FINAL RESEARCH REPORT

HOUSEHOLD AND COMMUNITY EXPERIENCES AND PERCEPTIONS OF CLIMATE CHANGE IMPACTS DUE TO DROUGHTS IN THE SAHEL REGION OF BURKINA FASO

MARCH 2014

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ACRONYMS AND ABBREVIATIONS

ACPC	African Climate Policy Center
AGED	*Association pour le Gestion de l'Environnement et le Développement* (Association for Environment and Development Management)
ARCC	African and Latin American Resilience to Climate Change
CILSS	*Comité Permanent Inter-Etats de Lutte Contre la Sécheresse dans le Sahel* (Permanent Interstate Committee for Drought Control in the Sahel)
CONASUR	*Conseil National de Sécour d'Urgence*
CREAF	Center for Environmental Research and Agricultural Training of Kamboinsé
CVD	*Conseil Villageois de Développement* (Village Development Council)
DRED-SHL	*Direction Régionale de l'Economie et du Développement - Sahel*
ECOWAS	Economic Community Of West African States
ENSA	*Enquête Nationale de Statistiques Agricoles* (National Survey for Agricultural Statistics)
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GDP	Gross Domestic Product
IDR	Institute of Rural Development
INERA	Institute of Environment and Agricultural Research
IPCC	Intergovernmental Panel on Climate Change
MED	*Ministère de l'Economie et du Developpement*
MRAH	Ministry of Animal and Fishery Resources
NAR	Natural Assisted Regeneration
OECD	Organisation for Economic Co-operation and Development
ORSTOM	Office de la Recherche Scientifique et Technique d'Outres Mer
PANA	*Programme d'Action Nationale d'Adaptation*
PLACE	Prosperity, Livelihoods, and Conserving Ecosystems Indefinite Quantity Contract
SRAT	*Schéma Régional d'Aménagement du Territoire*

SWAC	Sahel and West Africa Club
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development

GLOSSARY

Adaptation: Actions taken to reduce vulnerability to actual or expected changes in climate stimuli or their effects and consequences on communities' livelihoods, which lessens negative impact or exploits beneficial opportunities.

Adaptation Practices: Changes including adoption of technologies engaged by local communities to enhance their resilience and/or reduce their vulnerability to actual and expected changes in climate.

Adaptive Capacity: The ability of a system to adjust to climate change (including climate variability and extreme climate events) to moderate potential damages, take advantage of opportunities, or cope with the negative consequences.

Agriculture or Farming: Economic activity based on crop and/or animal productions. In Sahelian area, farming includes three major sub-systems: cropping, pastoralism, and agro-pastoralism.

Agro-Pastoralism: An integrated farming system aiming to capitalize on the complementarity between crop and livestock productions in order to diversify and increase farmers' livelihoods and resilience to climate stress, pests and diseases, and market risks. In this report, farmers practicing agro-pastoralism system are called agro-pastoralists.

Breeders: People involved in animal production, either through pastoralism or agro-pastoralism systems. Therefore, breeders include both pastoralists and agro-pastoralists.

Breeding or Animal Production: Animal raising for meat and/or milk production, either through pastoralism or agro-pastoralism systems.

Climate Change: A statistically significant variation in either the mean state of the climate or in its variability persisting for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces owing to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Community: A group of people living together in one place, e.g., in a village; also called "local community."

Composting: Improved process of producing organic fertilizers through decomposition of both vegetal and animal organic matters in a dugout ditch.

Crop Producers: People engaged in crop production either through cropping or agro-pastoralism systems.

Cropping System: Farming system based on crop growing for household consumption and/or income earning.

Farmers: People relying on farming, including crop and/or animal productions, for their major livelihoods.

Half-Moons: Large holes in the shape of a semi-circle where the excavated material is deposited on the semi-circle. They allow runoff water to be captured and can also hold organic material (see photos in Annex).

Household: A group of people, generally but not necessarily relatives, who live under the same roof and rely on same or common resources and farming for their livelihoods. This also includes individuals who live outside of the village but have not established their own family yet.

Natural Assisted Regeneration (NAR): Consists of promoting and protecting the shoots of woody species in the crop fields to promote regeneration of degraded soils and to create multiple-use agro-forestry systems.

Pastoralism: Farming system based essentially on animal breeding for milk and/or meat production and generally involving the practice of transhumance. "Pastoralism," therefore, has generally a mobile aspect characterized by the moving of the herds in search of fresh pasture and water. In this report, farmers practicing agro-pastoralism system are named pastoralists.

Sahel/Burkina: This is the part of Burkina Faso that falls within the Sahel; it is also the name of the one of 13 regions in Burkina Faso. This region is located in the northern part of the country, and borders Mali and Niger. It includes the provinces Seno, Soum, Oudalan, and Yagha. In this report, Sahel/Burkina is sometimes replaced by the term "study area."

Sahel: The agro-climatic and bio-geographic zone of transition localized from north to south between the Sahara desert and the Sudanese savannah. It stretches in Africa from the Atlantic Ocean to the Red Sea, covering countries such as Senegal, Gambia, Mauritania, Mali, Burkina Faso, Niger, Nigeria, Cameroon, Chad, Sudan, and Eritrea. In this report, Sahel is sometimes replaced by "Sahelian region".

Slow-onset: For the purpose of this study, "slow-onset" refers to the late starting of rains, its early cessation, or a "failure of rains" during the rainy season. Slow-onset events are very common in the Sahelian region and have significant implications on crop and animal productions.

Stone lines: Rocks deposited along contours to slow runoff water, increase infiltration, and capture sediments (see photos in Annex).

Technologies: Set or package of measures and knowledge used or which can be used (transferable) by farmers for better resilience to climate and other biophysical stresses and for better livelihoods.

Transhumance: Seasonal and cyclical migration of breeders over long distances across countries seeking of better grazing, water resources, and better market opportunities.

Zaï Technique: Digging small holes in the field before the first rains to retain runoff water. Organic matter and fertilizer is placed inside to create favorable growing conditions (see photos in Annex).

EXECUTIVE SUMMARY

INTRODUCTION

This one-year small grant on "Household and Community Experiences and Perceptions on Climate Change Impacts due to Droughts in the Sahel Region of Burkina Faso" began in April 2013. The grant was awarded to *Association pour le Gestion de l'Environnement et le Développement* (Association for Environment and Development Management [AGED]) by the African and Latin American Resilience to Climate Change (ARCC) project, a United States Agency for International Development (USAID) funded Task Order implemented by Tetra Tech ARD under the Prosperity, Livelihoods, and Conserving Ecosystems (PLACE) Indefinite Quantity Contract. The grant was implemented by AGED, a non-governmental organization based in Burkina Faso, with guidance from the United Nations Economic Commission for Africa–African Climate Policy Center (UNECA-ACPC) situated in Addis Ababa, Ethiopia.

The aim of this study is to identify key practices used by smallholder farmers in response to the impact of recurrent droughts in the Sahelian region of Burkina Faso and to understand the factors determining famers' adaptive choices. The research questions that guided this study are:

1. *What are the main strategies and measures adopted by people living in the Sahel area of Burkina Faso in response to the frequent incidences of drought?*
2. *What do local people report as the reason why they adopt one practice over another?*

By addressing these questions, the results of this study provide information that can help to identify practices that could enhance current responses to the impacts of climate change and climate variability among households located in the study area.

The study was carried out in the northern part of Burkina Faso located in the Sahel zone. The Sahel region of Burkina Faso was chosen for this study because of the zone's limited rainfall and frequency of drought. The targeted study populations of this study were smallholder farmers, including crop producers and agro-pastoralists, and pastoralist communities of the selected villages whose livelihoods predominantly depended on rainfall.

RESEARCH METHODOLOGY

Methods used consist of a combination of qualitative methods (focus group discussions [FGDs], and key informant interviews) and more quantitative methods (household questionnaire survey). Household questionnaires were administered to 500 respondents from 16 villages and three provinces. A total of 12 FGDs were conducted within four villages with men; women; youth; and key political, religious, and community leaders.

SUMMARY OF FINDINGS

The results of the study reveal that the socio-economic activities of people in the study area are predominantly crop production and livestock rearing. Crop production (also referred to throughout the paper as farming) constitutes the main livelihood activity of around 41 percent of households surveyed, while roughly 53 percent reported agro-pastoralism as their main activity. Crop production is primarily based on the growing of millet, sorghum, and cowpeas, while livestock rearing focused on breeding

cattle, sheep, and goats for milk and meat production. Only two percent of households reported practicing pastoralism as their primary activity. Non-farming activities, such as trading and panning for gold, are minor and only three percent of households reported non-form activities as their main livelihood. On average, households engaged in two livelihood activities, but some had up to seven.

The results indicate that drought is the main climate constraint for both crop and animal production in Sahel of Burkina Faso. Drought is an aggravating factor for the other biophysical constraints identified in the study, namely decline in soil fertility, pest and diseases, water scarcity, disappearing of grazing, erosion, and desertification.

These climatic and biophysical constraints affect the livelihoods of populations through significant impacts on crop production, livestock, food prices, and labor availability. The recurrent and severe episodes of drought lead to a significant drop in crop yields, as well as important environmental disturbances with the upsurge of plant and animal pest and diseases, the disappearing of grazing land, and the drying up of rivers and water sources used for livestock.

To deal with droughts and other biophysical constraints, populations in the study area are using a set of coping and adaptation practices to minimize the effects of climate change. These measures include practices for reducing exposure to climate risk and shock (adaptation practices) and post-risk management mechanisms (coping practices). The coping practices are often used after the onset of drought despite adaptive efforts, and can often have negative implications for households.

Risk and shock reduction practices, also referred to as adaptive practices, include the modification in farming systems and the adoption of water and land management technologies. Modifications in cropping systems include the adoption of new crop varieties, planting of several varieties, adoption of new crops, and the removal of crops and/or varieties deemed more vulnerable. Regarding the adoption of water and land management technologies, crop producers mainly use organic matter, mulching, stones lines, natural assisted regeneration (NAR), zai, and half-moons to reduce their exposure to drought. Crop producers also reported that they use organic manure, mulching, chemical fertilizers, stone lines, and zai to address the challenge of declining soil fertility. Measures used to combat erosion include stone bunds, NAR, mulching, and windbreaks.

Changes to livestock practices include the adoption of new animal breeds and species and the removal of breeds and species deemed more vulnerable to drought. Breeders also use crop residues, woody forage, transhumance, and groundwater due to increased water and grazing scarcity.

However, adaptive practices used to reduce risk and exposure to drought and shock were not seen to be sufficient to build farmers' resilience to respond to the severe and recurrent episodes of drought in the Sahel of Burkina Faso. Consequently, people have developed post-risk management strategies to reduce short-term risk and exposure. Post-risk management mechanisms, also referred to as coping practices, include asset liquidation, transfer and risk sharing, migration, changes in food habits, use of grain banks, participation in local and international solidarity networks, and the use of ecological services including forest and biodiversity resources. Women play an important role in this mechanism through selling some of their assets, and harvesting non-woody forest products that are used for food consumption and income.

Farmers' adaptive choices are determined by socio-cultural characteristics, access to technical services, awareness about climate change and adaptation, and the characteristics of their production systems. Gender and the land rights also significantly affect farmers' adaptation decisions. For example, individuals who do not hold land property rights are less likely to adopt land and water management micro-technologies. Similarly, the sex of the head of the household and women's decision-making authority affects the chances of adopting certain water and land management techniques. Furthermore, cases where a household member attended an awareness or capacity building training on climate change

adaptation were more likely to use water and land management technologies. Also, the more households are connected to the market, the more access they have to using technologies, such as drought-tolerant crop varieties. The proportion of degraded land and number of cattle or ruminants owned are other factors which significantly influence farmers' adaptive choices.

Despite their current adaptive efforts, people in the Sahel of Burkina Faso continue to experience the adverse impacts of drought and are looking for more effective and more appropriate measures to deal with drought. Efforts must be made to provide additional measures to strengthen the capacity of people who, despite their current efforts, still suffer from impacts of increasingly severe and recurrent episodes of drought. In conclusion, the study reveals the need to strengthen the capacity of crop producers, agro-pastoralists, and pastoralists in the study area to respond to extreme climate events, such as drought, through the promotion and improvement of adaptive practices.

RECOMMENDATIONS

The findings of this study have implications for policy makers and planners at both the county and national government levels. Several recommendations for future interventions are presented below.

- Promote and scale up the use of water and land management technologies, including organic manure, mulching, drought-resistant varieties, stone lines, NAR, agro-forestry, and zai.
- Improve farmers' access to information and markets to increase the ability to capitalize on market opportunities and to adopt alternative crops and economic activities.
- Improve farmers' access to credit in order to enhance their ability to adopt more advanced and input-demanding technologies, such drought-resistant varieties.
- Address the gender gap and social differentiations in resource control.
- Strengthen the existing mechanisms for risk sharing and transfer, such as grain banks and local and international networks for solidarity, among other mechanisms.
- Implement additional risk-sharing and transfer mechanisms in order to support risk reduction, such as micro-insurance programs and programs for social security.
- Increase awareness of climate change adaptation and/or land and water management practices through training and capacity building programs.
- Encourage integration of cropping and breeding systems through promoting multipurpose crop varieties (food and forage), composting and manure production techniques, and forage and crop residue storage techniques.
- Promote additional research efforts on agro-forestry, mixed crop-animal-tree systems, supplemental animal feeds, and land and water management technologies.

1.0 BACKGROUND

1.1 CONTEXT AND RESEARCH QUESTIONS

The Sahel zone in northern Burkina Faso has experienced recurrent and severe episodes of drought since the mid-1970s, which have had adverse impacts on communities' livelihoods. Today, there is a great concern about how this region can cope with current changes in climate patterns and secure their already more climate-sensitive livelihoods. For decades, local communities in the Sahel have used adaptation strategies to sustain their livelihoods during droughts and extreme climatic events. However, with the increased frequency and intensity of droughts and climate variability, there is a need for local communities to develop more complex and effective adaptation strategies. Available evidence leaves no doubt that extreme and slow-onset drought is undermining the livelihood resource-base on which Sahelian farmers, agro-pastoralists, and their families depend for survival.

The Sahel of Burkina Faso (referred to in this report as Sahel/Burkina Faso or the study area) region's socio-economic and ecological systems are under high exposure to climatic threats. The results from various studies indicate that climate change has already had significant impacts on the farming systems in the Sahel (Joachim, 2011; Kiema et al., 2013). The effects of climate change and climate variability have severe repercussions on farmers and pastoralists. Preliminary results from a case study undertaken by the Institute of Environment and Agricultural Research (INERA) in collaboration with the African Climate Policy Center (ACPC) on climate-related loss and damage among rural communities in the Sahel[1] indicated that drought was the climate extreme event that affected households the most in the Sahel region of Burkina Faso, as indicated by 98 percent of survey respondents. The same survey revealed that 98 percent of respondents still suffered from the negative effects of drought, despite adaptive measures used.

