pattern. Our natural environment provides a large source of endogenous knowledge about weather conditions to farmers who have learned from their grandparents to read and interpret its signs, or who can draw from daily own experiences. As presented on table 7, farmers used several traditional ways (trees, direction of rain, dew, stars etc.) of forecasting.

This result corresponds of the study carried out by Roncoli et al. (2002) who found that local rainfall forecasts rely on observation and interpretation of specific phenomena, such as trees, animals, and sky, or they may be spiritually manifested in the form of divination. However he also notes that understanding the indicators or the signs was not possible for every farmer. Only some old and wise persons have this knowledge. According to Roncoli et al. (2002), generally, elderly male farmers are considered to know more than younger men or women farmers, but knowledge varies greatly among elders. When everybody is not able to predict rainfall, social learning by experience sharing could be an appropriate strategy to inform people about rainfall season.

4.2.2 Type of adaptation

Based on theory of farmers adaptation highlighted by IPCC (2001) and FAO (2007) and presented in our literature review above, we came up that farmers strategies of adaptation is more autonomous and Short-term adjustments than planned and Long-term adaptations in the study area. For FAO, (2007) short-term adjustments are seen as autonomous in the sense that no other sectors (e.g. policy, research etc.) are needed in their development and implementation while long-term adaptations are seen as planned. They are major structural changes to overcome adversity such as changes in land-use to maximize yield under new conditions; application of new technologies; new land management techniques; and water-use efficiency related techniques.

This finding corresponds also with the study carried out by Maddison (2006), presented in our literature review. This author found that farmers whose livelihoods depend on rainfall agriculture have developed ways to cope with climate variability autonomously. However, anticipatory and planned adaptation is an urgent concern for farmers due to level of damage and the speed of risks.

The findings tell us that farmers' coping strategies of adaptation are based on their knowledge and local practices. When we referred to national framework and charter on climate change adaptation presented in our first chapter, we realized that there is a big gap. According to the government, the integration of climate change in national development strategies depends on Benin's efforts to "green" the Growth Strategy for Poverty Reduction. Furthermore, under the process of decentralization, the government of Benin has developed the national charter on environmental governance which creates the necessary condition for adaptation to climate issue.

4.2.3 Decision and limits to adapt to rainfall pattern

The first important and serious decision that farmers make at the onset of the rainy season, is about what, when, and where to plant. The answer to these questions is very determining in farmers' decision making and influenced by their availability of wetland, rainfall prediction and availability of short cycle of varieties of crops and labor force. Thus, farmer production strategies seek especially to manage uncertainties and reduce losses by diversifying field locations and cropping systems.

The most important limit of farmers' adaption of rainfall pattern is lack of information and knowledge. This limit was reported by all categories of farmers (45.83% of farmers with sloping plot and 55.56% of farmers with bottom of the slope). These findings are in line with Roncoli et al., (2002) who pointed out some factors which affect farmers' ability. These factors include accessibility and usefulness of climate information, the policy and institutional environment, and the socio-economic position of the household. Therefore, farmers' access to rural services, such as extension and credit can influence their behavior on adaptation to rainfall pattern.

FIVE: CONCLUSION AND RECOMMENDATION

This chapter provides major conclusions from the results of the research and offers some recommendations, based on the findings.

5.1 Conclusion

This research explored farmers perceptions and practices towards adaptation to rainfall patterns through survey research which focused on participatory approach (focus group discussion) in Dame village in Benin. The results provide more insight into how farmers in the study village perceive rainfall patterns and how they deal with this change in rainfall. Furthermore, the results justify that adaptation to climate risks depends on farmers' perception to the impacts and causes of these changes in rainfall.

The analysis of meteorological recorded data about rainfall on the period 1960-2009 shows an important variability and modification of precipitation. The analysis of these modifications shows that the short dry season experiences more rains than before. Thus, the decline of the precipitation is important in the beginning of the longer rainy season (April, May, June); this could mean that the beginning of cropping season is characterized by delayed rains. The analysis of temperature data from 1960 to 2003 also shows a trend of increasing rainfall that is very noticeable in longer rainy season while the longer dry season starts with less hot temperature. This modification of temperature justifies that there is a clear tendency to the climate warming with potential impacts on agricultural production. In addition, the survey data revealed that farmers' observations about rainfall patterns are related to the shift of the rainfall season (rainfall seasons start late and stop early), a bad distribution of rainfall during the cropping season (unequal distribution of precipitation), a decrease of the precipitation, a decrease of the number of rainy days, increased of temperatures, erosion and inundation of field and change of droughts frequency. Comparing the precipitations, temperatures trends from meteorological recorded data to the survey data show that farmers' perceptions of climatic variability are in line with climatic data records. Indeed, farmers in village of Dame are able to recognize that there has been a decrease of rainfall and the temperatures have increased based on their farming experiences. There is also important to notice that perceptions of farmers who are involved in this study may be based on their recent flood event

In the study village, farmers' conception of the causes of rainfall pattern is not homogeneous. All the causes reported by farmers do not reach unanimity within the rural communities. That is the case of lack of respect of the divinities mentioned as causes by the farmers whose attachment with the local tradition is strong and rejects those who do not have a faith in the tradition and reported the climate patterns to the work of nature (i.e. of God) . Other causes mentioned such as the lack of respect of the social norms and the deforestation reach unanimity within the farmers. To sum up, we notice that there was limited awareness, knowledge and capacity at farmers' level to understand rainfall pattern causes which are necessary to conduct long-term adaptation planning.

