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A Cross Villages Assessment of Environmental Change and Human Mobility in the Dano Watershed, Burkina Faso.

Thesis N^0…….

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DEDICATION

This thesis is dedicated to ……

- ✓ *The memory of my father and my mother for all of their sacrifices.* 

One day I asked my father: Dad what do you expect from me?

He said "my lovely daughter I want you to work hard". So this thesis is the fruit of his advices.

- ✓ *My sister Fatoumata Dansoko and my brothers Mahamadou Dansoko and Ousmane Dansoko for their support.*
- ✓ *My nephew Moussa Dansoko.*
- ✓ *All the innocent and vulnerable communities facing the impacts of Climate Change and Variability;*

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ACRONYMS

AU: **A**frican **U**nion.

CRP: **C**ore **R**esearch **P**rogramme.

ECOWAS: **E**conomic **C**ommunity of **W**est African **S**tates.

EROS: **E**arth **R**esource **O**bservation **S**ystem.

FAO: **F**ood and **A**gricultural **O**rganisation.

GCIM: **G**lobal **C**ommission on **I**nternational **M**igration

GFDRR: **G**lobal **F**acility for **D**isaster **R**eduction and **R**ecovery.

GIS: **G**lobal **S**ystem **I**nformation.

GSP: **G**raduate **S**tudy **P**rogramme.

ICRAF: **I**nternational **C**entre for **R**esearch in **A**groforestry.

IOM: **I**nternational **O**rganisation for **M**igration.

IPCC: **I**nter-**G**overnmental **P**anel on **C**limate **C**hange.

MSS: **M**ulti **S**pectral **S**canner.

NASA: **N**ational **A**eronautics and **S**pace **A**dministration.

NDVI: **N**ormalized **D**ifference **V**egetation **I**ndex.

NGOs: **N**o-**G**overnmental **O**rganisations.

NOAA: **N**ational **O**ceanic and **A**tmospheric **A**dministration.

PANA **N**ational **A**ction **P**lan for **A**daptation.

PANE **E**nvironment **N**ational **A**ction **P**lan.

RCPM **R**egional **C**onsultative **P**rocesses on **M**igration.

UNDP: **U**nited **N**ation **D**evelopment **P**rogramme.

UNEP: **U**nited **N**ation **E**nvironment **P**rogramme.

UNFCCC: **U**nited **N**ations **F**ramework **C**onvention on **C**limate **C**hange.

VRAM: **V**ulnerability and **R**isk **A**nalysis and **M**apping.

WASCAL: **W**est **A**frican **S**cience **S**ervice **C**entre on **C**limate **C**hange and **A**dapted **L**and **U**se.

WFP: **W**orld **F**ood **P**rogramme.

WMO: **W**orld **M**eteorological **O**rganisation.

ZEF: **C**entre for **D**evelopment **R**esearch, **U**niversity of **B**onn.

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ABSTRACT

This Master Thesis aims to build understanding of the factors causing migration in the Dano watershed area. For better understanding, the study analyses the vegetation dynamics as an important environment factor and linked it to migration trends towards the study area.

The work uses data collected across two (2) villages, namely Fafo and Dayére, both located in the Dano watershed, South-Western Burkina Faso. Focus group discussion and household interview were employed for data collection. The national population census data were used to examine the population dynamics and also to make projection for the year 2014. Satellite images were used to measure changes in land cover types for the years 1986, 1999 and 2014. Rainfall data were used to confirm the perception of the farmers about the impact of environmental change related to rainfall variability and change.

Pearson correlation analysis revealed the high positive correlation between population size and cropland (**coefficient** = 0.0419; $\mathbf{r^2}$= 0.99) while there was significant negative correlation between population size and vegetation cover (**coefficient** = -0.1434; $\mathbf{r^2}$= 0.93). The vegetation area was progressively converted into croplands with an annual rate of 0.92%.

In terms, of migration, the results suggest that the root causes of migration, in the study area, is socioeconomic condition but, environmental change is now influencing on farmers decision to non-farming activities.

Finally, the document outlines a set of policy initiatives and recommendations that will lead to better understanding of environmental management.

Key Word: Environmental change, Migration, Land Use/ Land Cover Change (LULC), Dano watershed, Burkina Faso.

RESUME

Cette thèse de Master a pour but de pointer la migration comme réponse aux changements environnementaux. Pour une meilleure compréhension, la recherche analyse la dynamique de la végétation comme un important facteur de l'environnement en la reliant aux migrations dans la zone d'étude.

L'étude utilise des données collectées dans deux (2) villages à savoir Fafo et Dayére, tous sont situés dans le bassin versant de Dano au Sud-ouest du Burkina Faso. Les Groupes de Discussion et l'interview ont été utilisés pour la collecte des données. Le recensement général de la population a permis d'examiner la dynamique de la population et faire la projection pour 2014. Les images satellitaires ont été utilisées pour mesurer les changements de la couverture végétale pour les années 1986, 1999 et 2014. Néanmoins les données pluviométriques ont servi à confirmer la perception des agriculteurs sur les impacts des changements environnementaux causés par la variabilité des pluies.

La corrélation de Pearson a révélé une forte corrélation positive entre la population et l'espace cultivable avec une valeur (**coefficient** = 0.0419; $\mathbf{r^2}$= 0.99) tandis que la corrélation entre la population et la couverture végétale est négative avec une valeur (**coefficient** = -0.1434; $\mathbf{r^2}$= 0.93). La végétation à été progressivement transformée en aux champs avec un taux annuel de 0.92%.

Les résultats ont montré que les causes profondes de la migration dans la zone d'étude sont d'ordres socio-économiques mais, les changements environnementaux ont commencé par influencer les changements d'activités des agriculteurs.

Finalement, le document ébauche un ensemble de politiques qui conduiront à un meilleur aménagement de l'environnement.

Mots clés: changements environnementaux, migration, utilisation des terres/changement de couverture végétale, bassin versant de Dano.

CHAPTER 1: INTRODUCTION

Environmental change related to climate change is increasingly affecting ecosystems and communities. The period ranging from 1970s to 1990s has had a potent environmental damage over the Sahel region due to decrease in rainfall and devastating droughts that hit the Sahel. This phenomenon has led to major environmental challenges (West *et al.*, 2008; Sow, 2012). However, Food and Agriculture Organisation (FAO, 2001) confirmed that the tropical regions have lost 15.2 million hectares of forests per year during the 1990s and countries like Senegal, Mali and Burkina Faso could have lost around 50 percent of their agricultural capacity. Therefore, people have responded with subtle strategies of income diversification and social innovation (Sow, 2012). Especially, migration has been a common strategy used by affected communities. Moreover, the 1990s scholarly community and experts predicted that there would be significant migration as a result of environmental changes. The starting assumption for the research is interaction between environmental change and mass migrations (Geddes and Somerville, 2013).

Environmental changes and migration have formed a relatively global concern in recent years (Schulz and Mahama, 2012). In the 21st century, environmental change related to climate change is projected to exacerbate the flow of people displacement (IPCC, WGII, 2014). These increasing human displacements, to meet livelihood subsistence and welfare were reported to be more important in arid and semi-arid regions. Moreover, in Burkina Faso migration becomes a major "coping strategy" to respond to the risks of environmental change so as to ensure livelihood security.

1.1. Problem Statement and Justification

Burkina Faso, like most West African countries, mainly depends on rain-fed agriculture; about 90 per cent of its population practices rain-fed subsistence agriculture (Ouedrago *et al*, 2009). While many regions of the world are subject to dramatic fluctuations in climate (West *et al.*, 2008) due to the long term change in the environment, the West African savannah area is characterised by the severity and persistence of the rainfall deficit that has been known to have lasted for more than three decades. West African countries are likely to experience greater rainfall variability and higher temperatures in the future than today within all agro-ecological zones. (IPCC, WGII, 2007). Moreover, the temperature is expected to increase on the average by 0.25°C from 2010 to 2020 (IPCC, WGII, 2007). The reduction of annual precipitation amounts is largely caused by a general decline in the number of rainfall events, from -20 to -40% (Nicholson et al., 2000). Within the same decades, land use and land cover changes are rapidly inducing a decline in natural resources mostly by human activities. Therefore, the impacts of environmental degradation/ change and migration have emerged in the past decades as important subjects of research (Sow *et al*., 2014).

In Burkina Faso, the density of population shifted from 17inhabitants per km^2 to 30 inhabitants per km^2 from the years 1986-2006 (Ouedrago *et al*, 2009). In 2010, in terms of emigration, Burkina Faso was the highest with 1.6 million emigrants in the Economic Community of West African States (ECOWAS) followed by Côte d'Ivoire (1.2 million), Mali and Nigeria (1 million each) (Gagon and Castéras, 2012). It is well established that migration is a common strategy to deal with livelihood risk (Renaud et al. 2007; Warner, 2011; IPPC, WGII, 2013; Sow *et al*., 2014).

Many studies on environmental change and population dynamic have been conducted in Burkina Faso especially in the Southern province (Paré *et al.*, 2008; Ouedrago *et al*. 2009; Ouedrago *et al*. 2010). They have found direct relationship between environmental change and migration. However, none of the recent studies have systematically assessed local understandings and scientific evidence in the context of environmental change related to migration in Ioba province. It is against this background that this research aims at assessing impacts of environmental change on rural livelihoods taking into account the role of migration as adaptation strategy to environmental change.in the Dano Watershed area.

1.2. Objectives

The main objective of this work is to build an understanding about the use of migration as a risk management strategy in response to environmental change in the Dano watershed. The specific objectives of the study are to:

- ✓ identify the socio-economic factors that persistently motivate human migration in the study area;
- ✓ evaluate the rate of land use and land cover conversion in time series as a result of migration in the study area from 1986 to 2014;
- ✓ identify the challenges that households have tried to overcome in their livelihood vulnerabilities to environmental change.

1.3. Research questions

- Are the socio-economic factors motivating household members to migrate?
- What is the dominant land cover type in the study area which influences outward or inward migration?
- How does household access resources to mitigate livelihood vulnerabilities to the impact of environmental change?

1.4. Hypotheses

- ➢ Environmental change is the main driver of migration in the Dano watershed area.
- ➢ Migration is widely used to improve households' livelihood condition in the Dano watershed.

1.5. The thesis structure: The present study is structured around five chapters.

The first chapter gives an overall introduction and problem statement of the study, the objectives, research questions and hypotheses. The second chapter deals with the literature review by discussing relevant studies related to environmental change and migration. The third chapter tackles the material and methods applied to achieve the objectives of this research. The fourth chapter presents the main findings, the discussion and the validation of the hypotheses. Finally, chapter five is about conclusion and some policy recommendations.

CHAPTER 2: LITERATURE REVIEW

This section gives a brief review of the literature in respect to the interest areas of the study.

2.1. Terminology and definitions

In the literature, different concepts and terminologies are used: *environmental refugee, environmental degradation, environmental migrants, "migration*", all these terms are highly controversial.

- The idea of ***environmental refugee*** is widely used since 1970s (Renaud *et al*., 2007, Hummel *et al.*, 2012). Later in 1985, the term was popularized by El Hinnawi in a report for the United Nations Environmental Program (UNEP) defined as "those people who have been forced to leave their traditional habitat, temporarily or permanently, because of a marked environmental disruption that jeopardized their existence and/or seriously affected the quality of their life (Renaud *et al*., 2007; Hummel *et al.*, 2012).
- ***Environmental degradation*** is defined as any physical, chemical, and/or biological changes in the ecosystem (or resource base) that render it, temporarily or permanently, unsuitable to support human life (Hummel *et al.*, 2012).
- ***Environmental migrants*** are described as "persons or groups of persons who, for compelling reasons of sudden or progressive changes in the environment that adversely affect their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad" (Warner, 2011). Furthermore, environmental migration refers also to human migration where environmental risks or environmental changes play a significant role in influencing the migration decision and destination. Migration may involve distinct categories such as direct, involuntary, and temporary displacement due to weather related disasters; voluntary relocation as settlements and economies become less viable or planned resettlement encouraged by government actions or incentives. All migration decisions are multi causal, and hence it is not meaningful to describe any migrant flow as being solely for environmental reasons (IPCC, WGII, AR5, 2013).

- ***Migration****: Permanent migration* can be defined as a move from the household of origin during at least six months per year to a place within the country or abroad with the purpose of working, studying or family reunification, over a distance that forces the concerned

person to settle at the destination to spend nights. Labour migration is migration primarily motivated by the aim to work and gain a living elsewhere. While *temporal or seasonal migration* can be defined as yearly recurring migration over periods less than six months a year (Rademacher *et al.*, 2012).

- ***Desertification:*** Land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities. It is defined as a reduction or loss of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest, and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as (i) soil erosion caused by wind and/or water; (ii) deterioration of the physical, chemical, biological, or economic properties of soil; and (iii) long term loss of natural vegetation (IPCC WGII AR5, 2014)
- ***Drought:*** a period of abnormally dry weather long enough to cause a serious hydrological imbalances. Drought is a relative term; therefore, any discussion in terms of precipitation deficit must refer to the particular precipitation-related activity that is under discussion. For example, shortage of precipitation during the growing season impinges on crop production; or ecosystem function in general due to soil moisture and during the runoff and percolation season primarily affects water supplies (hydrological drought). Storage changes in soil moisture and groundwater are also affected by increases in actual evapotranspiration in addition to reductions in precipitation. A period with an abnormal precipitation deficit is defined as a meteorological drought, while a mega-drought is a very lengthy and pervasive drought, lasting much longer than normal, usually a decade or more (IPCC, AR5, 2014).
- ***Climate change*****:** Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. The Framework Convention on Climate Change (UNFCCC) defines climate change as a change of climate which is attributed directly or indirectly to

human activity that alters the composition of the global atmosphere and which is observed over comparable time periods. Moreover, the UNFCCC makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes (IPCC, WGII, AR5, 2014).

- ***Environment:*** all of the physical, chemical, and biological conditions that together act on an organism or an ecological community and influence its growth and development. Soil, air, water, climate, plant and animal life, noise level, and pollution are all components of an environment. To survive, organisms must often adapt to changes in their environments (**S**agan, *et al*1979).

- ***Hazard*****:** The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. The term *hazard* usually refers to climate related physical events or trends or their physical impacts (IPCC, WGII, AR5, 2014).

- ***Exposure*****:** The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC, WGII, AR5, 2014).

- ***Vulnerability:*** The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, WGII, AR5, 2014).

- ***Risk*****:** The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard (IPCC, WGII, AR5, 2014).

- ***Adaptation:*** The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects (IPCC, WGII, AR5, 2014).

2.2. Environmental changes related to climate change

Land use and land cover (LULC) constitute key indicators of environment information; these terms are sometimes used interchangeably but they are actually different (Duadze, 2004). Land cover is what covers the surface of the earth (water, snow, grassland, deciduous forest, and bare soil), while land use describes how the land is used (wildlife management area, agricultural land, urban, and recreation area) (Horning, 2004). Land use comprises arrangements, activities, and inputs undertaken in a certain land cover type (a set of human actions). The social and economic purposes for which land is managed e.g., grazing, timber extraction, conservation (IPCC, 2000). Changes in land cover (biophysical attributes of the earth's surface) and land use (human purpose or intent applied to these attributes) are among the most important global concerns (Lambin *et al.,* 2001).