Impacts of droughts have increased in recent years. More severe crop failures and death of large numbers of livestock have directly affected millions of people whose livelihoods depend on these systems. Of all the challenges currently facing rural communities in the Sahel, the most pressing is halting, or at least lessening, the adverse effects of climate change on livelihoods.

This study attempts to document the various measures that communities and households have adopted in response to climate change impacts. In particular, the study looks at the two main livelihood groups in the Sahel: farmers and agro-pastoralists. Several studies have shown that more than 90 percent of households in the Sahel engage in crop production and/or livestock breeding as their main activity and primary source of livelihood (Ministry of Animal and Fishery Resources [MRAH], 2012). This study provides a base on which to identify practices and technical interventions that could enhance current response measures among communities and households in the study area.

Data collection was done through individual household surveys, focus group discussions (FGDs), in-depth interviews at the household and community levels, and key informant interviews. Specific attention was given to gender dimensions and disadvantaged groups. Data were analyzed using standard statistical procedures.

[1] INERA (2012). Climate related loss and damage assessment among rural household in the Sahel region of Burkina Faso. Draft Case Study Report.

This study is a starting point for understanding the points of entry for future interventions. It provides farmers and pastoralists with information about how various options will potentially increase income and crop yield, protect household food security, and help to decrease the negative effects of climate change at the household level. This study, and the sharing of its findings, seek to strengthen farmer and agro-pastoralists' participation in decision-making at the local level in order to increase the sustainability of interventions and improve the effectiveness of measures adopted. Finally, this study hopes to encourage future studies that measure the effectiveness of the adaptive practices identified and presented here.

There are several key gaps in the literature review and current research that this study seeks to address. First, no clear evidence could be identified in the literature review of the coping and adaptation practices currently being used by households in the Sahel zone of northern Burkina Faso. Second, there is no clear, documented understanding of why certain practices are chosen over others, or how and who makes those decisions. Our research questions intend to address these gaps. Specifically, the principal research questions are:

1. *What are the main strategies and measures adopted by people living in the Sahel area of Burkina Faso in response to the frequent incidences of drought?*
2. *What do local people report as the reason why they adopt one practice over another?*

The results of this study provide information on practices that could enhance household responses to the impacts of climate change and climate variability in the study area.

The main objective of the study is to analyze community experiences, perceptions, and responses to climate change impacts in the Sahelian area of Burkina Faso. The specific objectives are:

- Analyze perceptions about the impacts of drought on cropping and breeding systems in the Sahel/Burkina;
- Identify the major adaptation practices used by farmers in response to the recurrent and severe episodes of drought in Sahel/Burkina; and
- Analyze the determining factors of adaptive choices of farmers.

1.2 STUDY AREA

The Sahelian region in West Africa is the transition zone between the Sahara desert and the Sudanese savannah of Africa and stretches from the Atlantic coast of West Africa up to Sudan (Ridder, Stroosnijder, and Cissé., 1982). The zone receives 150–900 mm of rainfall per year. In West Africa, the Sahelian region covers several member countries of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS): Burkina Faso, Cape Verde, Gambia, Guinea-Bissau, Mali, Mauritania, Niger, Senegal, and Chad.

In Burkina Faso, the Sahelian area spans an area of 36,166 square kilometers and is one of the 13 administrative regions of the country according to the spatial indentation of 2001. It is characterized by a very limited rainfall and experiences frequent droughts. Sahel/Burkina covers three agro-ecologic zones including the Northern zone, the Sahelian zone and the South-Sahelian zone (Figure 1.1). The region includes four provinces (Oudalan, Séno, Soum, and Yagha), with 650 villages and 969,881 people grouped in 182,769 households (*Direction Régionale de l'Economie et du Développement - Sahel* [DRED-SHL], 2007). The population is composed of 49.7 percent males and 50.3 percent females (DRED, 2003), with a large ethnic diversity including Fulani/Peulh, Rimaïbé, Foulcé, Mossi, Gourmantché.

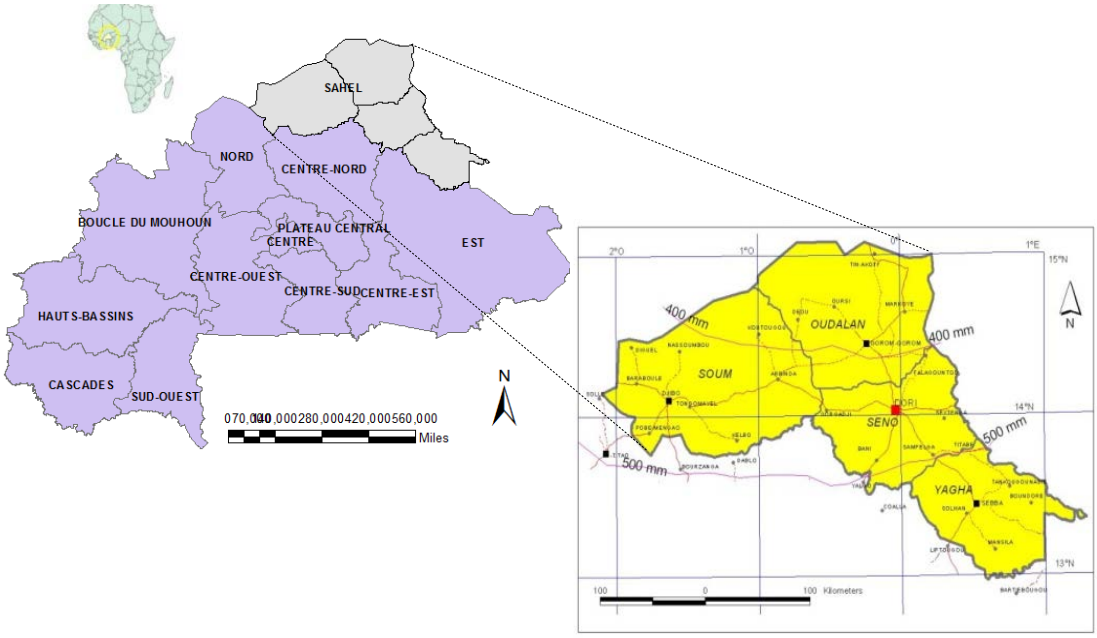

Figure 1.1: Provincial Boundaries of the Sahel in Burkina Faso
(Source: Kiema, 2008)

1.3 CLIMATIC CONDITIONS

1.3.1 Rainfall

The decrease in rainfall during the last decades is among the largest recognized effects of climate change in the Sahel (United Nations Environment Programme [UNEP], 2012). Actually, the Sahelian region has undergone important long term changes in the weather patterns with significant implications on rainfall which has decreased persistently during the last four decades (Somé, Toé, and Ouattara, 1998). It has been reported that the average rainfall in Sahel over the last four decades has remained below one of the period 1900-1970 average (Hulme et al., 2005). The decrease in rainfall continues (L'Hôte, Mahé, Some, and Triboulet, 2002; L'Hôte, Mahé, Some, 2003) although less dramatically after the mid-1990s compared to the 1980s. Recent evidences indicate a light increase of rainfall since 1990s, but the amount of precipitations is still low compared with a poor distribution to the periods before 1970 (Mahé and Paturel, 2009)

In Sahel/Burkina Faso, the annual rainfall has decreased drastically during the last five decades. The average annual rainfall over the 10 last years is 480±135 mm (Kiema, 2008). Studies have shown several decades of latitudinal shift of mean isohyets southward over the period of 1951–2000 (MECV, 2007). The shift of annual mean isohyets had significant consequences on the delineation of climatic zones in the region (Figure 1.2). Specifically, the Sudano-Sahelian zone has been narrowed with an extension of the Sahelian zone throughout 1951–1971. The decade 1981–1990 appears as the driest with the manifestation of the isohyets 300 mm at extreme north of the Sahel/Burkina (Figure 1.3). Some suggested that this drying trend in Sahelian area may be explained by either decadal modes of natural variability or by human-driven emissions. However Duncan et al. (2011) pointed to both aerosol and greenhouse gas emissions as triggers of the changes in weather patterns in Sahel.

Many episodes of severe droughts have been reported after 1970 in Sahel/Burkina Faso, including during the years 1970–1973, 1983–1984, 1991–1992, 1997–1998 and 2003–2004. Empirical evidences and knowledge about the impacts of these drought episodes in the region are sparse.

Figure 1.2: Rainfall by Agro-Climatic in Northern Burkina Faso

Figure 1.3: Zone Average of rainfall showing the dryness pattern of the Sahel region at the Northern Burkina Faso

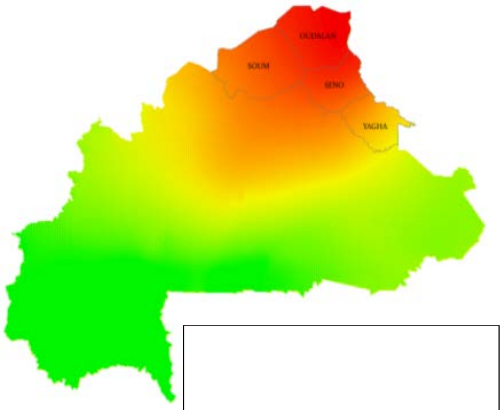

TABLE 1.1: CLIMATIC CHARACTERISTICS OF THE SAHEL REGION

Parameters	Values
Annual rainfall	< 600 mm
Length of the dry season rainfall	110 d
Number of rainy days	< 45 d
Average annual temperature	29° C
Seasonal amplitude	11° C
Humidity in the dry season	20
Humidity in the wet season	70
Annual evaporation	2,200–2,500 mm
Annual evaporation	3,200–3,500 mm

Somé, 2003

1.3.2 Temperature

Average annual temperature in the study area is 29°C. During the last decades, temperatures in the Sahelian areas have increased faster than the global trend, increasing from 0.2°C per decade before 1970 to 0.8°C since the late 1970s (ECOWAS-SWAC/OECD/CILSS, 2008). According to AGRHYMET (2008), it is predicted that global warming will cause the minimum temperatures increase up to +1°C, and the maximum temperatures to increase up to +0.5°C in Sahel. Half of the models used in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report: Climate Change 2007

have predicted an average increase of 0.5 degrees in Sahel (Christensen et al. 2007). Greater warnings of an increase of around 4° are expected in some parts, including in the western areas of the Sahel.

1.3.3 Extreme Weather Events

Extreme weather events, such as droughts, floods, temperature peaks, violent winds, and desertification, are expected to become more recurrent in Sahelian areas. In Sahel/Burkina Faso, people have experienced many unexpected flooding years during the last two decades. Particularly, the provinces of Yagha and Soum are most prone to flooding. August, July, and September are recognized as the most-sensitive flooding months, with increased flood risk compared to the annual average (*Programme d'Action Nationale d'Adaptation* [PANA], 2006). Deficits in rainfall are also assumed to be greater and recurrent due to climate change. Over the last two decades, the Sahelian region of Burkina Faso has experienced eight years of severe droughts resulting from significant deficits in rainfall patterns. These extreme climate events, previously experienced only in the province of Gorom Gorom, are spreading with greater intensity over the entire region with great threats to cover the whole nation. These events are potential accelerated factors of the erosion and desertification which already represent other natural constraint affecting Sahelian people.

1.3.4 Natural Resources

In the Sahelian region of Burkina Faso, communities are largely dependent on natural resources for their livelihood. The adverse effects of climate change on these resources threaten rural communities' livelihoods. The adverse impacts of climate change on the natural resources include land and vegetation degradation, biodiversity and ecosystem disturbance, and water scarcity.

Soils, Land, and Vegetation

The Sahel is characterized by soils mostly inadequate for vegetation due to their low permeability that inhibit the infiltration of water. The larger share of the lands is arid and uncultivated because of desertification and erosion. As a result, the smaller share of lands, which is more adequate for crop production, is continuously being over-exploited without any real efforts at maintaining soil productivity through using fertilizers. Soils are therefore generally infertile and equally very sensitive to physical degradation under the increased climatic and human threats. Pastoral lands even suffer from overgrazing and poor management. In addition, the advent and expansion of gold panning sites throughout the region have contributed to land degradation and scarcity.

Land over-use and degradation led to increased pressure on the vegetation. Starting in the 1970s, vegetation in the Sahelian region began declining (De Wispelaere, 1990). However, a slight recovery in vegetation was observed in the mid-1980s, particularly on the fossil dunes of province of Oudalan in Sahel/Burkina Faso (Rasmussen et al., 2001; Herrmann et al., 2005). Pastures and grazing become very scare with important implications on people livelihood mostly based on agro-pastoralism.

Soils are also subject water and wind erosion, which make them susceptible to degradation in addition to the impacts of poor farming practices.

Biodiversity and Ecosystems

Land, defined as the aggregate of all surface areas, excluding bodies of water, represents 91 percent of the Sahelian territory and is primarily covered with herbaceous plants. The other major ecosystem resources include river streams, reservoirs and ponds, floodplains, wetlands, and irrigated ecosystems. The real value of these different ecosystems for national economics and for livelihoods is still unknown.

Also, a major knowledge gap remains on the impacts of erosion on social and economic conditions of people (Warren et al., 2001).

Moreover, the biological potential of the land experienced increasing pressure from climate change and human activities. These pressures result in such impacts as:

1. Decreased ability to meet the demands for goods and services;
2. Disruption of biological resources due to significant migration into the Sahel; and
3. The acceleration of land degradation due to overgrazing and trampling.

Water Resources

Water resources in the Sahel/Burkina include rivers, tributaries, natural pools, and shallows. The main streams watering the area are the River Béli, River Gorouol, and River Sirba (and their tributaries). There are several retaining reservoirs in the area; the greatest is the dam of Yakouta, the capacity of which is estimated to be about 26 million m^3. Stream flows vary greatly throughout the year. The dry season exhibits a drop of the flows with a number of perennial pools. The most important of these pools are those of Oursi, Tin-Akoff, Yomboli, Dori, Darkoye, and Soum. During the rainy season, water levels increase and the pools spill over significantly. Over the last 50 years water availability in Sahel/Burkina has declined drastically. Rainfall deficits were estimated to be 15–20 percent during the 1980s. The river streams progressively disappear and even are discontinued in many parts as a result of decline in rainfall, sandbanks and sedimentation.

1.4 POVERTY AND VULNERABILITY

Sahelian people are particularly vulnerable to climate risks since their livelihoods depend greatly on climate sensitive sectors such as rain-fed cropping, free-range breeding and natural resources. A recent study indicates 96 percent and 93 percent of Sahelian people are involved in crop and livestock productions, respectively, against only 20 percent and 3 percent who are involved in trade and fishing (op cit, INERA 2011). But, many empirical evidences indicate that climate change is significantly affecting farming systems in the Sahel (Joachim, 2011; Kiema et al., 2009). According to Oxfam (2012), grain production in many parts in Sahel was 36 percent lower in 2011 than the average for the previous five years (2006–2010). The most affected households are those which depend on subsistence farming. The incidence of poverty for subsistence farmers is 44 percent against 36 percent for those who essentially produce for the market (Ministère d L'Économie et du Développement [MED], 2005). Women and other marginalized and disadvantaged groups are more vulnerable to poverty (Table 1.2). Youth are relatively marginalized by a gerontocratic social structure – where elder members of the household are the decision makers. The tendency among youth is to leave their villages at seeking of economic opportunities in cities and neighboring countries.

