Perception of environmental change and perception of change in daily life in environmental migration. A case study in Senegal.

Luyts Jelena, De Longueville Florence, Piguet Etienne, Bruening Loïc, Henry Sabine

Abstract –

This research develops a new conceptual framework to increase the understanding of environmental migration, based on the perceptions of environmental change and change in daily life. A case study in rural Senegal enables a first evaluation to appraise the interest of the new framework, mainly the inclusion of the perception of change in daily life. This new perspective would facilitate data collection and increase the reliability of survey data. All surveyed households perceive climate change. The interest if this study resides in the link between different perceptions of change and adaptation. Do rainfall, temperature, wind, or economy have a more important impact? The relevance of the perception of change in daily life is compared with the perception of environmental change through different regression models, to evaluate the link with different adaptation strategies. The results suggest that the perception of change in daily life indeed bring new and different information towards the understanding of the migratory intention. However, taken separately, both types of perception result in similar explanatory power, while their combination significantly increase the explanatory power of models. Therefore, it seems crucial to combine both types of perceptions, as both bring different information.

Key words –

Adaptation to environmental change, perceptions, daily life, migration

I. Introduction

Many places are subject to climate change such as sea level rise, desertification, coastal erosion, temperature rise, and so on. Populations facing these changes adapt in different ways, according to the region they live in, their economic activity, available resources, and socio-cultural factors (Nielsen & Reenberg, 2010). Nevertheless, among the most vulnerable populations are those relying on rain-fed agriculture or on pastoralism, their income highly depending on weather conditions (Juana *et al.*, 2013). In this regard, the Western African region should continue to receive extended attention since the region is and will be highly affected by climate change (Van der Land *et al.*, 2018). In addition, the agricultural sector occupies an important share in the economy of most countries in the region, while most of the rural population depends on the natural environment (Mertz *et al.*, 2011).

The past and future environmental changes in Western Africa and Senegal in particular, bring the need for adaptation to local populations. In this regard, migration, as an adaptation choice, has received increasing attention over the last decades (Ferris, 2020). The complexity of the phenomenon raises the need to look at it in more depth. Indeed, this form of adaptation involves not only the individual or household, but also the receiving community (Adger *et al.*, 2020). A better understanding of who migrates and why will help establish durable policies. However, looking at migration as one way of adapting among others raises a number of questions. Do people migrate after having tried other forms of adaptation? Do the same factors influence the choice to migrate as for other forms of adaptation?

In order for adaptation to take place, Abid *et al.* (2019) identified two preliminary steps. First, change in the environment has to be perceived, before leading to the second step of adaptation intention and finally leading to actual adaptation. The link between perception and adaptation has not only been established in the context of Pakistan (Abid *et al.*, 2019), but also in Kenya (Chepkoech *et al.*,2018), in Ghana (Yaro, 2013), or in Ethiopia (Deressa *et al.*, 2011) among others. In these studies, perception concerns the change in environmental conditions only, focusing on rainfall and/or temperature. Nevertheless, Yaro (2013) in their study highlight that the latter is more accurate when related to farm productivity and other livelihoods. Therefore, trying to increase the understanding of who adapts to environmental change and how, this article aims to introduce the perception of change in daily life, as complementary to the perception of environmental change. Daily life is defined here as events and aspects that, on a regular basis, impact everyday life. Therefore, certain characteristics such as the economic activity influence what is considered daily life. For instance, in the present study, the major economic activity being agriculture, elements such as land accessibility or soil fertility are considered to be part of daily life. This new perspective is expected to help in two ways. First, by shifting away from the social desirability related to environmental change. Indeed, social desirability is likely to influence respondents' answers (Félonneau & Becker, 2008). The information received at different levels has created a social norm that directs responses in a certain, socially accepted direction (ibid.). Second, it is expected that perception of change in daily life is more tangible to the population resulting in more reliable answers, increasing the explanatory power of regression models. For instance, several authors (Koubi *et al.*, 2016; Morrissey, 2012; Warner, 2011) have shown that if not asked directly about the environment, this latter is not mentioned as a factor driving adaptation. It seems clear then that for the individuals, if the environment influences, it does so through other aspects of their lives why the need to consider daily life.

Focus is lead in the present study on adaptation intentions and their link with perceived changes in the environment or daily life. Intentions overestimate the number of adaptations as not all intentions lead to actual adaptation (Grothmann & Patt, 2005). Nevertheless, studies have shown that intentions are a good indicator of future behavior (Wheeler *et al.*, 2013; Fielding *et al.*, 2008; Van Dalen & Henkens, 2008). In addition, a major advantage identified to consider intentions is that the population is still

living in the place confronted to environmental change. Therefore, the perceptions are more accurate since they are asked at the present time, and not retrospectively after adaptation has taken place. For these two reasons, intentions have been studied rather than actual adaptation behavior.