LULC also plays a role in the capacity of the vegetation layer's water transpiration function in the hydrological cycle. High rate of land use and cover change within a country are most commonly linked to population growth and its activities (Houghton, 1994; Lambin *et al.*, 2003; Ouedrago *et al*, 2009). There has been enormous expansion in economic activity, infrastructure development, human settlements, industrial growth, technological deployment and interdependence. This unprecedented growth has significantly increased societal vulnerability to a host of human-induced and natural hazards (UNEP 2002). On the other hand, the pressure on natural resources, loss of the forest (woody savannahs are largely being exploited for wood and charcoal production) has intensified over the last 40 years due to high demand of fuel wood (Traoré *et al*., 2014). The land use model suggests that cropland coverage in the Sahel has risen from 5% to 14% in the 35 years prior to 1996 (Taylor, *et al*., 2002). In addition, the scientific community has concluded, based on the field evidence that there is a strong correlation between population growth and land cover change mainly due to agriculture activities and urbanization (Lambin *et al*., 2003; Ouedrago *et al*, 2009). Population is a main driver of development but it is also a major source of environmental degradation when it exceeds the threshold limits (Jamil, 2009; Codjoe, 2004). The carelessness, mismanagement of resources and pollution are on the increase worldwide to such an extent that ecosystem services are being compromised in all

regions of the world (Renaud *et al*., 2007). Land Use /Cover Change (LUCC) through human activity have degraded almost two-thirds of the ecosystems on which humanity depends and have resulted in a largely irreversible loss of earth biodiversity and impact the ability of biological systems to support human needs (Vitousek *et al*., 1999; Lambin *et al.*, 2001; Renaud *et al*., 2007; Jamil, 2009). Monitoring the dynamics of vegetation and characterizing its spatial distribution will provide important indications about the changing environment and enable a better understanding of the physical processes across the geosphere, biosphere, and atmosphere boundaries.

Environmental issues have been taken in the wide range context of human security since the end of the Cold War (Renaud *et al*., 2007). Moreover, it has became clear from the literature reviews that satellite remote sensing data have been one of the best popular tool for monitoring environmental change (Marquette, 1997a; Codjoe, 2004; Elhag *et al.*, 2009; Ouedrago *et al.*, 2010; Traoré *et al*., 2014). An empirical research conducted in Senegal using remote sensing and field assessment from (1990-2005) shows a dramatic increase in croplands from 17% to 21% between 1965 and 2000, while savannah areas decreased from 74% to 70% (Hummel *et al*., 2012). Using the same method other recent studies in Mali, Ghana and Burkina Faso, found out a high rate conversion of forests into the croplands and settlements (Codjoe, 2004; Ouedrago *et al.*, 2010; Traoré *et al*., 2014).

Environmental change and the factors that drive them are subjects of global concern as they affect global climate pattern (Codjoe, 2004). Global climate change is the most critical environmental challenge over the recent decades. It is exacerbated by human daily activities (Jamil, 2009). Currently, human overuse of ecosystem services has contributed to the degradation of 60% of the environmental services. Therefore, it has taken importance in the global development agenda (Schulz *et al.*, 2012). The likely impacts of climate change on ecosystem services, agricultural production and livelihoods will represent a challenge to the adaptation strategies in many countries (Schulz *et al.*, 2012; Vliet, *et al.*, 2013) depending on the geographical location like arid region and the region dominated by poverty and subsistence food production (Schulz *et al.*, 2012; IPCC, WGII, 2014).

The effects of physical environmental change (e.g. frequent extreme weather events) on agriculture as well as livelihoods in especially rural areas in the developing countries have been identified as the major cause of people's displacement in different regions (Warner, 2011; Sow *et*

al., 2014). Displacement risk increases when populations lack the resources and experience extreme weather events. However, this common pattern is particularly used in developing countries with low income and rapid population growth (IPCC, WGII, 2014).

In addition, population proportion in urban area has risen over 40 percent from 1900 to 2009 and is projected to reach 59 percent by 2030 (IPCC, WGII, 2013). According to UNEP (2002) during the last century the earth's population grew from 1.6 to about 6 billion people. The percentage of the world's population tagged as migrants has risen from 2% to 3% over the last 50 years and South-South migration forms around 50% of these overall stocks (Gagon *et al.*, 2012).

Large changes in vegetation distribution and composition will likely affect local climate which, in turn will modify the amount and distribution of vegetation. Environmental change and climate change can impact the decision to migrate (Laczko, *et al.* 2009; Renaud *et al*., 2007; Sow *et al*., 2014). Furthermore, climate change may exacerbate the risk of conflict which may cause further migration. Subsequently, the effects of climate change lead to increased competition over scarce resources and the loss of livelihoods which may increase the risk of conflict and violence causing additional displacement.

2.3. Migration in West Africa

Migration has a long tradition in Africa (World Bank, 2007), especially West African countries has known a long historically trend of migration since pre-colonial period (Hummel et al., 2012; Sow *et al*., 2014). Migration in West African societies is explained as a colonial construction and solely in terms of "push-pull factors" (Korah 2008; Land *et al.*, 2013). Moreover, during that period the migration was presented in the following pathway i) centripetal movements in the West Atlantic region, with Senegal being the pole of highest attractiveness**;** ii) transversal migration within the coastal zone (especially from Ghana) into the oil economy of Nigeria**;** iii) reflexive movements between Côte d'Ivoire and to a lesser extent Ghana as receiving countries and Burkina Faso and Mali as sending countries (Hummel *et al.*, 2012). In Sahel, migration has been a traditional way of life for many years (Land *et al.*, 2013; Stiftung, 2014).

Migration flow started to increase in West Africa in the years 1970s and 1980s when the severe drought affected most countries, inflicting significant impacts on farmers livelihood such

losses of crops and livestock. Widespread famine prompted a mass exodus from more affected areas to the central, southern and across countries to coastal countries (West et al., 2008; Korah 2008; Ouedraogo *et al.*, 2009). Moreover, from that period up to now, migrating to less drought affected areas has become an important livelihood diversification strategy. The Fulani population in the northern region of Burkina Faso supplies a large proportion of the country's emigrants (World Bank, 2007).

Environmental change related to climate change and migration nexus issue have been frequently debated topics amongst scholars and school of thoughts and policies over the recent decades (Sow *et al*., 2014; Hummel *et al.*, 2012). The reviews have agreed that environmental change related to climate change induced extreme weather events are highlighted as root cause of increase migration flow (Jónsson, 2010; Sow *et al*., 2014; Vitousek *et al*., 1997; Renaud *et al*., 2007). From the empirical studies on migration, Sub-Saharan Africa is one of the regions affected by extreme weather events that leads to increasing migration flow (IPCC, WGII, 2013). This statement was later supported projection that millions of people will experience force migration in the 21st century (IPCC, WGII, 2014).

- Estimates of Displaced Population due to the Environmental Change Impacts over the world
  - People potentially at risk of being displaced because of desertification: 135 million (Almería Statement 1994).
  - Number of people who have fled because of floods, famine and environmental disasters approximately 24 million (UNHCR 2002: 12).
  - 162 million of people at risk of sea-level-rise by 2050 (Myers 2002).
  - 50 million of people at risk of droughts and other climate change events by 2050 (Myers 2002).
  - In 2050, 150–200 million of people are estimated to become permanently displaced climate refugees (Stern 2007).
  - 250 million Refugees due to climate change by 2050 (Christian Aid 2007).
  - 78 million of people will be displaced by 2030 (Global Humanitarian Forum 2009).

- The floods of the Zambezi River in Mozambique in 2008 have displaced 90,000 people (IPCC, WGII, 2013).
- In 2008 approximate 20 million persons displaced due to climate-related disasters (IOM, 2010).

Different assessments of future trends have recently produced contradictory conclusions. In most cases, climate change compels people to move and exacerbates current vulnerabilities that make it difficult for people to survive (Jónsson, 2010). More people migrated out of rural areas affected by land degradation than areas affected by poor climatic conditions (Jónsson, 2010). An approach in assessing future migration potentials, with considerable relevance to the African context focused on capturing the net effect of environmental change on aggregate migration through analysis of both its interactions with other migration drivers and the role of migration within adaptation strategies was conducted (IPCC, 2014). This assessment concluded that future migration is much more complex than previous assessments. Although human migration has been described as adaptation to climate event, it equally causes conflicts (Scheffran *et al*., 2011). Climate change can directly or indirectly increase risks of violent conflicts in the form of civil war and inter-group violence by amplifying well-documented drivers of these conflicts such as poverty and economic shocks.

2.4. Theoretical and Conceptual framework

The conceptual framework of environmental change has been explained by several experts. Following Malthus (1798; 1803) and Boserup (1981) theories on environmental change. Environmental change in low income countries has been linked to population pressure on resources and unsustainable exploitation of the land beyond its carrying capacity. However, population and environmental change can be classed into five factors: linear, multiplicative, mediating, development-dependency and complex systems perspectives (Codjoe, 2004).

2.4.1. Linear perspective

The Malthusian theory (1798 and 1803, republished 1960) formulated before the agricultural revolution is built upon the assumption that environmental resources (such as land) are fixed. Malthusian and Boserupian perspectives imply linear relationships between population and the environment. These perspectives emphasise the reciprocal, linear, and direct relationships which exist between populations and their environment.

2.4.2. Multiplicative perspective

Another current line of thought sees population size as interacting in a multiplicative way with other factors to create impacts on the environment.

2.4.3. Mediating perspective

Numerous studies focus on the context in which population and environment relationships occur or the social, cultural, institutional, and political factors which mediate relationships. Since the range of mediating factors which might be considered is wide, the various studies which have been carried out under this approach are also diverse. For instance, Bilsborrow framework for understanding the impacts of population growth on land use and agricultural production in rural areas in Latin America could be considered. This framework refers to considers how socioeconomic conditions such as poverty, government policies, and market demands determine whether population growth leads to technological change in agriculture, soil degradation, or out-migration.

2.4.4. Development- dependency

Another perspective collapses all social, cultural and institutional factors that mediate population environment relationships into the larger concept of "development" and focuses on the way in which development processes mediate population and the environment relations. The "dependency perspective" stresses the overwhelming role that common international political and economic forces play in shaping both demographic factors such as population growth and environmental outcomes such as degradation in developing countries. This approach further suggests that even major global environmental problems (depletion of ozone, greenhouse effects, toxic waste accumulation and loss of biodiversity) are the direct results of the prevailing model of development. Duplication of this model in rapidly growing developing countries, as is the current tendency, is seen as compounding negative environmental impacts.

2.4.5. Complex system perspective

An additional approach considers mediating factors as well as environment and population in a structured way or as a complex of interrelated systems. This approach aims to understand how ecological and human-driven systems (sociocultural, demographic, and economic systems) interconnect to form larger "socio-ecological systems". This approach also accounts for large-scale structural changes such as development processes which may cause

radical shifts in existing human and ecological systems and the relationships between them. (Marquette, 1997a; Codjoe, 2004).

In sum, it is important to recognise that both Malthus and Boserup specifically address population and environment. Malthus believed that the world's population tends to increase at a faster rate than its food supply. He did not foresee the technological changes that have accompanied modernization and allowed agricultural output to increase faster than population growth. But Boserup explicitly takes into account technological change and suggested that in some cases population growth and resulting increased population density might induce technological changes that allow food production to keep pace with population growth. Furthermore, Neo-Malthusian assumed that population growth would lead to migration and conflict due to resource scarcity. (As quoted in Jamil, 2009; Codjoe, 2004; Marquette, 1997b). The figure 1 below illustrates the interaction of population, environment and technology.

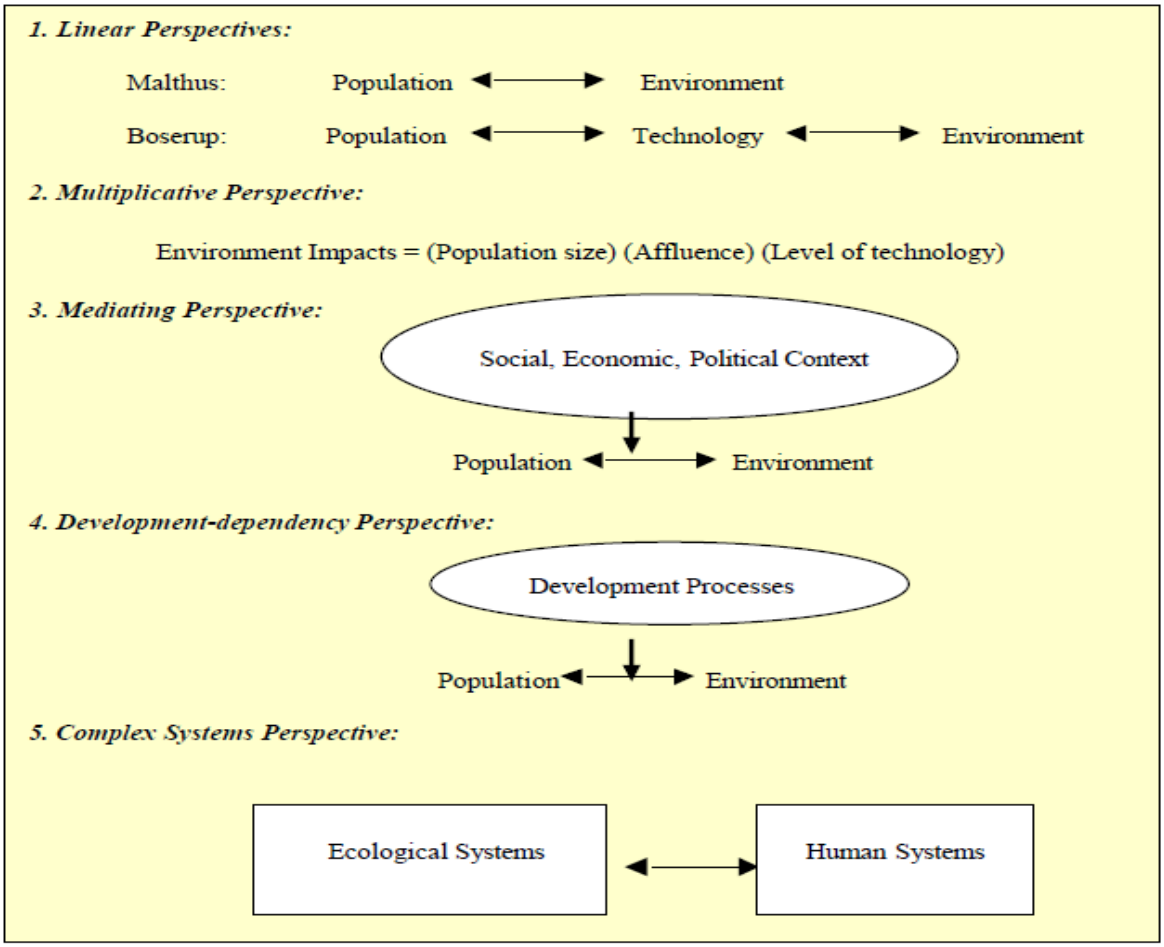


Figure 1: Conceptual approaches of population and environment nexus. Adopted from Codjoe, 2004.

CHAPTER 3: MATERIAL AND METHOD

3.1. Biophysical conditions of the study area

3.1.1. Geographical Location

This study was carried out in **Dano** watershed area (Figure 2) located within two municipalities (Koti and Dano) South-West of Burkina Faso. The watershed is composed by seventeen (17) villages within two provinces namely Ioba and Tuy. Its area covers around 582.42 km^2. The watershed has been selected because of several reasons: i) characterised by a high population dynamics with a negative net migration rate and pressure on available land; ii) high rainfall fluctuation and the area faced from several droughts and floods in the past; and it is expected to be affected by future extreme weather events like in many West African countries; iii) good records of existing long-term historical socio-economic data are available.

