Perception of Climate Change Impacts on Livelihoods in Central Mali

Original Research Article

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ABSTRACT

The main objective of this research is to analyze the perceptions of local communities on climate change and its impacts on livelihoods in Central Mali. A survey data collected using multistage random sampling methods have been used for that purpose. From the result, the multinomial logit analysis, shows that households in Central Mali are well aware of climate change, its different manifestations (change in temperature, in precipitation duration and amount, in wind etc.) and the related adverse effects on their livelihoods.However, they face considerable challenges in adapting to those changes in climate. Lack of funds and credit facilities, lack of access to timely weather information, lack of technologies (physical infrastructure, technical material and equipment), lack of knowledge regarding adaptation technics (required human skills, e.g., applying specific planning and management approaches and methods), lack of appropriate seeds have been identified as the major critical barriers to climate change adaptation in the region.These constraints probably explain why individuals often resort topoor but more affordableadaptationstrategies which are conflict sensitiveand likely to break the social cohesion among local communities. In this context, implementing policies aiming at improving the effectiveness of extension services in supporting households to better adapt to climate change could be of great importance.

Keywords: Climate variability, livelihoods, Central Mali, multinomial logit.

1. INTRODUCTION

Climate variability constitutes an important threat to rural livelihoods in most West African Sahelian countries such as Mali [1]. This is exacerbated by factors including the geographic position, the large dependence on agriculture and the lack of adaptation capacity due to poverty. The resulting consequences are disastrous and may even translate into violence and communal conflict according to scholars [2–4].For instance[2] found that experiencing drought and associated losses increase the likelihood of supporting the use of violencein the Democratic Republic of the Congo. According to [4]participation in violence would have been, on average, more likely if a person had been affected by climate change than if they had not.Similar findings are found in [5,6]. In short, these studies highlight a potential relationship between climate change and participation in violence at the individual level. However, we believe that participationin such violent and conflictual behaviors in response to climate change do not occur by default.This may necessarily involve as a precondition how local communities perceive climate change and their ability toappropriately cope. Hence, understanding the micro-level perception and management of climate change is therefore essential to inform policy makers especially for localities like Central Mali.Indeed,located betweenthe Sahara and the Sahel this areaseverelysuffers from violence and communal conflict see for instance [7–9]. In parallel,the regionis exposed to extreme climatic shocks with agriculture and livestock breeding being the main economic occupations of local communities[10].While it is argued that people tend to perceive climate change at local scale [1], little is known about how local communities in Central Mali perceive and cop with climate change.To address this pressing research need, this study is an attempt to documents the perceptions of climate change and related impacts on rural livelihoods using data from household interviews in the eight administrative cercles of Mopti.

Overall, this research is an attempt of understanding local people's perceptions of climate change, its impact on livelihoods and critical barriers to adaptation in Central Mali. Indeed, Affected people's responses to climate change likely depend on their perceptions of climate change [11,12]. More interestingly, the manifestation of climate change and its impacts are expected to vary across localities. Some areas are expected to get drier while other parts are expected to be much wetter [13]. By implication, individuals from different regions and localities are likely to have different experiences of climate change and related impacts. For instance,in a study on North-West Ethiopia[14]found that a higher educational attainment, respondent's age, the number of crop failures in the past, farming experience, climate information, duration of food shortage increase the likelihood of perceivingchanges occurring in climate.In Nigeria, the study of [12] revealed that there is high level of climate change awareness in the study area. According to respondents, increasing temperatures, unpredictable, erratic, heavy and increasing rainfall, late onset and early retreat of rains are the major changes intervening in climate in their localities. In the agricultural zone of Oyo State (Nigeria), respondents have mentioned delayed rainfall, higher temperature, unusual heavy rainfall and flood as their perception of climate change [15]. Similar findings isreported in South Ethiopia where[16] found that almost all participants in the sample has perceived climatic change and its negative impacts on agricultural production. The authors further found that this perception was significantly influenced by factors including age, education level, livestock holding, access to climate information and extension services. Increase in the frequency of strong wind, dust, frequent drought, high temperatures and number of hot dayswere identified in southern Mali as the main changes in climate [1].Key factors shaping this perception were age, educational level, farm size and gender. In the savanna zone of Central Senegal,householdsidentified wind and occasional excess rainfall as the most destructive climate factors[17]. The perceptions of cocoa farmers on climate change in rural Ghana were analyzed by [18]. The study has shown that all the cocoa growing regions in Ghana are aware of climate change and associated impact on livelihoods. Using the Heckman sample selection model [19] found that farmers' perception of climate change in the Nile basin of Ethiopia was significantly related to the age of thehousehold head, wealth, knowledge of climate change, social capital and agroecological settings. In Togo, evidence has shown that 85% of respondents out of 320 households (sample size) perceived increase in temperature while 85.58% observed decrease in rainfall amount and distribution. These perceptions vary across gender, the fact of owing the farm land and being located in the plateau region or savannah region of Togo.Farmers in northwestern Bangladesh indicated that drought, groundwater depletion, lack of canal and river dragging are the most prevalent climate events in this area because of rainfall and temperature variation [20].