The African Monsoon Multidisciplinary Analaysis (AMMA) existing database was used to study the impact of perceptions on adaptation intentions. The data was collected in 2008 and covers a wide range of aspects related to family adaptation intentions and perceptions. Perception of environmental change was asked on major trends and changes over the last 20 years, covering perceptions of change in rainfall, temperature, and wind. Perception of change in daily life was not defined within the survey, but questions were asked on the evolution of income, expenses or the household size. In addition, many aspects influencing the agricultural activity were covered, asking the evolution of accessibility and availability. The sample is composed of 169 households, spread over the two regions of Louga and Kaolack and in 17 villages. The latter are located in the groundnut basin of Senegal.

The aims of this study are multiple. First, this study explores the added value of including perception of change in daily life when studying adaptation intentions to environmental change. To do so, variables of perception of change in daily life are included in logistic regression models, afterwards compared to models excluding these variables but rather focusing on perception of environmental change. Second, within the intentions, short-term and long-term adaptation measures are considered. Short-term adaptation occurring after one period of predicted drought, and long-term adaptation occurring after a projection of permanent aridification. Finally, this study explores if similar factors help explain the intention of different types of adaptation. Focus is lead on migration and the selling of animals.

The first part of the study details the conceptual framework of the research. The second part entails the description of the study area, the data and methodology adopted. The different results constitute the third part. The paper ends with a brief discussion and conclusion.

II. Conceptual framework

a. Adaptation to environmental change: an overview of current frameworks

There is currently an already well-established body of literature on adaptation to environmental change. Specific topics nevertheless received more attention. One of them, if not the most important, is the environment-migration nexus. Why some people move while others stay when facing the same hazards puzzled many authors (De Groot *et al.*, 2011; Adams, 2016; Klepp, 2017) and pushed many others to explore the impact of a wide range of factors (Henry *et al.*, 2003; McLeman & Smit, 2006; Van der Land, 2015). This led to the development of increasingly complex frameworks, including not only environmental drivers but also social and psychological factors. Black *et al.* (2011) constructed one of the most used conceptual frameworks, being the first to include five drivers of migration involving in addition to environmental drivers, economic drivers, political drivers, demographic drivers, and social drivers. Furthermore, the socio-demographic characteristics as well as the meso-level obstacles and facilitators were also included resulting in the most comprehensive framework so far.

Nevertheless, Perch-Nielsen *et al.* (2008) brought attention to an important point that was not included in the framework by Black *et al.* (2011): the multiplicity of adaptation options people have when facing environmental change or hazards. One crucial element highlighted by the authors, is the non-permanent aspect of certain climate related events such as floods. As such, floods are a rapid-onset event, but there is no permanent loss of land as can be seen with sea-level rise. Therefore, other options rather than migration are possible to locally adapt. Many types of environmental change in this regard enable multiple responses by the population. For example, farmers can adapt to a decrease in rainfall by changing crops to more resistant ones, install an irrigation system, or increase soil fertility.

In order to know if certain phenomena will generate migration, at the center of attention today (Smith, 2007; Lustgarten, 2020), there is the need to better understand which elements influence the choice of adaptation measure, underlying the need to look at migration among other adaptation options.

By focusing on measured environmental change, conceptual models have omitted the perception of individuals. Rather than including perception in conceptual frameworks, authors have focused on the comparison between perceived environmental change and actual environmental change (De Longueville *et al.*, 2020). Yet, many authors indicate that perceiving change is necessary before any adaptation is considered (Grothmann & Patt, 2005; Deressa *et al.*, 2011; Simelton *et al.*, 2013; Huong *et al.*, 2017; Azadi *et al.*, 2019). Recently, Abid *et al.* (2019) developed a framework including perception of environmental change. They consider a three-step process. First, the perception of environmental change is either accurate, underestimated, or non-existent. This influence the second step, the intention to adapt or not. Finally, the last step is the adaptation step, the latter occurring or not. Furthermore, the authors include external and internal factors to their model, which can influence each of the three steps. While this framework seems simpler than the one developed by Black *et al.* (2011), they nevertheless give more importance to the decision-making process which is not instantaneous. Some combination of these two frameworks has therefore the potential of increasing even more the understanding of how people adapt when facing environmental change.

