UNIVERSITE JOSEPH KI-ZERBO

ECOLE DOCTORALE INFORMATIQUE ET CHANGEMENTS CLIMATIQUES

BURKINA FASO

Unité-Progrès-Justice

MASTER RESEARCH PROGRAM

SPECIALITY: INFORMATICS FOR CLIMATE CHANGE

MASTER THESIS

Subject:

Effect of migration on farmers' income and food security in the Kayes region, Mali

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Academic year 2O21-2022

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Dedication

By the grace of GOD, the Almighty, the Merciful, I dedicate this research to my parents who have always worked for my success. May they find here the expression of my deep gratitude.

Abstract

In several studies, literature authors have investigated migration. However, discourses on migration are more than just about migration; rather than employed as a factual reference to a particular more or less well-defined social phenomenon (Mueller et al., 2020).

However, West Africa's countries which are more vulnerable to CC has long been characterized by high levels of mobility, a trend that far predates the current configuration of borders established during the colonial era.

Mali a country in West Africa is particularly known to be vulnerable due to high climate variability, high reliance on rain-fed agriculture, and limited economic and institutional capacity to respond to CC (Sultan & Gaetani, 2016). This leads Mali be both a country of origin and transit for migrants in the West African region(Sultan & Gaetani, 2016).

Some regions of Mali are more affected by migration depending on the different factors.

The Kayes region is particularly known for migration patterns both within Africa and to France, some of which date back to the beginning of France's colonial rule in the late 1800s(REACH, 2020). A region which dominated by the Agriculture, so there is a need is to assess the effect of migration on farmers' income and food security in that region. A survey has been administrated to 97 households in the Cercle of Kayes: Kayes, Nioro, Diema, Yelimane.

It has been established that migration flows, both interregional and international, are explained by the constraints existing in the areas of origin: living conditions, income, and the development potential of these regions.

Also, the research found a positive correlation between migration, temperature maximal, and precipitation and the SPEI in Kayes. It is also well seen that, a decrease in the minimal value of SPEI from 2000 to 2020 refers to a severe drought in that period in which the migration rate increased considerably.

The impacts of migration in the Kayes region could be positive and negative on both countries' destination and origin. For a sustainable, the negative impacts dominate the positive ones. In order to decrease the trend of migration in Kayes, the research recommends to (i) conduct information and communication activities that raise awareness of behavior change through local radio communication system(ii) strengthen farmers' land ownership status in Kayes, (iii) economic growth is essential to improve household income, (iv) Promote literacy for women and men.

Keywords: Mali, Migration; CC; Farmers; Crop Yield, food security, Linear regression

Résumé

Dans plusieurs études, les auteurs ont étudié la migration. Les thématiques y relevant ne se limitent pas à la migration; plutôt que d'être utilisé comme une référence factuelle à un phénomène social particulier plus ou moins bien défini (Mueller et al., 2020).

Les pays d'Afrique de l'Ouest, plus vulnérables au CC ont longtemps été caractérisés par des niveaux élevés de mobilité, une tendance qui précède de loin la configuration actuelle des frontières établies pendant l'ère coloniale.

Le Mali pays d'Afrique de l'Ouest est particulièrement connu pour sa vulnérabilité en raison d'une grande variabilité climatique, d'une forte dépendance à l'agriculture pluviale et d'une capacité économique et institutionnelle limitée pour répondre au CC (Sultan & Gaetani, 2016). Cela fait du Mali à la fois un pays d'origine et de transit pour les migrants dans la région de l'Afrique de l'Ouest(Sultan & Gaetani, 2016).

Mais Certaines régions du Mali sont plus touchées que d'autres par la migration en fonction des différents facteurs. La région de Kayes particulièrement connue pour come une zone migration à la fois en Afrique et en France, dont remontent au début de la domination coloniale française. L'agriculture étant la source de revenu principale de la zone, il est donc nécessaire d'évaluer l'effet de la migration sur le revenu des agriculteurs et de surcroit la sécurité alimentaire. Une enquête a été administrée auprès de 97 ménages dans quatre(4) cercles de Kayes : Kayes, Nioro, Diema, Yelimane.

Il a été établi que les flux migratoires, tant interrégionaux qu'internationaux, s'expliquent par les contraintes existant dans les régions d'origine : conditions de vie, revenus et potentiel de développement de ces régions.

De plus, une corrélation positive entre la migration, la température maximale, et les précipitations et le SPEI à Kayes. Il est également bien vu que, une diminution de la valeur minimale de SPEI de 2000 à 2020 fait référence à une sécheresse sévère dans cette période dans laquelle le taux de migration a augmenté considérablement.

Les impacts de la migration dans la région de Kayes peuvent être positifs et négatifs sur les pays de destination et d'origine. De manière durable, les impacts négatifs dominent les impacts positifs. Afin de diminuer la tendance à la migration dans la région de Kayes, la recherche recommande de (i) mener des activités d'information et de communication qui sensibilisent au changement de comportement (ii) renforcer le statut de propriété foncière des agriculteurs à Kayes, (iii) la croissance économique est essentielle pour améliorer le revenu des ménages, (iv) promouvoir l'alphabétisation des femmes et des hommes.

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Acronyms and abbreviations

ACC : Adaptation au changement climatique ()

AETc :Actual Evapotranspiration

AGRHYMET :Agrometeorology and Operational Hydrology Training and Application Centre

APFS :Agro-Pastoral field schools

CCA : CC Adaptation

DS: Dry season

DTR : Daily range of temperature

EC: Early cessation

ECMWF: European Centre for Medium-Range Weather Forecasts

ECS: End of the cropping season

ED-ICC : Ecole Doctorale d'Informatique pour les Changements Climatiques

ERS: End of the rainy season

FAO: Food and Agriculture Organization of the United Nations

FER: Effective first rain

ITCZ : Intertropical Convergence Zone

IOM : International Organisation for Migration

ITF : Convergence Intertropical Front

LCCC: Lin concordance corrélation coefficient

LCS: Length of the Cropping Season

LRM (AP): Logistic Regression model (Anomalous Predictors)

LRM (DP): Logistic Regression model (Dichotomic Predictors)

MLR : Multiple Regression Model

MSE: Mean Squared Error

SPEI: Standardized Precipitation Evapotranspiration Index

Introduction

1.1. Problem statement

Migration in its broadest meaning spatial mobility can be regarded as part of the human condition. As with other social processes, forms, scale, and directions of migration are heavily influenced by the political, economic, cultural, ecological, and social context in which migration occurs (Bilger & Kraler, 2005). The migration can be within the country or abroad. Based on the research conducted in that field, Migration especially in Africa is being driven by a varied combination of push-pull factors for each country.

In 2017, the United Nations Conference on Trade and Development reported that about 41 million international migrants were moving within, from, or to, Africa, where 5 million were immigrants from the rest of the world, 17 million, were residents outside the continent and 19 million found to be residing within the continent (Harouna & Nyambe, 2019). Reports on African migration have focused on displacement and irregular migration, especially to Europe, and yet recent findings indicate that 80 percent of Africans thinking about migration have no interest in leaving the continent Ballo, (2009), and they have no intention of staying permanently. This phenomenon is well spread in the whole of Africa.

However, Western Africa has long been characterized by high levels of mobility, a trend that far predates the current configuration of borders established during the colonial era. An estimated 7.6 million international migrants resided in the sub-region as of mid-year 2020 (UN DESA, 2020), and this number is likely underestimated, as high levels of temporary and seasonal migration common from Western Africa are not fully captured by existing data.

This recent overview of the empirical evidence in Francophone west Africa indicates that migrants into urban areas are quite well adapted in economic and residential terms and their contribution to urban demographic growth is less and less important. In contradiction with conventional wisdom, migration trends in this region are responsible for a clear slowdown of urban growth (Beauchemin & Bocquier, 2004).

This migration could have many causes such as CC, and climate variability. West Africa's countries are more vulnerable to CC particularly, Mali is known to be vulnerable due to high climate variability, high reliance on rain-fed agriculture, and limited economic and institutional capacity to respond to CC (Sultan & Gaetani, 2016).

This leads Mali to be both a country of origin and transit for migrants in the West African region(Sultan & Gaetani, 2016).

Some regions of Mali are more affected by migration depending on the different factors.

The Kayes region specifically, situated at the western-most corner of the country, neighbouring Senegal and Mauritania, is particularly known for migration patterns both within Africa and to France, some of which date back to the beginning of France's colonial rule in the late 1800s(REACH, 2020).

The impact migration has had on the region and its inhabitants is pervasive: entire villages are built with remittances sent by migrants from Kayes, returnees are deeply ingrained in local government structures and diaspora communities are treated as key agents for development by local and international actors alike. Besides its impact on an economic level, migration has intensely shaped the local imaginary of success (REACH, 2020).

Leaving the origin country is part of the family strategy for survive (Harouna & Nyambe, 2019). Many research such as Bilger & Kraler, (2005) shows that migration can positively impact structural transformation in both origin and destination countries. However, previous research finds that remittance from migrants could contribute to the development of the origin country Feldman, (2021). In opposite, migration can also relatively lead to a decrease in the labor force of other origin countries.

Reasons for the relatively low impact included the loss of skilled labor and lower the country's economy. The migration could have an impact on agricultural productivity, food production, and natural resources, affecting food systems and rural livelihoods, including a decrease in the number of farmers (FAO, 2018).

Scientific discourses on migration in are closely correlated to wider social discourses about Africa in general, and about processes of economic.

Understanding the various narratives that exist on migration within, to, and from the kayes region, requires a look at the realities in terms of evidence from different countries, the lens through which migration is looked at and the impact the narrative has had on the response to migration at the national, regional and continental levels.

The present work is to assess the effect of migration on farmers' income and food insecurity in

the Kayes region. For that, the fundamental research question is settled.

1.2. Research questions

We answered the following question:

❖ What are the effects of migration on farmers' income and food security in the Kayes region?

Specifically :

- What are the factors that contribute to farmers' migration in Kayes?
- How does CC and resource mismanagement affect farmers' migration?
- How migration can contribute to food insecurity in the Kayes region?

To answer those questions, the following hypotheses have been tested:

1.3. Research hypothesis

❖ The migration contributes to enhancing the farmers' income and reducing food insecurity in the Kayes region

Specifically :

- The factors contributing to farmers' migration are climatical, environmental and socio-economic, and political
- CC and natural resource mismanagement cause conflicts due to limited resources which lead to migration.
- The farmers' migration contributes to food insecurity by sending the remittance.

To verify those hypotheses, we have settled the following objective.

1.4. Research objectives

The main objective of this study is to assess the effect of migration on farmers' income and food security. The study used machine learning (ML) Algorithms to model the relation between migration, temperature, precipitation, SPEI, and remittance. For this, we have to specifically:

- Determine the factors that contribute to farmer's migration
- To assess the link between CC and migration
- Quantify the contribution of migration to farmers' income and food security

Chapter 1: Literature review

In several studies, literature authors have investigated migration. However, discourses on migration are more than just about migration; rather than employed as a factual reference to a particular more or less well-defined social phenomenon (Mueller et al., 2020).

Current discourses over autochthony and citizenship in various African contexts are a powerful reminder of how narratives over migration and mobility have recently moved to the centre of political discourse and how claims over past or present migrations have turned into a pretext for exclusion (Comaroff 2001; Nzongola-Ntalaja 2004).

Mali is often seen as both a country of origin and transit for migrants in the West African region. The country has a long history of migration due to existing social structures, cultural practices, environmental challenges, policy changes, and/or armed conflict. (REACH, 2020)

The Kayes region is one of the regions of Mali most affected by international migration. So much so that it is perceived as the main lever of local development. (Harouna & Nyambe, 2019) Indeed, migrants from Kayes living abroad have contributed, for 50 years, to the development and dynamism of their region of origin through transfers of funds, skills, and know-how. (Harouna & Nyambe, 2019)

This section aims to present a concise overview of the migration context in the region of Kayes by providing a historical overview of key migration trends in the region.

The region is located by the Senegal River near the south-western border of the Sahara Desert and has traditionally been home to the Soninke people(Defrance, Sultan, et al., 2020).

An ethnic group engaged in commerce between the Sahara and the south, the Soninke played an important role in pre-colonial West African trade and were among the first itinerant traders (Dyula in West Africa. According to some authors[1], colonial domination increased regional labor migration, due to the tax the French imposed on the territory.

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[1] Kane, Francine &Lericollais, André. 1975. "L'Émigration en Pays Soninké". Cahiers ORSTOM 12(2): pp. 177-187. Kane and Lericollais argue that the colonial tax introduced required individuals to migrate to acquire sufficient funds to pay the taxes due and sustain their families

With the abolition of slavery in the early twentieth century, former slaves became increasingly involved in temporary migration as navetanes and later applied for military recruitment in French West Africa, joining the young males of the Soninke nobility. According to several authors, migration then became a declaration of independence, not only for former slaves but for young males more broadly, who, through migration, secured their source of income. (Manchuelle, 1989)

It is estimated that, by 1975, about one-third of the active male population in the Soninke homeland had migrated to France. (Kane & Lericollais, 1974)

At the time, most migration was done by heads of households, middle-aged men, who had families at home and returned to their villages of origin regularly, between every two to five years.

On another hand, in the late 1960s and 1970s, the Soninke homeland faced several severe droughts, notably in the periods 1969- 1974 and 1983-1985Bilger & Kraler, (2005); Harouna & Nyambe, (2019). The ever more unpredictable climate in the region has increased households' reliance on migration as an alternative livelihood source to agriculture, traditionally the primary livelihood in the region. According to Findley, (1994), since the 1980s, the typical Soninke household has not been able to grow enough food to support itself. Migration became not just a means of earning a profit, but a survival strategy Findley, (1994) Therefore, it has become increasingly important to understand better and assess the effect of migration on farmers' income and food insecurity.

On the other hand, even if the migration can contribute to improve labour productivity in destination countries, developing countries present a dissatisfaction with the spatial distribution of their populations. This irregularity of the spatial distribution is the result of migration (Beauchemin & Bocquier, 2004). Migrants have traditionally been viewed as responsible for excessive urban growth the uncontrolled expansion of urban areas and urban surplus labour. An increase in the stock of migration leads to an increase in the sector of productivity. This effect increases in magnitude for sectors that experienced relatively high migration in the past (agriculture, manufacturing, mining, construction, and services). Some reports find an increase in migration is associated with a rise in manufacturing value-added the note the value-added of productivity enhancements on job creation. This could be related to the relative scarcity of good quality, skilled manufacturing jobs in destination countries (Bilger & Kraler, 2005) &

(Beauchemin & Bocquier, 2004).

If migration is part of the present adaptation portfolio of households to different climatic conditions, it is reasonable to expect that it will also be an adaptation strategy to CC.

The interactions between climate and migration are complex, and the scientific literature on the subject is still in its early stages of development. Reuveny (2007) analyzed 38 cases since the 1930s in which environmental changes induced mass migration, and concluded that 19 of them resulted in some form of conflict over scarce resources.

Therefore, CC is affecting multiple aspects of livelihoods. Its effect on food production in low latitude countries will be negative and significant (FAO, 2018).

Higher temperatures will result in reductions in production yield. Water scarcity will affect livestock production, and rising temperatures will impact fisheries, which are a major source of income for many households (FAO, 2018).

In addition, the labor force plays an essential role in crop production to assure food security. And According to Harouna & Nyambe, (2019).

However, the population of the Sahel region is extremely heterogeneous, and the processes and factors that contribute to migration are complex. According to Sanfo et al. (2017), soil degradation, land tenure insecurity, and lack of rainfall are the major drivers the environment-induced migration.

- **Concept definition**

Migration: The movement of persons away from their place of usual residence, either across an international border or within a State.(IOM, 2011)

Emigration: From the perspective of the country of departure, the act of moving from one's country of nationality or usual residence to another country, so that the country of destination effectively becomes his or her new country of usual residence (IOM, 2011).

Immigration : From the perspective of the country of arrival, the act of moving into a country other than one's country of nationality or usual residence, so that the country of destination effectively becomes his or her new country of usual residence (IOM, 2011).