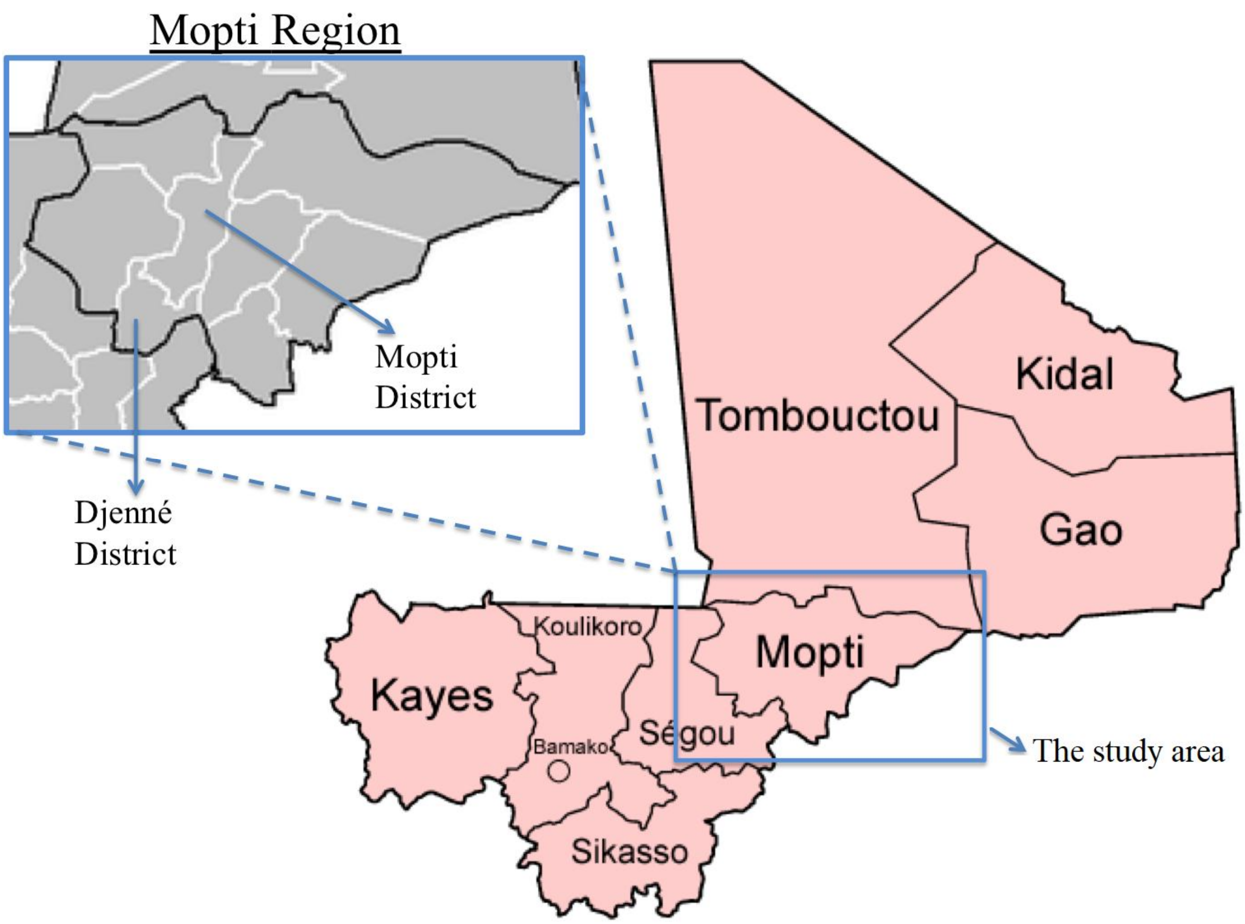
As the above discussion points out, different communities in different localities are likely tohavedifferent perception of climate change manifestation withvarious factors shaping those perceptions. This ultimately, raises the research questions guiding this analysis, specifically:(Q1) what are climate changes as perceived by local communities in Central Mali and the factors explaining this perception?(Q2) what are the impacts of these changes on their livelihoods? Indeed, in terms of impacts,climate change appears to be more detrimental for some localities than others.For instance,in a comparison study, [21] show that climate change is more detrimental for Sub-Saharan Africa (SSA) than non-Sub-SaharaAfrica(NSSA) developing countries.In Burkina Faso, evidence shows that a 1% increase in temperature is likely to reduce farm income by 3.6% (i.e., -19.9 USD per hectare). This is expected to reach 93% if the temperature increases by 5 degrees Celsius. Regarding precipitation, it is found that one percent decrease in rainfall amount will result in a decrease of the agricultural income by 14.7% (i.e., -2.7 $ USD per hectare), a decrease of 14% of rainfall will translate in 100% decrease in the agricultural income [22].Similar findings

are reportedin [23]. Their results show that a decrease in rainfall of 1 millimeter would decrease cereal production in Burkina Faso by 385 tons in the long term and 252 tons in the short term. This equates to a 9 kg increase in crop yield per hectare in the long term. The production of millet in Niger is expected to be about 13% lower (in 2025) as a result of decreasing rainfall amount associated to an increasing temperature [24]. In the Koutialacercle in southern Mali,[25] found that a decrease in average rainfall over the period June-September negatively affects crop production. With regard to temperature,result shows that an increase in mean temperature during the month of August and September, negatively affect the performance of crop production.Similar findings are recorded from Malaysia, where [26] found that an increase of temperature by 2℃ is likely to reduce rice yield by 0.36 ton per hectare.The economic loss induced by this reduction in rice yield to the Malaysian rice industry is estimated to be 162.531 million per year. In contrast to those findings, results from [27]'s study are a more optimistic. Indeed, the authors found that 10-degree Celsius increase in temperature (associated to 1 millimeter / month increase in rainfall) will lead to about US $ 4-15 increase in net crop income per hectare in Bangladesh.This contrasting effect of climate change may probably be attributed to the feature of the climatic zones being investigated. That ultimately call for caution regarding the characteristics of the climatic area while designing and implementing adaptation policies.
The rest of the paper is structured as follow: Section 2 presents the material and methods followed by results and discussion in section 3 and finally a conclusion in section 4.