The present research developed a new conceptual framework, building on the two major ones presented above, followed by a first empirical study to evaluate its interest. As the inclusion of perception in frameworks is very recent, this aspect is central in its evaluation. The influence of the national context, the networks, and individual socio-economic characteristics on adaptation measures when facing environmental change already being proven.

b. A new conceptual framework to study the impact of perceptions

At the core of the framework presented here (Figure 1) is the explanation of adaptation choices when facing environmental change. While Black *et al.* (2011) focused on migration as an adaptation, the broadening to different forms of adaptation enables to better understand why and how some individuals remain in place while facing environmental change. Furthermore, the juxtaposition of intentions and actual adaptation illustrates the different steps leading to a decision-making. In this regard, perceptions come first, as they indicate change occurred and some form of adaptation might be needed. Perceptions therefore influence intentions.

Nevertheless, in this framework, perceptions can be different according to the level of analysis. Indeed, an individual, a household, or a community can have different perceptions of the same environmental change. Knowing the level at which decision making is carried out is therefore crucial. In the present study, the household level has been scrutinized, since in the Western African context this level has been proven to be relevant (Belay *et al.*, 2017; Castells-Quintana *et al.*, 2018). However, the individual and community levels are still included as they might be of interest in other contexts or regions. Within the household level, certain characteristics in turn shape the intentions and adaptation choices. Previous research demonstrated the influence of socio-economic characteristics such as age, education, income, religion, or sex (Cordell *et al.*, 1996; Codjoe *et al.*, 2012; Schuman *et al.*, 2018). Since the framework is adapted to study farmers' adaptation to environmental change, land characteristics are included as well such as land ownership, number of plots, crop types, and so on. Different characteristics resulting in differed impacts of environmental change, and therefore influencing the adaptation choices.

If the perception of environmental change is more and more included when studying adaptation to environmental change, a novelty in the present framework is the inclusion of perception of change in

daily life. As mentioned previously, this inclusion serves two main purposes. First, it is expected that this type of perception is less prone to social desirability and answers are therefore less influenced by external (mass) information. Second, perception of change in daily life is likely to be more tangible to the population resulting in more reliable answers, and increasing the explanatory power of regression models. Moreover, a double-sided arrow links both types of perceptions, suggesting a mutual influence. In the context of environmental change in Western Africa, the changes occurring are likely influencing aspects of daily life such as the quality of harvest, the fertility of the land, or even the seed accessibility. Reversely, when daily life is impacted, individuals are more likely to denote how the environment is changing as they directly suffer from the change. Both perceptions therefore potentially influence each other, or even take on their full meaning when considered together.

Less detailed than in the Black *et al.* model, the national context, as well as the meso-level obstacles and facilitators influence the adaptation choice. These might in addition help explain which adaptation measures are put into place and when, i.e. influencing the chronology of adaptation. Mendelsohn (2000) suggests that each adaptation measure has a cost. Cost is often seen as monetary, but can nevertheless also be time or accessibility. The cost of a measure depends on many factors, at different levels. Taking migration as an example, national policies can increase the cost by making less visas available (Ianos, 1998). In addition, existing diasporic links reduce the cost of moving (Beine *et al.*, 2011). Finally, at the micro level, the departure of a member of the household results in the loss of labor force which could be necessary to the local economic activity. Hence, it is important to consider all levels to understand the decision-making process of adapting to environmental change.