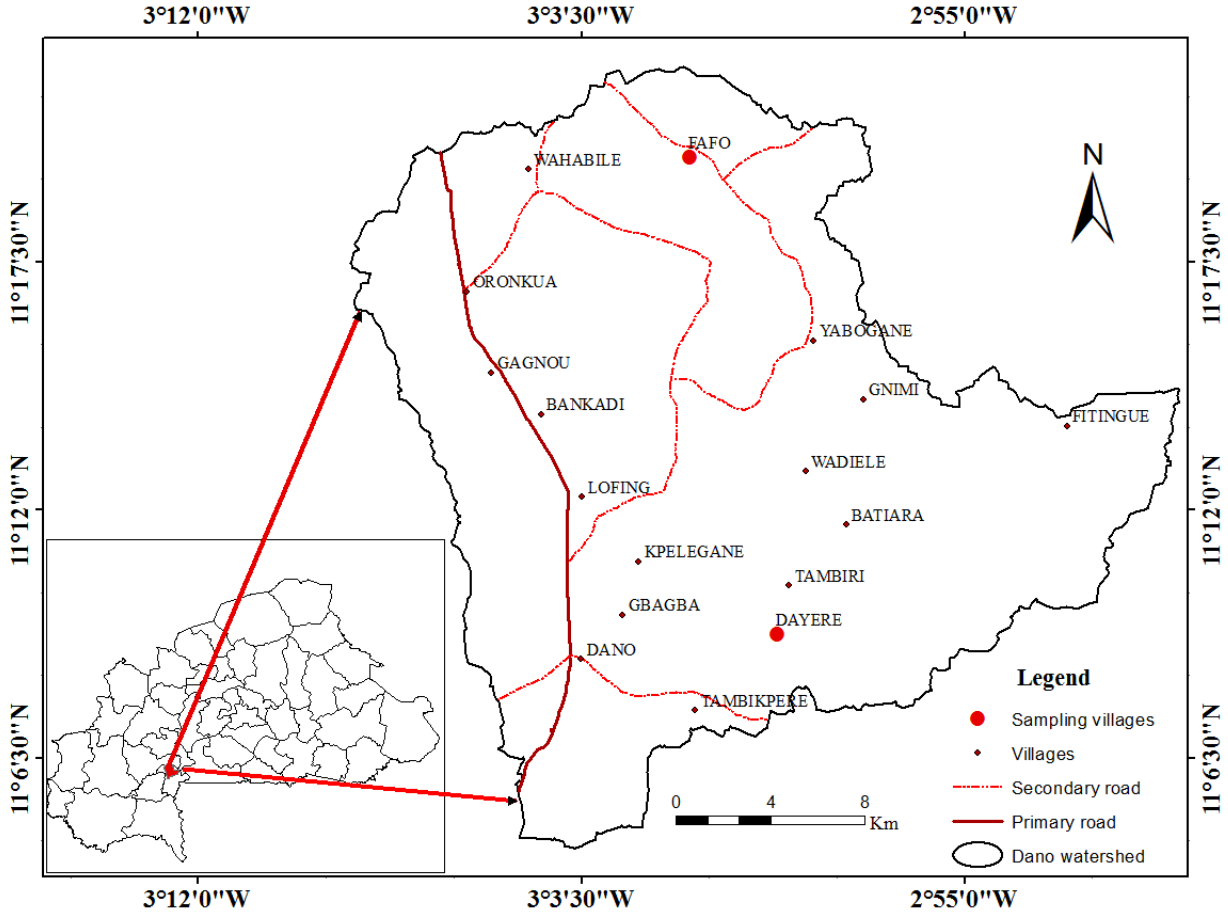


Figure 2: Map of the study area.

3.1.1.1. Climate

The Dano watershed is located in the North-Sudanian zone. The area experiences an annual average rainfall of 800 - 1000 mm. The wettest months are August and September. From November to March or April, there is almost no rainfall. The hottest period is March / April with temperatures up to more than 37 degree Celsius, a semi desert during the Harmattan period (defined as the period when stormy and dusty Sahara winds blow dry and hot) and the coolest months are August to September and the period from November to January with temperatures between 25 to 28 degree Celsius. Figure3 shows the seasonal distribution of rainfall in Dano watershed.

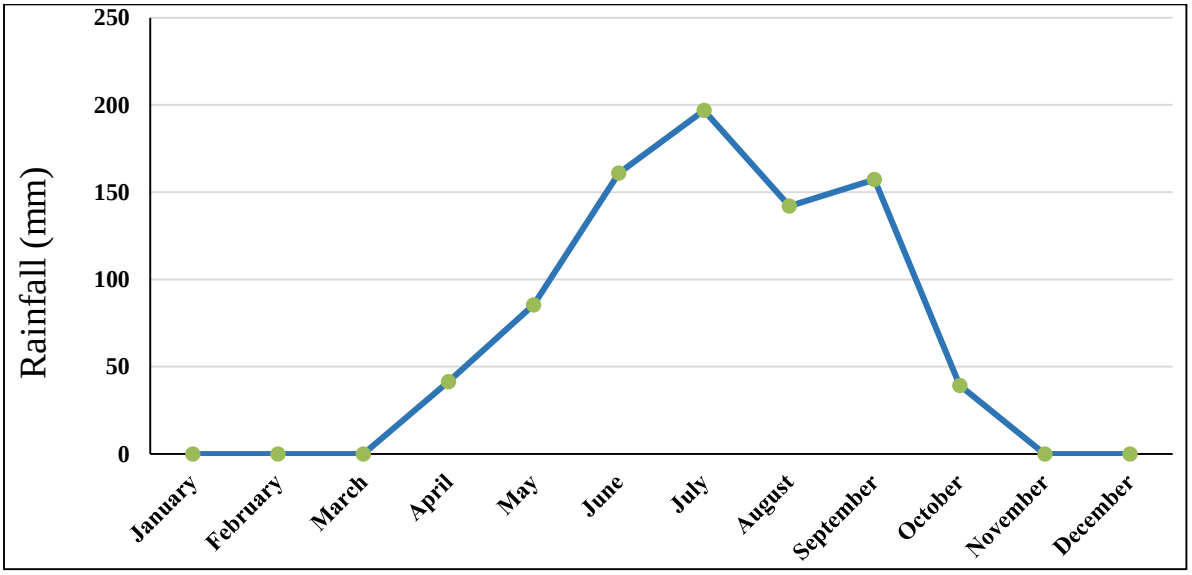


Figure 3: Distribution of seasonal rainfall. (Data source: Competence Centre of WASCAL).

3.1.1.2. Soils

Soils are a very important asset for life since they provide our basic need such as food and other natural resources (Traoré, 2015). The soils of the study region are dominated by leached ferruginous tropical soils washed on sand or sandy-clay material characterized by low a content of organic matter and phosphorus. According to the Food and Agriculture Organisation, soil classification system, the most frequent soil type is Lixisols, typical for woodland and grassland savannah systems in western Burkina Faso (Gerber, 2012). The stony red or reddish soils have a medium texture often underlain by an indurated lateric pan at shallow depth. Therefore, they

have a low water holding capacity and dry up quickly. On these soils, agricultural production, particularly weeding is difficult because of the stones. In depressions, the content of clay tends to increase. There, the greyish or brownish soils have a medium texture and a good water-holding capacity, thus, they are inherently unfertile (Gerber, 2012).

3.1.1.3. Flora and Fauna

The wildlife of Burkina Faso is composed of its flora and fauna. The area is largely wild bush country with a mixture of grass and small trees in varying proportions. Fauna, one of the most diverse in West Africa, includes the elephant, hippopotamus, buffalo, monkey, lions, crocodile, giraffe, various types of antelope, and a vast variety of bird and insect life.

3.1.1.4. Hydrography

Dano city is crossed by a big backwater "*Gbataziè*" which drains rainwater from southern to north. Other necks of water running through the town are the *Mouhoun* and the *Po*, a tributary of the *Bougouriba* river. In the watershed, Lake Moutori dam is a source for the water in the reservoirs. The lake Moutori is a very important water source for the development of agriculture for the perimeter irrigated land below the dam.

3.1.2. Socio-economic context

3.1.2.1. Population dynamics and Religion

The population is comprised of four main ethnic groups: *Dagara (*65.4%), Lobi (9.8%), Bwa (8.1%), Mossi (5.6%). Fulani and Pougouli are the minorities (DREP, 2006). The *Dagara and Bwaba* groups have been living in the area for centuries and are considered indigenous, while the Mossi, who are originate from the central plateau in Burkina Faso and the Fulani herders from the northern region of the country, are considered migrants. The dominant religious groups in Ioba province are Animist (51.2 %), Muslims (15.9 %) and Christian (32.64 %) (INSD/RGPH 2006).

3.1.2.2. Main economic activities

Livelihood activities in the study area are diverse and often complementary but the dominant activity is rain-fed agriculture. The area is suitable for crop production; for that reason, it is commonly known as the breadbasket of the country (Sanfo *et al.*, 2014). Non-farm activities include fishing in the nearby reservoirs and hunting; some technical activities and petty trade are

mainly run by women. Among the non-farm activities, brewing of the local beer, *dolo*, and selling cooked food are the most important activities providing an additional income particularly for women (Gerber, 2012). The *dolo* selling activities require a lot of fire wood, thus it has been identified during the focus group discussion (FGD) and interview as cause of deforestation in the study area. Non-farm activities basically serve as a source of additional income and are of crucial importance for gaining cash. It is noteworthy that children and elders are often involved in farming, housework and livestock herding. However, human mobility remains the second important occupation in the study area.

Migration is often claimed to be an important livelihood strategy in Burkina Faso. However, communities practice mostly rural-urban migration within its borders. According to Gerber (2012), households consider seasonal migration during the dry season to be an important strategy for household survival. Long-term migration between two and three years is rare and concerns mainly young men who leave the village to earn money in urban centres of Burkina Faso or on plantations of the neighbouring countries Ghana, and Ivory Coast.

3.2. Methods

The literature review from different researchers has yielded useful lessons that have guided this study. The first issue to be mentioned is the methodological approach. It becomes clear from the literature review that merging the satellite and census data into a single data could be the most challenging aspect of the study. Thus, the techniques used by most researchers have been noted and adopted for this study. For instance, there is the need to aggregate the land cover data to conform to the change of each land class that would be used, this methodology has been explicitly employed by Ouedrago *et al*. (2010) and other researchers on remote sensing field.

3.2.1. Conceptual framework for the study

Based on the literature review, the study adopted a following concept from a combination of the linear, development-dependency and mediating perspectives of the population dynamic and environment nexus. However, the overall idea of this framework is to illustrate the key drivers of environmental change in general. The following (Figure 4) describes how population growth and their daily activities cause environment change in Dano watershed.

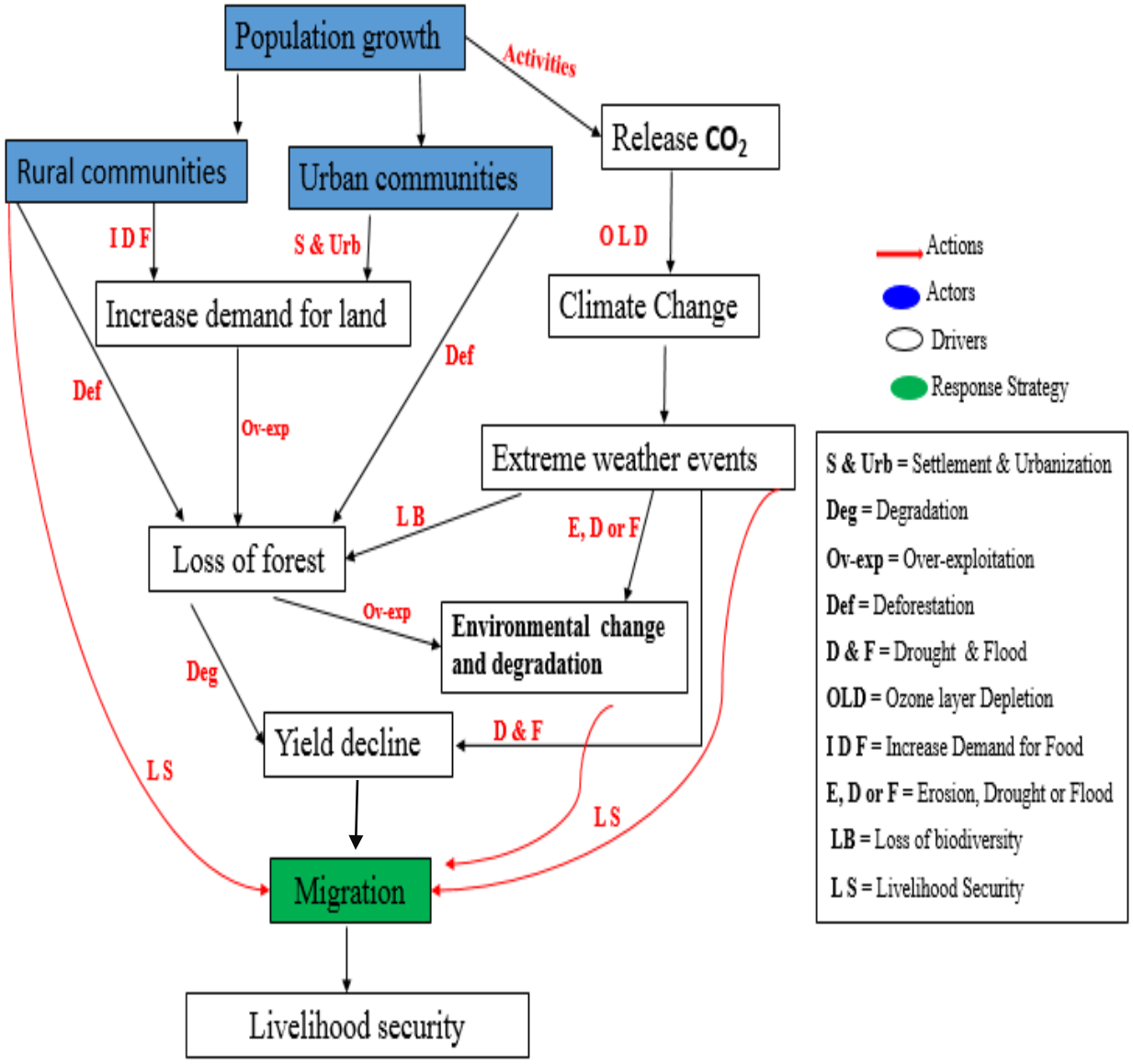


Figure 4: Conceptual framework for the study. Auther's elaboration.

3.2.2. Sampling method

Two (2) stage sampling techniques were used in selecting the respondents. The first stage was a purposeful sampling of two representative villages Fafo and Dayére. For that the sampling was based on some specific criteria, the location of the villages in the watershed, on the one hand, and the ethnic composition, on the other hand. The second stage of sampling involved the simple random selection of households in the two villages. The most common use and the

scientists suggest 10% of large populations and 20% of small populations (Schulz *et al*., 2012; Kokoyea *et al*., 2013; Yount, 2006).

In practice, all households were listed and a number was attributed to each of them. Later on, they were selected, using the table of random numbers. The sample size in each village is considered to be satisfactory as it covers 20% of the village household's size. Fafo village has been selected because of the multi-ethnic groups living in there; the reason was to know if those ethnic groups have migrated to the village due to environment factors (fertile soil and weather condition). This criterion was contrary to Dayére, where we have only the Dagara ethnic group. Data were collected in June 2015 and a total of 180 questionnaires were administrated successfully. Each survey lasts 45 to 50 minutes.

3.2.3. Data collection

In order to achieve our goal, we collected two (2) kinds of data: primary and secondary data. The primary data were the household survey and census, while the secondary data were focused on climate data (rainfall) and satellite data. Data collection was preceded by a pre-testing of the questionnaire. However, the overall idea of pre-testing was: to assess the understand ability of questions and test the appropriateness of questions in terms of sociocultural norms etc..,

3.2.3.1. Primary data collection: (Household data and census)

A combination of various conventional tools such as Rural Rapid Appraisal (the farming system approach and farmer level), Focus Groups Discussions (FGD) and questionnaire were also utilised. Rapid Rural Appraisal (RRA) is one of the most appropriate approaches for the identification of community problems and for understanding the socio-economic and cultural aspects of the community. The focus groups were divided into three groups (old men, young men and women). Each meeting has been done separately and at different places. The following pictures (1 and 2) show the focus group participants.