Migrant: IOM defines a migrant as any person who is moving or has moved across an international border or within a State away from his/her habitual place of residence, regardless of (1) the person's legal status; (2) whether the movement is voluntary or involuntary; (3) what

the causes for the movement are; or (4) what the length of the stay is (IOM, 2011).

Country of destination: In the migration context, a country is a destination for a person or a group of persons, irrespective of whether they migrate regularly or irregularly (IOM, 2011).

Country of origin: In the migration context, a country of nationality or of former habitual residence of a person or group of persons who have migrated abroad, irrespective of whether they migrate regularly or irregularly (IOM, 2011).

Country of transit: In the migration context, the country through which a person or a group of persons pass on any journey to the country of destination or from the country of destination to the country of origin or of habitual residence (IOM, 2011).

Remittances (migrant): Private international monetary transfers that migrants make, individually or collectively (IOM, 2011).

Remittances are primarily sent to people in countries of origin with whom migrants maintain close links, although, in some cases, they are also sent to relatives in other countries of destination. Increasingly, the terms "social remittances" or "social capital transfer" are used in the context of transfers of non-monetary value as a result of migration, such as the transfer of knowledge, know-how, networking, and skills.

Drought

Drought is a major cause of agricultural, economic, and environmental damage. Drought effects are apparent after a long period of a shortage of precipitation, making it very difficult to determine their onset, extent, and end. Thus, it is hard to objectively quantify the characteristics of drought episodes in terms of their intensity, magnitude, duration, and spatial extent. Much effort has been devoted to developing techniques for drought analysis and monitoring. Among these, the definition of quantitative indices is the most widespread approach, but subjectivity in the definition of drought has made it very difficult to establish a unique and universal drought index. Most studies related to drought analysis and monitoring systems have been conducted using either (i) the Palmer Drought Severity Index (PDSI) (Palmer, 1965), based on a soil water balance equation, or ii) the Standardised Precipitation Index (SPI; McKee et al., 1993), based on a precipitation probabilistic approach.

Heat Stress:

Temperature is a primary factor affecting the rate of plant development (Hatfield & Prueger, 2015). Therefore, heat stress has been recognized as a significant threat to food supply and security(Teixeira et al., 2013). Furthermore, crops and vegetation are among the most vulnerable systems to CC, particularly climate extremes (Sun et al., 2019). The rate of growth and development of plants depends on the surrounding temperature. Each species has a specific temperature range represented by a minimum, maximum, and optimum (Hatfield & Prueger, 2015). The responses to temperature differ among cultivated species throughout their life cycle and are mainly phenological responses, i.e., stages of plant development(Hatfield & Prueger, 2015).

The Standardised Precipitation-Evapotranspiration Index(SPEI)

The SPEI is a multi-scalar drought index based on climatic data. It can be used for determining the onset, duration, and magnitude of drought conditions concerning normal conditions in a variety of natural and managed systems such as crops, ecosystems, rivers, water resources, etc.

Chapter 2: Materials and methods

The methodology was conducted using an essentially quantitative approach. Throughout the research, quantitative research tools were used. The research also analysed some relevant qualitative information, in particular the perception of household managers in relation to migration and remittances.

Finally, the triangulation of information has been ensured through the diversity of both data collection tools and methods and information sources. The following sources of information were compared: secondary data from the literature search and primary data from data collection from study areas.

2.1. Study area

The research covered the region of Kayes, in the western part of Mali. Based on the literature review during the study, four cercles were purposively selected, as they were identified as communities with a historical culture of migration.

The region is located by the Senegal River near the south-western border of the Sahara Desert and has traditionally been home to the Soninke people (Manchuelle, 1989). An ethnic group engaged in commerce between the Sahara and the south, the Soninke played an important role in pre-colonial West African trade and were among the first itinerant traders (Dyula) in West Africa. According to some authors[2], colonial domination increased regional labor migration, due to the tax the French imposed on the territory.

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[2] Kane, Francine & Lericollais, André. 1975. "L'Émigration en Pays Soninké". Cahiers ORSTOM 12(2): pp. 177-187. Kane and Lericollais argue that the colonial tax introduced required individuals to migrate to acquire sufficient funds to pay the taxes due and sustain their families
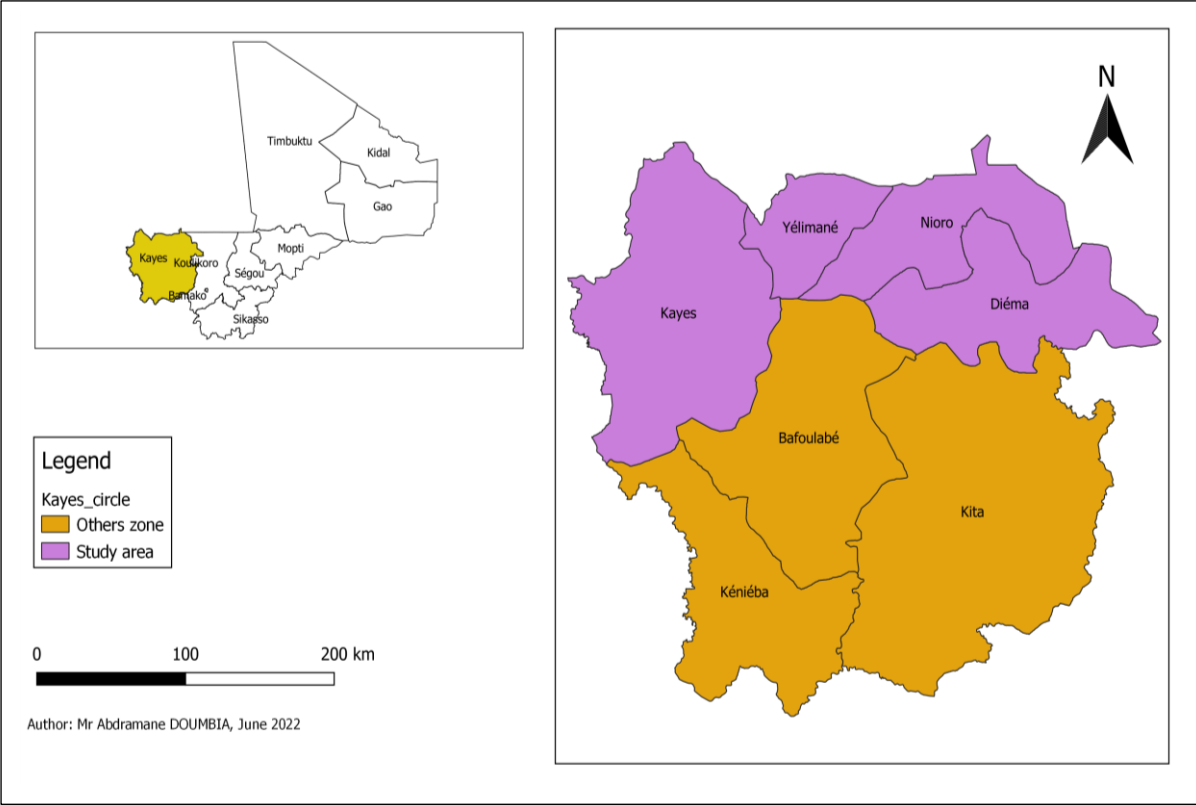
Figure 1: Study area

2.2. Data collection

The following techniques have been used to collect the data to assess the effect of migration on farmers' income and food insecurity.

The research is based on both secondary and primary data collection methods. During the first phase of the study, a thorough secondary data review was conducted, which was substantiated with preliminary discussions with actors knowledgeable about the context of migration based in Kayes. Primary data collection took place in four cercles in the region of Kayes.

2.2.1. Secondary data review

The secondary data review informed the research design, including the definition of the research scope, research questions, and the development of the data collection tools (REACH, 2020).

The questionnaire used to collect primary data has been developed based on previous research and migration theory's concepts of the 'culture of migration'. Furthermore, secondary data sources were used to triangulate or explain the result from the primary data collected and to triangulate with primary data.

The main sources of secondary data used in this research were (i) Displacement Tracking Matrix from IOM, (ii) UN migration data, (iii) Inward / Outward remittance flow from World Bank, (iv) Integrated management of chronic malnutrition in the Kayes and Sikasso regions, (v) World Agroforestry Center (ICRAF).

Also, documents from organizations related to migration were used. These include documents related to the migration, as well as documents obtained from national and international institutions working on migration such as INSTAT, IOM, NGOs, etc., also the primary data.

2.2.2. Primary data collection

Primary data collection took place during the dry season through a team of supervisors, searchers, and two enumerators, all of whom originated from the region of Kayes. These agents previously received training, which was led by the searcher. The training was mainly devoted to in-depth discussions on collection tools (concepts definition) and the translation of questions into the local language. At the end of the training, the pre-test of the questionnaires was carried out. The aim was to pre-test the input forms integrated into the smartphones, on the one hand, to familiarize oneself with the use of tablets, and on the other hand, to correct the imperfections of the collection tool forms.

To ensure comparability of survey findings across the four selected zones Kayes, Diema, Nioro, and Yelimane; the survey deployed was translated into one local language or Bambara. The

survey structure was set up to sample individual and household information on biographical data, migration history, migration aspirations and risk attitude towards migration, household income

In a second round of adaptations following piloting among respondents from Kayes in May 2022, the survey was shortened to increase the rate of participation and consider potential sensible questions. The pilot allowed for additional modifications through the adaptation of scaling questions that asked respondents to express the likeliness of an event. Consequently, answer options for scaling questions were reduced.

Second, language skills introduced additional limitations. Given varying degrees of literacy in the national languages of Bambara, Soninke, and Peulh, translation was limited to the oral interpretation of each data collector. To limit potential biases, the training conducted ahead of data collection included a joint session to translate and discuss key terms of the survey in each language.

Lastly, access to respondents in all four zones provided a challenge throughout the data collection process. In Nioro, access was difficult given the often-clandestine accommodation of transit migrants leading to a level of suspicion in answering questions related to the migration.

Also, the primary data have been used to downscale national data captured in the second data collection process.

2.2.2.1. Sampling

The goal of sampling is to reduce the cost of collecting data about a population by gathering information from a subset instead of the entire population. The sample size depends on several factors, including tolerable error, population size, the importance of certain subgroups, the expected rate of non-response, and the available budget. For the study, the sampling method chosen is simple random. The target farmers (women and men) to be surveyed will be randomly selected.

The randomness of the sample gives each individual an equal chance of being included in the sample and will allow us to infer the results from the entire survey population.

$$n = \frac{t2xp(1-p)*d}{e2}$$

(Durand, 2002)

e = Level of accuracy : 0.08 ;

p = Estimated proportion of the population with the characteristic is 20%

t = typical value associated with the required confidence level (95% > 1,96).

P= (1-p)= (1-0,20) = 0, 8%. With a precision level of +/-5% and a standard confidence level of 95%, we obtain the following sample size: 97

$$n = \frac{(1,96x1,96)x(0,2x0,8)}{0.08*0.08} = 97 \text{ households}$$

With a proportion of 0.05, the sample size was 97 households.

The inclusion criteria for the target households are as follows: (i)Households from the Kayes region within the village of Kayes, Diema, Nioro, and Yelimane, (ii) Households' main activities are farming, (iii) Household header or representative is equal or more than eighteen (18) years.

To compare households with migrants and households without migrants, the presence of at least one migrant in the household was not an inclusion criterion. Also, the risk to have a family without immigrants was minimized. Based on previous research (Jean-Paul Azam & Azam, 2004; MMC, 2020), the Kayes region is one of the regions of Mali most affected by migration. (Jean-Paul Azam & Azam, 2004)

Table 1: Households surveyed

District	surveyed	Population(%)
Kayes	50	52
Diema	12	12
Nioro	18	19
Yelimany	17	18
Total	97	100

Population(%): The percentage of the population in The Kayes region

2.2.2.2. Population of interest and sampling strategy

This phase of the study was divided into two moments: (i) Information and awareness of targeted actors in the region of Kayes, Diema, Nioro, and Yelimane, and (ii) Validation of the survey plan by the target actors such as Chief of the village, Mayor of Kayes ; (iii) Collection of information on the ground and the preliminary restitution of field findings to target actors. Further, the population of interest was disaggregated based on whether or not respondents have one or several household members residing outside of Mali.

2.2.2.3. Semi-structured and structured interviews

Before the field surveys, an official briefing session has been held with the institutions representing the government in the region, during which the purpose of the data collection has be explained. The structured interviews have been addressed to a sample of households. The chief of the household who is supposed to have the information related to the household income, and farming techniques, is the first involved. In case of absence of the chief of the household, the wife or the first son has been surveyed in place.

The research has adopted Computer-Assisted Personal Interviewing (CAPI) to collect the primary data. The data have been collected through a smartphone and sent to the server for storage. The server chosen by the research is Kobotoolbox. The data have been then exported to R for analysis.

2.2.3. Risk and ethical issues

2.2.3.1. Risks and mitigation measures

Table 2: Risk and mitigation measures for the research

Main risks	Mitigation strategies	Responsible
Security issues	Interview with the farmers in a safe and secure space	Searcher
Availability of respondents	Inform local and administrative authorities before the deployment of the collection team in the field	Searcher, partners
Delays in initial deadlines	Synergistic work and fluidity in communication, rapid feedback with supervisors	Searcher, Supervisors

2.2.3.2. Ethical issues

Data collection activities adopted a 'Do No Harm' approach to avoid causing any harm or injury to assessment participants. The research adhered to the following surveying principles to ensure ethics: (i) Informed consent: this study was conducted with participants (farmers) aged 18 years or above. Respondents gave their oral informed consent to take part in the research and participated in interviews voluntarily. (ii) Confidentiality: this study ensured that the confidentiality of the information provided by respondents was respected. All personal information in datasets was made anonymous and excluded from the final report. (iii) Ethics in data collection: the research design and development of data collection tools took into account the sensitivity of the issues discussed(clandestine migration).

The consent of respondents have been sought and obtained before any interview. The interviews will be conducted in an ethical standard. All interviews have been conducted in open areas but away from prying ears to preserve the privacy of the respondents.

2.2.4. SCHEDULE OF RESEARCH

In order, to achieve the research objective, the following schedule has been settled. It is important to notice the following schedule is a prevision for the research. Otherwise, some activities can be taken at the same regarding the situation in the field.
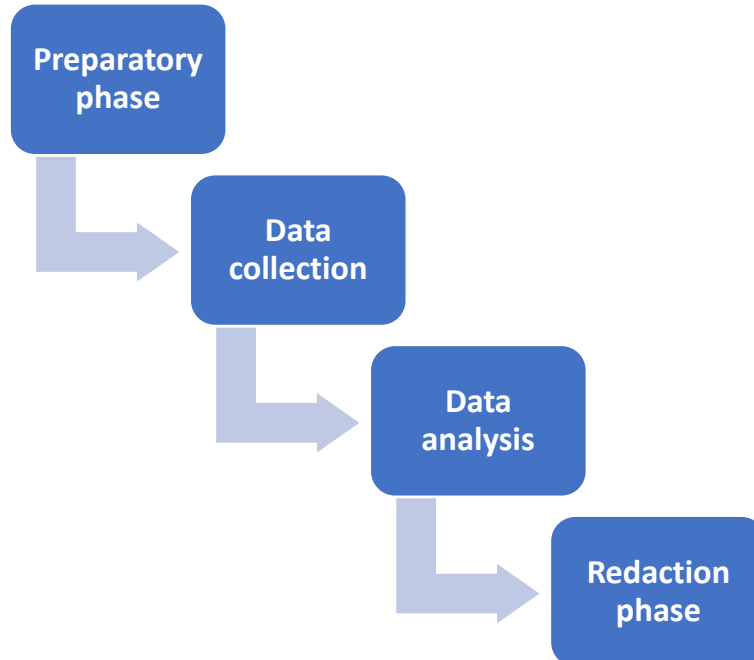
Phase 1: Preparatory phase

This phase of the research consists of a literature review, planning of the research schedule, meeting with the supervisors, and implementation of data collection tools. In sum, it includes:

- Literature review;
- Development of data collection tools: tools already developed by organizations in the field of Migration adopted by the searcher about the objective validated by the supervisors before the data collection in the field;
- Development of the data collection plan(indicator, sampling, data methodology collection, target, and period of data collection);
- Validation of the data collection plan by the supervisors;
- Establishment of the contact list for data collection (administrative representative contact)

Phase 2: Data collection phase

This phase of the study is divided into two (2) parts :

   Part 1: Informing and Sensitization of the target actors in the region of Kayes.