2. MATERIAL AND METHODS

2.1 STUDY AREA

The research was carried out inCentral Mali, specifically in theMopti region. Ranked as the fifth administrative region of Mali, Mopti is located in the center between the North (the Sahara) and the southern part (the Sahel) and extends between the parallels 15°45' and 13°45' north latitude on the one hand, and the meridians 5°30' and 6°45' west longitude on the other hand. Mopti is bordered by Timbuktu in the north, the Segou in the southwest, and Burkina Faso in the southeast. The region covers an area of 79,017 km² representing around 6% of the national territory and count about 2,037,330 of inhabitants (in 2009 during the last general population and housing census). Currently it is projected at 2 878 285 inhabitants (According to the 2020's modular and permanent survey of households/EMOP run by the National Institute of Statistic/INSTAT-MALI). Divided in eight (8) administrative circles, Moptiis made of two natural zones. The exposed zone which corresponds to the Dogon plateau zone includes Douentza, Bandiagara, Bankass and Koro. The flooded area corresponds to a part of the Inner Niger Delta and encompasses Mopti cercle, Youwarou, Djenne and Tenenkou.the resident populationismixed and composed of the Peuls (the fulani), Bozos, Somonos, Dogons, Bambaras and the Sonrhay.
Figure 1: map of Regions in Mali



Source: https://nataliegagne.wordpress.com/where-im-working-2/

The study areais essentially agro-pastoral and halieutic. The most important resources are those coming from agriculture (land), livestock (pasture land) and fishing (rivers, lakes, ponds and channels).The exploitation of these resources is mainly based on three production systems: the agricultural production system, the livestock production system and the fishing production system.The agricultural production system is mostly dominated by rice production and constitutes 40% of the national area cultivated in rice and 20% of the national area cultivated in millet and sorghum. The livestock production system is dominated by the breeding of cattle. Due to the diversity and richness of its natural pastures, the region is a breeding area par excellence and ranks first in number of cattle and sheep/goats in Mali. The region alone holds 22.10% of the country's national cattle population and 26.5% of the sheep-goat population.The fishing production system is the third economic activity of the region after agriculture and pastoralism due to the importance of the hydrographic network.All of these production systems co-exist and, at times, overlap, depending on the season.Climate in Central Mali is characterized by three main seasons. A pronounced dry season from March to June, rainy or wintering season from June to September and an off-season or cold season from October to February with a drying Saharan wind called the harmattan.

2.2 SAMPLING AND DATA

The data used in this research is cross-sectional and recorded in all the eight administrative cercles of Mopti region on September 2021.The targeted population was all resident households in the region. A multi-stage random sampling approach was employed to determine the sample to be surveyed.A structured interview was then carried out to collect information on households' characteristics and their perception of climate change.More specifically, questions were administered to ascertain whether individuals in Central Mali have observed changes in climate indicators such as temperature, rainfall, drought, floods, and winds. Were also recorded, the consequences of these changes on livelihoods as well as the adaptation strategies developed to cope with those changes and critical barriers toadaptation.

2.3 DATA ANALYSIS

Descriptive statistics was used to analyze the perceptions of local communities on climate change while aMultinomial Logit (MNL) regression is employed to identify the main determinants of perception. To evaluate in which extent the perception of climate change affects the likelihood of experiencing deterioration in livelihoods we resort to a binary logit approach.

THE MULTINOMIAL LOGIT MODEL (MNL)

The benefit of using the MNL model in our context is that, instead of presenting results for each category of climate attributes separately under a binary approach, it allows the analysis of perceptions in more than two categories without requiring any form of ordering and classification.

The outcome variable weused for MNL is the perception level of climate change which in this case,comprises five levels/modalities (see Table 2). The first level coded "0" meaning "perception of no change" is used as the reference outcome (the baseline); in the second, third, fourth and fifth level are respectively found perception of changes in precipitation amount,perception of changes in temperature patterns, perception of changes in flood patterns and perception of changes in violent wind frequency. To econometrically illustrate that, let Y_i for instance denote our random outcome variable taking on the above modalities $\{0,1,...5\}$ that indicates the choice made by the respondent (i). X is a set of conditioning variables. Specifically, Y_i represents the changes in climate as indicated by respondents in the study area and X the vector of respondents' socio-economic and demographic characteristics (such as: gender, age, education level, household size, farm size, marital status…). Our goal is therefore to evaluate all other things being equal, how changes in the variables of X (vector of individual' characteristics such as gender, age, education…) affect the response probabilities (perception of climate attributes):

$$P(Y_i = j \mid X_i) = F_{ij}(X_{ij}\beta), \quad \text{with } \; i = 1,2,...,N \;\; and \quad j = 0,...,5 \quad (1)$$

Where $P(Y_i = j \mid X_i)$ is the probability for an individual i to perceive the change j and X_i a vector of individual' characteristics. According to [28], If the 5 disturbances related to modalities are independent and identically distributed then The MNL model became:

$$P(Y_i = j \mid X_i) = \frac{\exp(X_i\beta_j)}{\sum_{j=0}^{5}\exp(X_i\beta_j)} = \frac{1}{1+\sum_{\substack{k=0\\k\neq j}}^{5}\exp[X_i(\beta_k-\beta_j)]} \quad (2)$$

Where β_j is athe characteristic vector of modality j.

Following Eq. (2) The log likelihood can be specified as:

$$\ln L = \sum_{i=1}^{N}\sum_{j=0}^{5} y_{ij}\ln P_{ij} \quad (3)$$

The coefficients coming from the estimation of the MNL do not directly represent neither the magnitude of the effects of the exogenous variables on the dependent variable nor the probabilities, they only give the direction of the relationship (positive or negative/ decreases or increases). However, it is possible to measure the magnitude of the effects by determining the marginal effects (or marginal probabilities) of the explanatory variables. This can be obtained by differentiating Eq. (2) with respect to the exogenous variables as displayed in Eq. (4).

$$\frac{\partial P_j}{\partial X_i} = P_j\left(\beta_j - \sum_{j=0}^{5} P_j\beta_j\right) \qquad (4)$$

Therefore, being functions of the probability itself, marginal probabilities measure the expected change in the probability of a particular choice being made relative to a unit change in an independent variable. The estimation of the model's parameters is done using the maximum likelihood method. Another fundamental characteristic of the MNL is the independence property referred to as the independence of irrelevant alternatives (IIA). This assumption supposes that the probability of choosing one modality needs to be independent from the probability of choosing another modality [1]. This independence assumption implies that the disturbances in Eq. (2) are independent and homoscedastic.