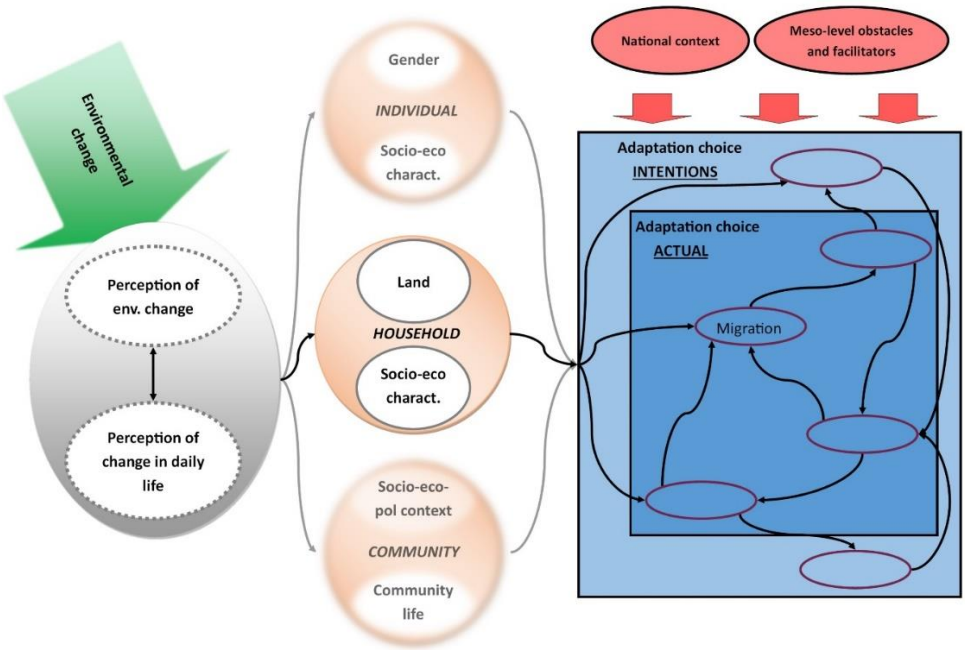

Figure 1: Conceptual framework including perception in explaining adaptation to environmental change

III. Case study area

In 2008, period where the data for this study was collected, the population of Senegal was nearly of 12 million inhabitants. The distribution of the population is very heterogeneous. Kaolack and Louga are the two most densely populated regions, after Dakar, with 10% and 7% of the population respectively. It should also be mentioned that agriculture occupies 30% of the population, and mainly rain-fed and subsistence agriculture are found in rural Senegal. Therefore, there is not much production at national level. (ANSD, 2009)

a. Rural Senegal

Senegal's urbanization rate is high compared to other countries in the region, 42% of the population already lives in urban centers. Disparities between rural and urban centers entail the household size which is on average larger in rural areas, polygamy being one major explanation (ANSD, 2006). The groundnut basin counts on average 13.1 members per household, while the national average in rural areas is 10, and the global national average counts 8 members per household (Hathie *et al.*, 2015). The economic occupation is also different. In rural Senegal, agriculture and pastoralism are the two main activities (ANSD, 2009). Oftentimes, pastoralism complements rain-fed agriculture in rural areas since this form of agriculture is very dependent on the environmental conditions and less reliable. At national level, 68% of Senegalese households own cattle but this percentage reaches 90% when considering rural areas (ANSD, 2009).

b. Environmental conditions in Senegal

Senegal is a sub-Saharan country with a very clear South-North decreasing gradient of average annual rainfall. This mainly explains the delimitation of the four agro-climatic zones defined by Salack *et al.* (2011), presented in Figure 2. The two central zones, receiving between 400-600mm and 600-800mm respectively entail the groundnut basin. Certain crop types can be cultivated with a rain-fed agricultural regime such as groundnut, millet and sorghum.

The majority of rainfall falls during the rainy season which extends from June to October (Faye *et al.*, 2018). If the annual rainfall gradient is very stable over the period 1979-2008 (Salack *et al.*, 2011), the timing of the rainfall can be more changeable severely impacting the agriculture. Recurring dry spells during the rainy season can result in major complications in the crop growth or development (Salack *et al.*, 2018), even if fertilizing or reducing density of crop planting (Faye *et al.*, 2018). In addition to climate variability, environmental degradation and human intervention resulted in the loss of 22% of plant biodiversity (due to erosion, salinization of soil, invasive plants, and so on) and the degradation of a majority of farm-land (ANSD, 2009). These events can result in the destruction of farm land and habitat leading to population displacement, but can also lead to the loss of human lives, or degrade infrastructures (ANSD, 2009).

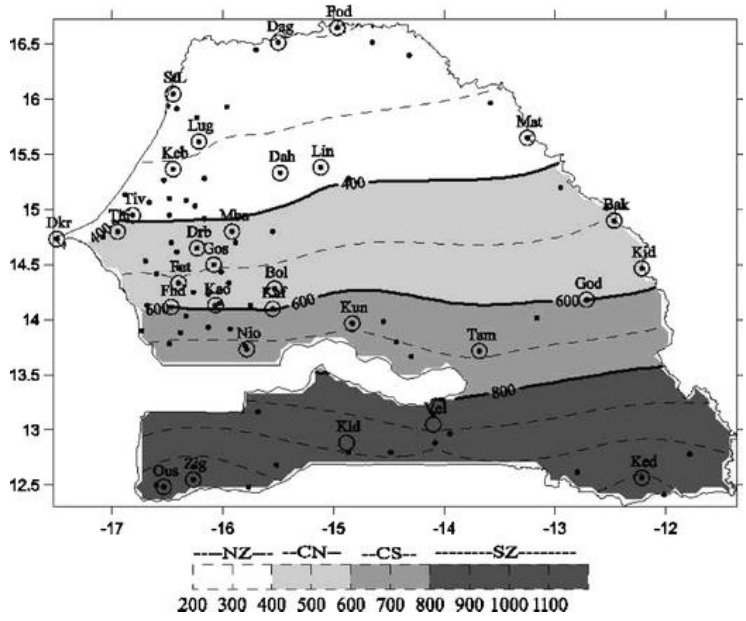

Figure 2: Four agro-climatic zones of Senegal defined by Salack et al. (2011)