The region is already food unsecured due to frequent and intense droughts that are caused loss of livestock and decreased crop production in the past. The production losses have led to severe hunger and malnutrition, loss of human lives, disease, and mass displacement of people from rural areas to nearby cities. Population mobility is exacerbated by recurrent drought episodes in the region, and is leading to significant conflicts around land, pasture and water control (Benjaminsen, Alinon, Buhaug, and Buseth, 2012). Actually, competition for natural resources is increasing and causing greater tension between transhumant breeders and other users of natural resources, such as crop producers and foresters (SWAC/OECD, 2010).

TABLE 1.2: VULNERABILITY OF SOCIO-ECONOMIC GROUPS

Socio-economic group	Incidence of poverty (%)	Depth level (ft)
Subsistence farming	43.7	13.0
Progressive agriculture	36.4	10.5
Inactive	28.7	8.3
Unemployed	23.4	6.9
Other assets	14.4	3.5
Nonagricultural independent	8.9	2.0
Unprotected workers	7.8	1.5
Protected workers	1.3	3.0

Sources: MRA (2005) / PANA (2006)

1.5 PRODUCTION SYSTEM

1.5.1 Cropping System

According to figures from the National Survey for Agricultural Statistics (*Enquête Nationale de Statistiques Agricoles* [ENSA], 1993), crop production is the main activity of people living in the Sahel area of Burkina Faso. Cropping represents the main activity of 81 percent of the active population and employs 93 percent of all men and 69 percent of all women. Crop production is staple crop-based, with millet, sorghum, and maize as the main crops. Crop production in the study area still remains very extensive and manual with a low input use. As a result, crop yields in this region are very low compared to Sudanian and humid regions. Estimates indicate that the average yields of millet and sorghum range from 150–400 kg/ha (Claude, Grouzis, and Milleville., 1991; Kiema, Ouedraogo, Nianogo, and Sanou, 2001). On average, households produce three staple crops and one cash crop. The average harvested acreage is of 5.75-8 hectares.

1.5.2 Pastoralism

Pastoralism in the Sahel is characterized by animal breeding for milk and/or meat production, and generally involving the practice of transhumance. The breeding is dominated by ruminants including cattle, sheep, and goats, but with also some monogastric stock such as donkeys, camels, horses, and poultry. The most common cattle breeds reared in Sahel are *Puli Puli* bovine (or *Fula* zebu in the Sahel), *Bodrogui* bovine (or *Bororo* zebu), *Goudali* zebu, and the Azawak zebu. Sheep breeds include *Bali* and the *Peul* sheep, while *Sahel* and *Maradi* represent the most common breeds of goat. Pig raising is minimal and is explained by the cultural characteristics predominated by Muslims.

On average, pastoralists own around 27-29 heads of cattle and around 23-16 and 14-11 heads of goat and sheep, respectively (DRED-SHL, 2007). Breeding techniques are various and more extensive. They include transhumance, which is one of the major practices used by pastoralists to gain access to natural grazing and water and to cope with the adverse effects of recurrent droughts on pasture resources. Animal feeding types include natural grazing (herbaceous and ligneous plants), crop residue (cereal straw, legume haulm, wheat bran, seed pod, and sorrel and sesame branches), and feed from picking (water lily bulbs). Crop residues and feed from picking are usually used as supplemental feed for more vulnerable animals, mainly young calves and dairy cows that are weakened by pasture scarcity in dry season. Increasingly, breeders' use natural grazing is becoming scarcer. Mineral salts also represent an important component of animal feeding in the study area. Some salts are kitchen salt, made in Niger, but

common salt and salt licks are also used (Claude et al., 1991). However, animal breeders still encounter significant challenges to feed and water their livestock.

1.5.3 Agro-Pastoralism

One of the fundamental economic characteristics of the study area is the coexistence of crop and livestock production in the farming system. Agro-pastoralism is an integrated farming system aiming to capitalize on the complementarity between crop and livestock productions in order to diversify and increase farmers' livelihoods and resilience to climate stress, pests and diseases, and market risks. While agro-pastoralists depend mainly on extensive breeding for their livelihoods, they also are greatly engaged in crop production for food security. About 94 percent of the Sahelian people practice crop production, while more than 80 percent are involved in various types of breeding (*Schéma Régional d'Aménagement du Territoire* [SRAT], 2006). In most cases, agro-pastoralism results in a reconversion of highly affected pastoralists who have experienced an irreversible loss of their livestock during the severe episodes of drought of 1973–1974 and 1983–1984. When livestock losses reach a certain threshold—often 50 percent of a cattle herd—it is difficult for the pastoralist to remain wholly on pastoralism for their livelihoods. Consequently, many pastoralist become agro-pastoralists by practicing unsecured crop farming. This explains the surge of agro-pastoralists during the last decades in the Sahelian area of Burkina Faso.

2.0 METHODOLOGY

The research approach includes qualitative methods through focus group discussions and key informant interviews, and quantitative methods based on household surveys.

2.1 FOCUS GROUP DISCUSSIONS

Focus group discussions were held in four villages distributed in the four provinces of the study area. Three FGDs were held in each village. The focus groups' participants included the leaders of the Village Council Development (CVD), the village heads, and members of other key groups such as women and youth. A total of 12 FGDs were conducted.

Villages were notified two-to-three days prior to the date of the discussions. This helped to spread the news and make the required arrangements to succeed the FGDs. For each group, the discussions were carried out with a discussion guide designed for this purpose (Appendix 1). Each discussion group was composed of 20–50 individuals including crop producers, agro-pastoralists, and pastoralists, with men, women, and youth well represented. The average duration of the discussion was about one hour. Table 2.1 presents the different villages involved in the focus group discussions. No major problems were reported during the FGDs.

TABLE 2.1: NUMBER OF FGDS PER VILLAGE

Province	Village	Number of FGDs
Séno	Sambonaye	3
Soum	Tongomayel	3
Oudalan	Bagawa	3
Yagha	Solhan	3
	TOTAL	**12**

2.2 KEY INFORMANT INTERVIEWS

Ten key informant interviews were conducted with resource persons. The people interviewed were adults of over 50. Interviews with resource people were carried out with a semi-structured survey guide. The resource people were selected in light of their experience in the region in diverse areas of development, particularly crop production, breeding, governance, politics, and leadership, and also took into account their understanding of the problems associated with climate change in the Sahel. Interviews focused on natives or long-term residents who have lived through or been repeatedly afflicted by the effects of climate changes in the region.

2.3 HOUSEHOLD SURVEYS

A total of 500 households distributed across 16 villages within four provinces of the Sahel region were surveyed as shown in the Table 2.2 (next page). Stratified sampling was used for these surveys. At the regional level, villages were selected in a manner to cover the four provinces. Villages were also selected in a way that could capture regional differences. Within each village, the persons to be interviewed were

chosen by neighborhood. Households were selected based on age and ethnic representation. Those interviewed were household heads or their representatives.

Data were collected using a questionnaire developed for this purpose. Data collection was carried out by enumerators under the control of supervisors. Both enumerators and supervisors are experienced in data collection, having at least secondary school and master's degrees, respectively, and the ability to speak the native languages of the study area. Data collected was recorded using SPSS software.

Data collected from vulnerable persons was also done using a survey questionnaire. This questionnaire was administered to people with a specific history of exposure to the effects of climate change; that is, people who were identified as those particularly vulnerable to the effects of climate change.

Before administering the survey, a training session for enumerators and supervisors was held to explain the research goals and data collection method. At the end of the training, the questionnaires were pre-tested in the village of Diouga with five households. Actual investigations lasted 45 days, from September 20–November 5, 2013.

For each village surveyed, a supervisor for two enumerators was assigned to provide advice to the enumerators and control the quality of the data collection. Investigation permits that briefly stated their mission objectives were issued to the supervisors by the Association for Environment and Development Management (AGED) in order to facilitate and formalize their interventions in the study area.

On average, each enumerator administered three household survey questionnaires per day. It took up to one day for supervisors to complete the survey forms on the vulnerable persons.

One constraint was that the questionnaire was very lengthy. Considerable time was required to fill out the questionnaire, which became a burden to household heads being surveyed.

The surveys were conducted at the interviewee's home. All the selected sites were accessible and the interviews went smoothly due the fact that AGED and INERA are institutions well-known by the farmers.

TABLE 2.2: SUMMARY OF VILLAGES AND NUMBER OF VILLAGES SURVEYED

Province	Village	Number of households
Séno	Sambonaye	25
	Lelly	40
	Diouga	20
	Niagassi	40
Soum	Tongomayel	40
	Belhou	30
	Koutougou	20
	PobéMengao	40
Oudalan	Tin Akoff	36
	Bagawa	18
	Darkoye	26
	Oursi	24
Yagha	Mansila	40
	Boundoré	34
	Solhan	22
	Titabé	45
TOTAL HOUSEHOLD SURVEYS		**500**

2.4 DATA ANALYIS

Data entry was done in SPSS using a template adapted to the survey form. After the entry, the data were cleaned before proceeding to the analyses. Descriptive statistics and logistic regression (Logit) were used for the analyses. Analyses were done by a statistical analyst at United Nations Economic Commission for Africa–African Climate Policy Center (UNECA-ACPC).

2.5 MAJOR CONSTRAINTS

The team observed that a significant amount of time was spent preparing for the interviews, especially the notification period for people to convene. Scheduling meetings with the resource persons was also difficult because of time conflicts, resulting in delays in conducting these interviews. The survey form was quite long. Administration time was relatively lengthy, which at times contributed to tiring the heads of households being interviewed. In spite of these challenges, no major problems were encountered related to data collection and analysis.

3.0 FINDINGS: GENERAL CHARACTERISTICS AND PERCEPTIONS

3.1 SOCIO-ECONOMIC CHARACTERISTICS OF HOUSEHOLDS

The heads of household surveyed were predominantly male (96 percent). The results indicate a large ethnic diversity in the study area. The ethnic majorities in the Sahel region are Peulh, Rimaïbé, Foulcé, Bella and Mossi. Islam is the principal religion and is practiced by approximately 97 percent of households surveyed. The other religions, namely Christianity and animism, have minimal presence and are only practiced by around 3 percent of households surveyed.

Agriculture remains the principal activity of people in the study area. Approximately 98 percent of households surveyed indicated agriculture as their principal economic activity. The other 2 percent depend mainly on non-agricultural activities, such as trade, gold panning, and crafts for their livelihood.

Of the approximately 98 percent who indicated agriculture as their principal activity, 41 percent of household are engaged in crop production as their principal activity, 55 percent indicated agro-pastoralism as their principal activity, and only 2 percent of households practiced pastoralism as their principal activity.

Other activities – including trade, crafts, gold panning, and wage earning – are practiced by around 3 percent of households as their principal activity. Households practice an average two activities, but practice up to seven activities in certain situations practice (Table 3.1). The average age of the head of household is 49 years old. The average household size is 12 persons, and the average duration of living in the region is 45 years.

TABLE 3.1: SAMPLE DISTRIBUTION BY PRINCIPAL ACTIVITIES FOR THOSE THAT INDICATED AGRICULTURE AS THEIR PRINCIPAL LIVELIHOOD

Province	Principal Activity		
	Crop production	Agro-pastoralism	Pastoralism
Seno	43% (n=52)	56% (n=67)	01% (n=1)
Oudalan	18% (n=19)	75% (n=78)	04% (n=7)
Soum	67% (n=83)	32% (n=39)	01% (n=1)
Yagha	38% (n=52)	61% (n=83)	01% (1)
TOTAL BY PRINCIPAL ACTIVITY	**43% (n=206)**	**55% (n=267)**	**02% (n=10)**

3.2 ROLE OF WOMEN IN AGRICULTURAL PRODUCTION

Table 3.2 indicates the role of women in the principal economic activities practiced in the study area. In crop production, women are often in charge of planting, collecting and transporting manure, weeding, and harvesting activities. For animal production, they are responsible for milking and processing and selling milk. Women also raise small ruminants and poultry. Women are specialized in small-scale trading and selling poultry products, especially eggs.

TABLE 3.2: GENDER DISTRIBUTION OF RESPONSIBILITIES IN ECONOMIC ACTIVITIES

Main Activities	Men	Women
Livestock	• Conducting grazing animals • Maintaining health and watering herds • Practicing transhumance • Processing milk and feeding/fattening	• Practice of fattening • Watering and feeding of calves and animals not taken to pasture • Processing and selling milk
Agriculture	• Seeding, plowing, weeding, fertilization (manure) harvesting, and collecting crop residues • Protecting damaged fields	• Seeding, thinning, manure collecting, weeding, and harvesting • Aiding in field protection
Artisanal craft making	• Masonry, jewelry, blacksmithing, and brick making	• Making straw mats and leather goods (manufacturing bags and other leather items)
Business trade	• Livestock commerce, grain and boutique items	• Small businesses (cakes, peanuts, and cola) • Selling poultry products • Selling farm-fed animals (sheep and cattle)
Gold panning	• Digging holes, grinding, washing, and extracting ores	• Blowing sand, washing and extracting ores
Exploitation of natural resources	• Collecting firewood	• Selling firewood, collecting and selling non-wood related products
Fishing	• Fishing	• Frying, smoking, and selling fish

Source: Focus group results

3.3 FARMERS' PERCEPTIONS ON RECENT DROUGHTS

According to focus group participants, the most recent severe episodes of droughts in the Sahelian region of Burkina Faso are those of the years 2004 and 2011. Those that occurred in 2004–2005 were characterized by a drastic reduction in rainfall with at most 30 rainy days. The drought of 2011 was characterized by a late onset and an early cessation of rains. Focus group participants noted a reduction in rainfall and an uneven distribution in time and location during the last 20 years, with some years having exceptional heavy rainfall.

The consequences of the extreme climatic events of 2004 and 2011 on crop and livestock production have resulted in decrease in crop yields and the upswing of destructive crop pests and diseases, such as locusts. For breeding, the lack of pasturage and the drying up of water sources for watering cattle were notable. This led to considerable herd loss and early and long departures for transhumance. Many pastoralists and agro-pastoralists are not fully recovered, as they have not yet restored their herds after the major losses experienced during these extreme episodes of drought.

At the social level, there was a strong migratory movement of youth and certain heads of household who left the study area for other villages or other regions. Some have even left their villages permanently. Many people sold personal equipment and assets (such as carts, bicycles, telephones, and

women's jewelry) in order survive and to cope with adverse of the drought. One anecdote reported was that some had even sold their beds. The drought affected the social fabric by weakening the sense of solidarity and social assistance that is part of the culture in the region. Some farmers noted that their dignity was violated because they were forced to resort to begging in order to assure their survival.