   Part 2: Data collection in the field and the preliminary feedback of field findings to target actors.

Phase 3: Data analysis

This phase includes analysis of the documents provided by the institutions, and NGOs related to the migration, and analysis of the primary data including farmers' perception of the migration.

Another part of this phase is a mitigation solution for farmers' migration due to CC. This consists of finding technologies or land management practices that contribute to reducing migration caused by CC with the regard to CC.

Phase 4: Redaction phase

This stage consists of the restitution of the work (draft report) to the supervisors for validation, then the final submission to the school. The report follows the format of the school.

2.3. Data processing and analysis

2.3.1. Indicators and variables

The data analysis starts with the development of an analysis plan that focuses on the set of objectively verifiable indicators to achieve the objectives of the research.

The following table indicates the main variable to measure the objectives of the research.

Table 3 :Indicators and variables

Indicator	Variable
Number of migrants	Number of migrants
Reason of migration	Reason of migration
Destination country of migrant	Destiny country of migrant
Factors that contribute to migration	Factors that contribute to migration
Water source	Source of water
sheep farming	Monthly income from sheep farming
Agriculture	Types of crops
	Monthly income from vegetable production
	Monthly income from agricultural production
	Farming tools
Number of migrants in household	Number of migrants in household

Number of migrants abroad in household	Number of migrants currently abroad in household
Source of income	Source of income
Remittance	Origin country
	Transfer mode
	Remittance value
Perception of farmers on CC	Perception of farmers on CC
Temperature	Temperature maximal
	Temperature minimal
Precipitation	Precipitation
Drought	Standardized Precipitation and Eva transpiration index (SPEI)

2.3.2. Net migration rate:

Net migration is the total number of immigrants (people moving into a given country) minus the number of emigrants (people moving out of the country). It is measured over the previous five years and is expressed as the average annual net number of migrants(*Migration, Refugee and Asylum Data Explorer*, 2020).

The net migration has been computed to state the dynamic of the migration flows in Kayes region. If the value of net migration is negative, this means the countries

2.3.3. Linear regression

How the variables are related is very important when dealing with data with multiple variables, and the relationship between variables. Regression is a set of techniques for estimating relationships.

In this research, we have focused on finding one of the simplest types of relationship: linear. This process is unsurprisingly called linear regression, and it has many applications.

Despite its simplicity, linear regression is an incredibly powerful tool for analyzing data ("Linear Regression," 2004).

2.3.4. Standardized Precipitation Evapotranspiration Index (SPEI)

As our main climate indicator, we use the Standardized Precipitation-Evapotranspiration Index (SPEI) from the high-resolution (0.5x0.5 degree) gridded dataset developed by Vicente-Serrano, Beguería, and López-Moreno (2010).

Several other objective drought indices have been developed and used, such as the Palmer Drought Severity Index (PDSI) or the Standard Precipitation Index (SPI), but the SPEI has several advantages over them. In particular, it allows for the comparison of drought severity through time and space whereas the PDSI does not, and considers both the role of temperature and precipitation variability while the SPI only considers the latter (Vicente-Serrano, Beguería, and López-Moreno (2010); Beguería, Vicente-Serrano, and Angulo-Martínez (2010)). As explained by Vicente-Serrano, Beguería, and López-Moreno (2010), taking into account temperature in addition to precipitation is crucial since the impact of rainfall on the growing cycle of a plant also depends on the ability of the soil to retain water.

This is captured by "potential evapotranspiration", which in turn depends on numerous parameters including surface temperature, air humidity, latitude, solar radiation, and wind speed. The SPEI is calculated as the difference between monthly precipitation and the potential evapotranspiration and has been shown to correlate better with hydrological and ecological variables than other drought indices in a variety of natural systems (Beguería et al., 2014).

In terms of their interpretation, SPEI values represent standard deviations above or below historical SPEI values in a given location. This allows comparing droughts across locations with very different climatology.

To take a simple example, in absolute terms (millimeters of rain) a -1 drought in a Sahelian region will be very different from a -1 drought in a tropical forest region, but both situations are comparable because they represent the same degree of deviation from the normal conditions at each site, to which the natural vegetation of the area is adapted (Beguería, Vicente-Serrano, and Angulo-Martínez, 2010).

To account for different types of droughts, the SPEI is computed from different time scales. Short-time scales represent soil water content and discharge in headwaters, while medium-time scales refer to storage of water sources and long-time scales illustrate variations in groundwater. To capture conditions that cause agricultural stress, we use the 12-month SPEI.

The intensity of drought is measured according to the value of the SPEI. SPEI values ranging from 0 to -0.99 correspond to a mild drought; from -1 to -1.49 to a moderate drought; from -1.5 to -1.99 to a severe drought, while an extreme drought corresponds to an SPEI value below -2. An excess of precipitation can be measured following the same logic, beginning with a value of +1.

The standardized anomalies of precipitation, evapotranspiration, and temperature are particularly intense in the years 1973-1974, 1982-1984, and 2002, with SPEI values during the growing season corresponding to severe droughts. Outside these sub-periods, averaged SPEI values are mostly negative, with a few exceptions. Given these patterns, our empirical analysis will mainly focus on dry events since there is no clear sign of excess precipitation over the period under concern, at least at the aggregate level.

Chapter 3: Results and discussion

3.1. Demographic profile of the migrants

3.1.1. Household with at least one migrant

A migrant household is defined by the following characteristics: at least one person who was previously a member of the household has left to live or work elsewhere, either in Mali or abroad. Women who out-migrated for marriage and children below 18 years of age at the time of interviews were excluded.

Figure 2: Household with at least one migrant   **Source:** survey data

Comment

In 97 rural households surveyed, 70 sent at least one household member in the migrant labor force (72.4%). Their distribution by ethnic group is given in figure 2. It shows that the incidence of migration is more frequent among Soninke households. This result could be linked to history. For Kane & Lericollais, 1974, Soninke emigration, which developed from the end of 1870 to 1914, and all the effects we have seen from it, are indeed the marks of a reinforced grip of the capitalist mode of production on the men and the economy of the region; its function, within

the framework of this integration, is to produce a labor force which is exploited externally.

3.1.2. Household with at least one migrant abroad:

A migrant abroad is defined by the following characteristics: at least one person who was previously a member of the household has left to live or work abroad. Women who out-migrated for marriage and children below 18 years of age at the time of interviews were excluded.

Table 4: Household with at least one migrant abroad

Cercle	Migrant status		
	Abroad	Not abroad	Total
Diema	8 (89%)	1 (11%)	9 (100%)
Kayes	24 (65%)	13 (35%)	37 (100%)
Nioro	12 (92%)	1 (7.7%)	13 (100%)
Yelimane	11 (73%)	4 (27%)	15 (100%)
Total	55 (74%)	19 (26%)	74 (100%)

Source: Survey data

Comment:

Table 4 captures the number of households with at least one migrant abroad. In all the study zones, international migration dominates.

Longstanding migration patterns from Kayes to the outside country have led to what many observers in the region call a 'culture of migration', a situation where 'migration becomes the norm and staying the exception (REACH, 2020).

It is the phenomenon being particularly accentuated among the Soninke, the predominant ethnic group in Kayes. However, France and the EU over recent decades have increasingly implemented more restrictive migration policies toward Malians (and African nationals more broadly).

Table 4 showed that intra-migration is not frequent compared to international migration. But because of raising in insecurity recently, intra-migration is commonly observed.

3.1.3. Type of household house

Table 5: Type of household house

Cercle	Type of house				
	Permanent	Semi-Permanent	Grass thatched	Grass house	Total
Diema	104 (100%)	0 (0%)	0 (0%)	0 (0%)	104 (100%)
Kayes	275 (100%)	0 (0%)	0 (0%)	0 (0%)	275 (100%)
Nioro	122 (99%)	1 (0.8%)	0 (0%)	0 (0%)	123 (100%)
Yelimane	95 (100%)	0 (0%)	0 (0%)	0 (0%)	95 (100%)
Total	596 (100%)	1 (0.2%)	0 (0%)	0 (0%)	597 (100%)

Source: Survey data

Comment

Table 5 shows that the households live in permanent houses. This means that the households involved in the study are not nomads. It is very important when it comes to remittance. When migrants can send home a part of their earnings in the form of either cash or goods to support their families, these transfers are known as workers' or migrant remittances. Also, remittances have been growing rapidly in the past few years and now represent the largest source of foreign income for many developing economies (Dodd, 2000).

The state of having a permanent living area will increase the need for remittance from the migrant in keeping the connection between the migrant and the community.

3.1.4. Level of education

The chief of the family commonly is the one who leads the farming. A low literacy rate of heads of households is a significant obstacle to their ability to inform themselves, preventing them from making informed decisions about good agricultural production techniques. These information barriers also severely limit their opportunities to benefit from agricultural support services such as credits, agricultural equipment, etc. This can lead to an increase in household vulnerabilities to food insecurity and then force them to migrate.
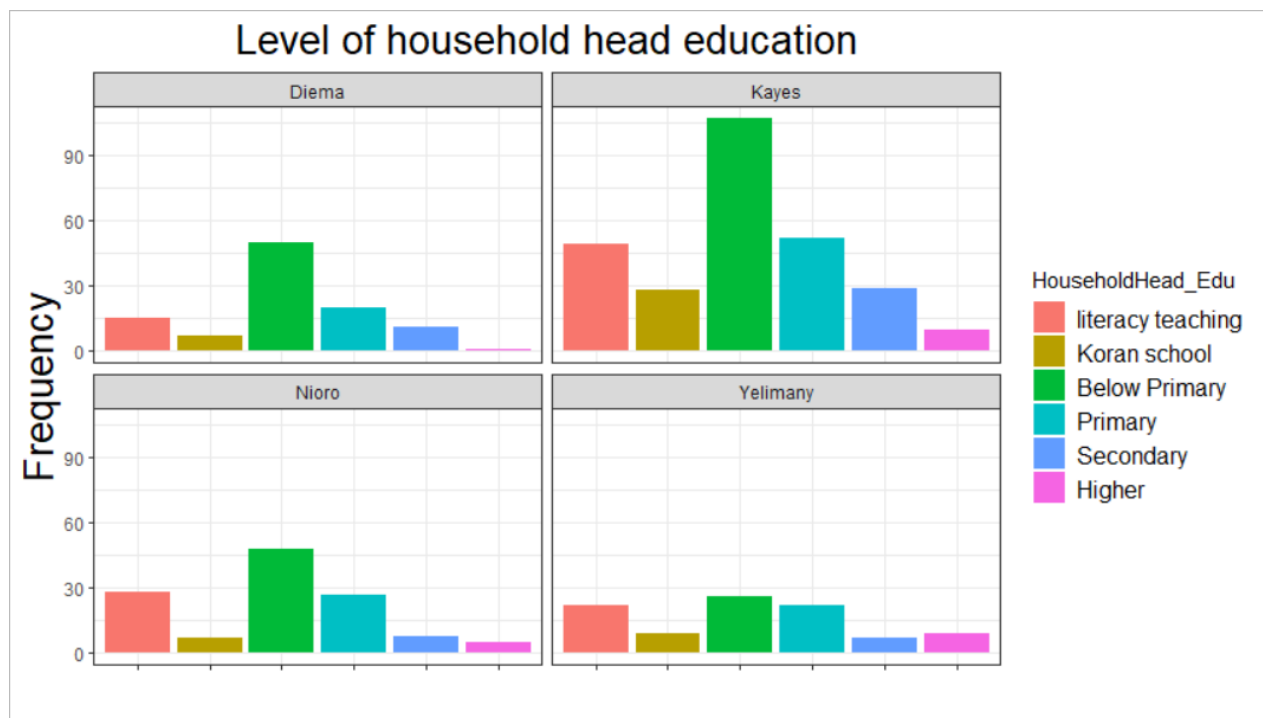
Source: Survey data

Figure 3: Level of education of household head

Comment :

Figure 4 shows the education level of the household head. Most household heads are below primary school. Education boosts farmers' ability to obtain, decode and understand information, thus enabling them to make better use of available information with solutions to production, market, and financing challenges. Farmers with good education possess improved decision-making skills and hence better manage resources to exploit farms of various sizes. (Ninh, 2020) Also, well-educated farmers are not only capable of utilizing available information but also better access to needed information, implying that education alleviates information asymmetry in several aspects, especially regarding input quality which is vital to agricultural output.

3.2. Factors that cause migration

Mali is often seen as both a country of origin and transit for migrants in the West African region. The country has a long history of migration due to existing social structures, cultural practices, environmental challenges, policy changes, and/or armed conflict. (REACH, 2020)

These trends are based on objective factors that are reviewed in the following section.

3.2.1. Social Factor

From many authors such as (Defrance, Delesalle, et al., 2020), longstanding migration patterns from Kayes to the outside country have led to what many observers in the region call a 'culture of migration', a situation where 'migration becomes the norm and staying the exception'.

Apart from the fact that the Kayes region is considered at the national level as repulsive, due to climate pejoration, two main categories of causes of migration in the Kayes region can be distinguished: on the one hand, social reasons and, on the other, economic causes.

Migration was perceived as extremely positive by the vast majority of respondents. This positive perception was either based on the direct experience of benefitting from migration within the household or the community, or on assumptions made from witnessing what migration had brought to other families, the community, and the region more broadly.

Most participants mentioned poverty, lack of work, and bad quality of life as at least one of the reasons why they aspire to migrate or had already migrated in the past. Participants mentioned that they were unable to find well-paying work in their area of origin, and thus left in search of a better income. Multiple participants that had already migrated spoke scathingly about previous generations that had simply accepted bad living conditions, expressing that the current generation knew that there was something better out there. Some participants also mentioned wanting to migrate to continue their studies abroad.

In tandem with family expectations, community expectations also form an important basis for migration aspirations among respondents.

A long history of migration in Kayes has formed a pattern of migration referred to as a 'culture of migration'. In this context, strong social expectations to migrate are well documented, and staying can be viewed negatively (Reach,2020). This sense that migration is very important for status in the community is brought up in qualitative interviews, especially about youth, where youth who migrate successfully gain a respected status in the community. The following figure shows the reasons for departure.
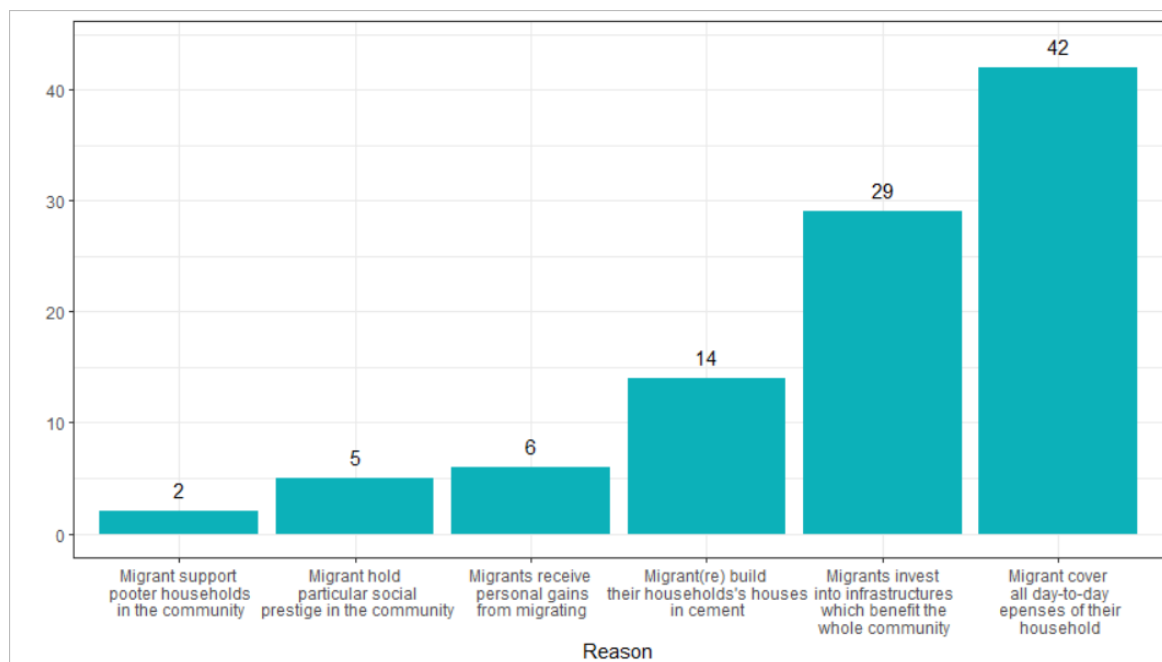
Source: Survey data

Figure 4: Reason for departure

3.2.2. Economic factors

The causes of migration are multiple, but economic reasons are predominant. It is simplistic to consider the relationship between migration and poverty in a univocal causal scheme. If the level of socio-economic development is a factor of migration, migratory movements can in turn affect the level of poverty in the environment of departure. (Ballo, 2009)

Emigration can contribute to improving the socio-economic situation in the departure zones by relieving pressure on resources, as well as through the flow of financial resources sent by migrants to their community of origin called remittance.