c. Adaptations to environmental change in Senegal

The Senegalese population, especially the rural population living on rain-fed agriculture, must adapt to the environmental changes the country is undergoing. According to interviews of Senegalese farmers carried out by Mbow *et al.* (2008), adaptations include change in crop production techniques, diversification of crops, use of manure, introduction of new crops, tree planting to reduce erosion, off-farm activities, and migration. In the present case, focus is lead on internal migration as this has been identified as the most common form of migration for rural populations in the region (Henry *et al.*, 2003). In the two regions of this case study, in 2008 there was more out-migration than in-migration. For instance, Kaolack had a deficit of 21'000 people making it the region with the most out-migration, while Louga had a deficit of 8'000 people and was the third region with the most out-migration (ANSD, 2009). The ANSD mentions the difference of level of development as the main reason for departures.

The most common adaptation is not migration, but rather on-farm adaptations related to livestock, crop types and cultivation method, soil and water management (Wiederkehr *et al.*, 2018). These can be a first step in the adaptation process, and be complemented further in time. This idea of incremental adaptation is not new and supported by several scholars (Juana *et al.*, 2013; Voss, 2021). Voss (2021) showed in his research how on-farm adaptation is an explicit response to environmental change and put into place rapidly. If agricultural outputs remain insufficient migration is likely to be adopted to find a job elsewhere and diversify income. Nevertheless, if on-farm adaptation is clearly linked to environmental change by interviewees, it is not the case for migration as highlighted by Voss (2021). The complexity of factors influencing the decision to migrate could justify why migration has been studied distinctively of other forms of adaptation, there is nevertheless a suggested temporal link between types of adaptations where migration comes after for instance on-farm adaptations.

IV. Data

This study was made possible by the African Monsoon Multidisciplinary Analysis (AMMA) database, within which 169 households were surveyed in 2008. The focus of the database is on agricultural and climate vulnerability in West Africa focusing mainly on adaptation and coping strategies during the past 20 years (Mertz et al., 2011). The questions asked cover a large array of aspects from the perception of environmental change to the adaptation choice passing by the intention of adaptation in different contexts.

Three groups of variables were used in this study in order to evaluate whether the perception of change in daily life is an interesting new perspective in studying environmental migration: contextual variables including socio-demographic and localization variables, variables of perception of environmental change over 20 years, and variables of perception of change in daily life. The list of variables can be found in Appendix 1. One aspect not covered by the database concerns other forms of adaptation that have been put in place. Nevertheless, intentions of adaptation have been more broadly covered. Indeed, two scenarios of future change have been presented to the respondent, who had to mention which adaptations they would put into place. The first scenario is a drought during one agricultural season. The second scenario is a permanent aridification of the area.

According to the amount of rainfall, the crop choices are different and entail different responses to environmental change. In this regard, a variable was created based on the localization of the village regarding the rainfall gradient. Three categories were delineated as described by Henry *et al.* (2003). One category of villages receiving less than 500mm, the second group of villages receiving between 500 and 700mm of rainfall, and the last group receiving over 700mm.

One major step in the data preparation was the management of missing values. Disparities in the database made it impossible to remove households with missing data. To overcome this problem, two steps were undertaken. First, variables of perception were completed using the random hot-deck imputation. The variables of perception of environmental change were imputed based on the average rainfall of the village they resided in. Therefore, missing values were replaced by the value from a randomly selected village but which pertained to the same group of rainfall average. The same was operated for the variables of perception of change in daily life, but specific variables were used to parameter the choice of the replacement value based on Fisher's exact tests. Tests were run on complete cases and correlations were used as a basis for choosing the variables on which imputations were based.
The second step consisted on grouping together categories of answers. For using logistic regressions, at least 10-15 observations are needed per type of answer (Peduzzi *et al.*, 1996; Concato *et al.*, 1995). In this regard, groupings were operated, based on logic. For instance, the answers "I don't know" was grouped together with the "stable" answer. One exception for the RAIN_FLOOD variable, as this variable presents 32 answers "I don't know". After this grouping, the "stable" answers were grouped together either with the "increase" or "decrease" answers, the one with the least answers was chosen. Two exceptions are the LAND_ACCESS and PAST_CORR variables as enough answers were obtained for all types of answers. Even after this process, RAIN_DURRS had to be deleted as only 9 answers were recorded for the grouping encompassing "I don't know", "stable" and "increase" answers.