3.4 CONSTRAINTS ON CROP AND ANIMAL PRODUCTION

Tables 3.3 and 3.4 present the ranking of major constraints confronting the farmers of the study area. The results indicate that the principal constraint for crop production is drought, which affects almost all activities. Around 98 percent of households surveyed reported being severely affected by drought at least once in the course of the last 10 years. The other major constraints noted are decline in soil fertility and plant diseases (Table 3.3). Erosion and desertification seem less important in the view of crop producers compared to the challenges of decline in soil fertility and plant pests and diseases. These results support those of the FGDs, which had also indicated an upsurge of insects, other crop pests, and animal diseases during the 2004 and 2011 episodes of drought.

TABLE 3.3: CONSTRAINTS RANKING FOR CROP PRODUCTION

Constraints	Average Rank	Priority
Drought	1.616	1
Soil fertility	3.78	2
Plant diseases	4.33	3
Desertification	5.03	4
Erosion	5.59	5
Flooding	5.89	6

For animal production, the major constraints indicated by the farmers are, in order of importance, drought, lack of pasturage, scarcity of water, and animal diseases (Table 3.4). These results also support those of FGDs. Market constraints linked to price reduction in animal protein products (such as meat, milk and eggs) are less important for breeding, given that considerable price drops of these products are less frequent. Numerous studies have indicated increased price and demand for such protein products, as meat, milk, and eggs during the recent last years in the Sahelian area.

Drought represents an aggravating factor of other constraints, including reduction in fertility, diseases, water scarcity, lack of pasturage, erosion, and desertification. During the FGD, farmers mentioned upsurge of pest and diseases as one of the implications of drought in 2004 and 2011. Implementing effective adaptation strategies of for drought control is therefore necessary to improve the livelihood of Sahelian populations, and could contribute to alleviating numerous other constraints that the farmers face.

TABLE 3.4: CONSTRAINTS RANKING FOR ANIMAL PRODUCTION

Constraints	Average Rank	Priority
Drought	1.86	1
Pasture scarcity	2.17	2
Water scarcity	2.38	3
Animal diseases	3.27	4
Desertification	3.35	5
Price drop	4.24	6

3.5 SENSITIVITY OF LIVELIHOODS TO DROUGHT

Figure 3.1 indicates farmer perceptions of the impacts of drought on their major livelihood. The results indicate a large sensitivity of the principal livelihoods of people in the Sahelian area of Burkina Faso to the effects of drought. According to the surveyed individuals, drought most severely affects crop and animal production, the prices of local foods (milk, staple crops, eggs, etc.), and the availability of natural resources. Around 90 percent of the surveyed individuals declared that crop production, breeding, natural resources, and food prices are highly affected by drought. Of individuals surveyed, 65 percent said that the availability of agricultural labor is also affected.

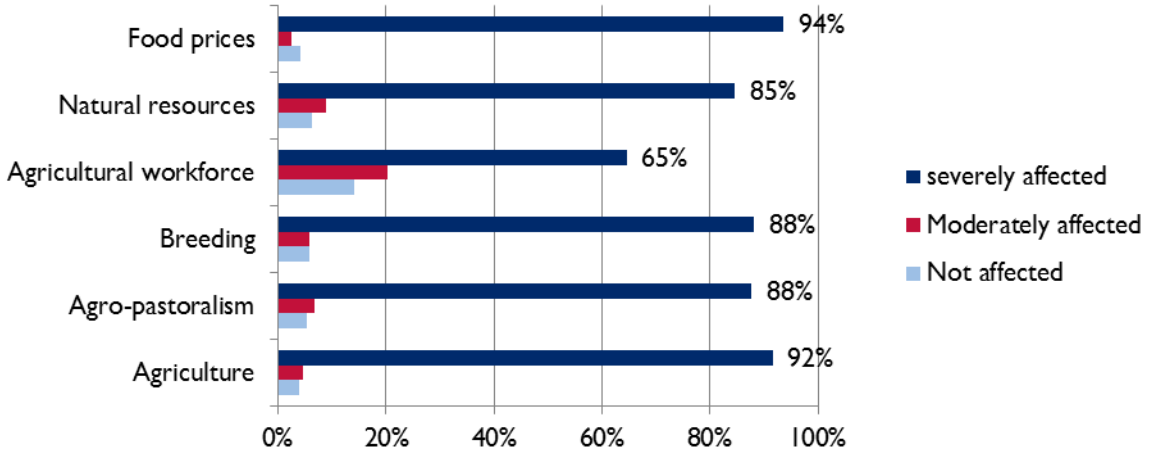

Figure 3.1: Severity of Effects of Climate Change on Farmers' Livelihoods

Nearly half the surveyed individuals stated that they lose all their cropping income in severe drought years, the rest of the surveyed individuals indicated that they experience loss of 25–75 percent when they are affected by drought. Around 12 percent of surveyed individuals indicated that they lose all their breeding income in drought years, while 38 percent stated that they lose 75 percent of breeding income (Figure 3.3). Half of the surveyed individuals indicate a decrease of 25–50 percent of breeding income during drought years. These results indicate diverse vulnerability levels of activities due to drought.

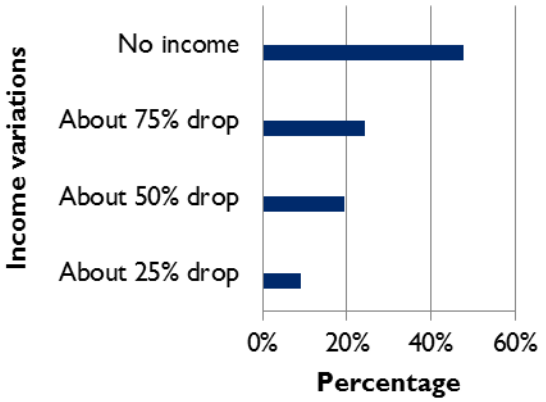

Figure 3.2: Impact of Drought on Agricultural Income

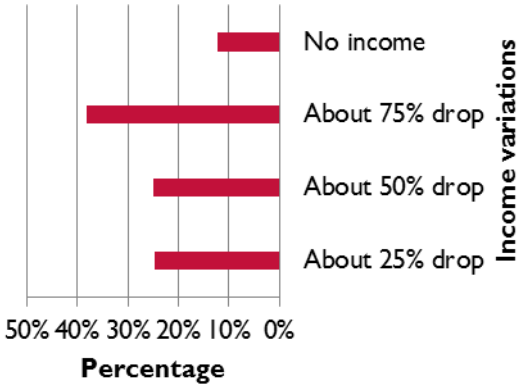

Figure 3.3: Impact of Drought on Livestock Income

Peoples' perceptions about the changes in their livelihoods align with the changes in their crop (Figure 3.2) and breeding (Figure 3.3) productions. The majority of respondents indicated that their levels of crop production have declined over the past decade in terms of either yield or area planted. More than half of crop producers (56 percent) reported a decrease in food crop yields over the past 10 years, and about 30 percent believe that the yields of cash crops have also decreased. The decline in crop yields reported by the majority of crop producers is partially explained by the occurrence of increased soil degradation and the rapid population growth during the recent decades. Both factors have pushed people to cultivate drier and poorer lands located in the north parts, where crops are more exposed to the risk of severe episodes of drought (Diakite, 2013).

In terms of income, 30 percent of crop producers indicated an increase in their cropping income during the past 10 years, while around 14 percent think having experienced a decrease. The majority of crop producers, around 70 percent, reported having observed an increase in their income generated from livestock over the last 10 years, as opposed to 23 percent who do not notice a change in their livestock income. On the other hand, 59 percent of crop producers reported a decrease in the amount of milk produced during the last 10 years. The increase in livestock income among the crop producers can be explained by the intensification or integration of livestock activities in the production system for the purpose of diversifying their livelihoods.

For agro-pastoralists, the results indicate that most have experienced a reduction in their animal production during the last 10 years. Approximately 75 percent of agro-pastoralists reported a decline in the size of their herds over the past decade, while about 80 percent indicated that their milk production has also decreased over the same period. Income from livestock declined for only 35 percent of agro-pastoralists while about 55 percent reported that they noticed an increase in their income from livestock. Regarding to crop production, only 17 percent of agro-pastoralists reported a decrease in their harvested areas of staple food crops in the last 10 years, while 56 percent think having not noticed any change in their harvested areas. However, about 67 percent reported that crop yields have declined over the last decade. These features support the evidence that there are more households moving into agro-pastoralism as a result of herders who have experienced an irreversible loss of cattle following extreme episodes of drought.

4.0 FINDINGS: ADAPTIVE PRATICES

4.1 MODIFYING CROPPING PATTERNS

Modifying crop systems is a strategy used by crop producers to confront dry climatic conditions and extreme events. This strategy involves modification of the production system through the adoption of new varieties or crops, diversification, or the abandonment of crops deemed most vulnerable. As demonstrated in Figure 4.1, the top practices adopted by the crop producers to reduce the effects of drought on crop production in the study area are resowing, adopting new varieties, integrating new crops, and planting/sowing several varieties.

Figure 4.1 shows all of the practices farmers reported using. These practices add up to more than 100 percent, as a single farmer uses a variety of strategies.

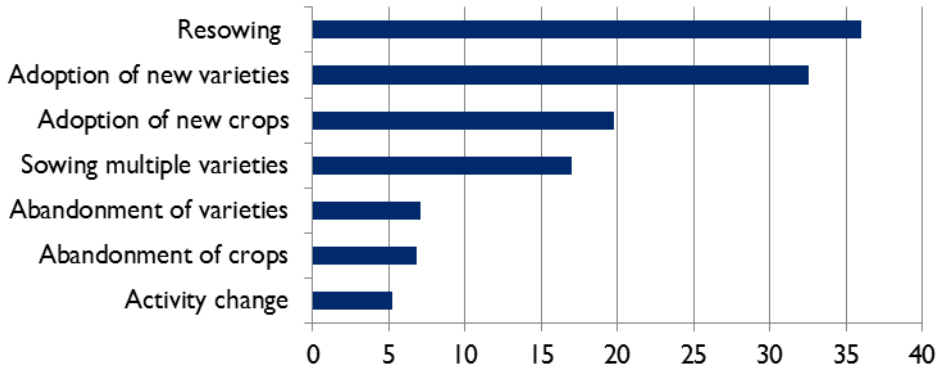

Figure 4.1: Modifications in Crop System

4.1.1 Resowing

Resowing is major practice by farmers to face to the impacts of droughts and is practiced by around 35 percent of the respondents. In resowing, a farmer will sow a field again if the first or successive sowings did not sprout due to erratic rainfall or temporary rain-break at the beginning of rainy season. It allows farmers to reduce the impacts of erratic rainfall on crop sprouting out and to reduce the impacts of drought at the beginning of the season.

4.1.2 Adoption of New Varieties

Around 33 percent of the farmers adopted new crop varieties during the last 10 years. Of the new varieties adopted, 62 percent were millet, 21 percent were sorghum, and 15 percent cowpeas. The main

reasons for adopting the new crop varieties are the shortness of the duration of the cycle and the resistance to drought. Around 70 percent of the adopters have indicated shorter cycles as the main reason for adopting the new varieties. Even for farmers are interested in adopting drought-tolerant varieties, the duration of varieties' growing cycle influences their decisions to adopt.

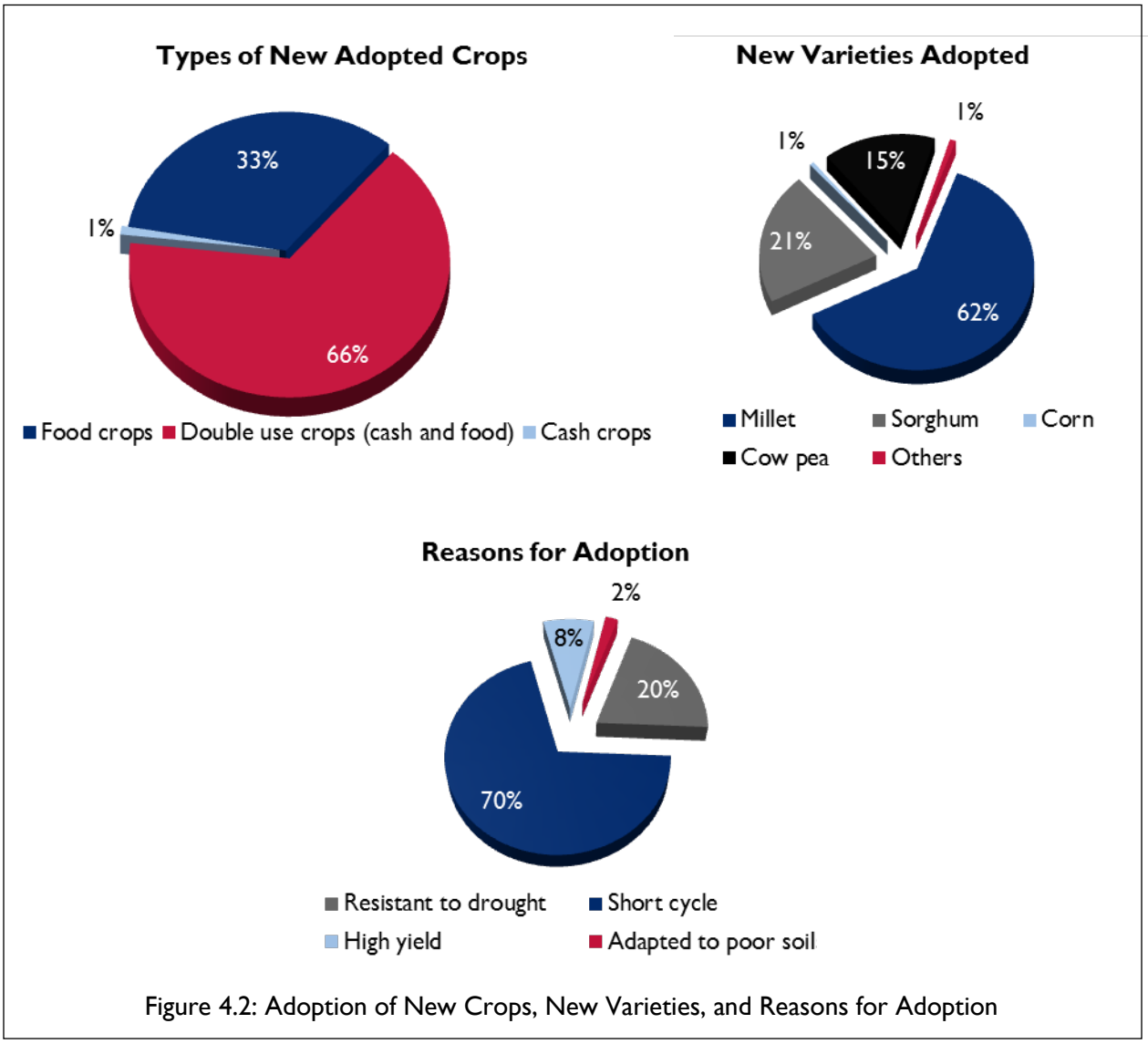

Figure 4.2: Adoption of New Crops, New Varieties, and Reasons for Adoption

4.1.3 Adoption of New Crops and Sowing Multiple Varieties

The adoption of new crops mainly involves dual-purpose crops (i.e., both subsistence and cash crops), allowing farmers to simultaneously increase monetary revenue and assure food security from their use. Around 66 percent of new crops adopted are dual-purpose crops, while 33 percent are staple food crops including millet, sorghum, and maize (Figure 4.2). According to Andres and Lebailly (2013), the adoption of dual-purpose crops becomes a practice more and more current in Sahelian area to confront numerous biophysical constraints, notably degradation and scarcity of natural resources, and also to reduce climatic risks while increasing profit from market opportunities.