But on the other hand, emigration can contribute to maintaining difficult living conditions; it can even worsen them when the labor force captured by emigration unbalances the organization of the local production system.

Some previous research founds that because of poverty, low human capital, and the virtual absence of non-agricultural employment opportunities, rural areas are the main source of migration in Mali. (Ballo, 2009)
Some previous research founds that because of poverty, low human capital, and the virtual absence of non-agricultural employment opportunities, rural areas are the main source of migration in Mali. (Ballo, 2009)

Also, DNSI & RGPH (2002) has established that migration flows, both interregional and international, are explained by the constraints existing in the areas of origin: living conditions, income, and the development potential of these regions. The intensity of migration would therefore vary mainly according to the importance of these constraints and the poverty index in the regions of origin.

3.2.2.1. Source of income of the household
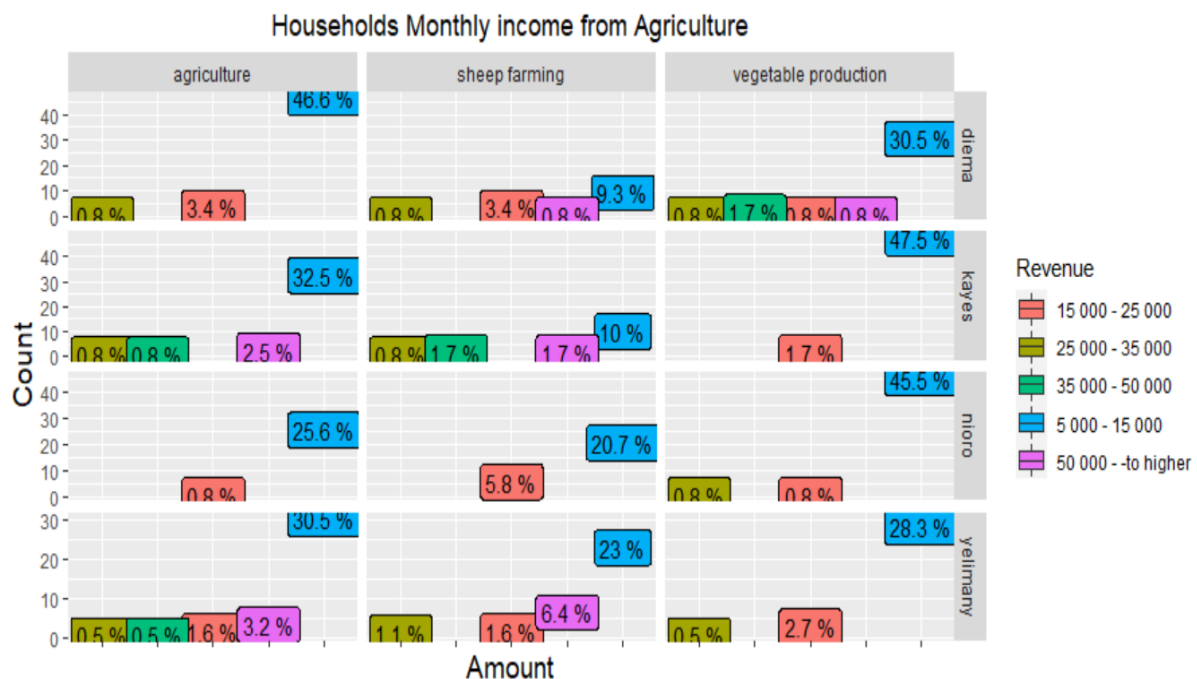
Source: Survey data

Figure 5:Source of income of the household

Comment

The major part of the household monthly income is in the range of 0.008 – 23.90($) in each

28

domain (agriculture, sheep farming, vegetable production). It is important to know that activities like vegetable production, and agricultural production is seasonal.

According to (LSMS-ISA, 2019), fishing is not as widespread as other agricultural activities and about 6 percent of households participate in this activity. So, the positive impact of migration on growth and socio-economic development in origin countries can be noticed. This is in line with other studies that show the estimated contribution of immigrants.

For households not involved in international migration, farm revenues, measured as the sum of the value of all crops and animal products either marketed or home-consumed during the year, are by far the most important source of income.

Farm- and non-farm earned incomes per capita in households with international migrants are much lower on average than those of non-migrant households.

3.2.2.2. Animal husbandry
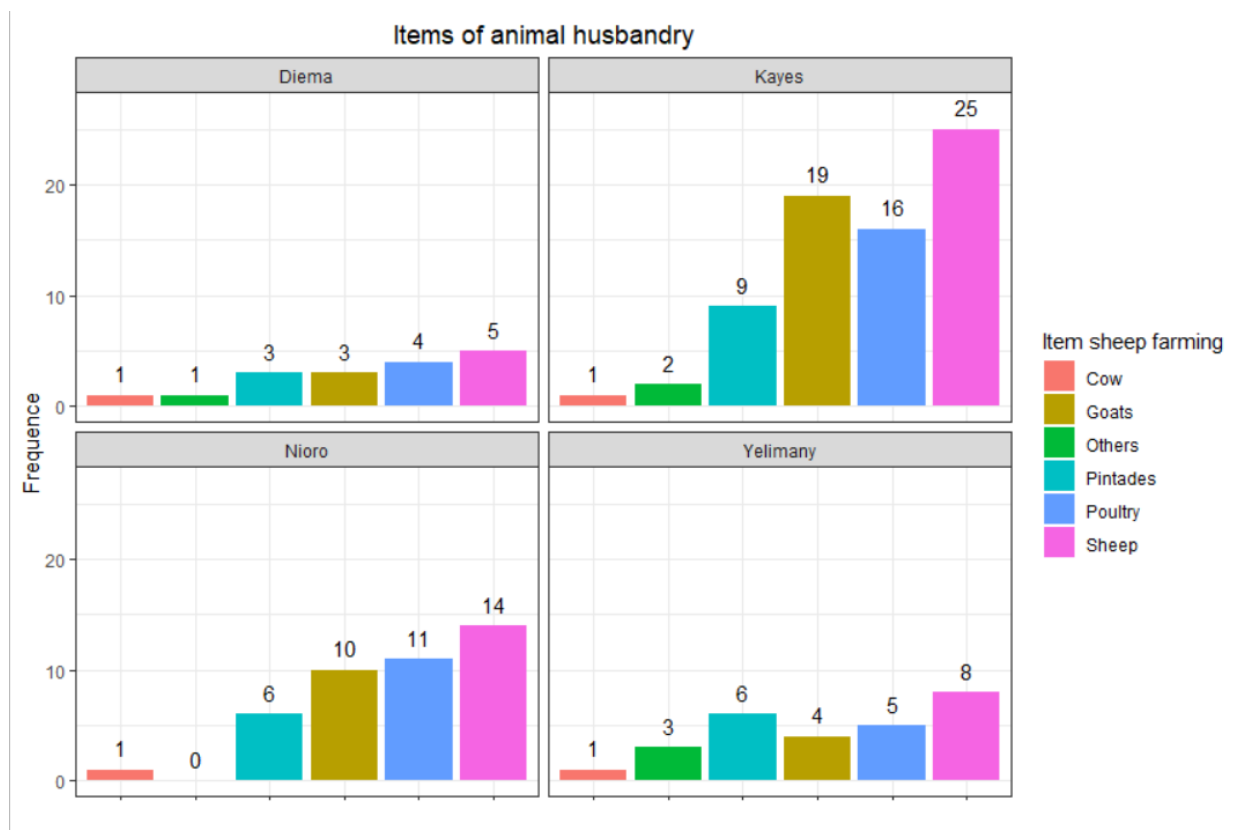
Source: Survey data

**Figure 6: Items of animal husbandry**

Comment

Figure 6 illustrates the items of animal husbandry in the circles of Kayes, Diema, Nioro, and Yelimane. From the above figure, we notice in each zone, cow production is dominating.

In Mali, livestock is the third-largest export after gold and cotton. At the end of the 2000s, the Malian herd included 9 million cattle, 11 million sheep, and 16 million goats. (JeuneAfrique, 2022)

Kayes is an animal husbandry area by predilection. It contributes to bolstering efforts at addressing the different shortcomings and, promoting intensive livestock rearing.

But the difficulties linked to the production of husbandry are multiple (Konaté & Famagan-Oulé, 2010). The condition of the pastures is medium according to the participants. Watering conditions are not good in the whole context. The overweight state of the herd is not satisfactory. The usual transhumance movements of herds towards the south of the region continue.

3.2.2.3. Vegetable production
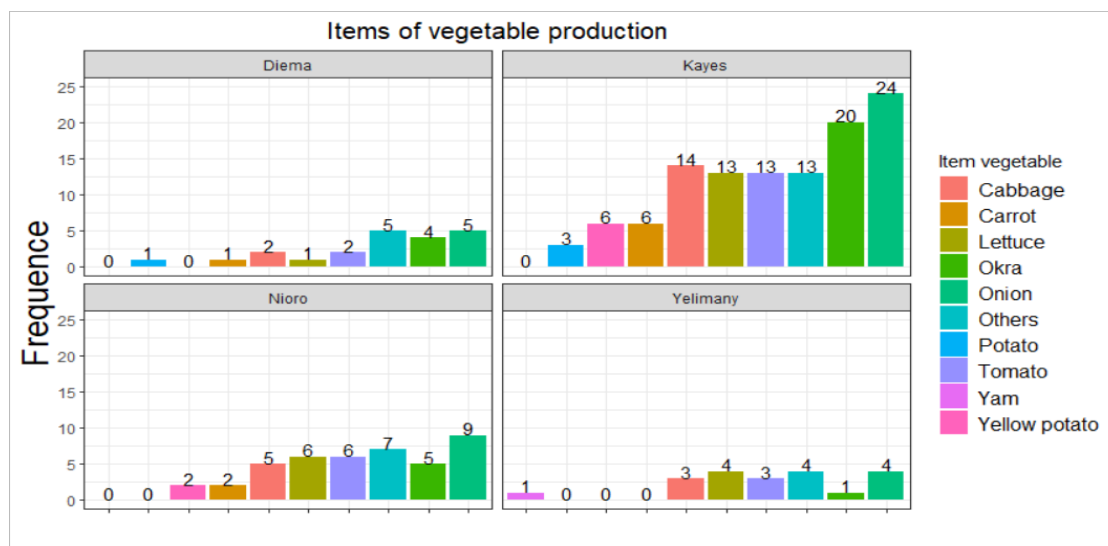
Source: Survey data

Figure 7: Item of vegetable production

Comment:

From the graph, vegetable production is currently good in Kayes and Nioro whereas, Diema and Yelimane are not much involved in vegetable production. The main crop produced is the onion followed by okra and lettuce in all zones.

The production of vegetables is mainly practiced by women. Based on the gender analysis done by LADYSS in 2021, it is difficult for women to have the labor force for production. This practice is mainly caused by the dominance of men which may decrease the income from

vegetable production and then make vulnerable women to food insecurity.

Also, the phenomenon could induce women migration in the region of Kayes. According to (Konaté & Famagan-Oulé, 2010), 8.3% of women emigrated for economic reasons such as looking for work, trading or being economically active in catering, hairdressing salons, etc.

3.2.2.4. Agricultural production
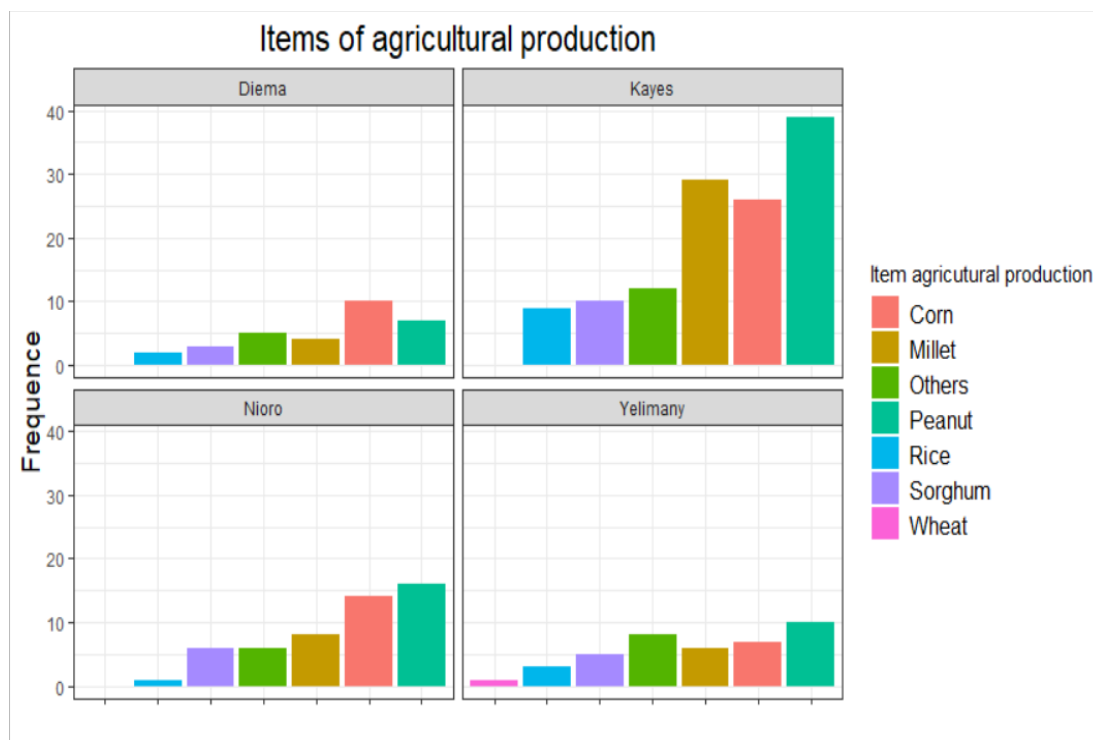
Source: Survey data

Figure 8: Item of agricultural production

Comment:

Peanut is the crop produced mostly on average. Nowadays, Malians consume more than 80 kg of rice per capita per year. The part of the rice in total cereal consumption is increasing; in 2017 it was about 35% (Bergounioux, 2007)

So, rice contributes significantly to the evolution of several indicators in nutrition. It is a central component of food and nutrition security. Progress has been made on social capital, gender, and working conditions.

On the other hand, access to land and water is problematic in the Kayes region. Agriculture such as crop peanuts, and rice needs more water compared to many crops. So, water resource is crucial to undertaking cereal production. This situation increases the vulnerability of the population and also the number of migrants.

3.2.3. Natural and geo-climatic factors

As Mali's economy is mainly based on the primary sector, living conditions, particularly in rural areas, are closely linked to climatic conditions. The Sahelian populations have always had to deal with more or less long-lasting water deficits. Droughts, depending on their intensity and duration, generate massive displacements or short-lived cyclical movements.

Also, according to the Intergovernmental Panel on CC (IPCC, 2014), CC and climate variability are expected to exacerbate poverty, food insecurity, inequality, violence, and conflict.

The interactions between climate, conflict, and migration are complex, and the scientific literature on the topic is still in its infancy and delivers mixed results. Beine and Parsons (2015) included the variables of violence and CC in their model on migration and found that the increased incidence of violence corresponds to increased migration flows.