The binary logit model

The binary logit model is employed to analyze the perception of climate change's effect on agricultural production. This because our dependent variable of interest has a binary form and is coded "1" when the respondents reported to experience a decrease in agricultural production and "0" otherwise. Indeed, this variable is the response to a survey question which is worded as: "Over the past 10-20 years, have you noticed any change in the production of animals and crops in terms of quantity and yield? If yes, respondents may also choose among a set of other responses (is this change?): (i) an increase; (ii) a decrease; (iii) don't know.

Indeed, the well-known linear regression models generally fail when the dependent variable is qualitative or categorical as the conditional expectation $E(Y/X) = X_i\beta$ can lie outside $[0,1]$ and does not represent a probability. In such case, the binary regression models appear to be the most appropriate. In contrast to linear remodels, the particularity of binary regression models is that, the probability of observing the modality 1 (called the event) is studied in those models. Let's consider for instance Y_i as this dichotomous dependent variable being studied in this dissertation. Y_i is designed as follows:

$$Y_i = \begin{cases} 1, & \text{if the respondent i observed a decrease in agricultural production} \\ 0, & \text{Otherwise} \end{cases} \qquad (5)$$

To analyze the probability that Y_i takes the value 1, we use a set of k explanatory variables $x_{i1},\ x_{i2},\ldots,x_{ik}$ that can be gathered into a vector X_i. The probability model could be then presented as follows:

$$P(Y_i = 1/X_i) = F(\beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_k x_{ik}) = F(X_i\beta) \qquad (6)$$

Where $P(Y_i = 1/X_i)$ represents the probability that Y_i is equal to 1 conditionally to the characteristics $x_{i1},\ x_{i2},\ldots,x_{ik}$. β is a vector made of $k+1$ parameters: $\beta_0, \beta_1, \beta_2, \ldots\beta_k$

. $F(.)$ is the distribution function of the quantity $\beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + ... + \beta_k x_{ik}$ ($X_i\beta$ in matrix form). The properties of the function $F(.)$ are such that for any variable z, $\lim_{z \to -\infty} F(z) = 0$ and $\lim_{z \to +\infty} F(z) = 1$. $F(.)$ is therefore a positive, continuous function and comprises between 0 and 1.

Hence, the general form of the model can finally be written as:

$$Y_i = F(X_i\beta) + \varepsilon_i \qquad (7)$$

Where ε_i is the error term.

The probability $P(Y_i = 1)$ depends thus on the distribution of the error term ε_i .

The Logit model make use of the cumulative distribution function of the logistic distribution specified as follow:

$$P(Y_i = 1 / X_i) = F(X_i\beta) = \frac{1}{1 + e^{-X_i\beta}}$$

(IV-10)

Using this logistic cumulative distribution, we finally obtained the Logit function defined as follows:

$$F(X_i\beta) = \frac{1}{\exp(-\beta X_i)} = \exp(\beta X_i) \qquad (8)$$

By taking the natural logarithm of $F(X_i\beta)$, it becomes:

$L = \ln(\frac{P_i}{1-P_i}) = \beta X_i$ where $\frac{P_i}{1-P_i}$ represents the relative probability of choosing $Y_i = 1$ and L varies from $-\infty$ (when $P_i = 0$) to $+\infty$ (when $P_i = 1$).

Hence, for each survey respondent, experiencing decrease in agricultural production is modeled as:

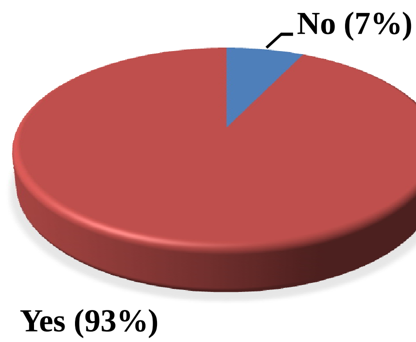
$$\begin{aligned} \text{Decrease in production}_i = {} & \beta_0 + \beta_1 \text{Drought}_i + \beta_2 \text{Decreasing precipitation}_i + \beta_3 \text{Erratic rainfall}_i \\ & + \beta_4 \text{Increasing temperature}_i + \beta_5 \text{Gender}_i + \beta_6 \text{Age}_i + \beta_7 \text{Education}_i \\ & + \beta_8 \text{Household size}_i + \beta_9 \text{Electricity}_i + \beta_{10} \text{I-Sanitation}_i + \beta_{11} \text{Health}_i \\ & + \beta_{11} \text{Credit}_i \end{aligned} \qquad (9)$$

3. RESULTS AND DISCUSSION

3.1 PERCEPTION OF CLIMATE CHANGE IN THE CENTRAL REGION OF MALI

Based on our household survey data collected in Mopti, this section presents summaries of how local communities perceived climate change in the study area. Practically, respondents were asked questions about their perceptions of long-term changes intervened in climate, as well as measures and options they have typically adopted in order to cope with those changes over the years. Those questions range from a general perception (that we called first-level perception) of changes in weather patterns to specific changes such as drought, erratic rainfall and so.