Dual-Purpose Crops

The main dual-purpose crops adopted during the last 10 years are sesame, cowpeas, and legumes. Sesame and cowpeas are emerging crops in the Sahel and in West Africa, and there has been large scale adoption of these (Andres and Lebailly, 2013). According to farmers' statements, the principal reasons for adopting dual-purpose crops in the last 10 years were primarily due to their market potential and the crops' early cycle and yield. A recent study (Andres and Lebailly, 2013) in the Niger indicated the new market opportunities through an increased demand and price, the resistance to drought, the low input requirement, and the higher yields are the principal factors that enhance the rapid and massive adoption of sesame in farming systems in Sahelian region. The annual rainfall requirements for sesame vary from 250–600 mm/year (Santens, 1980) and make its very suitable to the Sahalien climate. In addition, the annual evolution of its price is characterized by an average growth of around 28 percent between 2008 and 2009 with a still-growing demand (Andres and Lebailly, 2013). At household level, sesame contributes to economic, social, and nutritional balance. It allows households to ensure their food security and to minimize the risk of a bad year for staple food crops such as millet and sorghum. For instance, sesame is used as a substitute for peanuts or "soumbala", to make sauce or to mix with sorrel leaves. It also provides the opportunity to be processed locally and provides, especially for women, a source of income through the sale of sesame-based cookies and/or oil.

Cowpeas are another dual-purpose crop adopted because of the earliness of its growing cycle and its market opportunities. Cowpeas are often harvested early when still green to meet a growing local demand for green beans. The leaves and pods of cowpeas play an important role in the food security of the population and are a source of diversification or a substitute for staple foods such as sorghum and millet during the bad years. This makes the cowpeas a dual-purpose crop as they contribute to peoples' food security, even in bad years, while helping them to earn income through the market opportunities it provides.

Staple Crops Diversification

Staple crop diversification is another practice used by farmers to reduce their vulnerability to drought. During the last 10 years, many farmers who did not grow certain staple crops before started to introduce those crops in cropping system. The new staple crops adopted during the last 10 years are millet, sorghum, and maize (Figure 4.2). They are not new in the study area, but are new for some farmers who did not grow them before. Historically, millet and sorghum are the main staple crops grown in Sahel/Burkina, as reflect of their food habits. Due to the recurrent impacts of drought on food production, people started to diversify their food production. So, millet producers have started growing sorghum, and sorghum producers started growing millet. Millet is represents 62 percent of cases where farmers decided to diversify their staple crop production, followed by 21 percent for sorghum and 15 percent corn. According to farmers, the main reasons for adopting new staple crops and sowing multiple varieties are the early maturity, the yield, and the ability to resist drought (Figure 4.3). These results indicate that the farmers have a preference for the short-cycle varieties to confront the variable climate conditions and the risks of drought.

4.1.4 Abandonment of Varieties and Crops

Abandoning crops or varieties and changing economic activities are less frequent and are in each case practiced by less than 8 percent of the respondents. This indicates that diversification of the cropping system through diversification of varieties and crops is the most common modification farmers make to the cropping system for reducing the impact of droughts on crop production.

4.1.5 Change in Livelihood Activities

Around 5 percent of farmers indicated that they have changed their principal activities during the past 10 years because of decreasing crop yields, drought, market opportunities, the scarcity of pasture, and the loss of livestock (Figure 4.3). Some producers changed from crop production or pastoralism alone to agro-pastoralism or outright to non-agricultural activities such as small trading and gold panning.

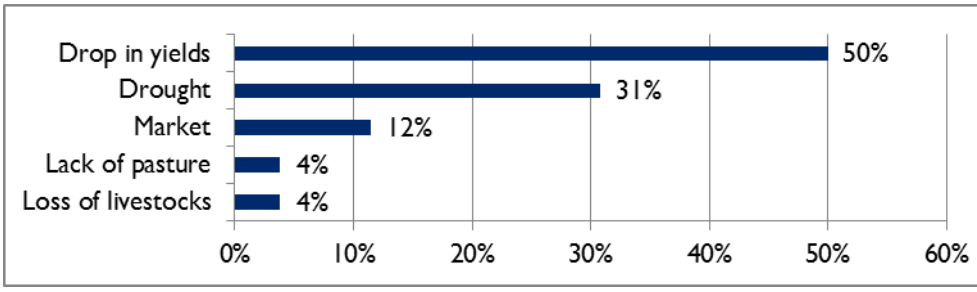

Figure 4.3: Reasons of Changes of Activities

4.2 MODIFYING LIVESTOCK (BREEDING) SYSTEM

The modifications to the livestock system involve the adoption of new breeds or species and/or the removal of other breeds or species more vulnerable to climatic constraints. Figure 4.4 indicates that in the last 10 years, around 12 percent of the respondents have adopted new breeds of animals, while 5 percent stated having integrated new species in their livestock system. The removal of animal breeds or species is relatively rare compared to adoption. The adoption of new breeds involves principally bovines (43 percent) and goats (52 percent). The new species adopted are goats (43 percent), bovines (39

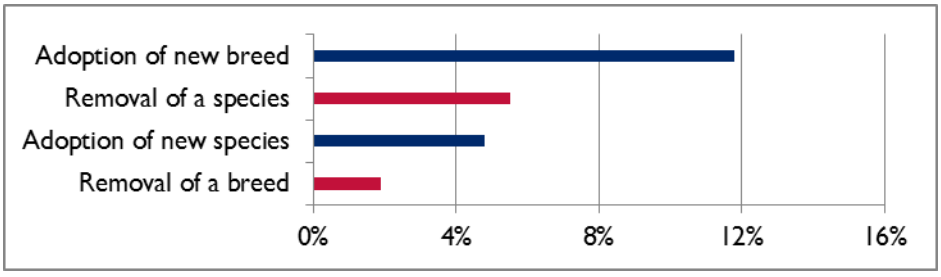

Figure 4.4: Modifications in Livestock System during the Last 10 Years

percent), and others (18 percent) (Figure 4.5).

The principal reasons for which breeders adopt new animal breeds are linked to the animals' capacity to adapt to drought, lack of pasturage, and the animals' resistance to diseases. Goats are very frugal animals and capable of searching for forage, particularly woody forage, during the dry season or drought episodes. The adoption of certain races of bovines was favored by projects and governmental programs with the objective of milk production. This was done most notably via the introduction of the Azawak

and Goudali breeds and to a lesser extent the Gir and Girolando breeds in the province. These breeds are characterized by their exceptional performance in producing milk. For instance, the average milk produced by Zebu Azawak is 8–12 liters/day compared to 2–4 liters/day for the local Zebu peulh breeds. With the breeds Gir and Girolando, farmers can produce over 20 liters/day. Yet those breeds are more feed demanding, and therefore less tolerant to pasture and animal feeding shortage compared to Azawak and local breeds. Also, Azawak, Gir, and Girolando breeds are more vulnerable to animal diseases compared to local ones as they are imported breeds.

The adoption of new species is by contrast determined by market opportunities, the productive

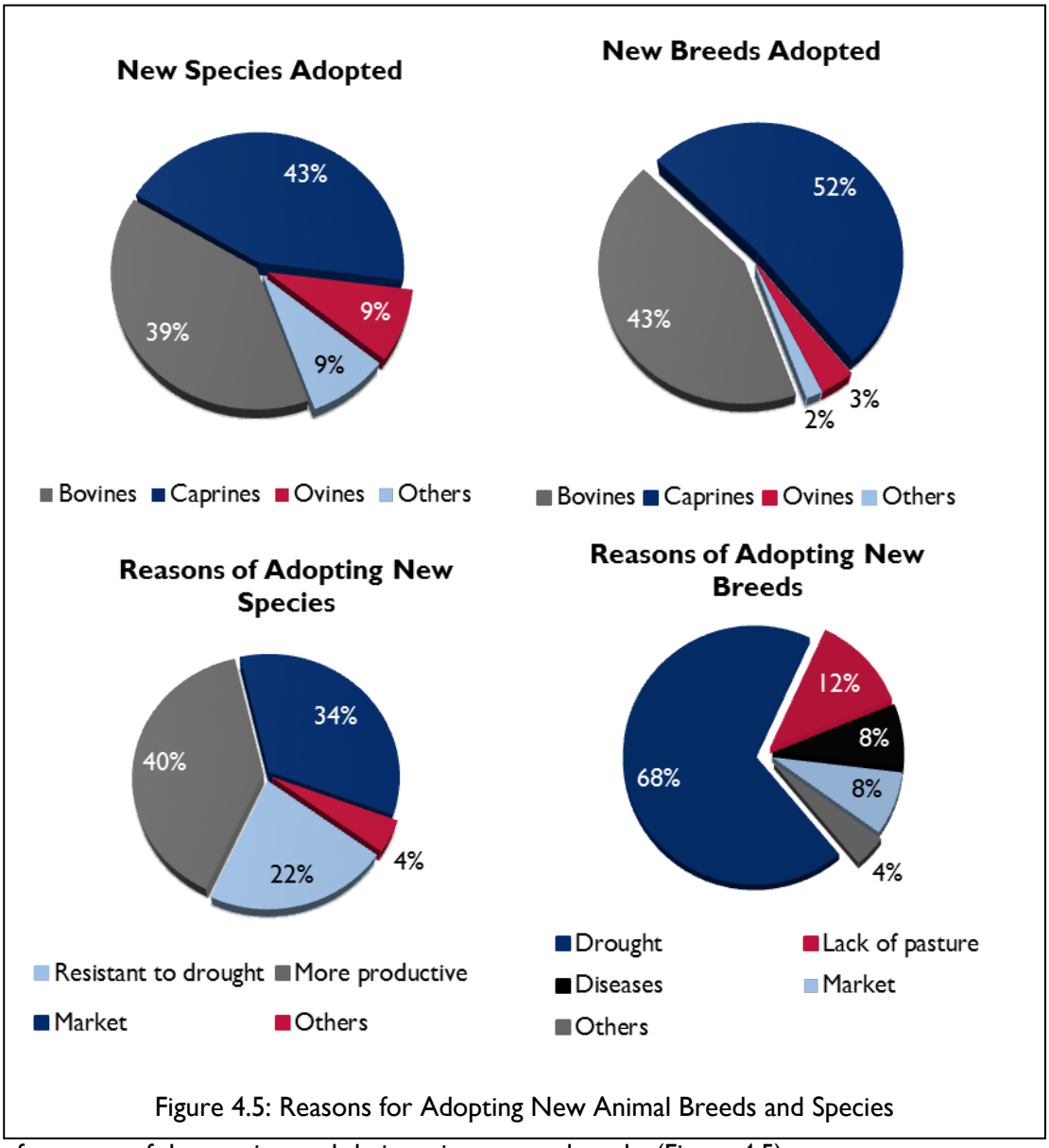

Figure 4.5: Reasons for Adopting New Animal Breeds and Species

performance of the species, and their resistance to drought (Figure 4.5).

4.3 SOIL AND WATER MANAGEMENT PRACTICES

Faced with recurring and severe episodes of drought in the Sahelian zone, farmers have been undertaking vast projects of land restoration, via local techniques of sustainable management of soil and water, especially related to water conservation, land protection, and agro-forestry. The techniques include a diverse range of integrated measures for improving water management, restoring fertility, and increasing soil humidity.

Figure 4.6 shows the principal practices identified in Burkina Faso in matters of soil and water management. Organic manure was mentioned as the most common practice. It is used by 88 percent of surveyed individuals for various functions. Other dominant practices are stone lines, natural assisted regeneration (NAR), and mulching, each used by 42 percent of those surveyed, followed by fallow land used in 23 percent of the respondents. Other less-dominant practices are zai, compost, half-moons, grass strips, and wind screens. However, farmers' perceptions about the effects and the roles of these various practices in regard to the different climatic and biophysical constraints they are facing are various. One practice can serve to combat many constraints.

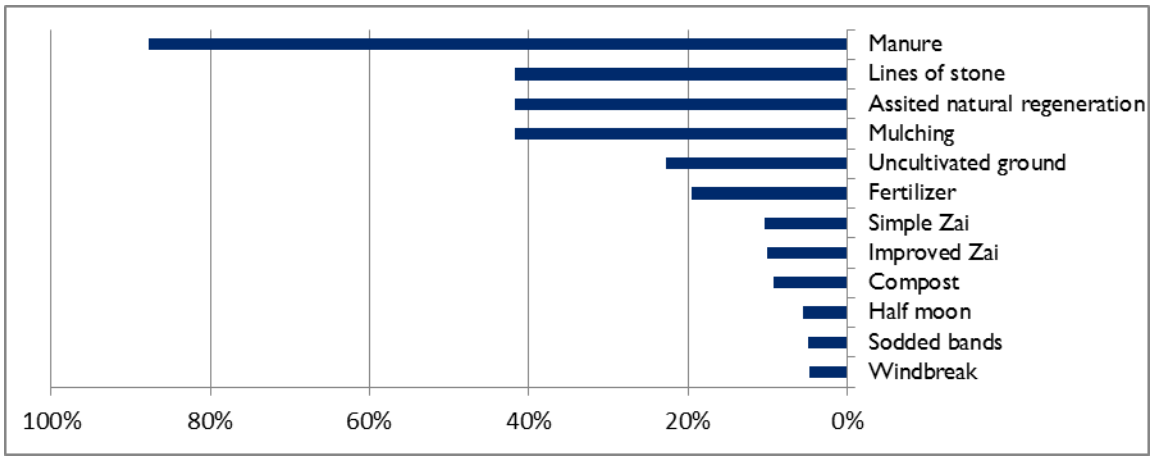

Figure 4.6: Water and Soil Management Practices

In the following sections, the paper further explores practices used to combat the specific constraints, including: drought (Section 4.4), soil fertility (Section 4.5), desertification (Section 4.6), and erosion (Section 4.7), and pasture and water management (Section 4.8). This was done intentionally, as it was clear that individuals make different choices based on the major constraints they are facing and their perceptions on the practice in combating a specific constraint. For instance, manure, mulching, and stones lines are the major water and soil management practices that the respondents use to combat drought, while stone lines are more used to combat erosion. The following sections help highlight why certain practices are chosen over others.

Some definitions

Zai: On-farm rainfall harvesting practice consisting of digging small holes in the field before the first rains to retain runoff water (***simple zai***). These holes are later used for sowing crops after the first rains. With ***enhanced zai***, organic matter or mulching and a little fertilizer are placed inside the holes to create favorable growing conditions (See photo in Appendix). Also, the way the holes are arranged with improved zai is different from simple zai, and takes into account the direction of runoff water on the plot with also some requirements about the spacing between the holes in order to enhance water catching in the holes.