V. Methods

Exploring this large array of variables will enable to give a first idea on the existing links between the two types of perceptions and to start evaluate the added value of perception of change in daily life in studying environmental migration. A multivariate analysis was performed to evaluate and compare the contribution of the variables of perception of change in daily life in explaining environmental migration, as opposed or combined to the variables of perception of environmental change. Logistic regressions were performed. Both types of perceptions are taken distinctively and in parallel for this purpose.

a. Logistic regressions: testing the importance of perception of change in daily life

Several possibilities exist to perform a multivariate analysis: discriminatory analysis, multiple regression analysis, and logistic regression analysis (Howell *et al.*, 2008). The latter has been preferred for several reasons. First, logistic regressions do not assume the normality for the independent variables (Pohar *et al.*, 2004), an important element as the independent variables of our study do not follow a normal distribution. Second, this type of regression enables the inclusion of both categorical and continuous variables (Ranganathan *et al.*, 2017). Finally, when considering a dichotomous independent variable, the logistic regression provides the most suitable regression line to fit the data in almost all cases (Howell *et al.*, 2008).

The objective of the logistic regression is to find the most suitable model to explain the dependent variable according to the independent ones, while remaining the most parsimonious (Pohar *et al.*, 2004). The link between several dependent variables with the independent variables has been tested in the present study. The dichotomous variables created based consist of the dependent variables tested. Those concern the intention to migrate and the intention to sell animals. The independent variables were composed of the social, economic, demographic and localization variables, as well as the variables concerning the two types of perception.

The regressions are implemented in the R software using the "glm" function, with the specification "family = binomial(logit)". The logit analysis computes the probability that $Y = 1$ also noted π, i.e. the

probability that the dependent variable equals 1. After applying the logit transformation $log[\pi/(1-\pi)]$, the model can be expressed as a linear function:

$$\log\left(\frac{\pi}{1-\pi}\right) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k$$

were α represents the baseline hazard function, X_k are the predictors (independent variables), and β_k parameters of the model (DeMaris, 1995).

To identify the best suited model, i.e. the model with the lowest AIC, the "stepAIC" function was used (Cama *et al.*, 2016). This function performs stepwise model selection based on the AIC. Nevertheless, the outcomes were confronted to hand tailored regression models to ensure their validity and relevance. In addition, multicollinearity was tested and variables with a VIF value over 10 were removed (Neter *et al.*, 1989). In order to compare the different models obtained, the R^2 of McFadden was used, a pseudo R^2 index. This index was preferred over others for mainly two reasons. First for its relative independence to the base rate of the binary outcome variable (Smith & McKenna, 2013). Second, its conceptual proximity to the coefficient of determination of multiple linear regression which eases its interpretation (Menard, 2000), based on the loglikelihood of the model and null model:

$$R^2_{McF} = 1 - \frac{LogLikelihood\ (model)}{LogLikelihood\ (null\ model)}.$$

The objective of this multivariate approach is to evaluate the added value of considering the perception of change in daily life. To do so, for each dependent variable, four logistic regressions were performed, always applying the stepwise model selection. The first model only included the social, economic, demographic and localization variables. In the following models, these variables were included as well. The second model included the variables of perception of environmental change, while the third model considered the variables of perception of change in daily life. Finally, the last model included all the independent variables. It is expected that the models including the variables of perception of change in daily life have a greater explanatory power than the models including the variables of perception of environmental change. Furthermore, the models including all the variables are expected to have the highest explanatory power. Overall, the models developed are quite restrictive regarding the variables considered which may explain why the explanatory power remains relatively weak.

This approach will give a first idea on whether it is relevant and of interest to consider perception of change in daily life when studying environmental migration and evaluate the relevance of the theoretical framework presented. The number of households included in the database being limited, further investigation might be needed.