Impact of rainfall patterns observed by farmers pertained mostly to agricultural production. Thus, the decline of yield was the major impact reported by all farmers. This decline of yield varies according to the position of the field. The lack of water, erosion, hot temperature is mainly factors used by farmers to explain the decline of yield on the slope field. On low lying fields, excess of water following sometimes by inundation are the major causes of decline of yield. These situations lead to serious loss of harvest and bad quality of products. The result of these phenomena was explained by dropping of farmers' income.

While most of the farmers reported that rainfall change is a threat for their agriculture production, other issues are also more important to adapt to rainfall patterns. In addition,

adaptation is limited by the lack of information and knowledge and lack of credit or financial support which suggests that farmers may be willing to adapt, but that they do not have financial support and any technical information about rainfall pattern. However, farmers have made changes in their farming practices by adapting their cropping calendar taking into account rainfall changes. They share their experiences and solutions followed by ritual offerings and prayer; thus by sowing same crop on different dates, by livelihood diversification etc. Availability of wetland (water) and short cycle of varieties of crops and labor force are seen as important issues that guides farmers' decision towards adaption. Therefore, it is clear that farmers have made no sustainable adaption strategy in their agricultural system. This situation leads to mal adaptation on the long-term of rainfall change, but they are coping with adaptation on the short term through autonomous strategy. .Furthermore, historically, farmers whose livelihoods depend on rainfall agriculture have developed ways to cope with climate variability autonomously (FAO, 2008). However, anticipatory and planned adaptation is an urgent concern for farmers due to level of damage and the speed of risks.

5.2 Recommendation

The discussion and conclusions of this study show that farmers are aware of climate pattern but their perceptions could be influenced by recent event of climate issues. Therefore, in order to confirm what farmers perceived as changed, it will be appropriate for the researcher to stay in the community for some years for in- depth research.

Based on finding of this research and to come up with a sustainable adaptation strategies of climate change, I would like to suggest that all various actors (agricultural entrepreneurs, researchers, consultants, policy makers, supplier and processing industries, retail, customers etc) who are involved in agricultural development sector in Benin should come together as one to create space for innovation towards adaptation to climate change through Visual Problem Appraisal (VPA).

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Annexes

Annex 1: Questionnaires for semi structured interview

1. Have you noticed any long-term changes in rainfall over the last 20 years? (please explain)
    - Has the number of rainfall days stayed the same, increased, or declined over the last 20 years?
2. Have you noticed any long-term changes in the mean temperature over the last 20 years? (Please explain).
    - Has the number of hot days stayed the same, increased, or declined over the last 20 years?
3. What adjustments in your farming have you made to these long-term shifts in rainfall?
    a. Alternate crops available/ spacing and time of planting /sowing different varieties of crop/ change crop variety
    b. Problems (yield & area under cultivation whether increasing or decreasing)
    c. Pest and diseases (relate to climate change)
    d. Harvesting and storage (how , when; yield loses; storage method and duration)
    e. Seed (source, storage, treatment and selection criteria)
4. What are the perceived hindrances to adaptation of rainfall variability?
    a. . Lack of improved seeds
    b. . Lack of knowledge on adaptation methods
    c. Lack of information on weather incidence
    d. . Lack of money to acquired modern techniques
    e. There is no hindrance to adaptation

Annex 2: Check list for focus group discussion

1. Farmers' perception of rainfall pattern?
2. Aspects of temperature, rainfall, storm events/drought are important or relevant to farmers crop production
3. The yearly rains are not supporting crop production as before
4. Rainfall pattern has lead to rural-urban migration
5. Rainfall variability has lead to the change of livelihood system
6. Adaptation strategies as potential responses to climate variability
7. Perceived hindrances to adaptation of rainfall variability?

Annex 3: Research planning

Activities	Jul.	Aug.	Sept.	Under Supervision
Travelling from Netherlands to Cotonou	9 to 10			VHL_Dr Loes
-Making appointment with Regional Centre for Agriculture Promotion staffs	12-13			
- Field trip Cotonou to Central Benin -Meeting with Regional Centre for Agriculture Promotion staffs for the choice of the village	14-14			
First data collection	15 to 24			
Travelling from Central Benin to Cotonou	25			
Synthesis of the first field work	26-27			Dr Vodouhe/ University of Abomey Calavi
- Field trip Cotonou to Central Benin -Second data collection	From 28 July to 7August			
Travelling from Central Benin to Cotonou		8		
-Review data gathered, review of literature		9 to 16		Dr Vodouhe/ University of Abomey Calavi
Travelling from Cotonou to Netherlands		17 to 19		VHL_Dr Loes
Complete results analysis Further literature review and finalize writing of thesis		From 19 Aug to 12 Sept		VHL_Dr Loes
Submitting of thesis			13	VHL_Dr Loes