Half-moons: Large holes with the shape of a semi-circle where the excavated material is deposited on the semi-circle. Millet, sorghum, and maize are sown in half-moons. The half-moons allow capture of the runoff water, and therefore to improve soil humidity and reduce water stress for the crops. Farmers may use manure as fertilizers in half-moons (see photo in Appendix).

Some definitions, continued.

Stone lines: Rocks deposited along contour lines in order to slow runoff, increase the infiltration, and capture the organic sediments that contribute to improve soil fertility (see photo in Appendix).

Natural assisted regeneration (NAR): Promoting and protecting the shoots of woody species in crop fields in order to enhance the regeneration of degraded soils and create a multiple-use agro-forestry system.

Composting: Improved process of producing organic fertilizers through decomposition of vegetal and animal organic matters in a dugout ditch.

4.4 DROUGHT CONTROL PRACTICES

Many studies have shown that water and land management practices have diverse and multiple effects, from improving fertility, restoring degraded land, and restoring vegetation canopy closure (e.g., Yameogo et al. 2013; Zougmoré and Zida, 2000; Doamba, Nacro, Sanon, and Sedogo, 2011). This study showed that techniques such as using organic manure, mulching, stone lines, NAR, agro-forestry, and zai are the most common practices employed by farmers for mitigating the adverse effects of drought on crops (Figure 4.7). Around 45 percent of those surveyed consider organic manure as a practice for combating drought. It is used in combination with other practices such as zai or placed directly at plant level to improve soil humidity and fertility and create favorable conditions to plant development. Stone lines, NAR, agro-forestry, and zai are other adaptation practices households reported using to combat the effects of drought on crop production. The different techniques employed by farmers indicate their usefulness for adapting to diverse needs and conditions.

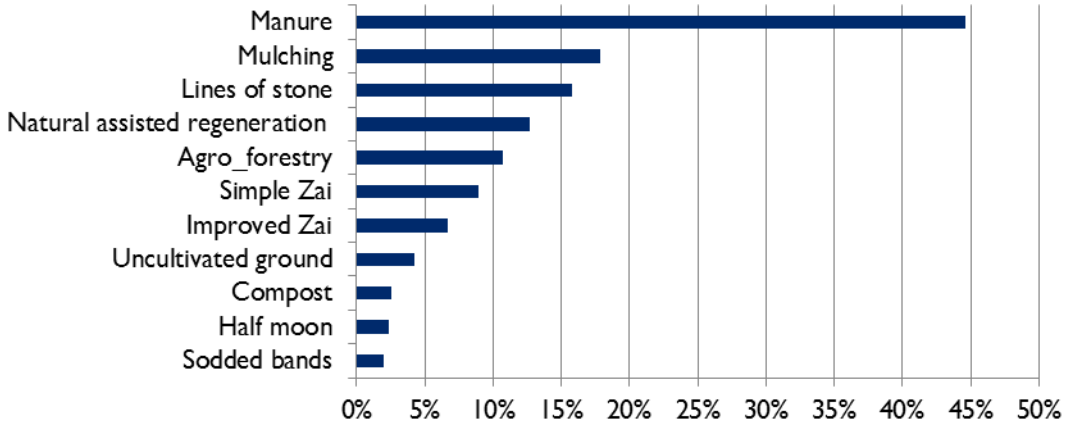

Figure 4.7: Drought Control Practices

The enumerators were trained on these different terms, which were explained to farmers in clear and simple words. For instance:

Drought: Unusual delay in the beginning the rainy season, unusual dry spells during the rainy season, and/or the shorting of the rainy season.

Desertification: Denudation of the vegetative cover on large extent of lands that were recovered before, making the lands unsuitable for cropping and grazing.

Water scarcity: The disappearing of natural and artificial water sources such as rivers, natural springs, lakes, artificial dams, and other water sources usually used to irrigate crops and/or water animals.

Erosion: Large ravishment of lands making them unsuitable for crop production.

Soil fertility: The drop of crop yields on the lands due to their over-use, at an extent where they require an intensive use of fertilizers (or to be left for fallow) before being suitable for crop production.

4.5 SOIL FERTILITY MANAGEMENT PRACTICES

According to farmers' statements, the decline in soil fertility is the second major constraint to crop production in Sahel/Burkina Faso. Farmers use mainly organic manure, mulching, stone lines, and chemical fertilizer to combat this (Figure 4.8). Results indicate a consensus relative to farmers' perceptions on the importance of these practices in managing soil fertility. The majority of users of these practices indicated they are the suitable measures for improving soil fertility. Other empirical studies confirm the farmers' perceptions of the importance of these for improving soil fertility (Yameogo et al. 2013; Doamba et al. 2011; Sawadogo et al. 2011).

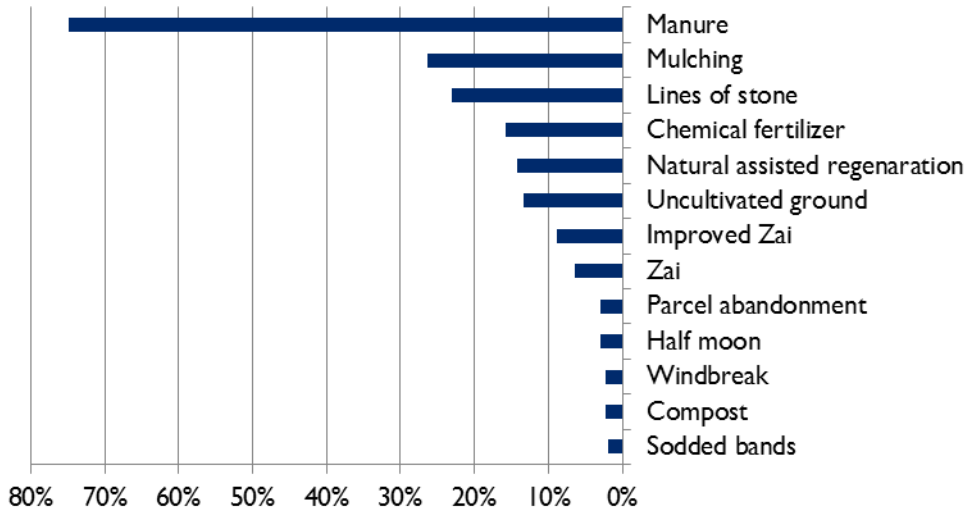

Figure 4.8: Soil Fertility Management Practices

4.6 PRACTICES FOR COMBATING DESERTIFICATION

For combating desertification, NAR, stone lines, and organic manure are the most used practices (Figure 4.9). Meanwhile, the proportion of farmers considering these practices as measures for controlling desertification is relatively small relative to the proportion of farmers using them. In the case of NAR, only one-third of adopters indicated that this practice combats desertification. It is the same for stone lines and organic manure, with only 13 percent of those surveyed having indicated each of these practices as measures to control desertification, while the rates of adopting these practices are 42 percent and 88 percent, respectively. This means that NAR is more suitable in combating desertification than other practices, which are more suitable in combating other constraints.

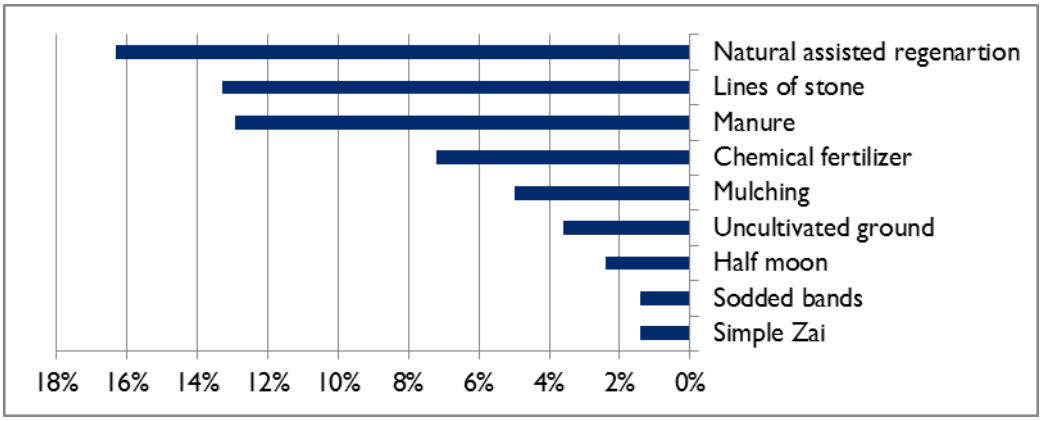

Figure 4.9: Practices for Combating Desertification

4.7 PRACTICES FOR COMBATING EROSION

For confronting erosion, farmers indicated that the stone lines are the principal practice used (Figure 4.10). The other practices indicated are NAR, grass strips, mulching, and windbreaks. Yet the proportion of those surveyed having indicated these practices as measures for combating against erosion is relatively small compared to share of respondents using these practices. This indicates that farmers prefer use stones lines to combat erosion rather than other existing water and land management practices. Those practices, as shown in previous paragraphs, are suitable to combat other constraints.

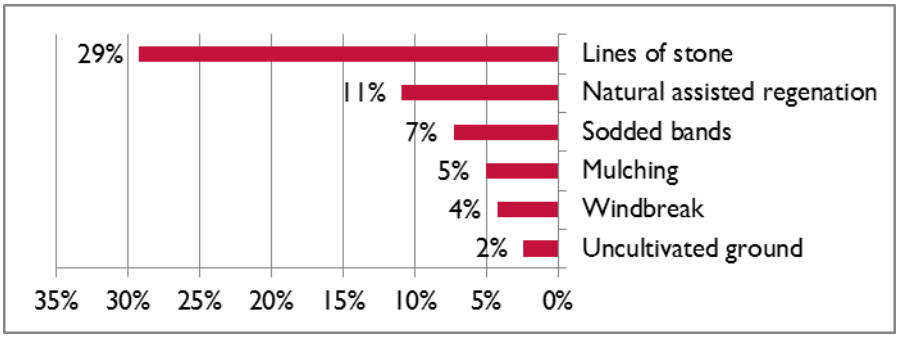

Figure 4.10: Practices for Combating Erosion

4.8 PASTURE AND WATER MANAGEMENT PRACTICES IN LIVESTOCK SYSTEM

The scarcity of pasture and water are the major effects of drought on the pastoral production in the Sahelian region. In light of these constraints, farmers resort to a range of practices, namely use of crop residue, woody forage, breeding/feeding, seasonal transhumance, and use of groundwater. According to the study, crop residue and woody forage were the most commonly cited techniques for addressing scarcity of pasturage in the Sahel (Figure 4.11). Around 25 percent of producers indicate that they practice more and more feeding, while others have resorted to seasonal transhumance in view of guaranteeing access to water and pasturage for their herd during periods of drought. Groundwater (i.e. pastoral wells and boulis) is used by around 5 percent of those surveyed as alternatives to the disappearance and lack of surface water for watering the animals, especially in the dry season.

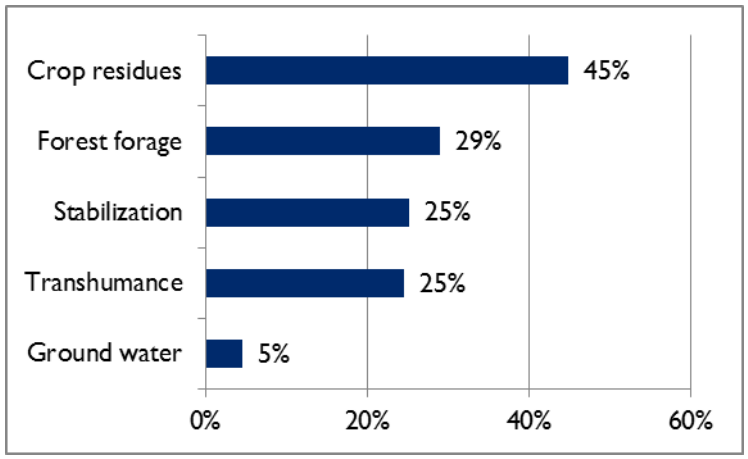

Figure 4.11: Water and Pasture Management Practices in Livestock

5.0 FINDINGS: COPING PRACTICES AND POST-RISK MANAGEMENT OF CLIMATIC SHOCKS

In our approach, we have split the adaptation practices in two major groups:

1. *Risk- and shock-reduction practices*, which include all strategies used by farmers to reduce their exposure to the shocks and its effects on their farming system. These practices are already described in previous sections and include changes in farming systems and water and soil management practices. They are implemented before the risk occurs, and are often thought of as adaptation practices.
2. *Post risk-management practices*, which include strategies used by people after the risk has occurred, despite the adoption of risk and *Risk- and shock-reduction practices*. These are often thought of has coping practices.

This section is devoted to post-risk management practices, which includes asset liquidation, transfer and risk sharing, migration, and changes in food habits, among others.

Despite efforts to reduce the negative impacts of climate change and variability, people in Sahel/Burkina Faso are not fully sheltered from the negative effects of drought on their livelihood. They are still vulnerable in various ways to drought that reduces their traditional sources of livelihood, namely crop and animal productions. The efforts to reduce vulnerability are therefore not sufficient to ensure the resilience of the Sahelian population to the effects of more severe and regular droughts. Being aware of this, the population implements post-risk management mechanisms as an additional resilience measure to risk reduction and exposure practices. Post-risk management mechanisms includes asset liquidation, transfer and risk sharing, migration, changes in eating habits, grain banks, local and international solidarity networks, and ecological services including forest and biodiversity resources.

5.1 ASSET LIQUIDATION

Liquidation of assets constitutes an important strategy for post-drought risk management in the study area. This strategy includes the sale of animals and other household assets such as such as carts, bicycles, telephones, beds and women's jewelry, All of these practices are common in the study area. Around 88 percent of households surveyed indicated that they sell animals as a drought coping strategy, while around 33 percent reported they sell other operating assets (Figure 5.1, next page).