VI. Results

This section presents the results of the multivariate approach, consisting of logistic regressions considering the intentions of adaptation. The data enables to consider several adaptation strategies. Therefore, both the intention to migrate is considered, as well as the intention to sell animals as these were the two most cited by the households in case of permanent aridification and in case of drought during one season. For each dependent variable, model 1 was performed only on the contextual variables, model 2 and 3 respectively add to the contextual variables the variables of perception to environmental change and the variables of change in daily life, and model 4 included all variables. In each case, a stepwise logistic regression was performed, and therefore only the variables remaining after this process are represented in the models resumed here.

a. Intention of migration in two scenarios of environmental change

Table 1 and 2 present the results of the logistic regressions concerning the intention to migrate in two scenarios. Table 1 concerns the scenario of a permanent aridification of the area. In this case, permanent migration was presented as an option. Table 2 concerns the scenario of a drought during one season. Here, temporary migration was proposed rather than permanent migration. A first look at the results suggest that both types of perceptions increase the understanding of the intention to migrate. This is true when taken each separately, but also when taken simultaneously. The R^2 of McFadden is much higher when considering the aridification scenario, suggesting that the variables considered have a greater explanatory power and are highly relevant, while for a seasonal drought, the inclusion of other variables seems crucial to increase the understanding.

Table 1

Logistic regression models, contextual, environmental change perception and change in daily life perception effects on the intention to permanently migrate in case of an aridification

	Explanatory variables	Modalities	**Model 1a**	**Model 2a**	**Model 3a**	**Model 4a**
	INTERCEPT		1.37**	6.99***	1.74	1.52
Contextual	NUMB_RAIN_PLOTS			-0.36**	-0.36**	-0.64**
	PERS_ACTAGRI		-0.18***	-0.22***	-0.24***	-0.40***
	PERS_INACT					-1.18***
	NUMB_HH		0.06*	0.08*	0.07*	0.12*
	GROUP_RAIN	> 700mm (R) 500 – 700mm < 500mm	 -1.61*** -3.29***	 -1.88*** -3.42***	 -2.16*** -2.40***	 Multi
Environment	RAIN_QUANTRS	Increase/Stable (R) Decrease		 1.67		 6.75***
	RAIN_HEUG			-1.25		-2.40
	RAIN_BREAK	Decrease/Stable (R) Increase				 -2.61**
	RAIN_INTEN	Increase/Stable (R) Decrease		 -2.02**		 -4.09***
	RAIN_FLOOD	Increase/Stable (R) Decrease Don't know				 0.51 -2.63
	TEMP_INTENDS					-1.81*
	TEMP_WARM	Decrease/Stable (R) Increase		 -1.99		 -4.66***
	WIND_SAND	Decrease/Stable (R) Increase		 -2.01**		
Daily life	INCOME					1.45
	EXPENSES	Decrease/Stable (R) Increase			 -1.39*	 -3.29***
	LAB_FORCE	Increase/Stable (R) Decrease			 1.76**	 4.03***
	SEED_ACCESS				2.53	
	COMP_ACCESS	Increase/Stable (R) Decrease			 1.64**	 3.67***
	FERT_ACCESS	Increase/Stable (R) Decrease			 -3.18*	
	MARK_ACCESS	Increase/Stable (R) Decrease				 3.32***

PAST_PASTURE	Increase/Stable (R) Decrease				1.47*
R^2 McFadden		0.32	0.44	0.43	0.60
AIC		118.01	111.1	111.37	98.551

(R) – Reference category; Results expressed as coefficients; *** p < 0.01; ** p < 0.05; * p < 0.10; – not significant but included in the model; Multi: deleted due to multicollinearity.

Concerning the contextual variables in table 1, the more individuals active in agriculture or pastoralism the less likely the household intents to migrate. The same way, the higher the number of plots owned, the less likely the household intents to migrate. A higher number of plots increases the potential production and therefore decreases the risk of not having enough food production. On the contrary, the more members in a household, the more likely the household intents to migrate. Finally, all rainfall zones have an influence. The lower the average rainfall, the lower the probability of migration intention. In model 4b, a problem of multicollinearity resulted in the removal of the localization variable.