For his part, Reuveny (2007) analyzed 38 cases since the 1930s in which environmental changes triggered mass migration, and found that 19 of them resulted in some form of conflict due to competition for scarce resources.

While it has been relatively easy to find evidence that migration is influenced by conflict, it has been difficult to find evidence that CC and environmental pressure cause conflict-induced migration (Abel et al., 2019). Drawing on the literature on the links between climate and conflict, Abel et al. (2019) designed a framework that highlights the interactions between conflict, CC, and migration(figure 9).
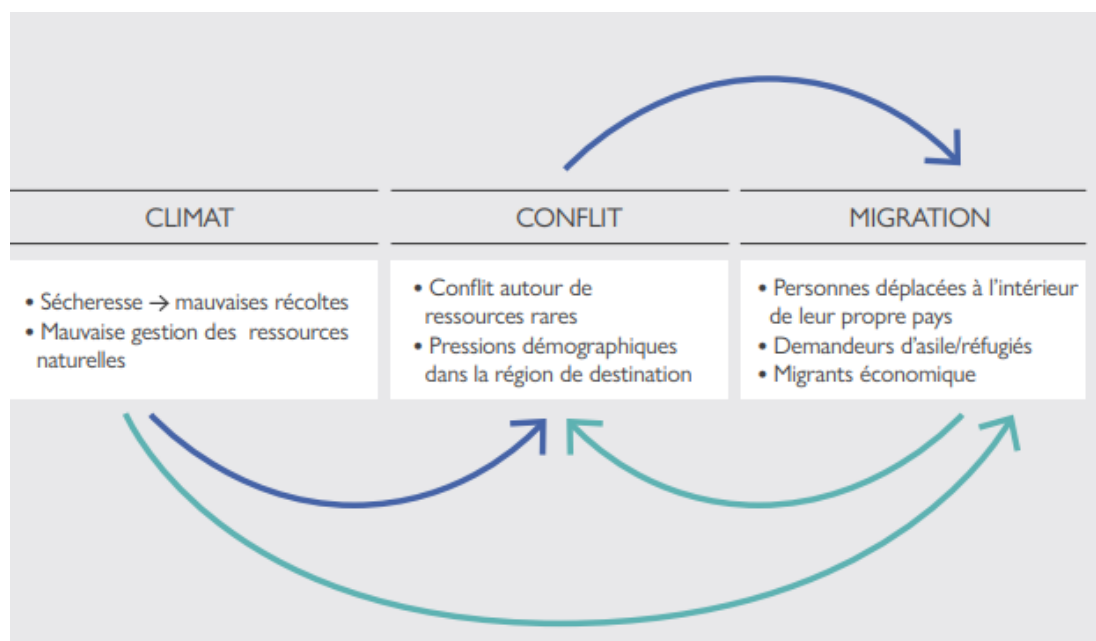
Figure 9:Link between CC, Migration, and conflict   **Source: Abel et al., 2019**

CC and mismanagement of natural resources exacerbate conflict and instability due to competition for scarce resources. As a result, climate-induced conflicts can trigger migration and displacement. This conceptual framework further shows that CC can cause migration and that both factors can contribute to the emergence of conflict.

3.2.3.1. Soil quality

Table 6: Soil quality

Cercle	Soil quality			
	High	Low	Medium	Total
Diema	0 (0%)	23 (22%)	81 (78%)	104 (100%)
Kayes	2 (0.7%)	65 (24%)	208 (76%)	275 (100%)
Niro	2 (1.6%)	30 (24%)	91 (74%)	123 (100%)
Yelimane	1 (1.1%)	26 (27%)	68 (72%)	95 (100%)
Total	5 (0.8%)	144 (24%)	448 (75%)	597 (100%)

Source: World Agroforestry Center data

Comment

Table 6 illustrates the perception of the farmer on the quality of the soil. In sum, 75% of the farmer perceive that the quality of the soil is medium. The indicators cited by the farmers are the colours of the soil.

Although, every farm needs fertile soil to produce healthy crops. Soil quality and health are essential factors in growing vegetables, plants, flowers, and much more. Industrial and small farms survive off of quality earth, though each sector cultivates it through different methods. This situation can worsen the household's vulnerability to food insecurity and then migration.

3.2.3.2. Reliable water source

Safe water and adequate sanitation are two essential factors in ensuring human health and protecting them from a wide range of diseases. (UNCTAD, 2018)

The International Decade for Action on Water for Life (2005-2015) urges the international community to redouble its efforts to increase access to water and sanitation for all by 2015 to combat disease and improve the health and well-being of the world's population.
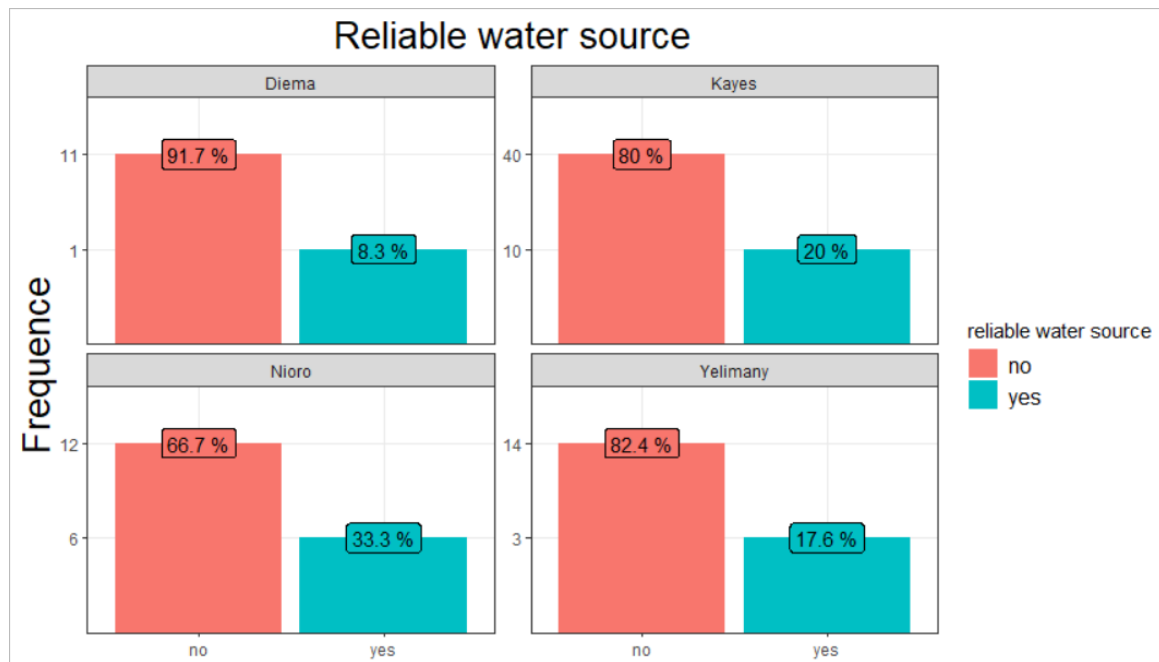
Source: Survey data

Figure 10: Reliable water source

Comment:

We can see from the figure 10, the access of reliable water source percentage is very low. In fact, in each zone more than 50% of the household don't have access to the reliable water source. This could have an impact on the livihood of the household and then to the migration

decision.

3.3. CC and migration

According to the Intergovernmental Panel on CC (IPCC) (2014), CC and climate variability are expected to exacerbate poverty, food insecurity, inequality, violence, and conflict.

The interactions between climate, conflict, and migration are complex, and the scientific literature on the topic is still in its infancy and delivers mixed results. Beine and Parsons (2015) included the variables of violence and CC in their model on migration and found that the increased incidence of violence corresponds to increased migration flows.

For this part, Reuveny (2007) analyzed 38 cases since the 1930s in which environmental changes triggered mass migration, and found that 19 of them resulted in some form of conflict due to competition for scarce resources.

While it has been relatively easy to find evidence that migration is influenced by conflict, it has been difficult to find evidence that CC and environmental pressure cause conflict-driven migration (Abel et al., 2019).

3.3.1. Farmer's knowledge of CC

Table 7: Farmers' knowledge of CC

Cercle	Have you heard about CC?		
	No	Yes	Total
Diema	30 (29%)	74 (71%)	104 (100%)
Kayes	80 (29%)	195 (71%)	275 (100%)
Nioro	40 (33%)	83 (67%)	123 (100%)
Yelimane	26 (27%)	69 (73%)	95 (100%)
Total	176 (29%)	421 (71%)	597 (100%)

Source: Survey data

Comment :

Climate and its inevitable symptoms of change are now becoming a part of people's life.

The global climate is changing rapidly, and it is not clear if agricultural producers in developing countries will be able to adapt fast enough to mitigate its negative effects.(Fierros-González & López-Feldman, 2021)

To be willing to take adaptation measures, farmers need to perceive that the climate is changing or could change, and they need to attribute enough weight to this perception to take action.

CC perception is a complex process that encompasses a range of psychological constructs such as knowledge, beliefs, attitudes, and concerns about if and how the climate is changing. (Whitmarsh & Capstick, 2018)

Perception is influenced and shaped, among other things, by the individuals' characteristics, their experiences, the information that they receive, and the cultural and geographic context in which they live. Therefore, measuring CC perception and trying to find its determinants is not an easy task.

Also, life experiences influence perception, individuals who have been directly affected by extreme climatic events tend to report that the probability of such events happening again is relatively high (Hansen et al., 2012);(de Matos Carlos et al., 2020).

Furthermore, we can deduct from the study that, the perception that a farmer has about CC can be influenced or modified by the information that he receives. Finally, it should be noted that perception is in part a subjective phenomenon, therefore, different people in the same locality might construct different perceptions of CC even though they experience the same weather patterns.

3.3.2. Aspect of CC known by farmers:
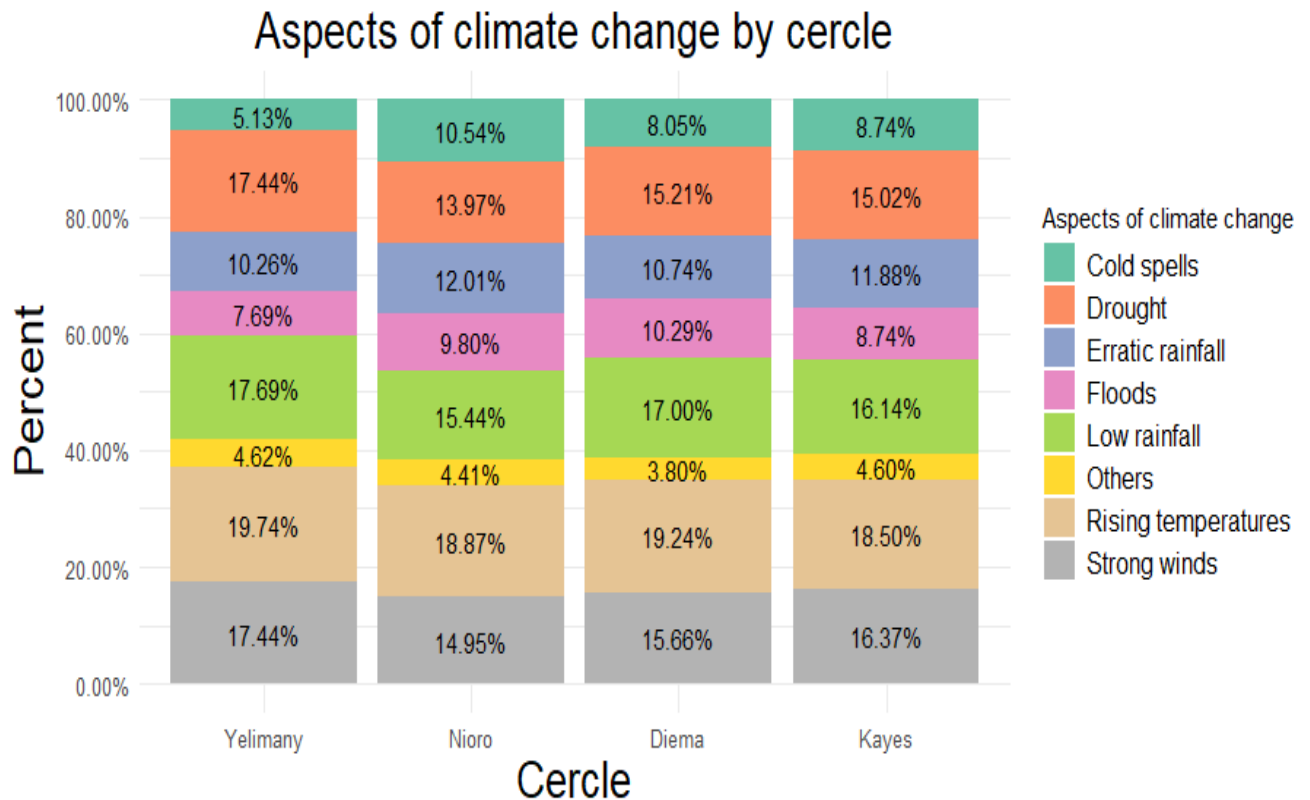
Source: Survey data

**Figure 11: Aspect of CC known by farmers**

Comment:

Rising temperatures, drought, strong winds, and low rainfall are the most CC aspect cited by the farmers in all the regions.

The variability that local weather can have from one day to the other, from one season to the next, and between years, is one of the many challenges that a person faces when trying to distinguish between normal short-run variations and CC manifestations(Hansen et al., 2012).

Local short-term variations tend to be more salient than long-term trends and hence can have a key impact on the formation of CC effects. Water supplies, reduced agricultural yields, health impacts in cities due to heat, and flooding and erosion in coastal areas are additional concerns. From the local source, CC is leading to more and more extreme events (droughts and floods) which particularly affect the productivity of traditional agro-pastoral systems by changing transhumance routes, contributing to the drying up of water points, the reduction and deterioration of vegetation cover and the pastures damage.

3.3.3. Factors affecting crop production
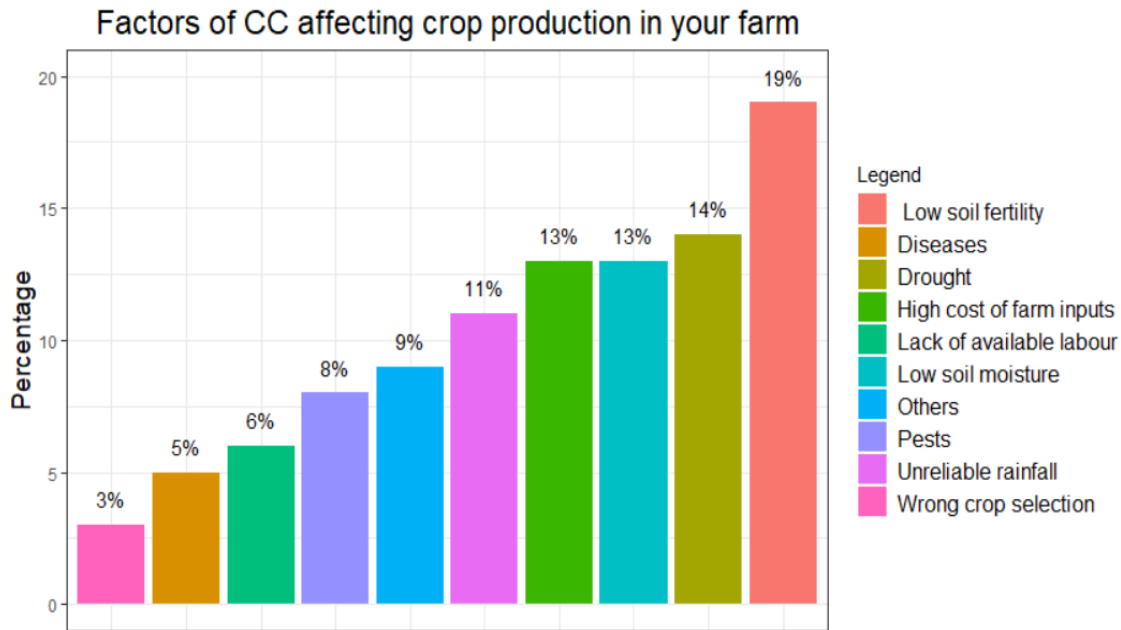
Source: Survey data

**Figure 12: Factors affecting crop production**

Comment:

Low soil fertility, low soil moisture, and unreliable rainfall are the key factors that affect mainly crop production in Kayes.(Defrance, Delesalle, et al., 2020)

So, there is a need to focus on the case of land degradation in the Kayes region. The major causes include land clearance, poor farming practices, overgrazing, inappropriate irrigation, urban sprawl, commercial development, land pollution including industrial waste, and quarrying of stone, sand, and minerals. (Eni, 2012)

High population density is not necessarily related to land degradation within Calabar South, but it is what a population does to the land that determines the extent of degradation. In the study area, where a large proportion of the human population depends almost entirely on land resources for their sustenance, this over-dependency results in the increasing competing demand for land utilization such as crop farming among others.