Picture 1: FGD with young men.

Picture 2: FGD with women.

The census data were collected from the town hall of Dano, Koti and Orankua. This database contains population total per village and the number of households. The questions were organised in four key sections: a) identification: sex, age, educational level, income source etc.; b) environmental change/ climate change: the causes, impacts and adaptation strategies; c) migration: motivation, advantage and disadvantage of rural livelihood. In addition, the questionnaire was addressed to the old persons and young persons and both sexes.

3.1.3.2. Secondary data

- ***Climate Data***

Climate data involved in this study were the monthly amount of rainfall. The dataset covers the time series from 1970 to 2013 at the Dano station. Climatic data were obtained from the WASCAL **C**ompetent **C**entre of **O**uagadougou, Burkina Faso. The missing data were replaced by the average value of the series over long period.

- ***Satellite data: Image acquisition procedure***

Remote sensing techniques were used to provide a land cover map to derive vegetation cover characteristics as input parameters for land cover type. Three (3) satellite images (Landsat TM, ETM+ and OLI) from the Global Visualization Viewer (***GloVis***) were available that covered the research area. The Landsat image datasets were obtained from the United States Geological Survey (USGS) data archives (http://glovis.usgs.gov).

Systematic studies of changes on the landscape using high spatial resolutions satellite data sets provided a detailed spatial quantification and description of the land use, land cover change and the rate of land conversion (Traoré, 2015). Cloud free Landsat image with 30 x 30 m spatial resolution were collected for three periods: 1986, 1999 and 2014 respectively from Landsat TM (Thematic Mapper), ETM+ (Enhanced Thematic Mapper Plus) and L8 OLI (Operational Land Imager). The image pre-processing of the Landsat dataset included common procedures of satellite data treatment. The acquired images were geometrically corrected, using a polynomial order1 through ERDAS Imagine 8.6 and classified using the maximum likelihood by using ENVI 4.7 software. Finally ArcMap10 was applied for the maps purpose. Table1 shows the characteristic of different satellite images used in the study.

Table 1: Characteristics of the satellite images (TM, ETM+ and OLI)

Satellite	Sensor	Scene reference	Spatial resolution	Acquisition date
Landsat	TM	path196; raw 052	30 m	08 Oct 1986
	ETM+	path196; raw 052	30 m	08 Oct 1999
	Landsat8/ OLI	path196; raw 052	30 m	21 Oct 2014

3.3. Analysis

3.3.1. Household data analysis

SPSS was used for household data entering and analysis "descriptive statistics". The usefulness of SPSS software is that the quantitative and qualitative data can be used. Furthermore, excel (2013) software was used to plot figures.

3.3.2. Analysis of population dynamic and change

To estimate the current data on the population in the villages, I reviewed a complete population census information recorded in the years 1985, 1996 and 2006. Moreover, 2006 census data was computed for each village to project the population in 2014, using the following equation1.

$$P_{(n)} = P_{(0)} * \left(1 + P/100\right)^{N} \quad \text{(Equation 1)}$$

Where $P_{(n)}$ is the population projection for year x, $P_{(0)}$ is the population at the beginning (base), p is the growth rate, and N is the number of years.

3.3.3. Analysis of Climate data

- Change in precipitation

The change in precipitation were measured using the rainfall data from rain gauge in the study area. This study computed the Standard Precipitation Index (SPI) as indicator of rainfall variability. The SPI base gives a better representation of abnormal wetness and dryness. It was designed to be a spatial invariant indicator of drought that recognizes the importance of time scales in the analysis of water availability and water use (Khan et al., 2008). Positive SPI values indicate greater than median precipitation and negative values indicate less than median precipitation. Drought periods are represented by relatively high negative deviations. The SPI were computed as follow:

$$\boldsymbol{SPI} = \frac{X_i - X_m}{S_i} \quad \text{(Equation 2)}$$

- X_i is the cumulative rainfall for year *i*;
- X_m and *Si* are respectively the mean and the standard deviation of annual rainfall observed in the series.

3.3.4. Detection of land use change

The Maximum Likelihood Classifier (MLC) from supervised classification method, which is the most widely adopted parametric algorithm (Bailly et al., 2007), was used. For this purpose, the training data were collected using ground truth survey, historical land use map of the area, Google earth satellite images and expert knowledge. We used the kappa statistics to assess the accuracy of classification. The rates of land conversion between periods were computed using the "from-to" function and a cross tabulation matrix were produced.

Moreover, in remote sensing it is important to measure the reliability of the classification. Thus, the kappa statistics were used to assess the accuracy of the classifications (Traoré, 2015). Kappa (*k*) is commonly used for accuracy assessment. The overall accuracy was to determine if the values contained an error matrix represent a result significantly. Kappa is computed as

$$K = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_{i+} \times x_{+1})}{N^2 - \sum_{i=1}^{r}(x_{i+} \times x_{+1})} \quad \text{(Equation 3)}$$

where *N* is the total number of sites in the matrix, *r* is the number of rows in the matrix, x_{ii} is the number of observation in row *i* and column *i*, x_{+i} and x_{i+} are the marginal totals of column *i and row i.*

3.3.5. Rate of LULC change analysis

The rate of land conversion between periods were computed using the "from-to" function and a cross tabulation matrix were produced.

Once the areas of land use/cover types were obtained for each period, the rate of change (r) was calculated by using the following equation (Mas *et al*., 2004):

$$r = 1 - \left(1 - \frac{A_1 - A_2}{A_1}\right)^{\frac{1}{t}} \quad (Equation\ 4)$$

where A_1 is the area covered by a given land use/cover at time 1, A_2 the area at time 2 and t is the number of years for the period of analysis.

3.3.6. Evaluation of population dynamic on land use and land cover change

To relate land cover change with population dynamics, Pearson correlation analysis was performed for each annual cropland and vegetation cover. Correlation test was also performed between area of annual cropland and population density. Data from the census data were analysed by using descriptive statistics. All statistical analyses were performed with SPSS 20 and excel was used to plot figures.

CHAPTER IV: RESULTS AND DISCUSSION

4.1. Results

4.1.1. Characteristics of the Sample

The sampling characteristics help us to better understand the different structures of the people in the study area; among them we have social, economic and religious ones. The households interviewed during the field work comprised of men and women of different ages (young and old) and level of their education. Therefore, ages from 18- 39 years are considered young and those above 40 as old. They are described in details below.

4.1.1.1. Sex ratio and average age of the sample

89% of respondents interviewed during the field survey were men; it was a little bit difficult to interview females due to some social and cultural norms constraints. Female respondents did not want to give different opinions from these given by males. It has often been said during the focus group discussion that women are not allowed to talk about family issues. Therefore, only 11% of respondents were females. These female respondents were mostly widows and some women who were not widows responded when their husbands were not around. Figure 5 shows the percentage of male and female interviewed.

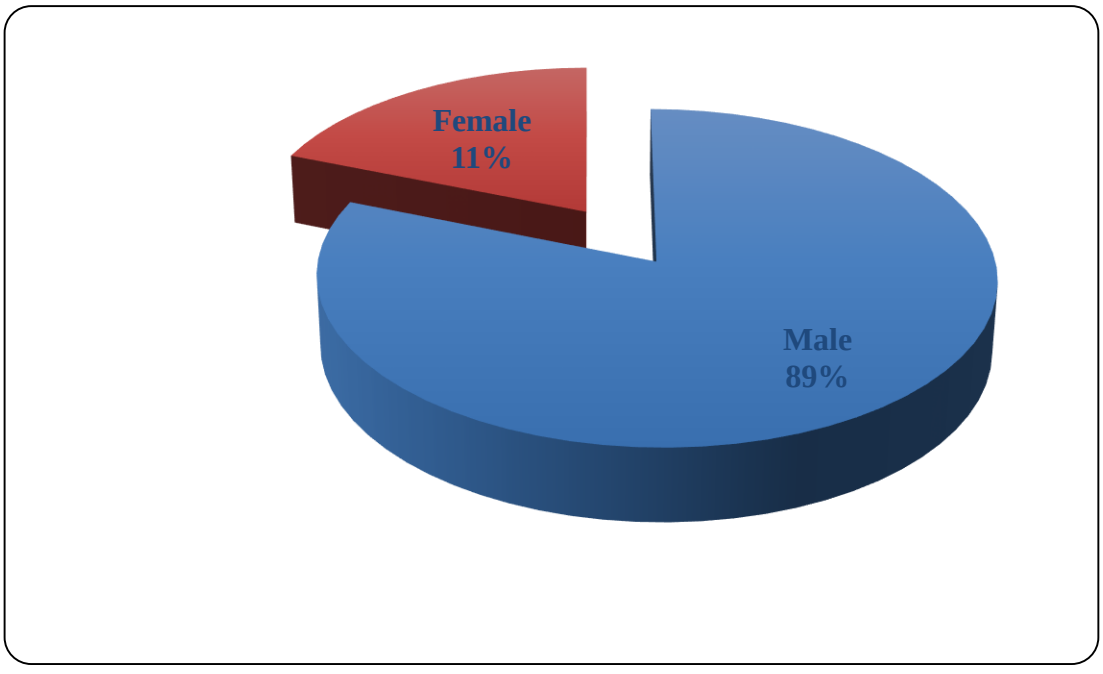


Figure 5: Sex ratio in Dano watershed.

One of the important lessons drawn during the questionnaire pre-test was that most of the farmers have difficulties in determining their exact age. Therefore, to avoid this challenge the age profile was designed by different age bracket. (41%) of the farmers are 30-35 years old, followed by (22%) of 40- 45 years old; 19% of respondents are18-25 years old. The farmers interviewed with ages between 50 -55 made up of 11% of respondents while only 6% respondents were above 60 years of age. Referring to Figure 6, it is glaring that the population in the Dano wathershed is mainly young.

Furthermore, the age class between 50-55 and 60 years and above have gave a good understanding about the environment in the study area, while 30-35 old respondents and 18-25 were not able to give in detail explanation on environmental change issues but good information about migration.

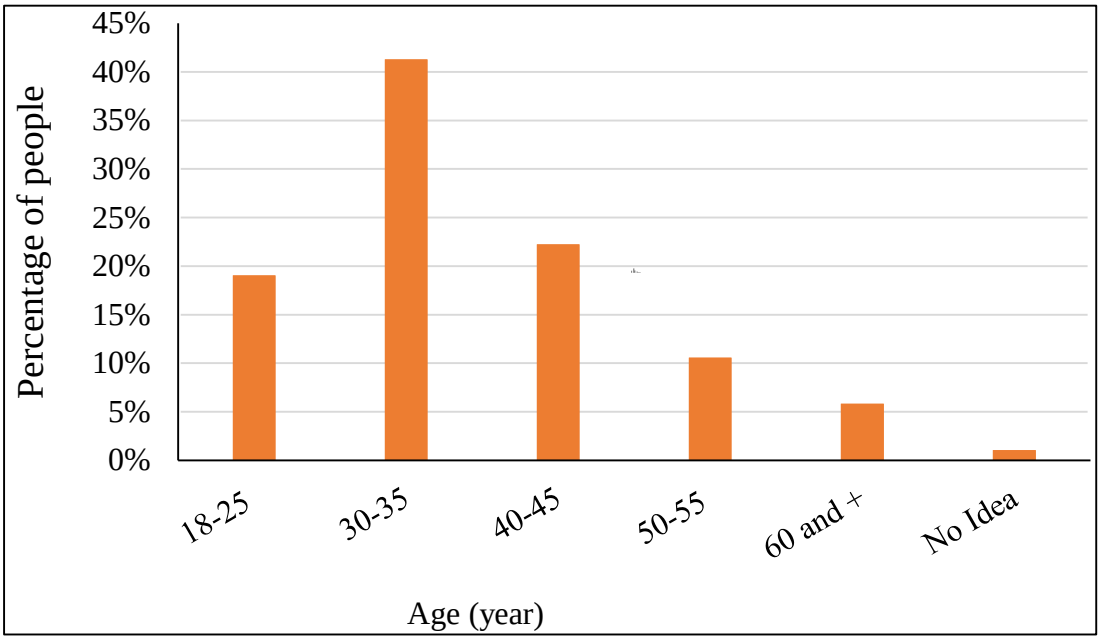


Figure 6: Age profile in the study area.

4.1.1.2. Education rate in the Dano watershed area

Figure below shows an overview of the education level in Dano watershed area. The illiterate rates is predominant 54% followed by primary school level 20%, literate 12%, 6% attended secondary school, high school 5% and for Arabic school 3%. However, the Arabic

school is practiced by Muslims specially, the Mossi ethnic in the study area. As regard to the literate, the Church has developed rapidly the rate of literate, since it is used for bible comprehension.

The illiterate and primary school attendee rates are very high because of poverty, gender inequality and lack of school facilities. Those factors identified during the focus group discussion continue to constraint school enrolments in the research site. Education for rural girls and women has a great impact on the socioeconomic development of a society because girls and women are the pillars and backbones of the communities; although African girls and women are instrumental in for the survival of their families. Girls in Burkina Faso, and specifically in that part of Burkina, do not have access to basic education or they early drop out of school. Figure 7 gives an overview on different types of education practiced in the study area.

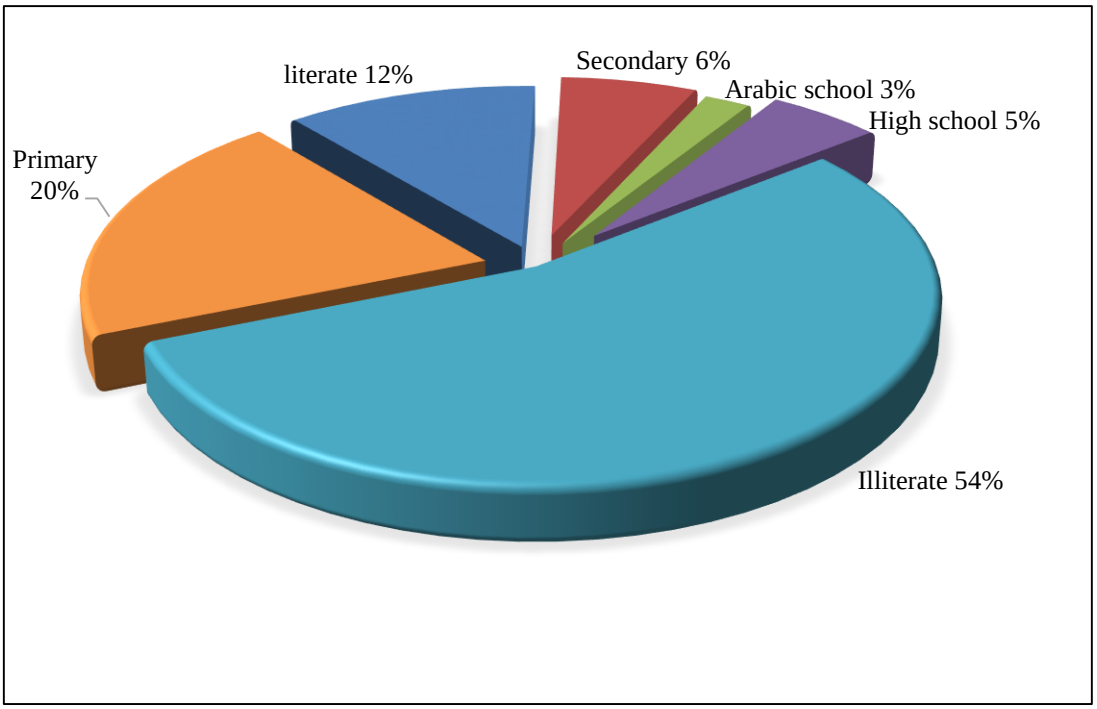


Figure 7: Literacy rate in the Dano watershed.