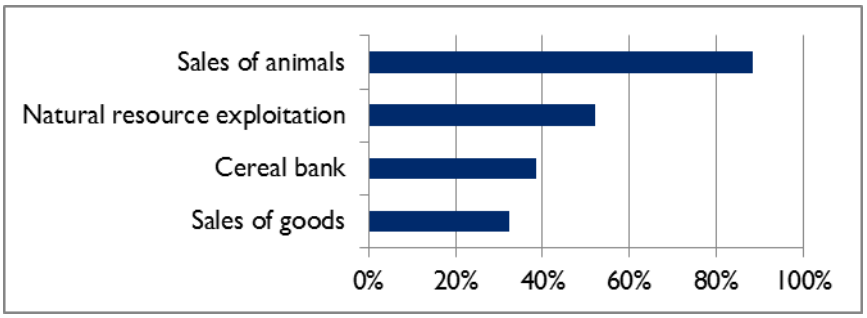

Figure 5.1: Asset Liquidation

5.2 USE OF ECOSYSTEM SERVICES AND NON-WOOD OR WOOD FOREST PRODUCTS

Natural resources, namely forests products, play a significant role in Sahelian communities' livelihoods and resilience to drought and others bio-physic constraints. Around 98 percent of surveyed people have reported that they depends on forest woody-species for various needs such food security, animal feeding, earning income, both animal and human health as well plan protection. Actually, 45 percent of the respondents indicated that they use many woody-products including fruits, leaves or seeds for their food needs. Also, around 40 percent of the respondents reported that they use usually forest products for animal feeding, while about 10 percent have indicated that they use these products for human health. However, more than half (52 percent) of those surveyed indicated that they rely on natural resources, namely non-wood forest products, including fruits, leaves, or seeds for their food needs during drought years. Around 50 percent of the respondents use these products at any time throughout the year, 16 percent use only during dry season, and 22 percent only during harvest period. The most woody-species used by people are *Tamarindus indica*, *Combretum glutinosum*, *Diospyros mespiliformis*, *Faidherbia albida*, *Acacia sp*, *Terminalia sp*, and *Parkia biglobosa*.

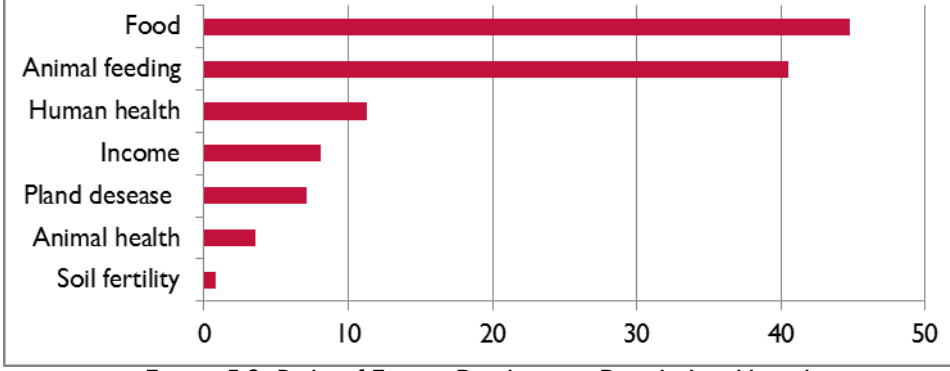

Figure 5.2: Role of Forest Products in People Livelihoods

5.3 GRAIN BANKS

Grain banks constitute another widespread practice. Grain banks are village-level food reserves implemented by local communities with or without the support of development agencies and/or the government to cope with recurrent food crises or food insecurity in the Sahel. Grain banks are used by around 40 percent of the households surveyed as a post-risk management measure for the effects of drought on food security. Grain banks are becoming a popular strategy to fight against food insecurity and drought impacts in the study area, and they play a strong role during the years of extreme climate events. The grain banks are managed by a local committee who buys staple crop foods during harvesting period where food prices are lower, stocks them in granaries, and sells them later for its members during the driest season when food becomes scare and more expensive. The members contribute to the implementation of grain banks in kind with their crop harvest, labor force, or in cash. The stored grains include crops such as maize, millet, sorghum, and rice. The poorest and marginalized individuals or those experiencing food crisis are given priority and can be allowed to buy the food at credit.

5.4 MODIFYING EATING HABITS

Most people surveyed reported that they usually change their diets in terms of the number of meals and/or quantities of food to cope with the impacts of drought. Figure 5.3 shows that about 80 percent of surveyed households reduce their usual number of daily meals during drought periods, and 73 percent of them decrease the volume of meals. Diet diversification through the introduction of new crops/foods is also a strategy used by people to ensure their survival during periods of drought. Approximately 26 percent of surveyed households reported having introduced new crops/foods into their diets as a post-risk management strategy from the effects of drought. The main foods that have been introduced to their diets are rice and cowpeas. For some, dietary diversification is also a coping strategy. For example, some respondents reported that previously, millet was their staple food; now they have added sorghum, cowpeas, or rice to their diets, and vice versa for those who considered sorghum as their staple food.

Around 26 percent have reported that they have included new crops (millet, sorghum, rice, cowpeas, or others) in their eating habits in the last 10 years. Those who did not frequently eat millet before have started to consume this crop, and vice versa for sorghum. Sometimes, they make mixed flour of millet or sorghum; if the conditions are not favorable, they consume only millet or sorghum as usual. Yet almost all farmers did not give up their main staple crops, and prefer to consume this crop if they do not face constraints on their production system.

Historically, millet and sorghum are the principal foods of the population in the study area. They crops are not new to this area, but some farmers have newly adopted them. Some farmers who did not grow millet before have started to produce this crop, similar to the case with sorghum. The region's populations still remain dependent on these two crops for their essential food needs. Currently, millet is the staple food for 70 percent of surveyed households while 30 percent of households reported sorghum as their staple food. The results show that dietary habits have not changed over the past decade, as millet and sorghum continue to be the main staple foods in the same proportions today as in

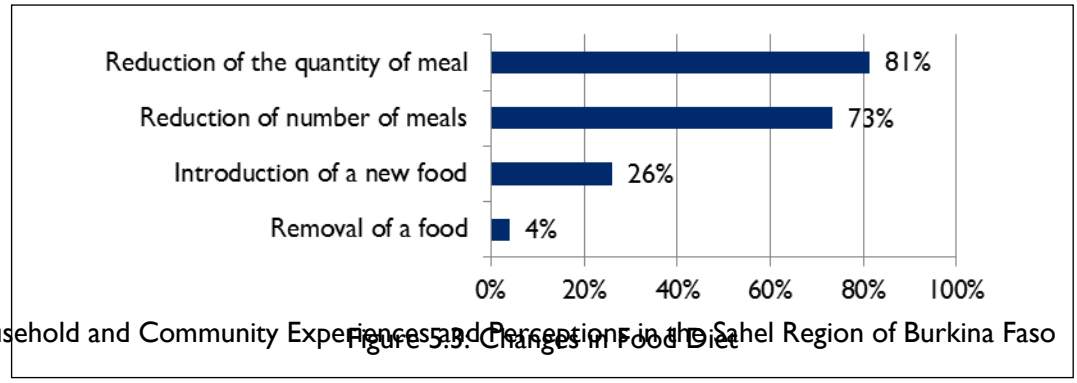

Figure 5.3: Changes in Food Diet

the past. However, significant changes were noted in diets during periods of drought.

5.5 RISK SHARING AND TRANSFER: MIGRATION, TRANSFER, AND FOOD ASSISTANCE

The transfer and sharing of risks also play a part in the post-drought risk management strategies used by the farmers. Measures include migration, food or cash transfers, food aid, and the use of local and international solidarity networks such as borrowing of food from other households and food assistance.

Food aid and loans play an important role in post-risk management of drought; about 50 percent of surveyed households reported that they have used at least one of these two strategies during periods of drought. Temporary migration is also a common response as indicated by about 40 percent of the surveyed households. Migrations are generally toward urban centers such as Ouagadougou and Bobo Dioulasso, but more and more toward gold washing sites currently emerging. Other mechanisms and risk transfers observed are the transfers of food in terms from other households in living same the village or in neighboring villages. Some households depend on remittances or food transfers from household members living outside the village. In fact, 20 percent of surveyed households reported that they benefit from remittances from members living outside of the village; while about 20 percent of others receive food transfers instead (Figure 5.4). The remittances give farmers the ability to purchase food and diversify the eating habits.

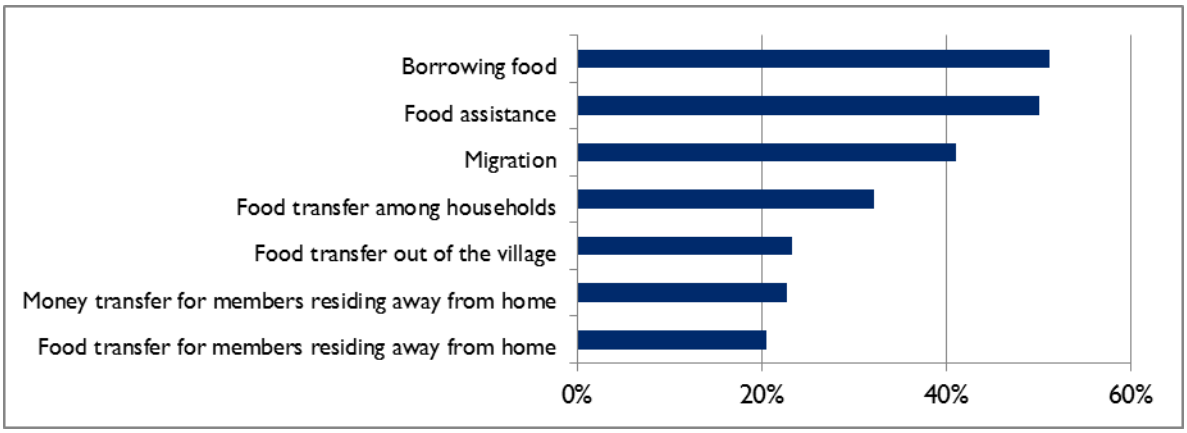

Figure 5.4: Drought-Risk Sharing and Transfer Strategies

5.6 CLIMATE INSURANCE

Climate insurance is a post-risk management strategy that does not actually exist in the study area according to the statements of persons surveyed. In fact, almost all households surveyed stated they have no knowledge of climate risk insurance or of its operating mechanism. Meanwhile, most of the farmers displayed a positive interest in subscribing to a service of drought insurance if there were access. This indicates that the adaptation mechanisms described in the preceding sections are not sufficient for facing the effects of drought, and the households continue to sacrifice their livelihoods following major drought events. Climate insurance against the risk of drought could therefore constitute a complementary alternative to mechanisms already in place in view of increasing resistance of populations to drought, given that this measure already receives a large acceptance of farmers. In general, between 79 and 91 percent of crop producers and agro-pastoralists are available to subscribe

to an insurance service against drought (Table 5.1). Farmers' ability to pay is variable. The crop producers are more disposed to pay than the agro-pastoralists and pastoralists (Table 5.1).

Climate insurance is difficult to implement, but this mechanism is gaining a great deal now in developing countries and many trials are now going on. This indicates that local communities are still experiencing the adverse effects of climate change, despite the current adaptation efforts, and they are still seeking others or better strategies. This also indicates that climate insurance can work with Sahelian people if its meets their conditions and ability to pay.

TABLE 5.1: INDIVIDUALS WILLING TO PAY FOR A CLIMATE INSURANCE FOR DROUGHT CONTROL (PERCENT)

Province	Crop Producers	Agro-Pastoralists	Pastoralists
Séno	54.9	97.0	100
Oudalan	73.7	81.8	28.6
Soum	82.9	94.9	0
Yagha	98.1	94.0	100
Sahel	78.8	91.4	40

5.7 PERCEIVED EFFECTIVENESS OF THE PRACTICES

Most farmers have positive perceptions of the efficacy of the dominant adaptive practices they employ for combating the effects of drought. For most of the practices identified in the region, between 65 percent and 90 percent of the adopters indicated that these practices are effective at reducing the negative effects of drought on their principal livelihoods (Figure 5.5, next page).

Many of the techniques used by the farmers have been presented in the literature as effective adaptive practices by numerous empirical studies. In a recent study on the Burkina Faso plateau, Yameogo et al. (2013) showed that improved zai, stone lines, and organic manure have significantly contributed to improving the infiltration of water in the soil, and have restored fertility. The techniques increased the sorghum yield by four-to-six times compared to the control plots where these practices are not used. Techniques such as NAR, improved zai, stone lines, and half-moons have restored or improved the fertility of hundreds of thousands of previously degraded hectares, and consequently have contributed to improving the resilience of the Sahelian populations to the risks of more severe and recurring droughts (Zougmoré et al. 2013).

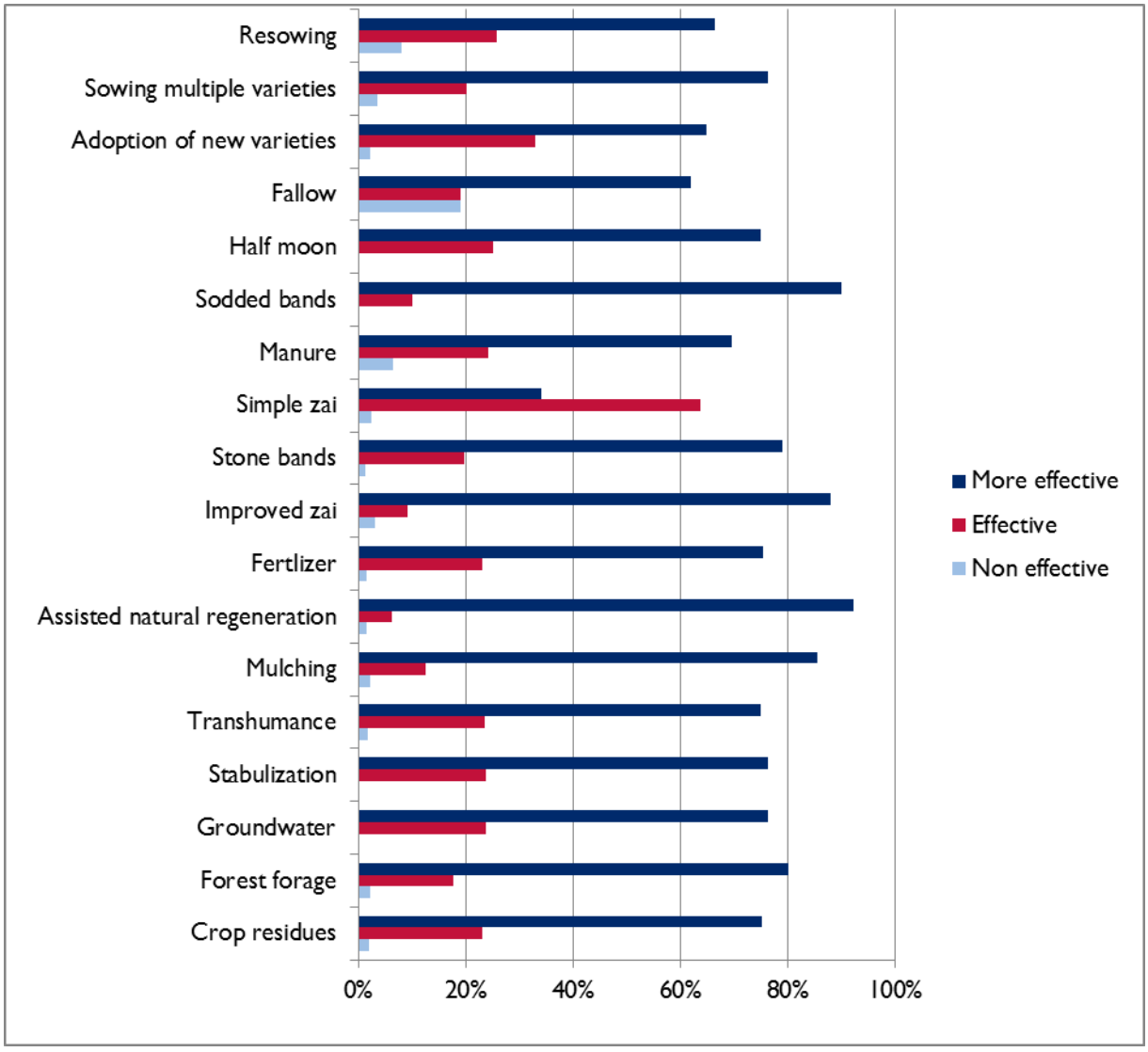

Figure 5.5: Farmers' Perception of the Effectiveness of Adaptive Practices in Response to Drought

6.0 ANALYSIS OF COPING AND ADAPTATION PRACTICES

The gender and sociocultural characteristics of farmers influence their decisions in terms of choice of adaptation to drought and other practices linked to climate change in the Sahel. In this section, the findings related to determining factors of adaptive choices of famers are examined.