In addition, Agriculture, fisheries, and animal husbandry are highly dependent on the climate. Increases in temperature and carbon dioxide (CO2) can increase or decrease some crop yields

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in some places[3]. But to realize these benefits, nutrient levels, soil moisture, water availability, and other conditions must also be met. Changes in the frequency and severity of droughts and floods could pose challenges for farmers and ranchers and threaten food safety. The next figure illustrates the changes experienced by farmers related to CC.
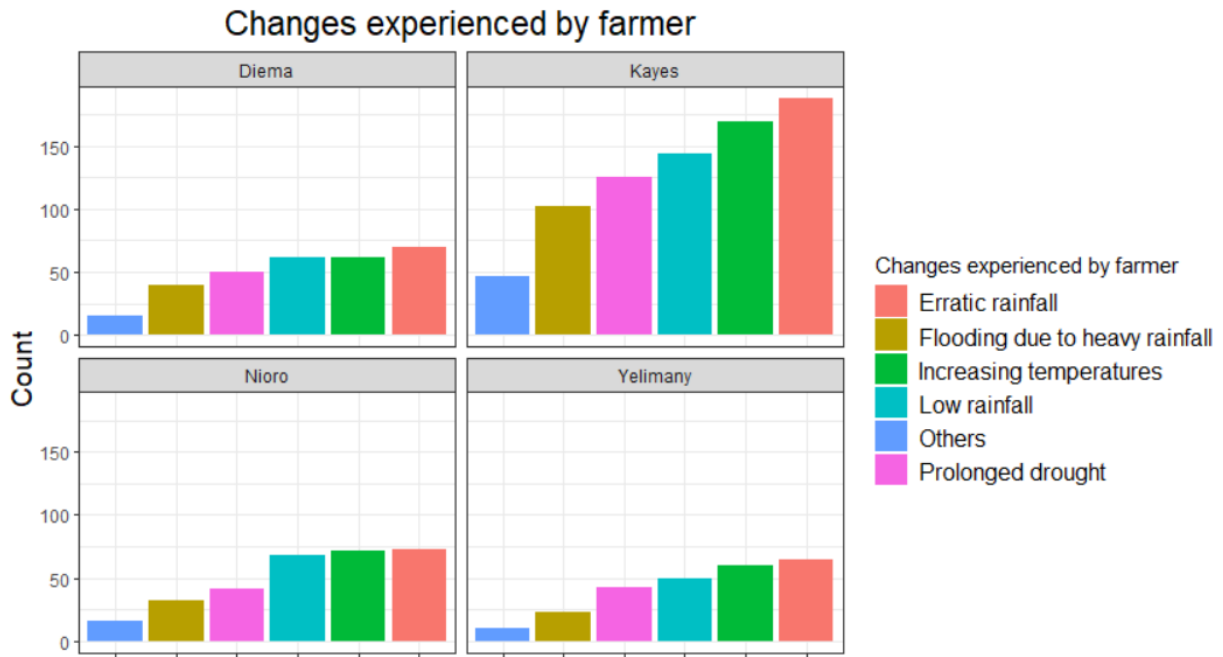
Source: Survey data

Figure 13:Changes experienced by farmers in kayes

Comment

The perception of the farmers about the experiences they have faced related to CC Erratic rainfall, increasing temperatures, and low rainfall. Those phenomena linked to CC could impact negatively the migration trend in those regions.

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[3] In a study of local ecosystem sustainability, Mohan Wali and his colleagues at Ohio State University noted that as temperature rises, photosynthetic activity in plants increases until the temperature reaches 20 degrees Celsius (68 degrees Fahrenheit). The rate of photosynthesis then plateaus until the temperature hits 35 degrees Celsius (95 degrees Fahrenheit), whereupon it begins to decline, until at 40 degrees Celsius (104 degrees Fahrenheit), photosynthesis ceases entirely. 17

Agriculture is extremely vulnerable to CC. Higher temperatures eventually reduce yields of desirable crops while encouraging weed and pest proliferation. Changes in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines. ("The Long Road to Recovery," 2005).

Global food security relies on both sufficient food production and food access. Impacting negatively the yield would induce to migrate to find a better solution.
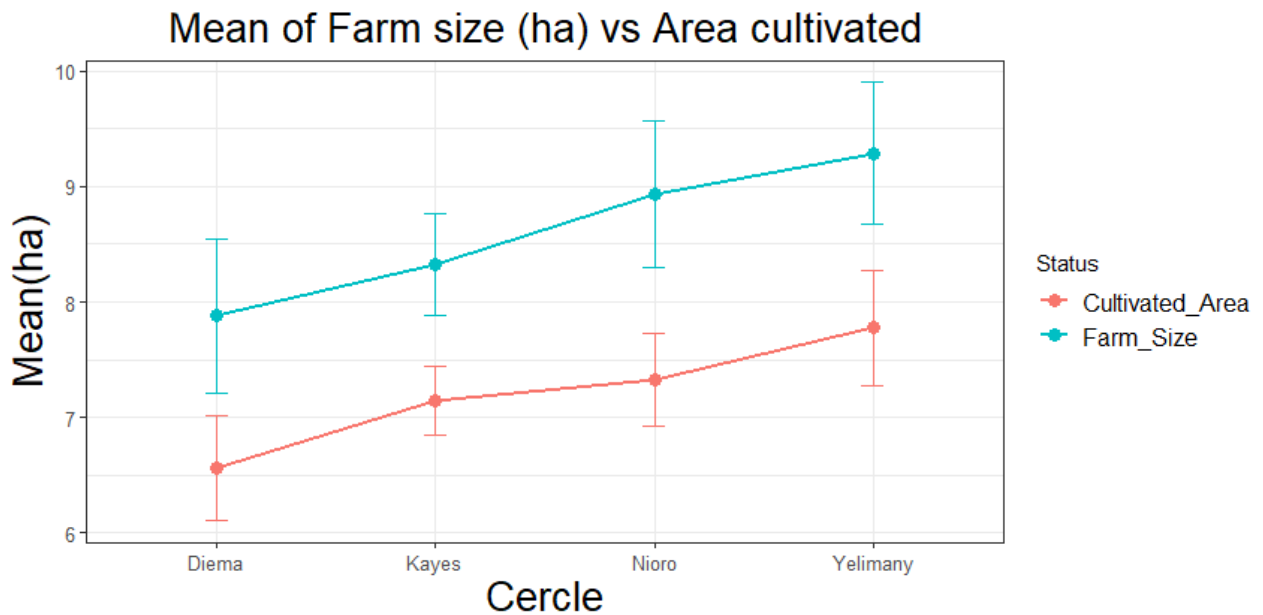
3.3.4. Impact of CC on agricultural activities
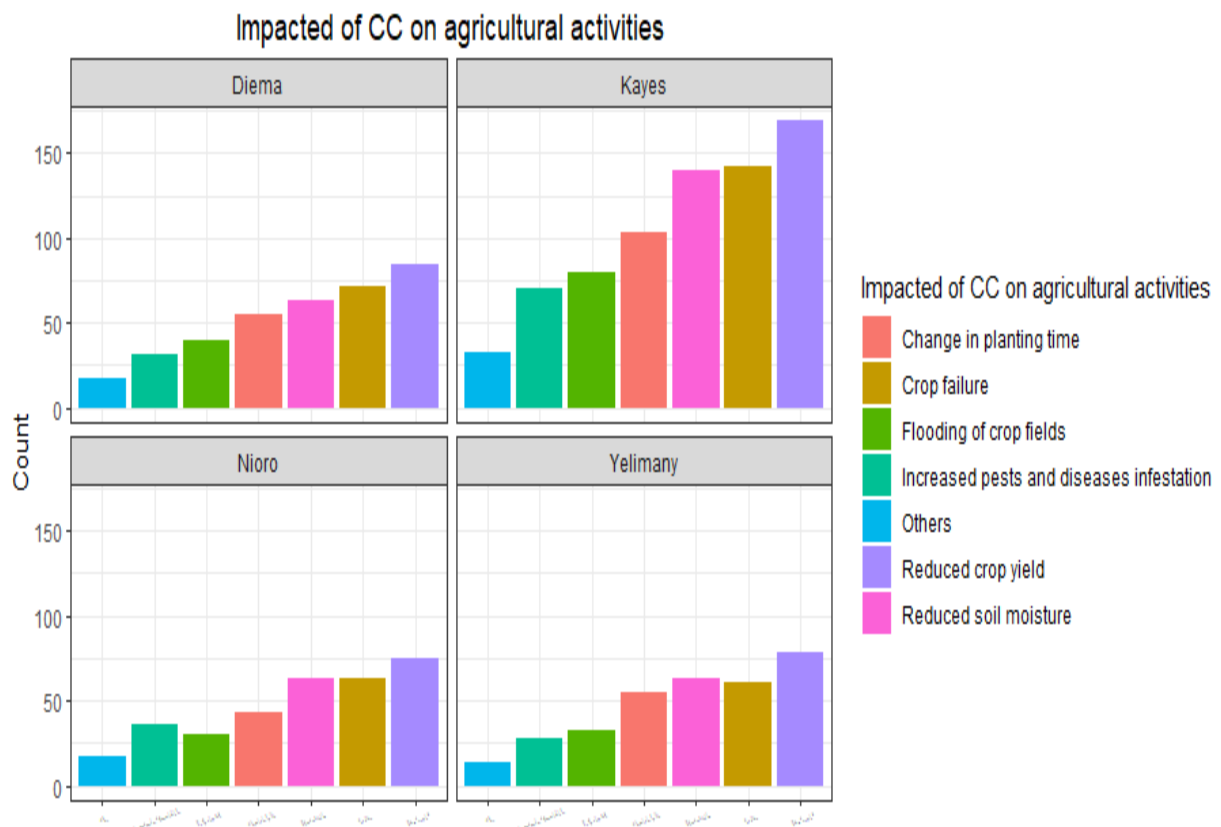
Source: Survey data

Figure 14: Impacts of CC on agricultural activities

3.3.5. Farm size vs Area cultivated

Source: Survey data

Figure 15: Farm size (ha) vs Area cultivated

Comment:

In Mali, the constant threat posed by drought and CC to a resource that is already weakened by unsustainable farming practices has contributed to hampering the productivity of smallholder farms.

It is noticed, that the average size of the farm is higher than the cultivated area. This could be one of the consequences of the migration phenomenon in the region. The great mass of the population cannot cultivate the land in their possession for lack of manpower.

Also, land possession is a major factor in the capacity of farming. The level of investment will decrease or increase based on the ownership of the land. The land could be for the community or individual land. The following figure illustrates the distribution of the ownership of the land in Kayes.
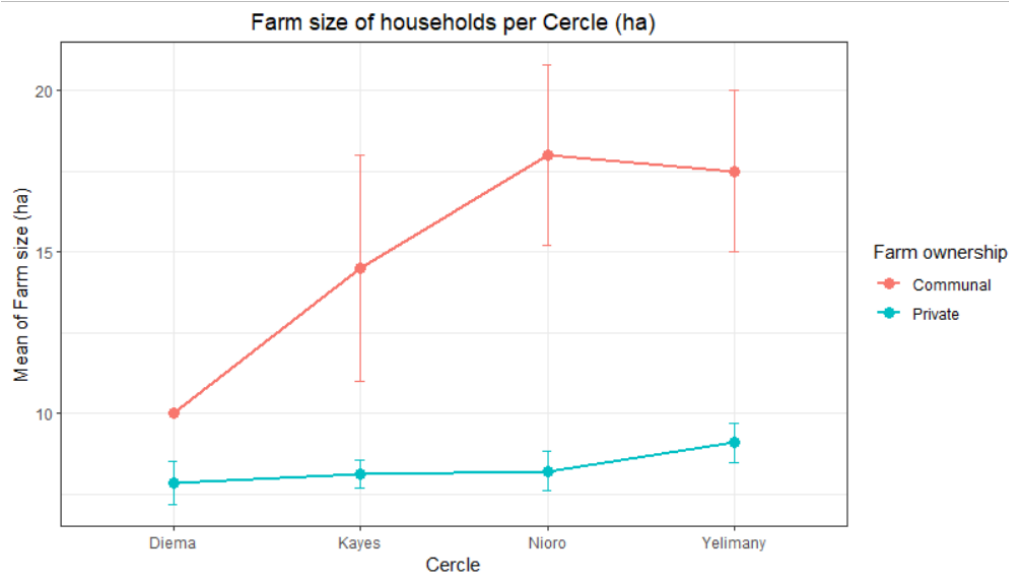
Source: Survey data

Figure 16: Mean farm size vs Farm ownership

3.3.6. Response to CC

Throughout human history, farmers have adapted to changing environmental, social, and economic conditions (Kurukulasuriya and Rosenthal, 2013). Nonetheless, it is not clear if agricultural producers will be able to keep up with the unprecedented speed at which climate is expected to change in the coming years (Jones et al., 2012). The negative effects of these changes will be higher for agricultural producers that practice rain-fed agriculture, as well as for those with limited access to credit and insurance, and those that are disconnected from regional or national markets (Skoufias et al., 2011; Quiroga et al., 2015; IFAD, 2016; Castells-Quintana et al., 2018). To ameliorate these negative effects, public policies and interventions to promote and facilitate adaptation will be needed (Howden et al., 2007; Kumar et al., 2020). Nonetheless, to be willing to implement adaptation measures, farmers need to be aware of CC (Silvestri et al., 2012; Simelton et al., 2013; Meldrum et al., 2018). In that sense, the perception that farmers have about CC not only informs their planting decisions but also determines the adoption of adaptation measures (Meldrum et al., 2018; De Matos Carlos et al., 2020). Therefore, understanding farmers' perceptions about CC can be seen as a condition for the design and successful implementation of the mitigation strategy.
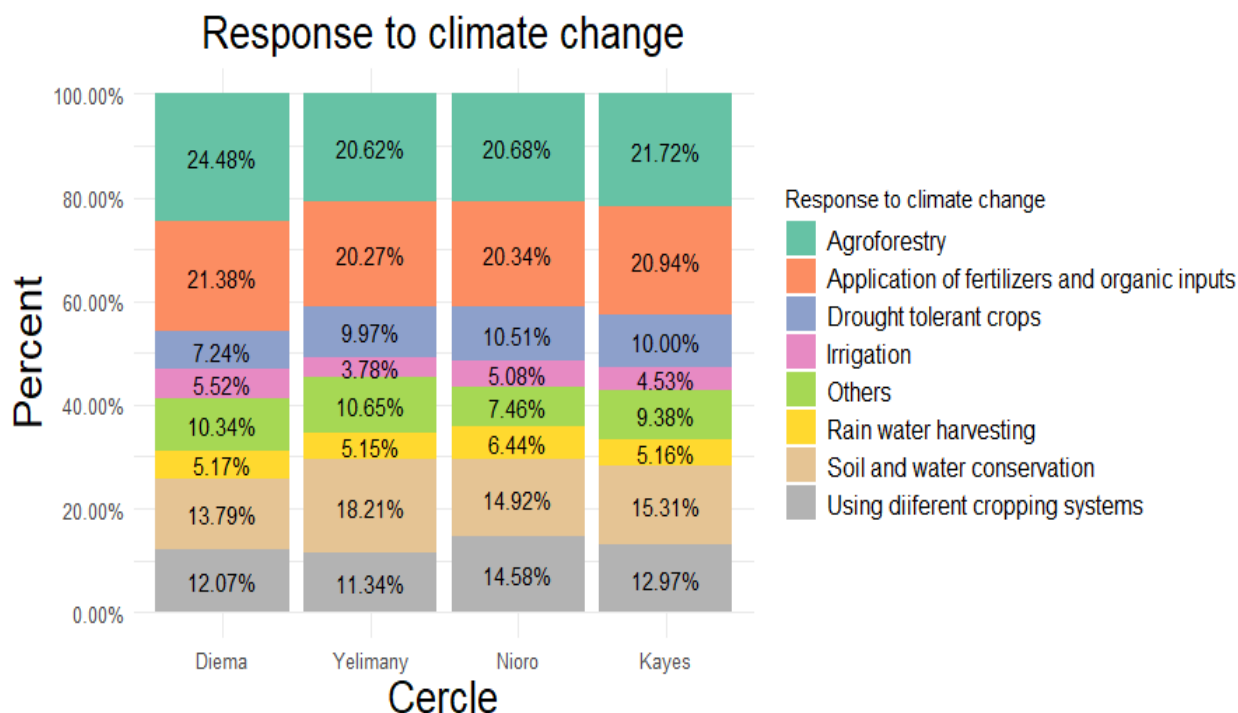
Source: Survey data

Comment

Figure 17: Technical response to climate change adopted by farmers

- **Land cover**

Farming throughout the globe has its specifics that depend on weather conditions, with the CC impact on agriculture being tremendous. ("The Long Road to Recovery," 2005)

Climatic peculiarities nowadays are not the same as they were before. Analyzing how CC affects agriculture, farmers have to adopt methods they have never previously tried.