4.1.2. Land use / land cover mapping

The land use and land cover (LULC) maps were overlaid in order to generate three (3) maps describing the change which occurred during the years 1986, 1999 and 2014. They are figure 8 (map A, B, and C). In this study, five (5) LULC classes were identified and mapped.

These were: Bare land, Cropland, Dense Vegetation, Low Vegetation and Water Bodies. Table 2 gives a brief introduction of the different classes of land use and land cover identified in the study.

Table 2: Description of LULC classes used in this study.

Land cover types	Description
1. Bare land	Areas with sparse or no vegetation cover due to prolonged drought or degradation (this class also encompassed roads and build up areas).
2.Cropland	Cultivated formations with or without scattered trees (canopy coverage 20%). These areas are characterized by annual crops (mainly millet and sorghum), harvested in October–November, followed by a period of bare soil with crop residues.
3. Dense vegetation.	Mixed class. Land with herbaceous vegetation and a woody cover covering. Land with a dense cover of trees covering approximately >70% of the delineated polygon.
4. Low vegetation	Land covered with approximately > 20% herbaceous vegetation and with woody vegetation covering approximately < 20% of the delineated polygon.
5. Water bodies	Permanent or temporary water bodies such as small dam, rivers or stream.

Adapted from Traoré 2015.

As shown in the figure8 (A, B and C), the most dominant LULC class in 1986 was low vegetation which occupied 24843.96 ha (43 % of the catchment). This is followed by the cropland with 18828.51 ha (32%), dense vegetation with 12990.18 ha (22%), bare land with 1480.75 (3%) and water bodies with 99.04 (0.1%). Early in the year 1999, the area of water body has increased to 195.77 ha. Increased water body area is as result of water conservation management after the second drought in 1980s, this in order to facilitate farming during the dry season through irrigation.

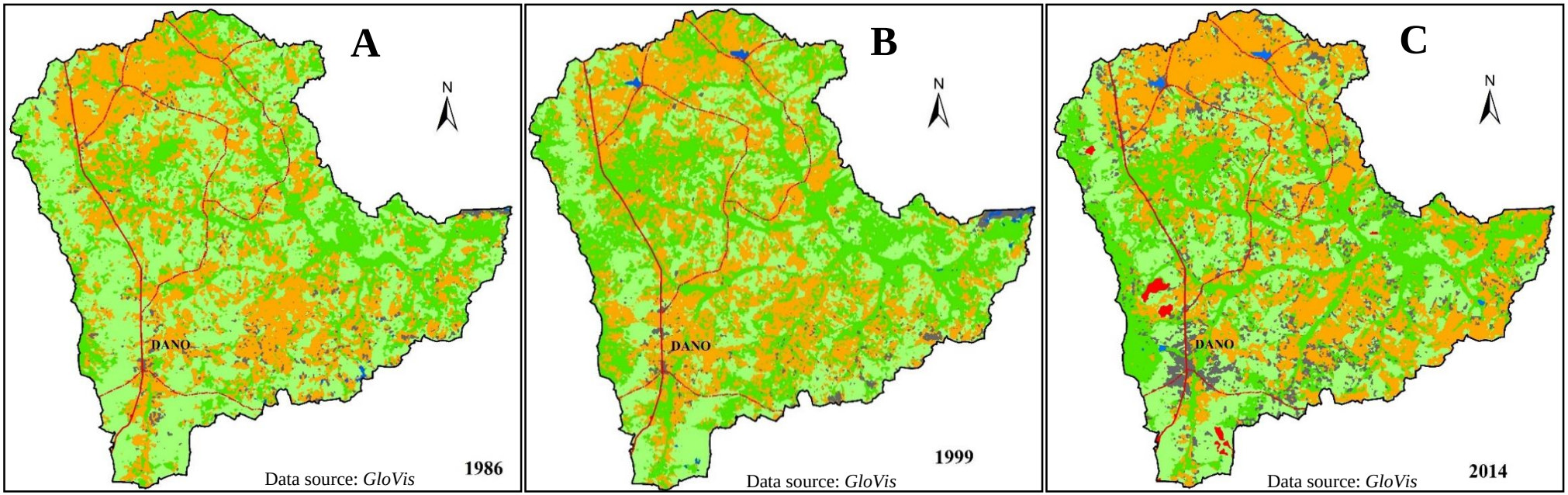


Figure 8: (A, B and C) showing LULC change in the study area.

Table 3 shows the order of magnitude and the spatial extend of the LULC classes in 1986 which were different from 1999. In 1986, the most dominant LULC class was low vegetation about 24843.96 ha (43%). This was followed by the cropland of 18828.51ha (32%) and dense vegetation 12990.18 ha (22%). In 1999, there was not much difference among the areas of dense vegetation 19310.75 ha (33%), low vegetation about 18469.4 ha (32%) and cropland of 19185.82 ha (33%). However, in 2014 about 1% of the catchment (338.58%) was burnt and removed from the statistic. An important point to remember is that the cropland was substantially high in 2014 and it has exceeded both dense vegetation and low vegetation cover. It can be well observed in the year 2014 an increasing of cropland for about (34%) while a decrease have been occurred in the areas of dense vegetation (26%) and low vegetation about (30%) compared to its coverage in 1999. In addition, the area of bare land also has increased as compared to the previous period partly due to increase in population growth among others. This statement is supported by the census data and also the information from field, there has been also progressively conversion of vegetation cover to the roads and settlements over the recent years.

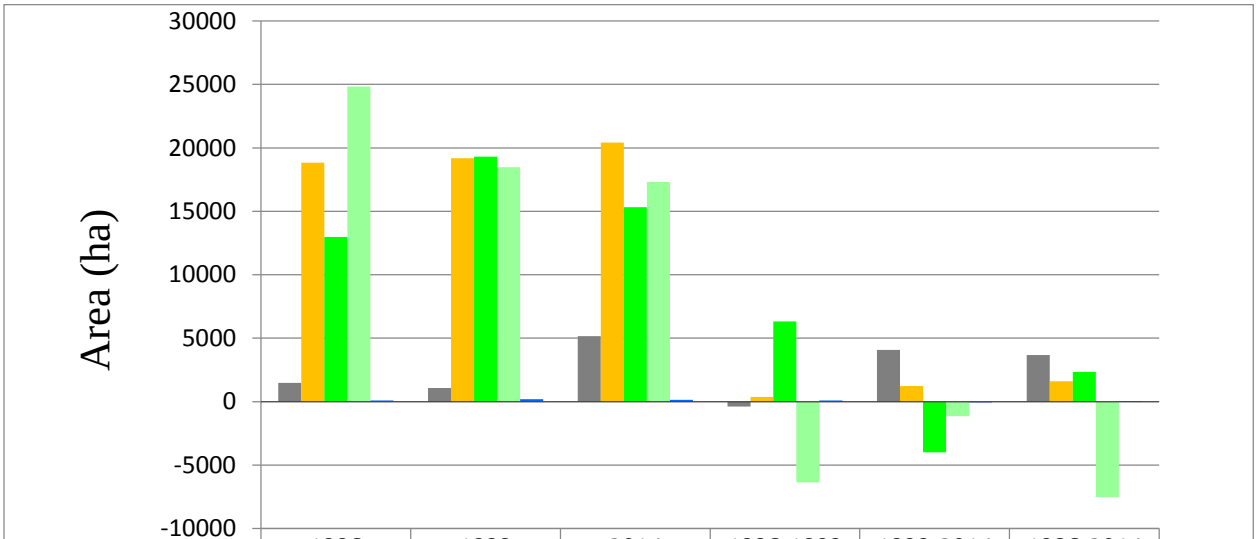
Table 3: Total area of land cover types in 1986, 1999 and 2014.

Land Use Classes	**1986**		**1999**		**2014**	
	Total (ha)	**%**	Total (ha)	**%**	Total (ha)	**%**
Bare-land	1480.75	3	1080.75	2	5153.46	9
Cropland	18828.51	32	19185.82	33	20073.61	34
Dense Vegetation	12990.18	22	19310.75	33	15315.67	26
Low Vegetation	24843.96	43	18469.4	32	17222.81	30
Water Bodies	99.04	0.2	195.77	0.3	138.14	0.2
Burned Area	0	0	0	0	338.74	1

Furthermore, the area of change has been observed during the study periods in each class (Figure 9). Analysis shows that over the study periods, low vegetation lost 7517.21 ha and decreases continuously up to now, which was contrary to cropland with an annual rate of increase of 0.93%. From 1986 to 1999, a negative change was recorded in the areas of low vegetation (-6374.53 ha) and bare-land (-400 ha). From 1999 to 2014 a decrease was more

notable in the dense vegetation (-3995.08 ha), low vegetation (-1142.68 ha) and water bodies (-57.63 ha) this could be explained by increase of frequent rainfall anomalies and increase demand for natural resources.

The overall result of LULC demonstrated a tendency of environmental degradation in the study area. This finding is highly supported by survey data, the majority (78%) of the respondents mentioned deforestation as the major driver of environmental change in the Dano watershed. However, in the study area cutting down of trees for firewood and cropland expansion is very common. In addition, the area has also experienced several rainfall anomalies which in turn have impacted negatively life cycle of ecosystems and loss of some species of wildlife and plants.



	1986	1999	2014	1986-1999	1999-2014	1986-2014
Bare land	1480.75	1080.75	5153.46	-400	4072.71	3672.71
Cropland	18828.51	19185.82	20421.57	357.31	1235.75	1593.06
Dense Vegetation	12990.18	19310.75	15315.67	6320.57	-3995.08	2325.49
Low Vegetation	24843.96	18469.43	17326.75	-6374.53	-1142.68	-7517.21
Water Bodies	99.04	195.77	138.14	96.73	-57.63	39.1

Figure 9: Statistic of LULC change areas.

4.1.3. Accuracy and Validation of the Confusion Matrix

In any LULC mapping procedures, it is essential to evaluate the performance of the designed classification method. This gives a chance to experts to have a degree of confidence in

the results (Congalton, 1991; Manandhar *et al.,* 2009). The different confusion matrixes derived from the assessment of the satellite images are presented in the following (Tables 4, 5 and 6).

In the TM images processing, the overall accuracy was 96% where 6299 pixels out of a total of 6576 were correctly classified with a kappa Coefficient value of 0.94. Table 4 shows the number of the misclassified pixels from the different classes. For the cropland, the total sampling pixel was 2511 while 78 pixels were misclassified to bare land, 34 pixels to dense vegetation, and 16 pixels to low vegetation. The totals of 1679 pixels out of 1765 pixels were digitized as low vegetation. Regarding the dense vegetation, a huge number of sampling has been well classified 2153 pixels out of 2202 pixels.

Table 4: Confusion matrix of the Landsat TM (1986).

	Correctly classified					
Misclassified pixels	**Classes**	Bare-land	Cropland	Dense vegetation	Low vegetation	Water bodies
	Bare land	**62**	78	0	2	0
	Cropland	12	**2383**	24	6	0
	Dense Vegetation	0	34	**2153**	77	0
	Low Vegetation	0	16	25	**1679**	2
	Water bodies	0	0	0	1	22
	Total	**74**	**2511**	**2202**	**1765**	**24**

During the ETM image classifications processing of the different land class types (Table 5), misclassified pixels were identified. For example in the cropland with 1720 pixels of the total sampling pixels where 115 pixels were misclassified to dense vegetation and 88 pixels to bare land. In sum, the overall accuracy of ETM image was 92 % where 6055 pixels out of a total of 6576 were correctly classified and its kappa coefficient value was 0.89.

Table 5: Confusion matrix of the Landsat (1999).

	Correctly classified					
Misclassified pixels	**Classes**	Bare land	Cropland	Dense vegetation	Low vegetation	Water bodies
	Bare land	**129**	88	10	99	1
	Cropland	8	**1492**	51	38	0
	Dense vegetation	0	115	**1855**	62	1
	Low vegetation	10	25	9	**2208**	1
	Water bodies	1	0	2	0	**371**
	Total	**148**	**1720**	**1927**	**2407**	**374**

Table 6 below gives an overview on the OLI image classification. The statistic was very significant with an accuracy of 93% and 4941 pixels out of a total of 5434 were correctly classified with a Kappa Coefficient value of 0.91. The highest misclassified pixel was determined on low vegetation with 197 pixels during bare land classification.

Table 6: Confusion matrix of the Landsat (2014).

	Correctly classified						
Misclassified pixels	**Classes**	Bare land	Burned area	Cropland	Dense vegetation	Low vegetation	Water bodies
	Bare land	**755**	0	8	0	6	0
	Burned area	3	**445**	0	0	90	2
	Cropland	3	11	**245**	0	0	0
	Dense vegetation	0	3	2	**1378**	11	0
	Low vegetation	197	34	15	2	**1995**	0
	Water bodies	0	0	0	0	0	**368**
	Total	**958**	**493**	**270**	**1378**	**1995**	**370**

4.1.5. Relationship between Land Cover Conversion and Population density

4.1.5.1. Correlation between area of vegetation and population dynamics

The Dano watershed, like other parts of the country, has known a rapid population growth over the two (2) last censuses. However, the Pearson correlation confirmed a negative correlation between area of vegetation and population with high significant level at 0.93 (Figure 10). This means that population growth impacts negatively upon vegetation cover. Result from Pearson is highly supported by the survey result 68% of farmers don't have available land.

Referring to our conceptual framework (Figure 4), population growth in either urban or rural area causes environmental degradation or change through cropland expansion and over-exploitation of natural resources. However, results from census data also confirmed that the population density has shifted from 91 habitant/ km² in 2006 to 118 habitants / km^2 in 2014. This result is supported by Gerber (2012), who found out that the population density in the Ioba province is among the highest in Burkina Faso.

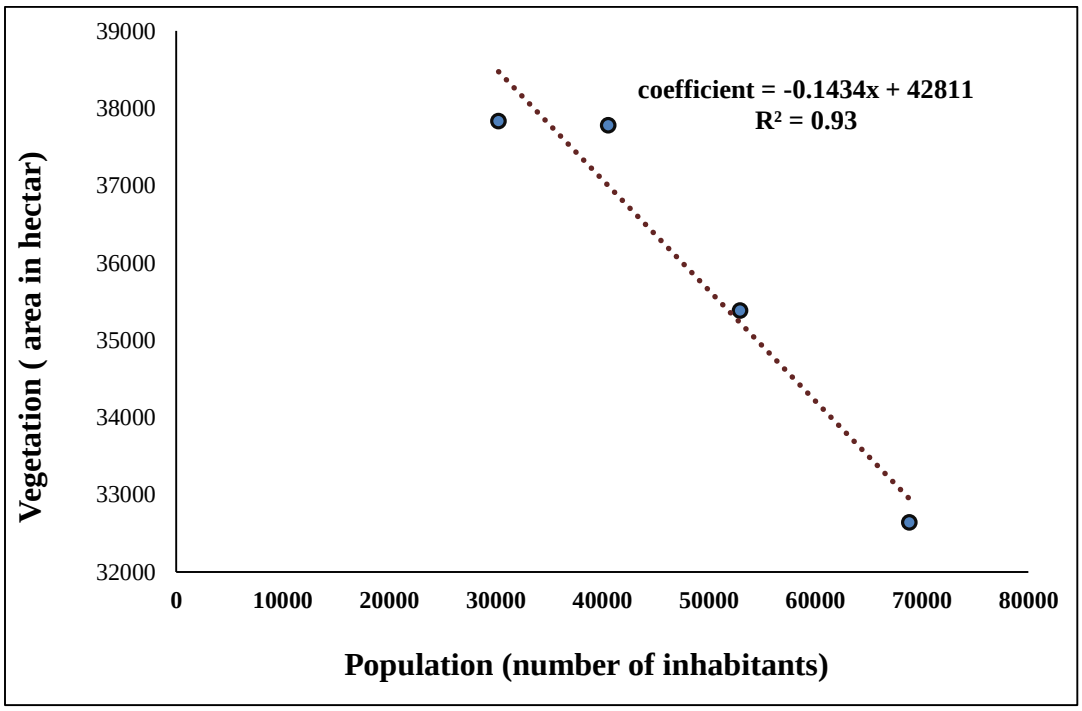


Figure 10: Scatter-gram showing correlation between area of vegetation and population density.