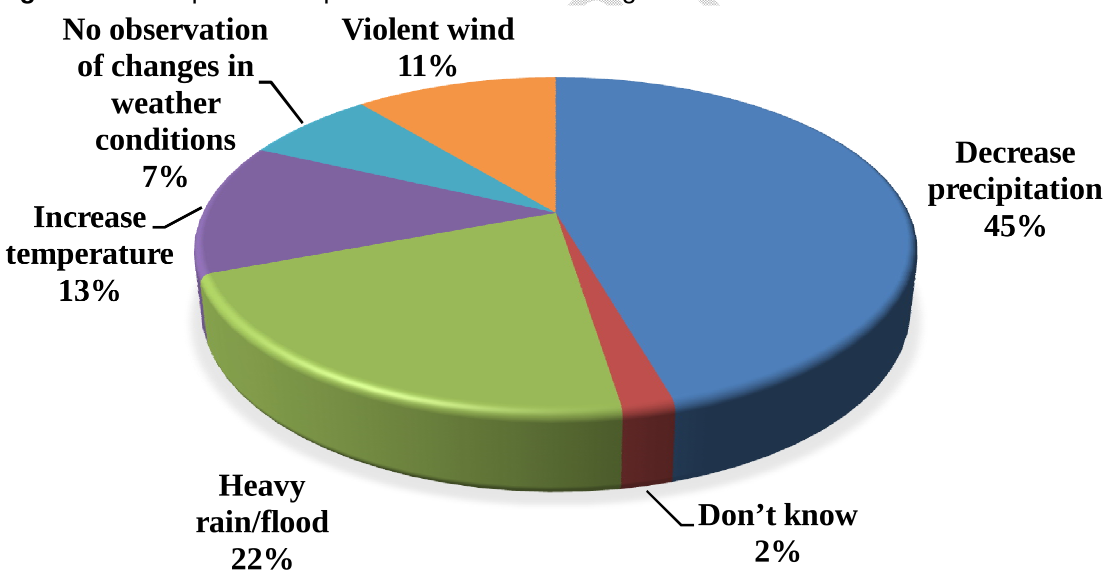
Figure 2: Respondent's perception of changes in Climate conditions over the past 10-20 years



***Source**:Author's construction using the survey data*

Regardless the nature of the change, results (See Figure 2) show that the majority of respondents have perceived that climate has been changing over the last 10-20 years in Central Mali (92.89 percent). Those who noticed changes in weather patterns are then invited to describe the changes they observed. Enumerators have been provided with a not exhaustive list (established during the pilot survey)includingkey potential changesin weather patterns. This list was not presented to respondentsto avoid the risk of framing bias. the respondents verbally described the changes they observed and the interviewers checked the corresponding changes from the list.

Figure 3: Description of respondents' observed changes in weather

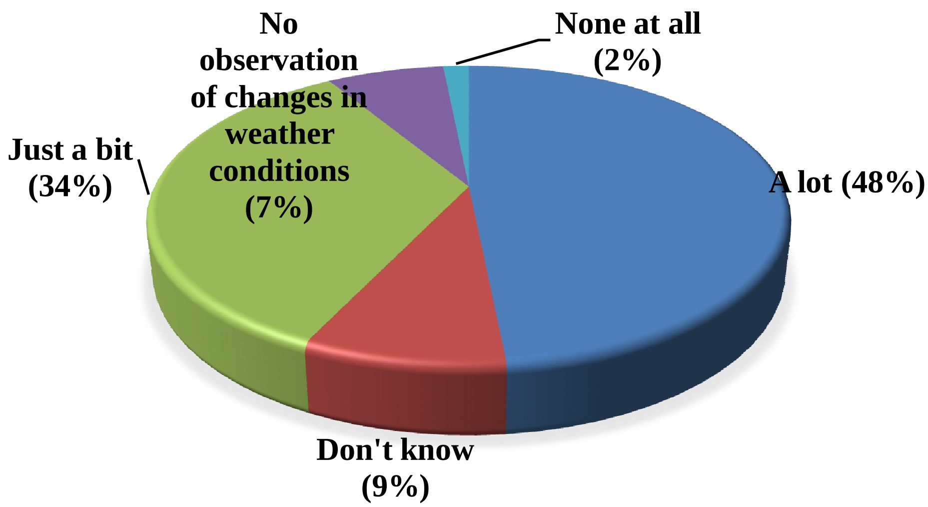


***Source**: Author's construction using the survey data*

Statistics revealed that a significant proportion (45.33 percent of respondents) reported a decrease in precipitation/rainfall (in terms of amount and frequency) while 21.56 percent recorded frequent heavy storms which most of time turn out to flood. Together irregularities in precipitation patterns (whether it is scarcity or abundance/flooding) were observed by almost 67 percent of the respondents.Regarding temperature, 12.67 percent of the participants observed an increasing trend (in terms of hot days) over the past 10-20 years. Recurrent violent wind has also been identified among changes occurring in climate (10.89 percent). Similar findings arereported in studies including [29] in the Hindu-Kush Himalayan region; [30] in Madhya Pradesh; [31] in in northwestern Kenya; [16] in South Ethiopia; [1] in southern Mali; [12] in Nigeria.

In addition, questions were also administrated to respondents to check whether the changes observed in the weather conditions affected livelihoods. Results summarized in Figure 3 show that 48.44 percent of respondents agree that weather changes affect livelihoods “a lot” (in a great extent) in the study area. 34.22 percent consider that climate change does affect livelihoods but in a lesser extent (just a bit) while 1.56 percent consider that climate change do not affect livelihoods at all.