Agricultural lands encompass a great deal of land not exclusively dedicated to the production, including wetlands and woodlands. Some types of agricultural lands, such as hay and pasture lands, provide forage and grazing for livestock but also reap important benefits such as wildlife habitat and carbon storage.

Good management of agricultural lands keeps them healthy and productive, while also sustaining biodiversity, helping maintain a stable climate, and providing other important benefits for Saskatchewan residents.
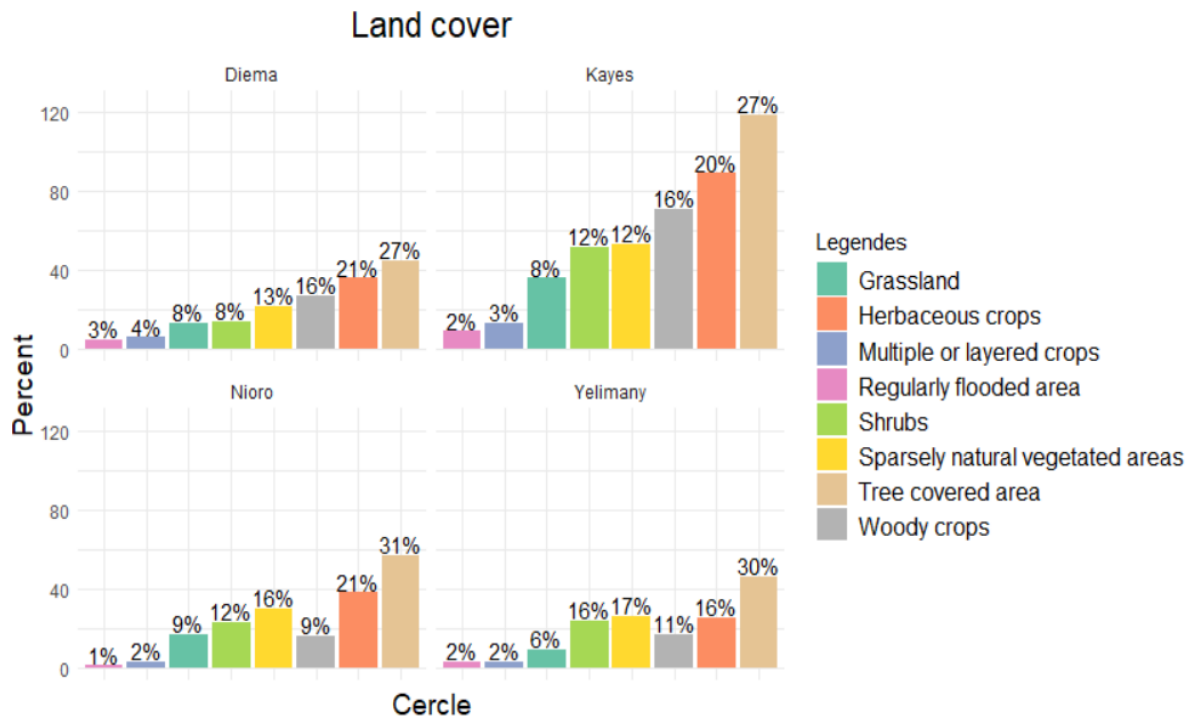
Source: Survey data

Figure 18: Land cover by Cercle

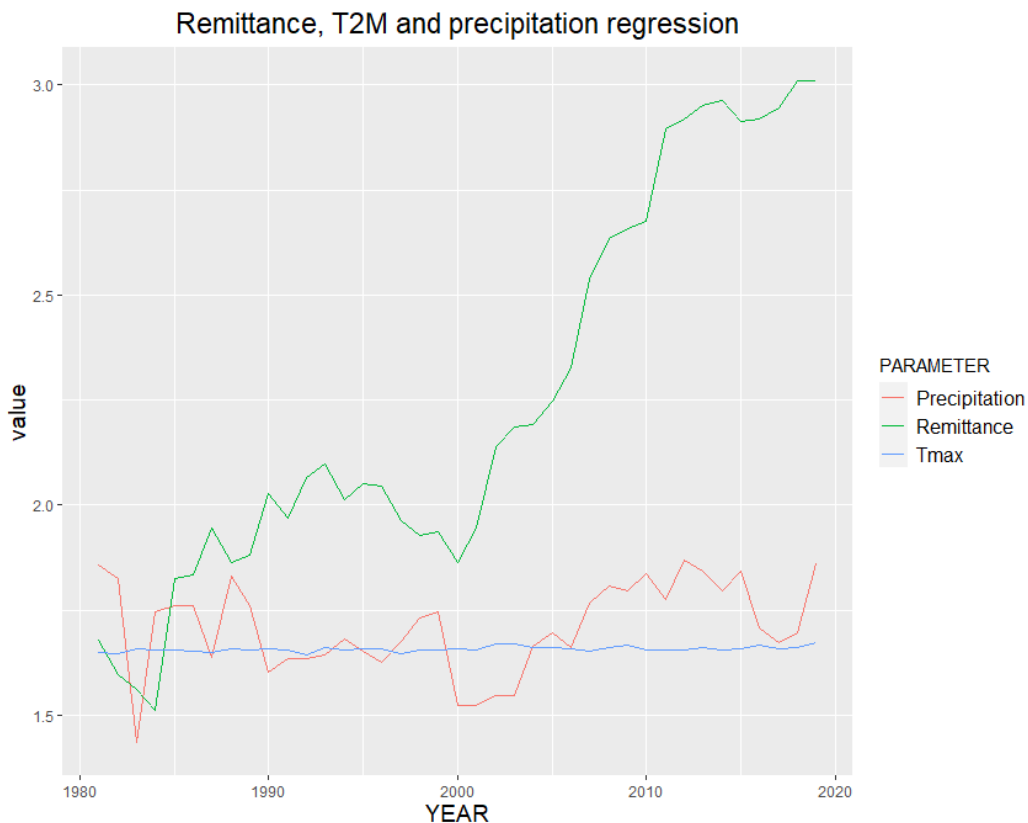Among the land cover used by a farmer in the Kayes region, Tree covered areas, Herbaceous plants, woody, etc. Based on previous research such as ("The Long Road to Recovery," 2005), those techniques are considered mitigation solutions for CC in agriculture.

3.3.7. Link between CC and migration:

Source: Word Bank data, Mali meteo data

Figure 19: Comparative plot between the remittance, precipitation, and maximal temperature

Comment:

The figure shows the positive correlation between the remittance, maximal temperature, and precipitation in Kayes. The increase in remittance may imply an increase in the migration rate. In Kayes, the primary source of water for agricultural production is rainfall. Many studies found a major cause of farmer migration is the decrease in the yield of crop production which implies the water resource in Kayes. The increase in maximal temperature could have explained the increase in of rate migration.

High temperature, even for short period, affects crop growth, especially in temperate crops like wheat. High air temperature reduces the growth of shoots and in turn reduces root growth. High soil temperature is more crucial as damage to the roots is severe resulting in a substantial reduction in shoot growth (Climate et al., 2017) .

In opposite, we can see from the figure 19 an increase in precipitation over the years. More deeply, three main characteristics of rainfall are its amount, frequency, and intensity, the values of which vary from place to place, day to day, month to month, and also year to year. Precise

knowledge of these three main characteristics is essential for planning its full utilization.
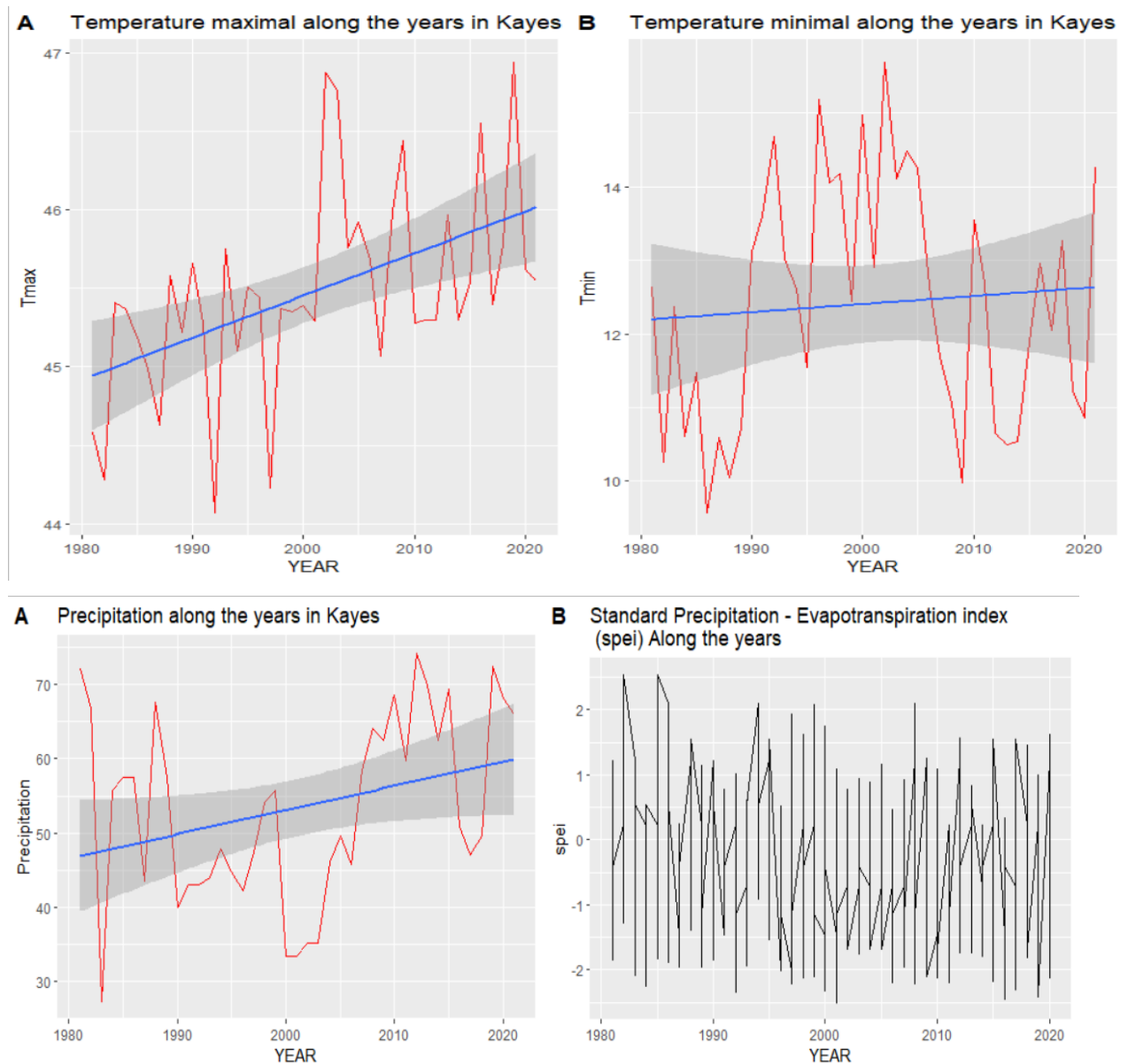
Source: Word Bank data, Mali meteo data, SPEI data

Figure 20: Comparison Remittance, Maximal Temperature, Minimal Temperature, Precipitation, SPEI

Comment :

We push forward the previous analyses to test for the increased precipitation and the increase in remittance. To this end, we compute Standard Precipitation – Evapotranspiration Index (SPEI) interaction terms between drought frequency variable and factors expected to potentially influence migration rates. By so doing, we aim at providing insights into the mechanisms linking climate and migration.

We assessed to what extent the agroecological context matters in the drought-migration relationship. We can notice the decrease in the minimal value of SPEI from 2000 to 2020 at the bottom right plot. These values refer to a severe drought in that period which may have affected the production and then lead to the migration.

In the past, Mali thus constitutes an interesting case to investigate the impact of climate events on migration intensity and patterns. In comparison to most previous studies, we can analyze the long-term effects of climate events on migration decisions at a highly disaggregated scale.

Therefore, CC is affecting multiple aspects of livelihoods. Its effect on food production in low latitude countries will be negative and significant. An increase in temperature, fluctuation in precipitation, and devastating drought may have contributed to the increasing migration rate in the Kayes region.

3.4. The link between the remittance and the benefice of Agriculture

This section will explore the relationship between migration aspirations and assistance received by interviewees. In the Kayes region, according to a study conducted by the International Organization for Migration (IOM) among Malian emigrants returning from France with a financial contribution, transport comes second on the list of investment. In a society and economy based on the mobility of people and goods, and with the extent of urbanization in the region, the development of transport activity is timely. This can take the form of repairing a vehicle bought when the individual was migrating, and when a relative who remained in the village drives or buys a car on returning to the village. Most of the time, the neo-transporters become taximen and offer travellers a round trip between Kayes and their town or village of origin.

The linkages between agriculture, food security and migration can also be indirect as a strategy by households to cope with income uncertainties and food insecurity risks. Sending one or more family member to work in economic sectors other than agriculture can increase their capacities to cope in the event of adverse shocks.

3.4.1. Importance of remittance

Seventy percent of the socio-economic investments in the Kayes circle come from abroad (Jean-Paul Azam & Azam, 2004). And it is in this spirit that the Regional Council tries to systematically involve members of the diaspora in development. Including those born outside Mali. (Konaté & Famagan-Oulé, 2010).

The new trend of the diaspora tends much more to develop business. They want to do development differently. It is not a question of doing charity, but of getting involved through business. They often look at promising sectors to help their territories of origin and are sometimes initiators of important projects for the region. (Jean-Paul Azam & Azam, 2004)

The president of Onddega talks about the electricity supply project: "We were motivated and encouraged by one of our sons from the diaspora, who is now part of a large consortium. He wants to help us set up hybrid power plants, which can cover not only the Gadiaga (his origin village), but also the Kayes cercle, or even the Kayes region. He just asked us to provide reliable feasibility studies."

Secretary-General of the Coordination of Associations for the Development of the Kayes Region (Caderkaf) in France, Diane Touré confirms the reorientation of the objectives of diaspora transfers. "The first migrants arrived and coped with their means: we contribute, we face an emergency, to prevent families from going hungry so that families can have a health center so that families can have a well [for access to water]... Indeed, it is not very productive. But today, there is still this organization, it is still there. But with the new generations, new orientations: we must organize differently, invest differently to create economic wealth."[4]

The Kayes Regional Council pays full attention to diaspora initiatives, according to them. "Our desire is that like the Gadiaga, all the territorial groups of the region can bring us concrete projects, in which the Regional Council will be inscribed, to bring what it can in terms of realization."