4.1.5.2. Correlation between cropland and population

The result from Pearson confirmed a strong positive correlation between cropland and population dynamics with high R^2 value (0.9979). This explains by high rate cropland expansion. It can be seen from the (Figure 11), that a unit increase in population would cause a corresponding increase of unit in cultivable land. Over the study period, the annual rate of increase in area of cropland was 0.92%.

In addition, population growth increases pressure on agricultural land although significant fertility declines always happens in the study area. This is asserted when the farmers confirmed that they add a new portion of land to their farms each year, mostly drivers by demand for food. In addition, population growth continued to increase pressure on agricultural land although significant fertility declines have occurred in the study area.

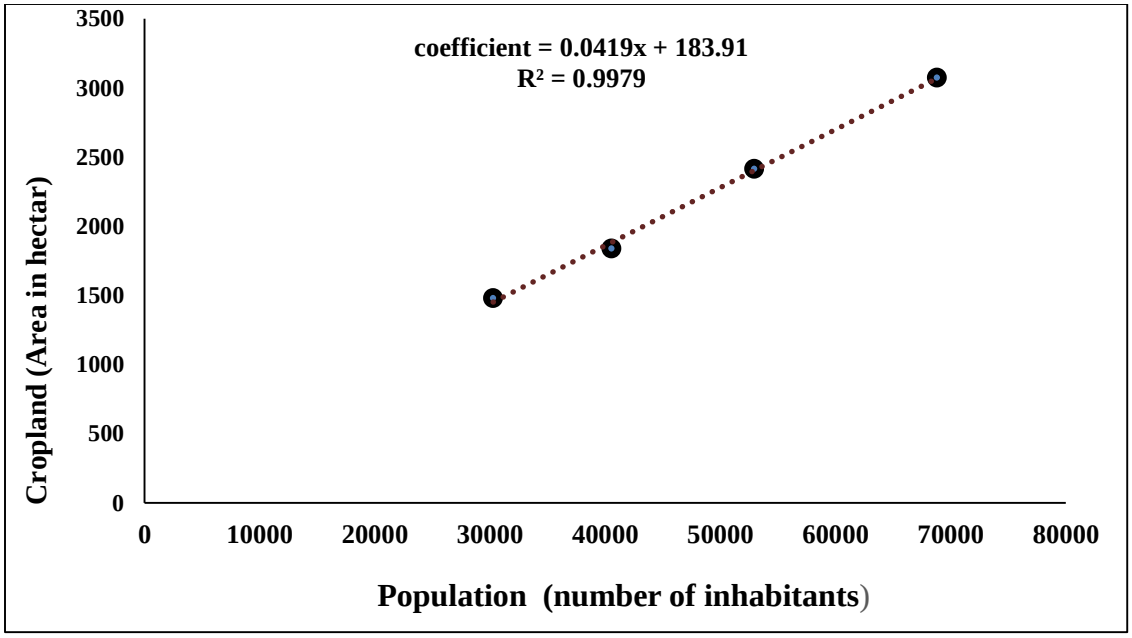


Figure 11: Scatter-gram showing Correlation between area of cropland and population density.

4.1.6. Farmers perceptions on environmental change related to climate change

Many farmers (82%) were aware of environmental related to climate change through oral sources and indicators. Farmers have stated that disruptions of weather patterns have occurred for the last 15 to 20 years.

4.1.6.1. Drivers of environmental change

Table 7 below shows the drivers of environmental change mentioned by the farmers. The majority (78%) attributed environmental change to deforestation. Followed by overpopulation (8%), 7% of farmers indicated that these changes have been caused by God willing. According to them, the occurrence of this event has been predicted in the Bible. More than 2% of respondents said having no idea about the changes that happened. For most of them, changes that occurred are a natural process. In addition, behaviour changes (sins represented 3% for example) were mentioned by the traditional religion practice; they mostly linked the causes to the abandon of the ancestral practices like traditional ceremonies.

Table 7: Drivers of environmental change.

Answers	**(%)**
Deforestation	78
Over-population	8
God willing	7
No idea	3
Sins	3

In terms of deforestation, picture 3 shows an overview of firewood extraction in the Dano watershed. It is noteworthy that deforestation is not only done for charcoal production and firewood selling but also for their own domestic use like cooking food and local beer (*dolo*).

Picture 3: Cutting down of trees for firewood.

As regards to over-population mentioned by the respondents as one of the drivers of environmental change, this perception is supported by the census data (Figure 12).The population in the study area rose from 52936 inhabitants in 2006 to 68817 inhabitants in the year 2014. Meanwhile, the respondents especially, the young men and women linked early marriage and incoming migration (because of mining activities) to rapid population growth. Example, eighteen years old girls are mothers of two children at least. Therefore, demographic factors appear to be of importance in both agricultural intensification and fuelwood use.

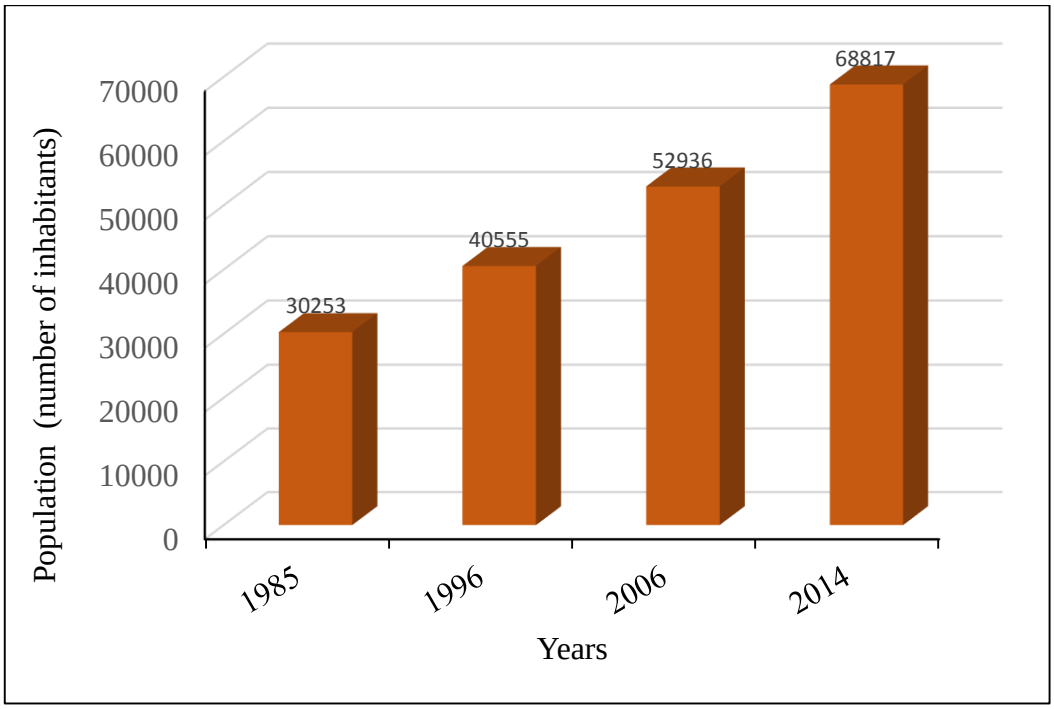


Figure 12: Population dynamics of the research site.

`*4.1.6.2. Impacts of environmental change on rural livelihood*

About 71% of the farmers explained environmental change by a decrease in rainfall, 16% identified strong wind, 5% said bad distribution of rainfall, 3% targeted drought while 2% accused increase of temperature and late onset of rainfall. Only 1% of interviewees stated increase of rainfall (Table 8). One farmer states it well:

"*The late Onset of rainfall started since 2001 cropping season to up to now, before the onset, effectively took place by the end of May or the beginning of June But nowadays the onset is extent to the end of June or the beginning of July*".

In addition, farmers have different opinions on the changes in the duration of the rainy and dry seasons in the study area. Both seasons occurred to arrive the same month before but over the last two (2) decades, but now the dry season seems to be longer than the rainy season. This study comes to a common finding with one from Sanfo (2014) who also carried out farmer's perception about climate variability and change in Burkina Faso. More than 4% of respondents perceived bad distribution of rainfall worse than decrease of rainfall. This reason is that sometimes it rains when the crops do not need water and that may destroy the crop and lead to yield losses which, in turn cause food shortage.

Table 8: Manifestations of environmental change.

Answers	(%)
Strong wind	16
Increase of temperature	2
Decrease of rainfall	71
Late Onset of rainfall	2
Bad distribution of rainfall	5
Drought	3
Increase of rainfall	1

4.1.6.3. Some evidence on rainfall variability and change in the study area

The household survey documented changes in rainfall patterns over the past 10 to 20 years observed in the Dano watershed area. Using rainfall data from weather stations in Dano, Lamb Index was calculated for the period from 1970 to 2012. The result suggests positive indicative trend but not significant (0.0077).

Figure13 shows the decrease of rainfall from 1990 to 1998 which followed to the second drought period in the Sahel. This phenomenon has caused a lot of damages on human well-being, environmental condition and has had other indirect effects. In Burkina Faso, for instance, thousands of people and even greater numbers of cattle perished due to famine and lack of forage. Tens of thousands of families were dislocated and left destitute (West *et al.* 2008). Furthermore, the result reveals that the area under study has recorded less rainfall from 1990 to 1998 corresponded to another drought event. However, in 1999 the study has recorded a flood event area and following the years from 2007 to 2009 another drought occurred.
Recent rainy years such as 2010, 2011, and 2012 could be seen as a comeback of good rainfall years. Unfortunately, there is indicative positive trend, the area has experienced rainfall anomaly in following year 2013. This means that the area may experience drought in the future. The evidence from Vliet, *et al.;* (2013) suggests that environmental change related to rainfall will be a challenging issue in future development.

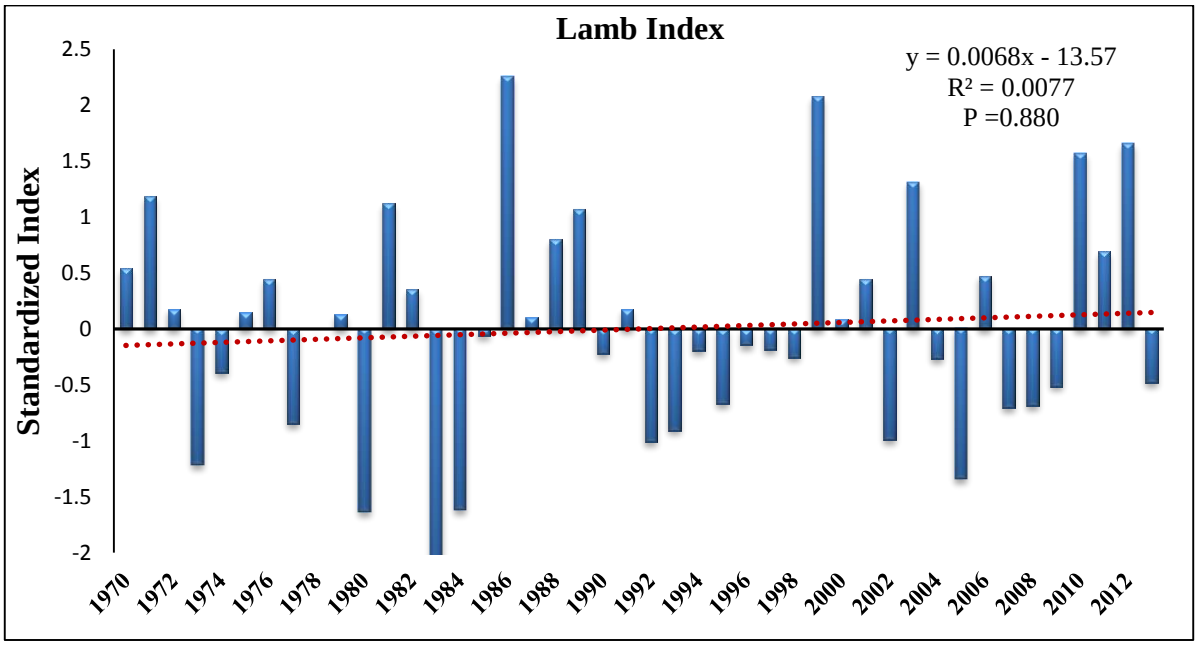


Figure 13: Rainfall anomalies in Dano watershed. Data source: Wascal Competent Centre.

4.1.6.4. Adaptation and Coping Strategies in the study area

The chief of Fafo village has admitted during his interview that adaptation strategies remain a big challenge for the farmers since the phenomenon is unpredictable. They are lucky to have projects and NGOs working with them in the context of capacity building but they are still suffering from environmental degradation. For example, erosion rate increase in Fafo village, decrease soil fertile as well as humidity. Therefore, among the projects in the village of Fafo, the "*Programme de Développement Agricol*" (PDA) is fighting against erosion.It is equally improving management of scarce water resources, building up soil fertility through use of stone bund and adopting new crop. In addition, "*Office de Développement des Evangéliques*" (ODE) enhances food security through implementation of irrigation system and "*Sofitex*" makes easy the availability and accessibility of the entrant, enhancing the production of cotton. Clearly, Burkina Faso has experienced an expanding of development and land conservation projects (Gerber, 2012).

Also, it is assumed that the church has had an important role on the lives of farmer's especially women because of an increase in positive behavioural changes, open mindedness about environmental change, etc. It has been confirmed by the church member that the church has brought some opportunities to improve the family condition for instance the implementation of the site gardening for the women, micro-credit facility, training etc.

Coping with food insecurity caused by rainfall variability and change, farmers have adopted planting early crop (31%) migration (31%), increase use of entrants (17%), activity diversification (16%), the use of Stone bund (3%), earth basin (2%), and traditional method (1%).

Table 9: Response strategies to environmental change in the study area.

Coping and Adaptation strategies	**Answers (%)**
Stone bund	3
Activity diversification	16
Migration	31
Traditional method	1
Earth Basin	2

Use of entrants	17
Early crop	31

In term of livelihood diversification, most of the farmers (69%) practice small businesses. The latter are presented in Figure 14. Among the second activities mentioned, four (4) are widely used and identified as important. The first common is breeding with (17%), followed by gardening (16%), small trade (15%) and mining (10%). However, the miners are considered as the migrants because they are not stable.

Meanwhile, the farmers have determined some challenges related to the secondary activities. Concerning gardening, for instance most of them except farmers who have small portions of land around the water reservoir, stop the activities due to the lack of water in the traditional well. This water shortage usually happens in April. They explained that the duration of the water in the well depends on the amount of the rainfall received.