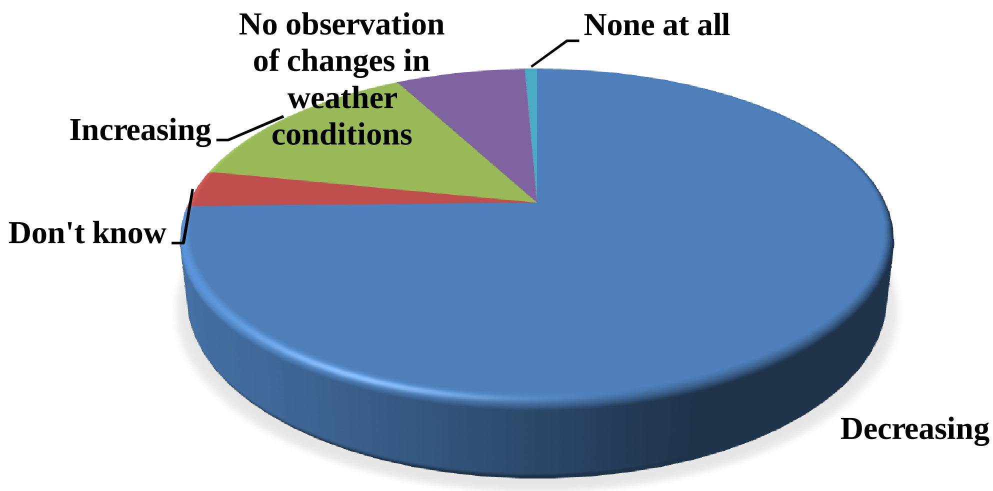
Figure 4: Perception of climate change impact level



***Source**: Author’s construction using the survey data*

To determine the nature of the observed impact (whether it is negative or positive) respondents were further asked to sharethe sense in which climate change impacts livelihoods. The exact wording is: “Based on your opinion, is this impact on livelihoods positive or negative? Hence, 74.67 percent of respondents consider that the impact of climate change on livelihoods is negative, accordingly climate change decreases crop and livestock yield while 14 percent of the participants perceive the impact as positive (see Figure 5).

Figure 5: The nature of climate change's effect on livelihoods in Central Mali



***Source**: Author’s construction using the survey data*

Moreover, a binary logit analysis wasperformed to check in which extent the perception of climate change would affect the likelihood of indicating (experiencing) a decrease in livelihoods.The correlation is found to be statistically significant. As displayed in “Table 1”,the perception of erratic rainfall increases the likelihood of experiencing bad agricultural production by 22,20%, perception of decreasing rainfall amount increases it by 19.19% while perception of drought increases it by 12.60%. Suitable weather conditions are absolutely necessary to agricultural production specially in Central Mali where irrigation is less practiced due to the high cost it implies. The adverse meteorological conditions are very detrimental to crops and animal production. Erratic rainfall completely disrupts the agricultural calendar and is likely to mislead farmers regarding favorable periods for planting, for applying pesticides, for applying fertilizer and so on. The decrease in rainfall amount as well as drought considerably affect plants’ growth and development hence preventing them of giving their full potential. These findings give evidence that climate change seriously undermined livelihoods in Central Mali. Similar findings are found in the studies of [22] and [23] in Burkina Faso. They are also in line with results from [24] in Niger and [25] in the administrative cercle of Koutiala in Mali.

No statistically significant relationship was found between perception of increasing temperature and experiencing bad agricultural production. This may likely be related to rural community poor knowledge regarding the role of temperature in growing crops. Indeed, temperature intervene mostly in the photosynthesis process and plant pollination which are not straightforward and require a minimum formal training.

Table 1: Odds Ratio resulting from the logistic regression

Variables	Odds ratio	dy/dx	Std. Err.
Drought	1.976***	0.127***	0.263
Decreasing precipitation	2.805***	0.199***	0.246
Erratic rainfall	6.277***	0.222***	0.664
Increasing temperature	1.110	0.198	0.298
Gender	1.186	0.033	0.404
Age			
[20-30] Ref			
[31-51]	1.064	0.012	0.443

[51- over[	0.755	-0.053	0.456
Education			
No formal education [Ref]			
Primary	0.841	-0.033	0.552
Secondary	0.797	-0.044	0.432
University	0.100**	-0.518**	0.985
Married	2.182*	0.166*	0.470
Household size	0.948	-0.009	0.0548
Access to electricity	0.228***	-0.334***	0.412
Access to health facilities	0.618*	-0.087*	0.252
Access to credit	1.695*	0.092*	0.278
Log pseudolikelihood			-225.498
Pseudo R^2 de Mcfadden (en %)			16.08
Prob > chi2			0.000
Number of observations			450

***Source**: Author's construction using the survey data*

*Note: ***, **,* and Ref denote respectively the threshold of 1%, 5%, 10% and reference modality.*

3.2 SOCIO-ECONOMICS AND DEMOGRAPHICS CHARACTERISTICS INFLUENCING CLIMATE CHANGE PERCEPTION IN CENTRAL MALI

The explanatory variables included in the MNL model are: age and gender of the household head, education level, household size, wealth in terms of non-productive asset, whether the respondents is a farmer, whether the respondents have multiple livelihoods sources, whether the respondents has gone without food over the past two years, access to extension services and access to credit [30]. Results are presented in the Table 2.

Table 2: Results of Multinomial Logistic Regression, displaying the coefficients

Independents variables	Outcome2 Coefficient	Outcome3 Coefficient	Outcome4 Coefficient	Outcome5 Coefficient
Age	-0.011	0.005	-0.006	-0.025*
	(0.352)	(0.630)	(0.641)	(0.090)
Education	-0.287	-0.207	-0.311	-0.126
	(0.347)	(0.558)	(0.330)	(0.720)
Gender (Male)	0.191	0.288	0.541	0.515
	(0.707)	(0.630)	(0.320)	(0.439)
Household size	-0.059	-0.221**	-0.051	-0.000
	(0.423)	(0.025)	(0.535)	(0.998)
Farmers	-0.265	-0.974	0.460	0.316
	(0.618)	(0.107)	(0.396)	(0.665)
Multiple sources of livelihood	1.153***	0.884*	0.891**	0.347
	(0.006)	(0.068)	(0.049)	(0.503)
Gone without food/ the past 2 yrs	1.014**	1.140**	0.948**	0.854*
	(0.014)	(0.016)	(0.034)	(0.082)
Flooded zone	-0.609	-0.846*	1.498***	1.145
	(0.169)	(0.096)	(0.002)	(0.790)
Access to credit	-1.026**	-1.318***	-1.556***	-1.137**
	(0.011)	(0.008)	(0.001)	(0.031)