6.1 SOCIOECONOMIC, SOCIOCULTURAL, AND GENDER FACTORS

Farmers' adaptive choices are determined by many sociocultural characteristics of the households, their access to technical services, awareness about climate change and adaptation, and characteristics of their production systems.

6.1.1 Type of Livelihood

The findings of the study indicated adaptive practices differ depending on the main livelihood identified by the respondent. For example, the results indicate that agro-pastoralists are more likely to use new crop varieties than are crop producers. Agro-pastoralists own less acreage than crop producers do, as they practice cropping as a supplemental activity greatly for their food security, rather than as a primary source of income. Consequently, they resort to intensives practices in order to increase their crop production. Also, while the use of organic manure is very common in the study area, agro-pastoralists are more likely to use this practice than crop producers. This might be explained by the fact that agro-pastoralists have more facilities for producing manure than crop producers. The number of herds of ruminants held by the farmers also affects their likelihood to organic manure: the more the ruminants the farmer holds, the more he could use organic manure. These results indicate that ruminant breeding is a determining factor in a farmer's ability to use organic manure. This is explained by the fact that manure is essentially produced from bovine herds and small ruminants.

Moreover, subsistence farmers are less likely to adopt drought-resistant varieties compared to those practicing agro-business or those whose production decisions are oriented toward the market. The more the farmer is connected to the market, (i.e., the more the farmer produces cash crops), the more he is able to use technologies such as drought-tolerant varieties. Adoption of new seed varieties implies numerous requirements and additional costs, such as the use of fertilizer and the purchase of seeds. The more the farmer produces cash crops, the more they will be able to get in cash, and consequently be able to purchase improved crop varieties and required inputs.

6.1.2 Age

The use of mulch is inversely and significantly influenced by the age of the head of the household. In other words, households consisting mostly of elderly persons and infants are less likely to use mulch as a measure for addressing the effects of drought. Mulching is a labor-intensive practice, requiring the collection and transport of leaves from one place to another.

6.1.3 Land Tenure

The results indicate that access to land plays an important role in the decision to use mulching. The individuals who do not hold land property rights are less likely to adopt land and water management micro-technologies such NAR. Numerous empirical studies have shown that property rights favor adoption of water and land management practices (Paris et al. 2002). Farmers having only the rights of use on the land are in a situation of land insecurity; and this limits their incentive to invest in enhanced land management practices.

6.1.4 Gender

The amount and quality of lands under control of female heads of household influence significantly and positively the likelihood to adopt certain water and land management technologies. Resource control and the type of land rights significantly affect farmers' decisions to adopt practices. Similarly, the sex of the head of the household and women's control on land resources influence significantly the chances to adopt certain water and land management techniques.

6.2 ACCESS TO ADVISORY SUPPORT SERVICES AND MARKETS

Capacity building and access to advisory services is decisive in the adoption of many practices. For example, attending training on water and soil management or climate change and adaptation increases the chances of adoption of many drought controls practices. Contact with extension services also plays an important role in the farmers' decisions to use NAR and enhanced zai. In contrast, contact with extension services significantly reduces the likelihood to use simple zai and mulching, as enhanced zai is an improved technology proposed by technical services in place of simple zai. It consists of combining simple zai with organic matter and a bit of manure to create favorable plant conditions. Also, the way the holes are arranged with improved zai is different from simple zai, and takes into account the direction of runoff water on the plot and has some requirements about the spacing between the holes in order to enhance water catching in the holes. Improved zai is therefore more effective than simple zai in terms of on-farm water fertility management, and consequently attracts more interest of technical services. Consequently, the more the farmers are in contact with technical extension services, the greater their chance to be exposed to enhanced technologies. Those without contact with these technical services remain using older practices.

6.3 PRODUCTION SYSTEM CHARACTERISTICS

The characteristics of the production system play a significant role in farmers' choices in terms of the drought adaptation practices and addressing other biophysical constraints. The use of zai and half-moons seem to be significantly correlated with the proportion of degraded land under control of the household. The larger the share of degraded land under the control of the household, the more the he will be interested in using these practices. In contrast, the use of NAR and stone lines is negatively and significantly affected by the proportion of degraded land under control of the household. This can be explained by the fact that both half-moons and zai are "quick results" practices for land restoration and water management compared to other practices such as stone lines and NAR. Therefore, stone lines and NAR are not appropriate for farmers with large shares of degraded lands and who are seeking for a rapid response to ensure their livelihood.

The use of new varieties is significantly correlated with the use of several other practices to combat the effects of drought and to address other biophysical constraints. This is the case with practices such as organic manure, half-moons, and enhanced zai. This can be explained by the measures taken by the

farmers to guarantee good yields when adopting improved varieties, as adoption of these varieties is generally accompanied by such costs as purchase of manure, seeds, or labor, which must be recovered.

Altitude is shown to be a determinant in the adoption of several practices. Farmers located at higher altitudes are less likely to use certain practices such as half-moons, enhanced zai, and stone lines, as well as utilizing improved varieties.

7.0 CONCLUSION

The principal objective of this study was to analyze the choices of farmers in matters of adaptation practices faced with climatic constraints, notably drought in the Sahelian zone of Burkina Faso. The research questions aimed to identify the principal strategies and measures adopted by farmers and/or herders that help them face the frequent incidences of drought and to know the principal reasons for their choices.

The results of the study show what the Sahelian populations really do when faced with numerous biophysical and climatic constraints that threaten their livelihood, which mainly depends on agricultural and pastoral production. The major biophysical constraints in agriculture are, in order of importance, drought, reduction in soil fertility, crop diseases and pests, desertification, and erosion. The major constraints for pastoral system are, in order of importance, drought, lack of pasturage, scarcity of water, and animal illnesses. Drought appears to be the principal climatic constraint to both vegetable as well as to pastoral production. It is also a factor for other constraints identified in the area, such as fertility, disease, scarcity of water, lack of pasturage, erosion, and desertification. Faced with these multiple constraints, farmers have implemented a range of practices and measures for reducing their vulnerability or for being able to survive after a climatic shock. The reduction of sensitivity measures consists of the crop and animal raising systems and the water, land, and pasturage management practices.

The principal modifications noted in crop system are adopting new varieties, planting several varieties, and abandoning crops and/or varieties judged most vulnerable. The major modifications in pastoral system are adopting new breeds of animals, adopting new species, and/or withdrawing the most vulnerable breeds or species. Concerning water and agricultural land management techniques, the principal measures adopted by the producers are using organic manure, stone lines, NAR, mulching, fallow, zai, compost, half-moons, grass strips, and wind screens. The farmers do not have the same appreciation of the effects of the various practices when faced with different climatic and biophysical constraints, and use them therefore for a wide variety of reasons. They principally use organic manure, mulching, stone lines, NAR, and zai to combat the adverse effects of drought. Faced with a decline in soil fertility, farmers principally use organic manure, mulching, stone lines, and chemical fertilizer. To combat desertification, NAR, stone lines, and organic manure are the most used practices. The measures used to address erosion consist of stone lines, NAR, grass strips, mulching, and wind screens. For animal raising, the producers used crop residue, woody forage, breeding/feeding, seasonal migration, and ground water to combat the adverse effects of drought on pastoral production. Efforts to reduce exposure to risks are not sufficient to assure entirely the Sahelian population's resilience to the effects of more and more severe and frequent droughts. They have also implemented a range of post-drought resilience strategies that complement pre-risk exposure reduction strategies. The post-drought strategies include savings and liquidation mechanisms, transferring and sharing risks, local and international assistance, and changing eating habits.

The analysis of reasons and factors determining the choices of producers in matters of adaptation indicates that the primary motivation of farmers is their perceived effectiveness. This effectiveness is evaluated based on numerous, often interlinked factors. These factors include the scale and characteristics of individual operations, their access to technical services and access to markets, and the characteristics of their production systems. At the sociocultural level, additional factors include ethnic origin, gender and age of the head of household, type of operation, female control of resources, land

tenure status, and dependency ratio. For example, individuals who are land-insecure are less disposed to use the techniques to combat the effects of drought. In the same manner, the gender of the head of operations or the level of control of women over land resources significantly influences the use of certain techniques. Ethnic origin, the objective of production, and the type of operation (agricultural, agro-pastoral, or animal raising) also influence the adoption of many practices. In addition, access to extension technical services or participation in training for water and soil management techniques and/or in climatic change and adaptation play a significantly important role in the adoption of most practices to combat the effects of drought. In general, the operations for which at least one member has participated in training in water and soil management techniques or in adaptation to climate change have a greater change of using the techniques. The degree of openness to the market (number of cash crops produced), the proportion of degraded lands in the operation, and the size of the cattle or ruminant herd are characteristics of the production system that significantly influence the adoption of techniques to combat the effects of drought. The operations having the most degraded land prefer to use rapid effect techniques such as zai, manure, mulching, or half-moons, and have a tendency to reject techniques which produce effects in the medium to long term such as stone lines and NAR.

8.0 RECOMMENDATIONS

The study revealed a wide range of often interlinked reasons and factors for adapting certain practices. Many of these reasons and factors are independent of climate change, and include a wide variety of sociocultural, economic, institutional, and physical factors. In light of the results of this study, the following recommendations could help farmers deal with the adverse effects of drought in the Sahel.

8.1 SCALING-UP ADOPTION OF WATER AND LAND MANAGEMENT PRACTICES

Water and land management technologies are the major strategies that people are using to cope with the adverse effects of drought in the Sahel region of Burkina Faso. The most effective practices mentioned by farmers are using organic manure, mulching, stone lines, NAR, agro-forestry, and zai. Yet the study showed that the rate of adoption of many of these practices is still low. An important effort could therefore be to expand the use of these technologies to enhance farmers' resilience to climate change.

8.2 IMPROVING ACCESS TO INFORMATION AND MARKETS.

The study indicates that livelihood modifications through the use of alternative crops and alternative economic activities are important adaptation mechanisms. On the one hand, these measures are greatly motivated by market opportunities; on the other hand, they are constrained by information access, including access to information about improved technologies such as drought-resistant varieties. Improving farmers' access both to the market and to information could provide farmers with a greater range of alternatives for modifying and diversifying farming systems.

8.3 IMPROVING CREDIT ACCESS

Improving farmers' access to credit would also enhance their ability to adopt more advanced and more input-demanding technologies.

8.4 ADDRESSING GENDER GAP AND SOCIAL DIFFERENTIATIONS IN RESOURCE CONTROL

The study revealed that when women's control of agricultural and pastoral resources is low, the ability of households to adopt some practices is limited. Because women play an important role in ensuring household's livelihoods during severe climate events, addressing gender differences in the control of land resources could help to increase the adoption of certain drought control strategies and thereby reduce household vulnerabilities.

8.5 IMPLEMENTING MECHANISMS FOR RISK SHARING AND TRANSFER IN SUPPORT OF ADAPTATION (RISK REDUCTION) STRATEGIES

In spite of their best adaptation efforts, the study showed that local people still suffer from the adverse effects of climate change. Mechanisms for risk sharing and transfer such pooled insurance schemes, food and cash transfer, and social security programs could supplement other drought risk reduction strategies. In addition, the existing mechanisms for risk sharing such as cereal banks and local-or community-level food reserves should be strengthened.

8.6 TRAINING AND CAPACITY BUILDING

The study clearly showed that training on climate change adaptation and/or land and water management practices are a determining factor in farmers' ability to adopt coping strategies. Many farmers are not still aware of ways to cope with climate change impacts. It is therefore crucial to increase extensive services that would improve all farmers' capacity through training and awareness of land and water management practices and climate change adaptation strategies.

8.7 ENCOURAGING INTEGRATION OF CROPPING AND BREEDING SYSTEMS

Many farmers and agro-pastoralists described ways in which they are supplementing their primary form of livelihood with secondary forms of livelihood—e.g., agro-pastoralists invest in limited agricultural production to help ensure food security while cattle remains their primary source of revenue generation. Integrated agriculture-livestock systems help diversify communities' livelihoods and therefore reduce their vulnerability to many of the adverse impacts of climate change. Integrated systems also improve farmers' access to some important inputs such as manure and mulching. Efforts to enhance system integration will therefore play a significant role in communities' resilience to climate change. In this context as well, attention should be also given to addressing gender issues of women's control of pastoral resources. Also, the use of multipurpose crop varieties (food and forage), techniques of composting and manure production, and techniques of forage and crop residues should be promoted to help improve soil fertility and crop and breeding production.

8.8 ADDITIONAL RESEARCH EFFORTS

It is particularly important to enhance research efforts on agro-forestry and land and water resource management. The most woody-species used by people are *Tamarindus indica*, *Combretum glutinosum*, *Diospyros mespiliformis*, *Faidherbia albida*, *Acacia sp*, *Terminalia sp*, and *Parkia biglobosa*, and their further integration into mixed farming systems should be explored. Although perceptions of the efficacy of most of the practices studied were positive, the literature review did not reveal any relevant and strong scientific evidence of the long-term cost-effectiveness or environmental sustainability of these practices. An assessment of the cost-advantage and environmental impacts of the different adaptive practices is therefore needed to inform decision makers' choices of the most suitable measures to build communities' longer-term resilience to climate change. These can be tested through field and farm-level research, ideally carried out hand-in-hand with the farmers.

For pastoral production, developing supplemental animal feeds through research trials with resources/inputs available at the local level is a great way to explore alternative responses to increased scarcity of pasture in Sahelian area. Such locally available resources include crop residue (millet, sorghum and cowpea), woody forage (Pods of *Acacia raddiana, Piliostigma reticulatum, Faidherbia albida*, etc.), and *Cassia tora.*

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APPENDIX 1: EXAMPLES OF ADAPTATION TECHNIQUES IN THE STUDY AREA

Half-moon technique

Forage crop cultivation

Mulching technique

Half-moon technique

Stone lines technique

Half-moon making by Delfino tractor

Half-moon before rainy season

Half-moon during rainy season

Scarification technique

Forage storage and conservation

Sheep fattening

Traditional fattening place

Crop residue use by cattle herd after harvesting

Manure and stone lines techniques

Manure application on zai hole

Crop residue storage for dry season use

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