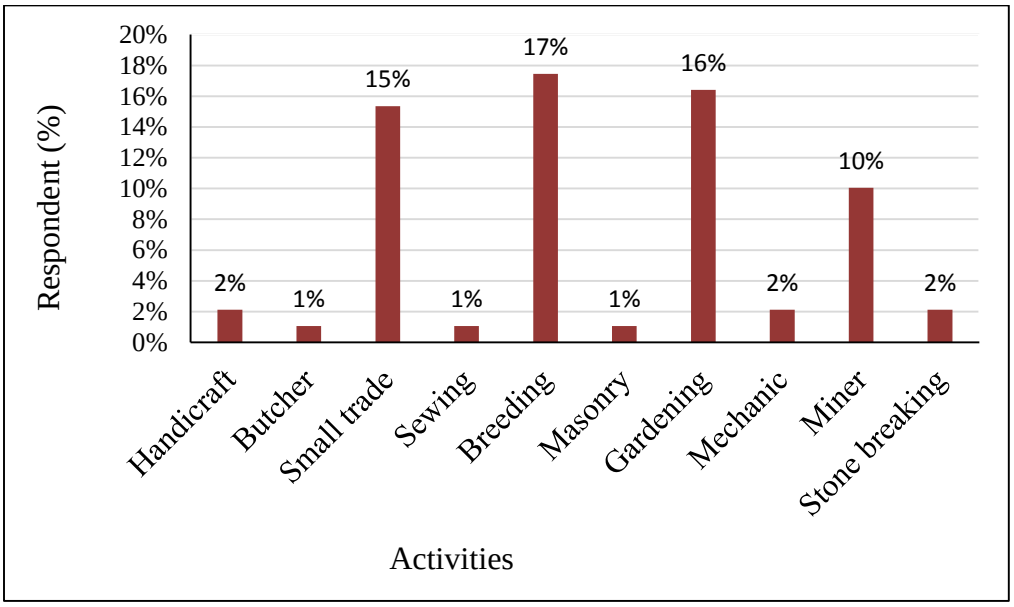


Figure 14: Secondary activities run in the study area.

4.1.7. Migration as response strategy in the study area.

Migration in the study area is not a new phenomenon. It is part of the tradition. In fact, due to social and cultural norms male migration is more common than female migration. Results

from the household survey showed that 57% practiced migration each year while 43% did not practice migration. The analyses further suggest that, in the research site about 62% of household has at least one migrant.

4.1.7.1. Causes of migration in the study area

Based on the findings, both temporary and permanent migrations are practiced in the study area. A Majority of respondents (64%) mentioned that when households are confronted with food insecurity, they tend to engage in migration. During the focus group discussion and household survey the farmers pointed out that migration flow is increasing in the recent years due to gold mining site within Ioba province. The household survey results showed fourteen (14) reasons of migration (Table 10) but three are identified as the most important reasons and they are ranked by order of importance: No activity after harvest (24%), gold mining (22%), and poverty (18%). From the migrant perception the overall cause of migration is mainly economic factor. However, our finding confirm this statement. Finding reveal that environmental change is not the root cause of migration but socio-economic conditions although environmental change influences the migrant's decision especially young ones in the study are. The results reveal that environmental change is not the direct cause of migration but socio-economic conditions although they are facing to environmental change challenge.

Table 10: Causes of the migration in the study area.

Answers	Percentage %
No activity after harvest	24
Gold mining	22
Poverty	18
Curiosity	7
To realize my dreams	6
Bad harvest	5
Social problem	4
Grazing	3
Agriculture	3
Gardening	2
To search for work equipment	2

For trade	2
For teaching	1
To work here	1

Another cause mentioned by one 18 years old respondent was that when a migrant returns to his family he always comes with some changes, it may be behavioural changes or material things so, the other people of the family will be thinking why do we not do the same and get what he gets.

In addition, migration to rural areas for gold mining is becoming popular. This type of migration is mainly practiced even during the rainy season when the gold appears, for instance in particular area. Miners are willing to move any time to the gold site including during farm activity season, because the harvest is no longer good. Nowadays, the gold mining activity has become more and more fashion in the research site and this has an influence on the destination too.

A gold digger in the Fafo mining site even declared:

> **"***I like this hard job than agriculture because it is more profitable. I abandoned farm activity four (4) years ago so I can move anywhere the gold appears and at any time***".**

Another miner confirmed that they are ready to move for mining activity even during the rainy season due to bad season and lack of fertile land. Interestingly, migration for fertile land was very low only 1%. The 7 % young men around eighteen (18) years old mentioned curiosity and 6% wanted to realise their dreams. More than 2% who said agriculture as cause of migration are those who have contract for the whole season in Ghana or Ivory Coast. They prefer to send money to their family during the rainy season for hire the labours to work in their farms. The 2% said garden, are those who move to the area where there are small dam, reservoir or the backwater for irrigation purpose. The 2% who mentioned trade are the Mossi immigrants. But, most Mossi ignored to be immigrants simply they were born in the village. Two per cent of the respondents mentioned search for equipment of agriculture, specially the carts for ploughing and weeding. The remaining 1% who teachers and to works in the village.

4.1.7.2. Type of migration in Dano watershed area

The two (2) types of seasonal migrations are practiced in the research site: one that lasts six months per year and another one which covers a period less than six (6) months (Rademacher *et al.,* 2012). However, the result shows that (59%) of the respondents practiced the second type of seasonal migration and (41%) the first type. Focus group discussions on human mobility and seasonal calendars indicated that migrants usually move after harvest in October - November and normally return in May-June to assist their family during the rainy season. In addition, the migrants and family members mentioned the before the return at the end of April to the 15th of May. However, due to the late onset of the rainy season most of them wait until parents informed them.

In terms of destination, the result from field work confirms that the migrants move within the country and beyond borders. Three (3) localities are listed international destination (33%), rural- urban places (12%), rural-rural (55%). The cross boundary migration to Ghana and Ivory Coast is commonly used by the young men for cocoa production and other farm work. Girls usually migrate to Bobo Dioulasso and Ouagadougou to look job like house helps. The girls migrate just to get job and be able to buy things such as plates and clothes before the wedding.

4.1.7.3. Benefits and life improvement from migration

4.1.7.3.1. At household level

Migration has improved life condition in many households in the study area. Figure15 shows the benefit and life improvement from the migration. At the household level, the benefits are ranked in order importance: family needs (44%), saving (41%), purchase of motorbike (5%), building of houses (4%), agricultural input (4%) and procurement of knowledge (1%). The income from migration is on family needs; these include school fees for the kids, health care and other unexpected events. Additionally, migrants and their family members claim that the income from the migration guaranteed the food security in their households. The saving is mainly used on the small breeding (goats, chicken, cheep, pig etc.). This activity plays an important role in their economic life.

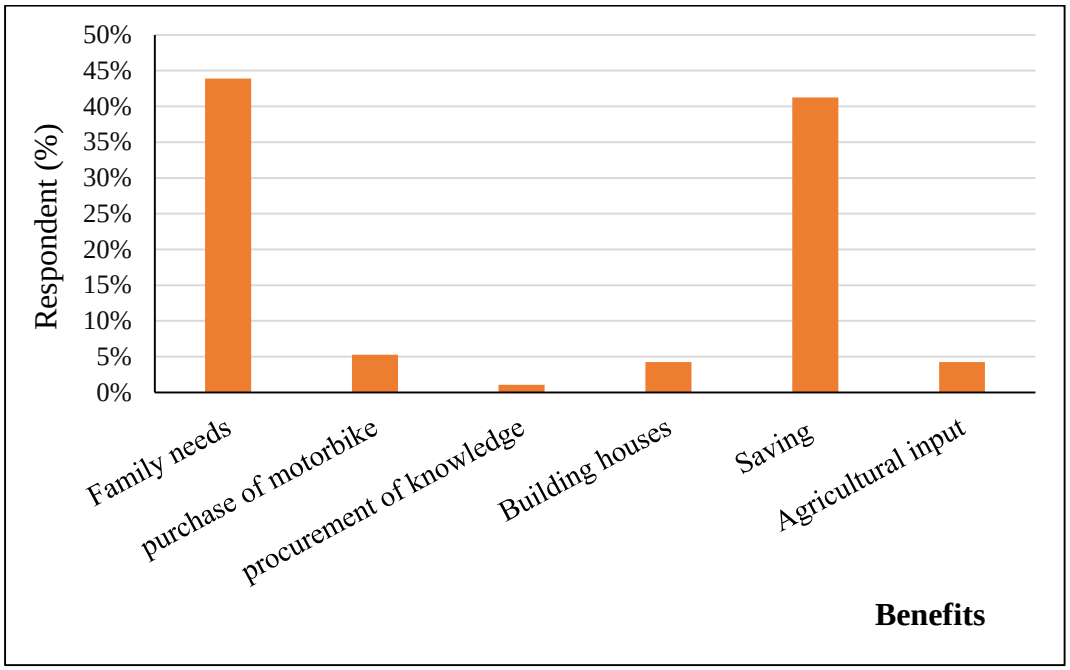


Figure 15: Benefits from migration by household in the study area.

4.1.7.3.2. At village level

It is important to note that migration has always played an important role in sustaining and expanding people's livelihoods in many different ways in the villages. Most of the villagers (84%) found migration as a good strategy for village development. Some important benefits of migration in the study include the facility of transport. Most of the young men in each household have their own bicycle or motorbike. Migration has equally improved the level of education of the young migrants and their relatives.

Figure16 shows the benefits from the migration in the study area stated by the migrants and the relatives were the following: Poverty reduction 38%, improvement of living standards (27%), building of modern houses (13%), transport accessibility or facility (12%), the immigrants invest in the village (7%) and the establishment of workshop in the village (3.2%).

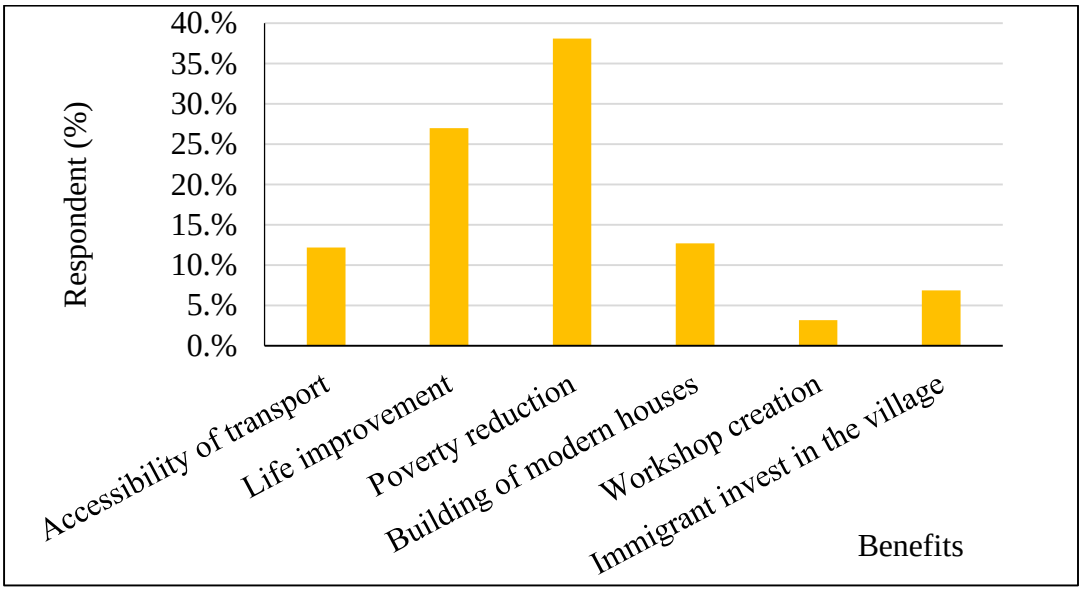


Figure 16: Benefits from migration at village level in the study area.

4.1.7.3. Challenges related to migration

Migrants and their relatives have identified some challenges they face at their destination. More than 21% of respondents have mentioned conflict, especially when it is time for them to return to their villages, some of their bosses are reluctant to pay their salary or refuse to pay the complete amount they have worked for. This problem happens usually with the girls. In addition, the girls also mentioned domestic violence: they are at times threatened by the sons of their bosses or family members. Furthermore, 14% have lost their properties during the war in Ivory Coast while 2% were seriously sick due to infectious diseases or malaria.

4.2. Discussion

Findings obtained reveal an important change in the spatial distribution of land use types in the study area from 1986 to 2014. In the year 1986, the survey results showed large areas of low vegetation (24,843.96 ha) which represents (43%) of Dano watershed while cropland covered an area about (32%) of watershed. Early in 1999, the superficial increase of dense vegetation and water bodies also could be the result of the environmental policy introduced after the drought period. When it comes to the spatial trend of the cultivated areas from 1986 - 2014, it is interesting to note that the change occurred progressively. In the years 1999-2014, the negative change in terms of area were more notable in the dense vegetation (-3,995.08 ha), low vegetation (-1,142.68 ha) and water bodies (-57.63 ha). However, the decrease in dense forest and low vegetation area could be explained by relaxed environmental protection and expansion of cash crops like cotton (Ouedrago *et al*., 2009; Gerber, 2012).

The farmers mentioned that, even though there is uncertainly in rainfall distribution and cotton production. However, yields vary due to weather conditions; nonetheless, farmers are motivated to engage in cotton production since those who plant cotton have access to soft loan facilities to purchase input such as herbicides and fertilizer. However, the traditional agricultural methods are more common in the study area, only about 38% of the households have at least one pair of oxen. This method is very common in the tropical regions (Lambin *et al.*, 2003; Ouedrago *et al*., 2012)

The next stage of the analysis concentrated on the relationship concerning population size, vegetation and cropland. As shown in the figures (10 and 11), there is high significant negative correlation between population size and vegetation (R^2 0.93) while population size and cropland is positively correlated with high significance (R^2 0.9979). The explanation, following Malthus and Boserup, states that a country with a high population growth will be stimulated to have greater expansions in their agricultural land area. However, Boserup focused more on technologically advanced forms of farm inputs as drivers of cropland expansion (Marquette, 1997a). Our finding supports this statement, the majority of farmers at 73% in the Dano watershed applied herbicide on their farms. In addition, the conversion of forest land to cropland means often an abrupt change in biomass (IPCC, 2008, Vliet, *et al.*, 2013).

Land use and land cover (LULC) changes are closely interconnected in multiple and bi-directional ways to changes in local livelihoods and the provision of ecosystem services. Also

implementation of new farming techniques together with the increasing demand for food to feed the growing population may have contributed to important ecosystem degradation in Burkina Faso. Numerous studies have concluded LULC changes related to environmental degradation and change have been changing for the worse on rural livelihood in Burkina Faso (West *et al*., 2008; Paré *et al.*, 2008; Ouedrago *et al*., 2009; Ouedrago *et al*., 2012, Sanfo *et al.* 2015).

Farmers have linked environmental change as a threat to their livelihood security. They identified two (2) pillars of human security which are now affected in the study, i.e. food and health security. The farmers perceived that the existing impacts of environmental change (Table 4) results in crop and livestock production failure. However, majority of the respondents at 71% find direct link between the decrease in rainfall and economic situation of the household. In addition, long dry spells during critical stages in the planting season seriously influence crop production, leading to reduced yields.

Sorghum and cotton were also identified as being more vulnerable, among other crops. The overall situation results to undermine the availability and quality of food and forage for livestock. It was noted that when crop yield fails, that influences the price for that particular crop which increases as a result of high demand and low supply. For instance the price of sorghum and maize increases the very month it is harvested, and it will keep going up until the new harvest.

In the context of health related to environmental change, the respondents especially the Fulanis mentioned observing the appearance of some insects like suckers, trypanosomiasis, ticks and other new diseases. Findings of this Master Thesis also corroborate with the ones from Sanfo, *et al* (2015) who carried out a study on violent conflicts between crop farmers and agro-pastoralists in the Eastern and Plateau Central Regions of Burkina Faso. Meanwhile, suckers are insects that normally suck the plants eventually leading to the destruction of the plants; also these insects survive better in drier and less water conditions.

Furthermore, the dust during Harmattan is indicted to have increased the occurrence of certain diseases (e.g. meningitis). Also in the rainy season, the strong winds seriously damage and collapse houses and trees, and usually disrupt cloud formation during the rainy season. It is also clear that, according to some findings from Sanfo et al. (2014), that the ground speed of winds in the Ioba province has increased from 1 m/s (1970) to 1.9 m/s (2013). However, this

increase in wind speed in the study area could be linked to deforestation since most of the trees have been cut down.