Access to extension services	1.480***	1.226***	0.818*	1.190**
	(0.000)	(0.007)	(0.051)	(0.010)
Wealth index	0.178	0.309	-0.014	-0.310
	(0.432)	(0.228)	(0.956)	(0.377)
Intercept	1.607*	0.949	-1.094	0.026
	(0.096)	(0.411)	(0.299)	(0.983)
Log pseudo likelihood	= -565.53058			
Number of observations	= 450			
Prob > chi2	= 0.0000			
Pseudo R2	= 0.1131			

***<u>Source</u>**: Author's construction using the survey data*

Note: *** Significance at 1% level; ** significance at 5% level; * significance at 10% level.

Between parentheses are assigned (two-tailed tests)

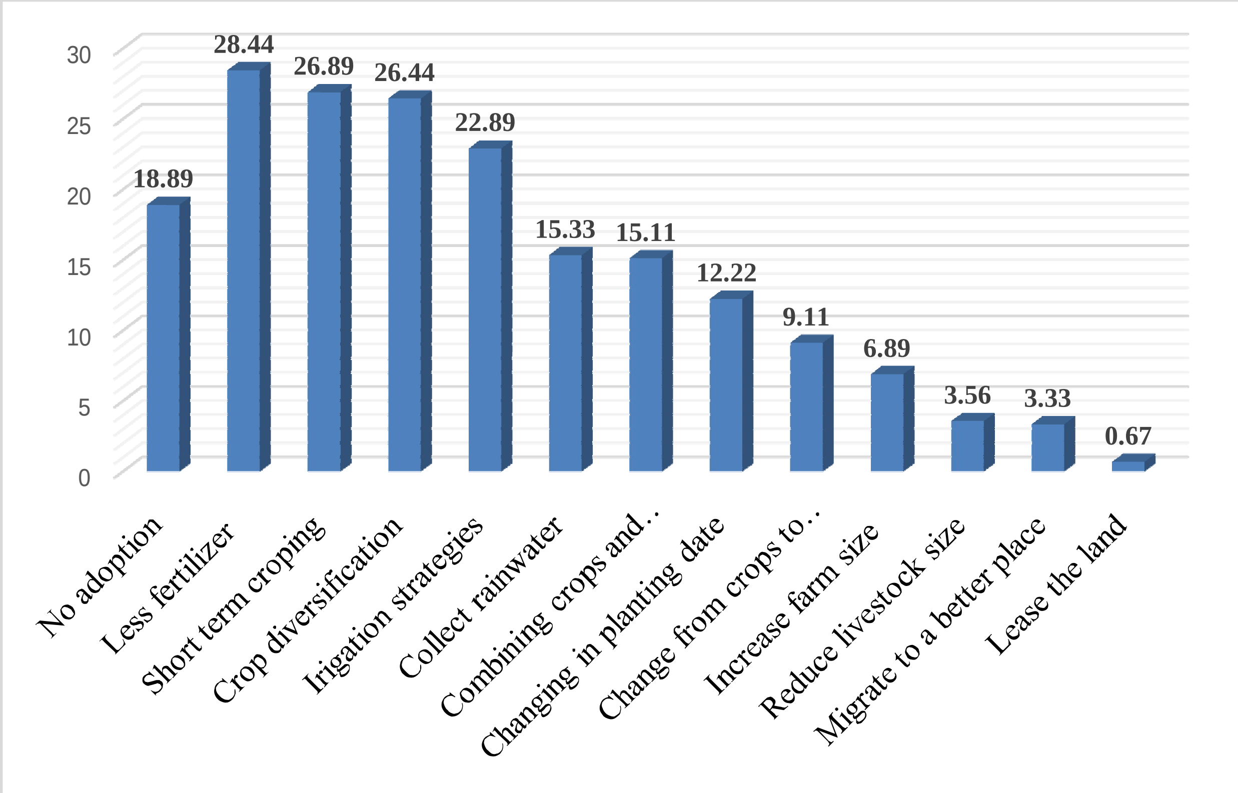
From the socio-economic characteristics examined, the results suggest that those who have access to credit and other financial facilities in general are less attentive of changes happening in climate compared to those not having access to these facilities.Implicitly, this result shows thathavingaccess to credit allows to invest in more resilient cropping systems and other activities less sensible to climate changewhich may consequently decreases the vulnerability and awareness regarding climatic shocks.The MNL analysis also revealed that access to extension services in the study area significantly increases the likelihood that households perceive changes inclimate. This is likelydue tothe fact that extension services provide the local communities withweather information and create a greater awareness of climate change and related chocks. These results are consistent with previous finding made in other countries [16,31].

The findings further suggest that, the more the individual is food insecure the more aware he is regarding climate change. This finding is likely associated to the negative impact climate change have on livelihoods activities such agriculture. Indeed, as shown in the descriptive statistics, most of the households in the study area derive their livelihoods from agriculture and animal breeding. Since yield and productivity in this sectorcontinuously deteriorate under climate change, thisis likely to draw the affected people's attentions toward the most important production factor they do not have control onaccordingly the climatic conditions.Additionally, we found that being involved in multiple livelihood activities is positively correlated to the likelihood of perceiving climate change. This is probably evidence of people multiplying their activities in order to compensate the losses induced by the negative shocks of climate change. Indeed, as the traditional livelihoods activities (agriculture, livestock production and fishing) are less capable of sustaining living under environmental change, people may naturally try to associate other activities in order to fill in the gap.Our different results arein line with findings made in Kenya [31],in South Ethiopia[16], in India, [30], in southern Mali [1], in South Ethiopia [16]as well as in North-West Ethiopia[14].