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[4]   https://www.infomigrants.net/fr/post/33875/mali--terre-demigration-la-region-de-kayes-compte-enormement-sur-sa-diaspora

- **Farming Equipment**

The lower income earned from farming by migrant households is not due to obvious differences in cultivation practices, like the use of farming equipment. The survey was specifically designed to assess the impact of migration and remittances on agriculture. The following figure shows the farm tools by household migration status.
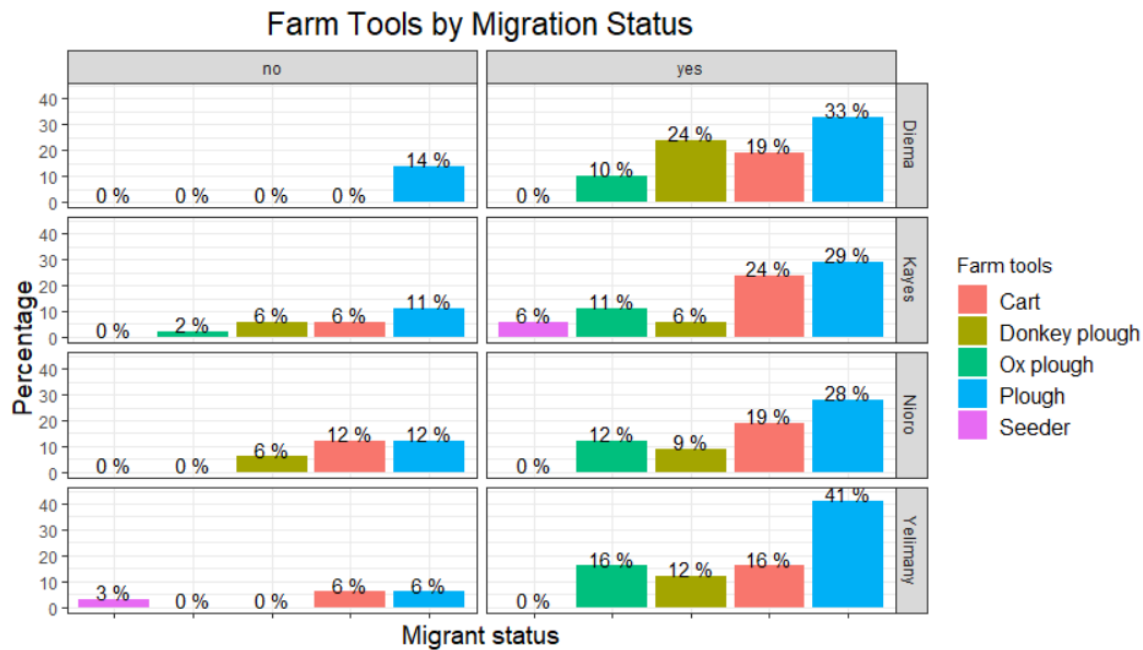
Source: Survey data

Figure 21:Farm Tools by Migration Status

Comment:

Figure 21 provides information concerning farm tools among the sample households, by migration status. We can see from the figure, that only households with migrants have modern equipment such as ox plows, and carts.

A significant difference comes out from comparing the two sub-samples regarding their equipment. The adoption of modern agricultural tools such as ox plows or carts is strongly and positively correlated with out-migration. Moreover, discussions with farmers revealed that the acquisition of productive agricultural assets always followed migration, suggesting that migration contributes to relaxing the credit constraint through remittances.

The lack of equipment makes agricultural productivity very low. Having quality equipment could give 3 major benefits: (i) Reduced production time,(ii) Increased efficiency, and (iii) Reduced Downtime.

In sum, in Kayes households with migrants could through remittance access the equipment more than a household without migrants within.

3.4.2. Financial transfers made by emigrants to the region of Kayes

Remittances are the essential basis for contact with the family back home. In Kayes, migrants' money is seen as the breadbasket of families. (Jean-Paul Azam & Azam, 2004)
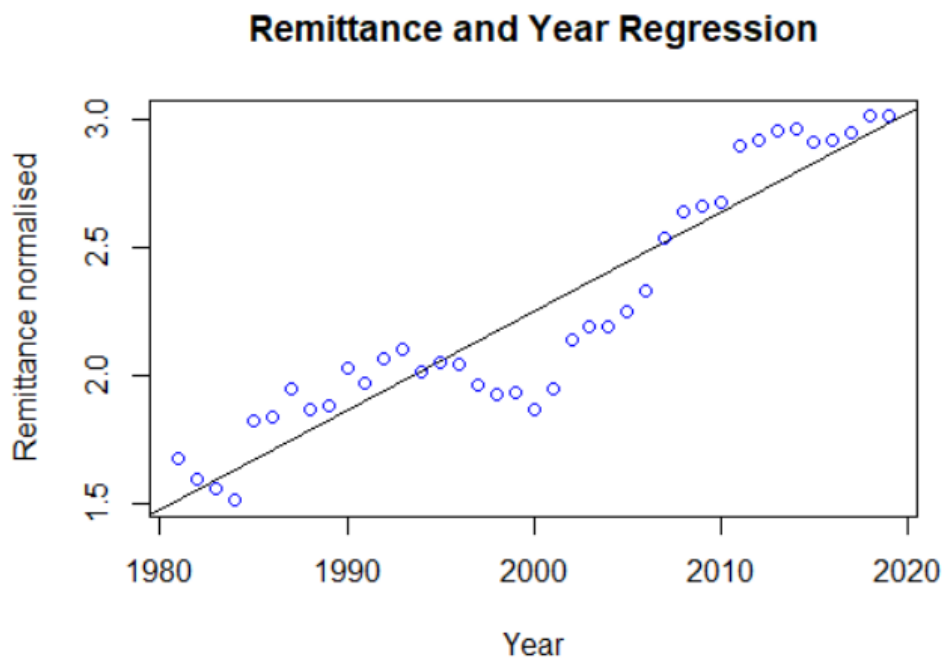
Source: Survey data

Figure 22:Remittance along the years

Comment:

An examination of this figure shows that the amounts sent by migrants are increasing over the years. This situation could be explained by the increase in several migrants or household lifestyles.

Indeed, during the time frame 2010 – 2020, the amounts received increased significantly. This is explained by the security crisis at the national level degraded since 2010.

Table 8: Linear regression - Remittance and the year

Call:

lm(formula = dfRemittance_Norma$Remi ~ dfRemittance_Norma$YEAR)

Residuals:

Min	1Q	Median	3Q	Max
-0.38496	-0.13747	0.04111	0.12281	0.22083

Coefficients:

	Estimate	Std. Error	t value
(Intercept)	-74.893791	4.653717	-16.09
dfRemittance_Norma$YEAR	0.038572	0.002327	16.58

	Pr(>|t|)
(Intercept)	<2e-16 ***
dfRemittance_Norma$YEAR	<2e-16 ***

Signif. codes:

0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1635 on 37 degrees of freedom

  (1 observation deleted due to missingness)

Multiple R-squared: 0.8813,   Adjusted R-squared: 0.8781

F-statistic: 274.8 on 1 and 37 DF, p-value: < 2.2e-16
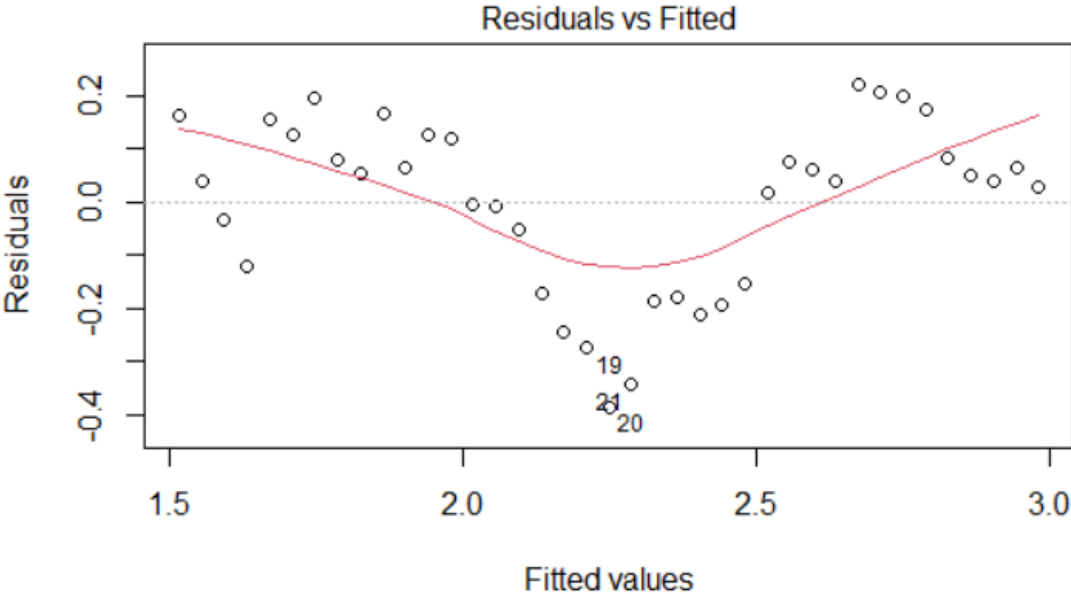
Figure 23: Residual vs fitted

Comment

The residual plot above from linear regression beaten Remittance sent by migrants and the years. The residuals appear on the *y* axis and the fitted values appear on the *x-axis*.

The residual is calculated by the difference between an observed value of the Remittance and the value of the Remittance predicted from the regression line.

Positive values for the residual (on the y-axis) mean the prediction was too low, and negative values mean the prediction was too high; 0 means the guess was exactly correct. We can see from the plot; that the model predicts both outlier positions (left and right).

3.4.3. Methods of money transfers and use by heads of household

The modes of transfer used are numerous and varied: they rely on institutional networks such as banks and transfer organizations, but also social networks. Transfer agencies were mainly mentioned. They are followed by those made during the emigrant's visits to Kayes, followed by the means that combine the use of transfer agencies and visits. The transfer agencies and the service of a shopkeeper from Kayes (who delivers goods to the emigrant's family before being reimbursed during a stay in France) were involved in a proportion of 1.1%. (Konaté & Famagan-Oulé, 2010)

A large proportion of remittances (85.2 percent) are used by heads of households for the maintenance of families(Konaté & Famagan-Oulé, 2010). Another part (11.4%) is for food and construction projects inside the concessions, while the last part is devoted to the purchase of livestock or consumption. (Konaté & Famagan-Oulé, 2010)

3.4.4. Destination of Migrants from Kayes to abroad
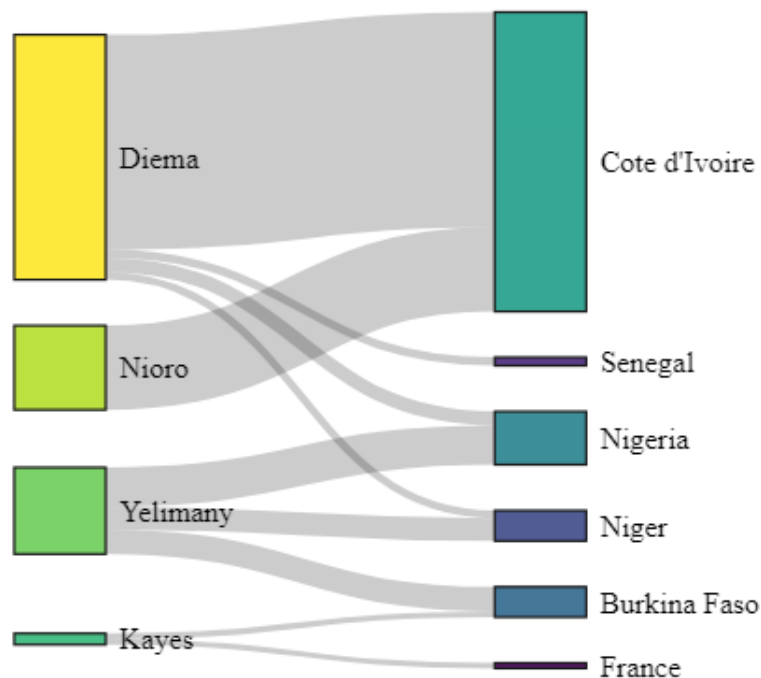
Source: World Agroforestry Center

Figure 24: Destination area by migrants

Comment :

The figure shows the destination of an international migrant from the Kayes region(Diema, Nioro, Yelimane, Kayes). Cote d'Ivoire and Nigeria are the most destination country.

Historically, The persistence of economic difficulties, social inequalities in the redistribution of national wealth, and the effects of the great famines of 1970 and 1980 contributed to placing Mali in a situation of particular socio-economic crisis, which led to the strengthening of migratory flows to Côte d'Ivoire, then a prosperous and stable country. ("The Long Road to Recovery," 2005)

At that time, the country (Code d'Ivoire) needed able-bodied arms for its coffee and cocoa plantations, in maritime activities and the exploitation of fisheries resources, as well as in the transport sector. Involved in these vital sectors of the Ivorian economy, Malian immigrants could constitute an important economic rent, whose repatriation to Mali served to initiate the local development of communities, especially rural ones. ("The Long Road to Recovery," 2005)

Conclusion and perspective

- **Conclusion**

In this paper, we combine both secondary and primary data collection methods to assess the migration in the Kayes region. This report examines the complex interlinkages between migration, agriculture, food security and climate factors.

It has been established that migration flows, both interregional and international, are explained by the constraints existing in the areas of origin: living conditions, income, and the development potential of these regions. For Kayes, the migraiton is based on three main factors which are: social factors, economic factors, natural and geo-climatic factors, and political and security factors.

The interactions between climate and migration are complex in Kayes region. The research founds a positive correlation between migration, temperature maximal, precipitation and the SPEI in Kayes. It is also well seen that, a decrease in the minimal value of SPEI from 2000 to 2020 refer to a severe drought in that period in which the migration rate considerably.

The impacts of migration in the Kayes region could be positive or negative. Moreover, migration gives rise to both opportunities and challenges.

In Kayes, migration is part of the present adaptation portfolio of households to different climatic conditions. Seventy percent of the socio-economic investments in the Kayes circle come from abroad (Jean-Paul Azam & Azam, 2004). The migration has had on the region and its inhabitants are pervasive: entire villages are built with remittances sent by migrants from Kayes, returnees are deeply ingrained in local government structures and diaspora communities are treated as key agents for development by local and international actors alike.

We finally make some predictions of future migration patterns in Mali based on our regression estimates. Our results show that climate events increase migration from rural areas, regardless. Between 2000 and 2020, droughts episodes could lead to an increase in the migration rate.

Competition for land may increase as certain areas become climatically unsuitable for production. In addition, extreme weather events, associated with CC may cause sudden reductions in agricultural productivity, leading to rapid migration.

- **Perspective**

Three research themes seem to us to stem from this work. The first step would be to research female migration. These obey logic different from those of men, but here we have only touched the heart of the subject. It would then be a question of continuing to dig into this question of the changes in status brought about by the trajectory of migration and in particular to conduct a reflection on the relationship to work, which appears quite central in the migratory logic. Finally, it would be a question of monitoring the future of the processes underway in the Kayes region to measure their impact in the medium term.

CC is leading to more and more extreme events (droughts and floods) which particularly affect the productivity of traditional agro-pastoral systems by changing transhumance routes, contributing to the drying up of water points, the reduction and deterioration of vegetation cover, and the pastures damage.

To protect households from these vulnerable impacts of CC and strengthen their resilience, the focus must be on developing and promoting the integration and adoption of specific CC Adaptation (CCA) strategies, practices, and technologies, while strengthening the capacities of small agro-pastoralists in the Kayes regions, particularly through Agro-Pastoral field schools (APFS). A set of recommendations is formulated by research results and based on findings from the study.

It is recommended to:

- Conduct information and communication activities to raise awareness of behavior change through local radio stations, talks, sketches, posters, etc.) ;
- Strengthening farmers' land ownership status in Kayes
- Improve the economic status of households through support for the development of income-generating activities;
- Promote literacy for women and men;
- Work with producer organizations and associations to support campaigns and advocacy efforts

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