Famers have developed several coping and adaptation strategies to guarantee household security. Among the strategies (Table 11), migration has been classified as a crucial strategy to diversify household income. It is well documented by several studies that migration has always been a local response or survival strategy of people confronted by environmental changes that endanger human welfare. (Renaud et al. 2007; Hugo, 2008; Paré *et al.*, 2008; Warner, 2011; Renaud, *et al*., 2011; Ouedrago *et al*., 2012). Unlike those studies that have detected a large connection between environmental change and rural migration, we find a moderate relationship between them. Therefore, based on our findings, migration seems to be the traditional practice in the Dano watershed due to no activity after harvest. Thus, the hypothesis that environmental change is the main driver of migration in the Dano watershed area is rejected.

Furthermore, among the causes of migration, the most important are as follows: no activity after harvest (24%), gold mining (22%), and poverty (18%) are directly linked to socioeconomic factors. This means that the socio-cultural and economic factors contribute most to migration than environmental factors. Thus the second hypothesis that migration is widely used to improve households' livelihood condition in the Dano watershed is accepted.

The linkage between environmental change and migration in the study area is that, environmental change is influencing on farmers attitude, especially since some of the youth have extended their seasonal migration period (e.g. in gold mining) into the rainy season activities. This is a common finding with the ones from Henry *et al.* (2003). In fact, before the migrant used to spend only the dry season away (usually after harvest i.e. October -November) and return in April in order to get ready for the rainy season. But nowadays, the return of the migrants depends on the onset of the rain, which has now changed and farmers now have a challenge in predicting the rainy season. In addition, environmental change is compelling farmers to empower their non-farming activities (e.g. small trade, gold mining, and livestock breeding). For instance trade was mainly conducted by the Mossi ethnic group in the Dano watershed but many other tribes (e.g. Dagara and Bwaba) are now involved in trade.

CHAPTER 5: Conclusion and recommendations

5.1. Conclusion

The work has discussed the linkage between environmental change and human mobility using the case study of Dano watershed area in Ioba province south-western Burkina Faso. The overall conclusion from our findings is as follows:

A number of inferences are drawn from the analysis of the available data and available scientific evidence. Results from the present study disclosed a substantial land cover change in the Dano watershed. However, the contribution of environmental variables in the explanation of migration was slightly lower than for the socio-demographic variables. In terms of environmental change, population dynamic had a greater explanatory power than high variability and change of rainfall pattern. Increase demand for natural resource (cropland and firewood), mostly driven by rapid population growth couple with frequent rain-fall anomalies are subject to environmental degradation and change in the study area. Moreover, this long term change has negative effect on the present climate parameters in the study area on one hand and in the whole country on the other hand. In addition, it will continue to influence on the farmers thought even to discourage young generation to abandon agriculture. The increased variability and change of rainfall patterns have compromised the ability of farmers to predict seasonal calendar.

Households in the Dano watershed have copped to environmental by changing their agricultural practices (soil conservation, early mature crop etc.) and diversifying their livelihoods make them less dependent on rain-fed agriculture. Indeed, policy decisions regarding environmental change and rural migration must be taken into account. The following section suggests some recommendations.

5.2. Recommendations

Populations have developed coping strategies and adapted livelihoods to the impact of environment constraints. This study addresses here some recommendations to policy makers and to the local communities.

- There is an urgent need for agricultural intensification related policy initiatives to discourage the expansion of cultivated lands and its associated fragmentation of forested areas.

- Rural livelihoods other than farming need to be encouraged and even supported by government's macroeconomic policies.

- Concerted efforts should be made to define appropriate strategies and new policy. This has to include extension services and trainings that could help to balance agricultural production, forest conservation through dialogue with stakeholders and reinforcement of farmers' participation. For instance, tree planting schemes must involve all members of the community.

- Authorities and local institutions must control the migration flow which otherwise might generate conflicts between indigenous and migrant populations in the long run, particularly migration related to gold mining.

5.3. Limitation of the study

- ✓ Merging the satellite and census data into a single data was the most challenging aspect of the study.
- ✓ Drawing, of migration flow has been not done because of the lack of data on migration.
- ✓ Another issue with regard to the methodology was household surveys. The farmers were not available because of the activities the rainy season. For this reason, the time for field work was extended. In addition, some of the respondents do not agree the meaning of migration for instance the Fulanis. They understand migration as the displacement of the whole family. Thus, it has influenced our finding.

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Annex: Some Tools used for Data Collection

I. FOCUS GROUP DISCUSSION

Partie I : Situation actuelle de l'occupation du sol

1- Quelles sont les types d'occupation (végétation, pâturage, eau, champs, habitat) du sol aujourd'hui ? + carte d'occupation.

2- Quelle est la proportion de ces ressources en termes de superficie ?

Occupation du sol	Superficie (hm^2)
Végétation	
Pâturage,	
Eau,	
Champs	
Habitat	

3- Quels sont les types de sols du terroir ? carte des sols

4- Quelles sont les espèces végétales (arbres) dominantes ?

5- Quelles sont les espèces verdoyantes ?

6- Pendant quelle période de l'année les arbres perdent leurs feuilles ?

7- Quelle est la période des semis ? et période de récolte si possible par type de culture ?

Culture	période des semis	période de récolte

Partie II : Changements et causes de changement environnementaux

1- Avez-vous observé un changement de la couverture végétale autour du village comparé aux périodes anciennes ? expliquez ces changements.

2- Est-ce que vous avez observé un changement (diminution ou augmentation) des espèces végétales depuis 1990 ? Oui /-------/ Non/-------/
Si oui, citez les espèces disparues/ en diminution / en augmentation et expliquez.

3- Est-ce que vous avez observé un changement de la quantité des herbes ? expliquez.

4- Avez-vous remarquez un changement de la pluviométrie et cela quand ? commentaire.

5- Est-ce que le nombre d'animaux a augmenté pendant les derniers périodes ? Explique.

6- Est-ce que les périodes de semis ont changé ? quand est ce que commence les semis / énumérer par type de culture et depuis quand vous avez remarqué ce changement ?

Partie III : Démographie, Mobilité et accès aux ressources

1- Combien de personnes vivent dans le village actuellement ?

Homme	
Femme	
Enfant	
Total	

2- Est- elle inferieur à celle de 1990 ? estimation du nombre si possible

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3- Y'a t-il des migrants dans le village ? personnes venant d'autres localités si oui que font-ils ? Et comment ils ont accès à la terre ?
Location/--------/ Prêté/-------/ Acheter/--------/

4- Ya-t-il dans le village des personnes qui partent en exodes ? où ? pour combien de temps en moyenne ?

5- Est-ce qu'il y'a des raisons? si oui explique.

6- Est-ce que ces personnes à l'exode vous envoient de l'argent ? si oui comment vous investissez cet argent ?

7- Est-ce que la migration a des atouts? Si oui explique.

8- Est-ce que la migration a des contraints? Si oui explique.

Partie IV : Pratiques culturales

1- Décrivez votre system culturale (rotation des cultures depuis la friche)

2- Quelles sont les types de cultures ? citez en fonction de leur importance

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3- Est-ce cella est la même depuis 1990 ? commentaire

4- Qu'est ce qui vous motive à faire des nouveaux champs ?

Quelle est la fréquence pour faire un nouveau champ ?

5- Ya-t-il toujours des terres disponibles pour l'agriculture ? vers ou (points cardinaux)?

6- Est-ce que les superficies cultivées dans le village ont augmenté depuis 1990 ? si oui pourquoi ?---

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7- Est-ce que le rendement aussi a suivi la même tendance (augmente) ? si oui pourquoi ?

8- Combien de vos champs sont en jachères ? estimation de superficie

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9- Quelle est la durée moyenne de la jachère ? est-elle plus courte ou longue par rapport à 1990 ? pourquoi ?

Partie V : Gestion des ressources naturelles

1- Quels sont les acteurs de gestion des ressources naturelles ?

2- Y'a t-il des règles pour défricher un nouveau champ ? lesquelles ?

3- Avez-vous des zones protégées ? (pas de coupe ou site traditionnel) vers ou (points cardinaux)?

Depuis quand ?----------

4- Existe-t-il des zones de coupe de bois ? localisez.

5- Avez-vous des marchés de bois /charbon ? localisez.

6- Est-ce la distance pour les coupes de bois de chauffe a augmenté ou diminué par rapport au passé ? Enumérez les raisons.

II. QUESTIONNAIRE SOCIO-ECONOMIQUE

Section1: LOCALISATION

1.0. Date	----------/----------/ 2015	
1.1. N^0 de la fiche	1.4. Village	
1.2. Province	1.5. Nom de l'enquêteur	
1.3. commune	Coordonnées	Longitude:
		Latitude:

NB : S'il vous plait écoute attentivement l'enquêté(e).

Section2 : Identification de l'enquêté (e)

N^0	Question	Réponse	Code
2.0	Nom et Prénom		
2.1	Sexe	1. Masculin 2. Féminin	
2.2	Statut matrimonial	1. Marié(e) 2. Célibataire 3. Divorcé(e) 4. Autres?	
2.3	Quel âge avez-vous ?	1. [18ans-25ans [2. [30ans-35ans [3. [40ans- 45ans [4. [50 ans- 55 ans [5. [60 ans et plus [	
2.4	**ê**tes-vous autochtone ?	1. Oui 2. Non	1⟹2.7
2.5	Si non d'où venez-vous ?		
2.6	Depuis quand ?/Nombre d'années dans le village		
2.7	Quel est votre ethnie ?		
2.8	Quelle est votre religion		

2.9	Nombre de personne vivant dans le ménage	1. Homme 2. Femme 3. Enfant (0 à 15 ans)		Total
2.10	Combien de personne du ménage travail dans votre champ?	1. Homme 2. Femme		
2.11	Avez-vous fréquenté l'école ?	1. Oui 2. Non		
2.12	Quel est le niveau d'études que vous avez atteint ?			

Section 3: socioéconomiques

	Question	**Réponse**	**Code**
3.0	Quel est votre principale source de revenue?		
3.1	Avez-vous des activités Secondaires	1. Oui 2. Non	
3.2	Si oui Quelles sont ces activités ?		
3.3	Depuis quand avez-vous commence cette activité ?	1. 1an 2. 2ans 3. 3ans et plus	
3.4	Si c'est moins de cinq (5) ans, poussez-vous nous dire la raison ?		

Section 4: Evaluation des ménages.

4. a. Combien de champ possédez-vous ?

Type de champs	Mode d'acquisition	Superficie (ha)	Rendement	Utilisation du rendement

[1] Coton
[2] Mil
[3] Sorgho
[4] Arachide
[5] Haricot
[6] Mais

[1] Héritage
[2] Don
[3] Prêt
[4] Métayage

[1] 100% Autoconsommée
[2] 50% Autoconsommée et 50% vendue
[3] 75% Autoconsommée et 25% vendue
[4] 75% vendue et 25% Autoconsommée
[5] 100% vendue

4. b. Est-ce que votre rendement est suffisant pour nourrir la famille ? ……...

Si non pourquoi ?……

N₀	**Question**	**Réponse**	**Code**
4.1	Possédez-vous le tracteur ?	1. Oui 2. Non	
4.2	Possédez-vous la charrue?	1. Oui 2. Non	
4.3	Employez-vous des ouvriers?	1. Oui 2. Non	
4.4	Si oui nombre par an	1. Homme 2. Femme	
4.5	A combien ?	1. Mois 2. Jour	
4.6	Utilisez-vous les intrants ?	1. Engrais 2. Herbicide 3. Insecticide	
4.7	Est-ce que vous avez accès aux intrants	1. Oui 2. Non	
4.8	Si non pourquoi ?		

4.9. Elevez-vous des animaux?

Types d'animaux	Nombre	Rôle

[1] Bovin
[2] Caprin
[3] Volaille
[4] Autre à préciser -

[1] Labour
[2] Ventre (pour couvrir la dépense)
[3] Production du lait
[4] Transport

4.10. Avez-vous toujours des terres disponibles pour l'agriculture ? Oui /------/ Non /------/

Si non pourquoi ?----------

4.12. Avez-vous reçu des appuis des projets ou ONG au cours de 5 dernières années ?

Nom du Projet/ ONG	Intervient-il toujours ?	Domaine	Type d'appuies

1. Agriculture
2. Elevage
3. Santé
4. Environnement
5. Autre à préciser

1. Matériel
2. financière
3. Formation
4. Autre à préciser

Section5 : Perception sur changement climatique

N^0	Question	Réponse	Code
5.0	Avez-vous observe un changement climatique?	1. Oui 2. Non	
5.1	Si oui comment manifeste-il dans le village ?		
5.2	Est-ce que ces phénomènes vous causent des problèmes ?	1. Oui 2. Non	
5.3	Si oui pouvez-vous nous expliquer ?		
5.4	Est-ce que vous pourrez nous citer les causes de ce changement ?		
Stratégie d'adaptation du changement climatique			
5.5	Est-ce que vous luttez contre le changement climatique ?	1. Oui 2. Non	
5.6	Si oui, comment ? quelles sont les stratégies/moyens que vous		
5.7	Est-ce qu'il y'a un programme dans le village ?	1. Oui 2. Non	
5.8	Si oui quel est son rôle ?		
5.9	Suivez-vous ces conseils?	1. Oui 2. Non	
5.10	Si oui quel sont les avantages		

Section 6: Migration

A- **Les autochtones**

N^0	**Question**	**Réponse**	**Code**
A.0	Avez-vous migré dans les 5 dernières années?	1. Oui 2. Non	1 ⟹ A.3
A.1	Est-ce que un membre de la famille a migré dans les 5 dernières années?	1. Oui 2. Non	
A.3	Quelles sont les types de migration?	1. Saisonnière (1-6 mois) 2. Permanente (7mois-année)	
A.4	Quelles sont les destinations ? **BN : Nom de l'endroit**.	1. Rural-rural 2. Rural-Urban 3. International	
A.5	Pouvez-vous nous dire les causes/motifs de la migration?		
A.6	Est-ce que vous tirez un bénéfice de la migration?	1. Oui 2. Non	
A.7	Si oui lequel?		
A.8	Pensez-vous que la migration est une bonne stratégie pour satisfait tes besoins?	1. Oui 2. Non	
A.9	Si oui quels sont ses avantages?		
A.10	Si non quels sont ses inconvénients?		
A.11	Pensez-vous la migration a amené un changement dans le village?	1. Oui 2. Non	

A.12	Si oui comment ?		
A.13	Si non comment?		
A.14	Pensez-vous qu'on doit encourager la migration?	1. Oui 2. Non	
A.15	Si oui pourquoi ?		
A.16	Si non pourquoi ?		

B- **Les immigrants**

N^0	**Question**	**Réponse**	**Code**
B.1	Quand êtes-vous arrivé dans le village ?	1 [0- 1 an] 2 [2- 3 ans] 3 [4- 5 ans]	
B.2	Pour quelle raison vous êtes dans le village?		
B.3	Pensez-vous retourner dans votre village/ Pays?	1. Oui 2. Non	
B.4	Si oui pourquoi?		
B.5	Si non pourquoi?		
B.6	Pensez-vous que la migration est une bonne stratégie pour satisfait tes besoins?	1. Oui 2. Non	
B.7	Si oui pourquoi ?		
B.8	Si non pourquoi ?		

B.9	Pensez-vous la migration a amené un changement dans le village?	1. Oui 2. Non	
B.10	Si oui comment ?		
B.11	Si non comment ?		
B.12	Pensez-vous qu'on doit encourager la migration?	1. Oui 2. Non	
B.13	Si oui quels sont ses avantages?		
B.14	Si non quels sont ses inconvénients?		