3.3 ADAPTATION PRACTICES IN CENTRAL MALI

To identify adaptation strategies the local communities in Central Mali practiced,respondents (those who observed changes in weather) wereinvited to share the adaptation strategies they implemented to cope with climate change. The results (see Figure 6) revealed that many households in the Central region of Mali are struggling somehow to limit the adverse effects of climate change on their livelihoods (almost 82 percent of the participants). Specifically, 28.44 percent of the respondents are adding less fertilizer as a means of coping with climatic adverse effects. 26.89 percent used short term crops and varieties. Crop diversification is implemented by up to 26.44 percent of the respondents. 15.33 percent are using water conservation technics. Among these conventional coping technics are found less conventional means practiced by local communities.These includes:"increasing the farm size" practiced by around 7 percent of the survey respondents; "migrating to better and resilient places" practiced by 3.33 percent of the respondents and developing "irrigation strategies" which is practiced by up to 22.89 percent of the respondents. Similar findings arereportedin southern Mali [1].

Figure 6: Adaptation strategies used in the Mopti region (% of respondents)

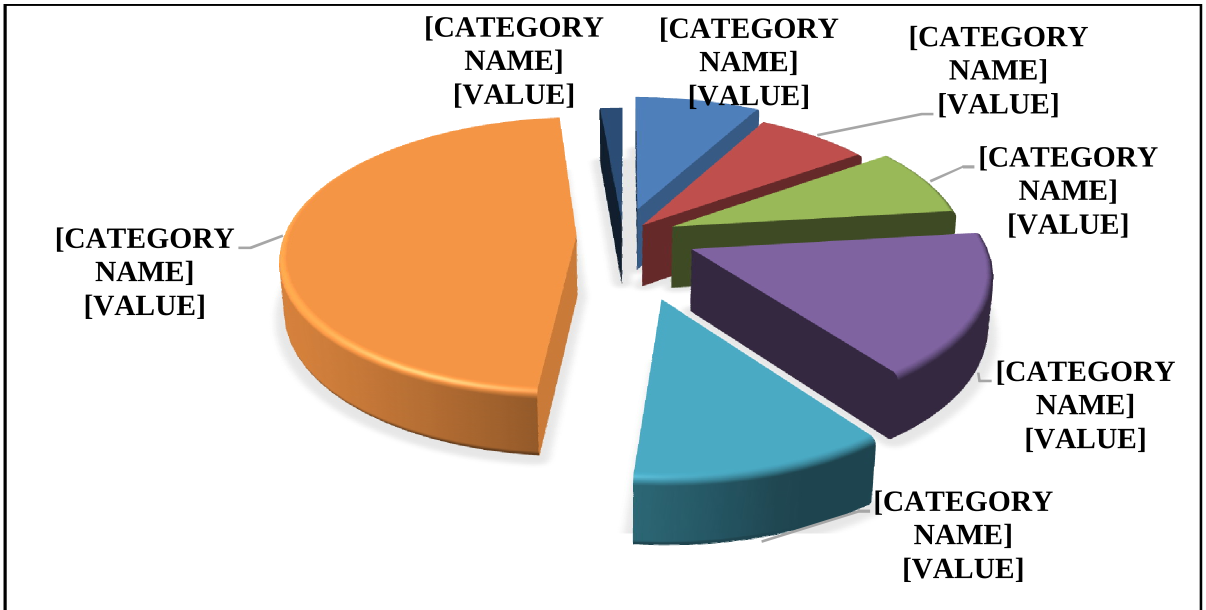


***Source**: Author's construction using the survey data*

PERCEIVED BARRIERS TO ADAPTATION IN CENTRALMOPTI

Although, climate change it self negatively affect local communities' livelihoods in Central Mali, its effect is further exacerbated by several constraints to the adequate implementation ofadaptation strategies. According to our findings, lack of funds and credit facilities, lack of access to timely weather information, lack of technologies (physical infrastructure, technical material and equipment), lack of knowledge on adaptation technics (required human skills, e.g., applying specific planning and management approaches and methods), lack of appropriate seeds have been identified as the major critical barriers to adaptation in Central Mali. The most important constraint indicated was the lack of funds and credit facilities (mentioned by almost 50 percent of the survey respondents). This probably limits the ability of the affected people to provide the adequate technologies necessary to adjust and limit the adverse climatic condition faced. It may also explain the lack of appropriate seed regarding the high cost of farm inputs in the region. The lack of knowledge about adaptation technics and methods as well as the lack of information related to weather conditions are likely due to the poor access to extension services in the study area. These are consistent with recent findings by [32,33]. They are also in line with [11]findings in Botswana.

Figure 7: barriers to adaptation in the Central region of Mali (% of respondents)



***Source**: Author's construction using the survey data*

4. CONCLUSION

The analysis provided in this analysis aimed at investing the changes in climate as perceived by the local communities in Central Mali. It also evaluated the socio-economic and demographic factors shaping that perception as well as the effect of climate change on agricultural production in this region. The descriptive analysis, shows that households in Mopti are well aware of changes occurring in climate, its different manifestations and the adverse effects on their livelihoods. We also found that, this negative effects on livelihoods is further worsened by considerable challenges local communities faced in adapting to changes in climate. Specifically,lack of funds and credit facilities, lack of access to timely weather information, lack of technologies (physical infrastructure, technical material and equipment), lack of knowledge regarding adaptation technics (required human skills, e.g., applying specific planning and management approaches and methods), lack of appropriate seeds have been identified as the major critical barriers to adoption in the Central Mali. These constraints generally explain why individuals often resort to options which are more affordable in terms of cost but which also on the other hand affect the sensitivities of other actors in the rural area and fuel tensions. The analysis further shows that climate change perception in the area is most shaped by socio-economic factors such as access to credit, access to extension services and experiencing food insecurity over the past two years.

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