Models 2a and 3a have similar values for the R^2 of McFadden, with model 2a having a slightly higher value. Including only the variables of perception of change in daily life therefore does not improve the explanatory power of the model compared to including the variables of perception of environmental change. Nevertheless, combining both types of perception increases substantially the R^2 of McFadden, moving from 0.32 in model 1a to 0.60 in model 4a. The combination of both types of perceptions did not change much regarding the variables of perception of change in daily life, compared to model 3a. For instance, the perception of increased expenses reduces the probability of migration intention among the households. While this might seem surprising, Henry *et al.* (2004) showed that migration has an important cost that cannot be sustained by everyone. A detrimental change in the economics can therefore result in an incapacity to migrate. A perceived decrease in labor force availability increases the probability of migration intention. The same is observed for a perceived decrease in accessibility of compost, or a perceived decrease in accessibility to the market. Finally, a perceived decrease in pasture area increases the probability of migration intention.
However, the combination of both types of perceptions impacts the significance of many variables of perception of environmental change, compared to model 2a. For instance, only a perceived decrease in rain intensity and a perceived increase in dust and sand wind intensity, decreases the probability of migration intention, when only considering perception of environmental change. The inclusion of the perception of change in daily life does not change the impact of the perceived intensity of rainfall, but the perceived intensity of dust and sand wind does not impact the intention to migrate anymore. Nevertheless, three other variables of perceived rainfall evolution are significant. A decrease in the amount of rainfall during the rainy season has a strong and important effect on the intention to migrate, which becomes more likely. On the opposite, a perceived increase in the duration of rainfall breaks reduces the likelihood to intent to migrate in case of an aridification. Finally, an increase in duration of hot spells considerably reduces the likelihood of the migration intention. These changes suggest a link between the different variables of both types of perceptions, which could imply that the perceived environmental changes influence the perceived changes in daily life.

The observations made in Table 1 suggest an important influence of the perceived evolution of rainfall, whether it be the amount of rainfall during the rainy season, or the intensity of the rain. In addition, several aspects of perceived change in daily life have their importance such as the expenses, the availability of labor force, or the accessibility to the market. Furthermore, the R^2 of McFadden confirm that the combination of both types of perception result in a model with a high explanatory power.

Thus, perception of change in daily life and perception of environmental change help explain the intention of migration in case of an aridification of the area where the households are living.

Table 2

Logistic regression models, contextual, environmental change perception and change in daily life perception effects on the intention to migrate in case of one seasonal drought

	Explanatory variables	Modalities	**Model 1b**	**Model 2b**	**Model 3b**	**Model 4b**
	INTERCEPT		-0.63***	-3.20**	-6.26***	-9.14**
Contextual	PERS_ACTAGRI				-0.10*	-0.10
	PERS_INACT		-0.51**	-0.46*	-0.85***	-1.31***
	NUMB_HH				0.08**	0.10**
	GROUP_RAIN	> 700mm (R)				
		500 – 700mm			1.08*	0.89
		< 500mm			1.59*	2.01*
Environment	RAIN_QUANTRS	Increase/Stable (R)				
		Decrease		-0.91		-1.53
	RAIN_BREAK	Decrease/Stable (R)				
		Increase		1.11**		1.41*
	RAIN_INTEN	Increase/Stable (R)				
		Decrease		-0.96**		-1.57**
	RAIN_FLOOD					
		Decrease				-1.22
		Don't know				0.83
	TEMP_WARM	Decrease/Stable (R)				
		Increase		1.44*		
	WIND_DS	Decrease/Stable (R)				
		Increase		1.87*		4.24
Daily life	EXPENSES					0.20
	LAND_ACCESS	Stable (R)				
		Decrease			-1.08*	-1.60**
		Increase			-1.18	-0.59
	COMP_ACCESS	Increase/Stable (R)				
		Decrease			1.86***	2.66***
	AGRI_EQUIP	Increase/Stable (R)				
		Decrease				-0.80
	MARK_ACCESS	Increase/Stable (R)				
		Decrease			3.58***	4.54***
	PAST_CORR	Stable (R)				
		Increase				-0.78
		Decrease				-1.84**
	PAST_PASTURE	Increase/Stable (R)				
		Decrease			1.36**	2.64***
	PAST_REST	Increase/Stable (R)				
		Decrease			-0.91	-1.58*
R^2 McFadden			0.03	0.16	0.27	0.43
AIC			181.92	169.49	157.99	149.02

(R) – Reference category; Results expressed as coefficients; *** p < 0.01; ** p < 0.05; * p < 0.10; – not significant but included in the model.

As in table 1, table 2 showing the result for the intention of migrating in case of a seasonal drought, presents a lot of significant independent variables. Nevertheless, it shall be noted that the value of the R^2 of McFadden is considerably lower in the case of a seasonal drought, than it is in the scenario of a permanent aridification. Some interesting indications are worth of mentioning.
The number of persons active in agriculture or pastoralism has little or no influence on the intention to migrate. However, an increase in the number of inactive persons decreases the probability of having the intention to migrate as could be observed previously (see table 1). The increase in the number of persons in the household slightly increases the probability of intending to migrate. While in the case of an aridification, the localization in a dryer zone was linked to less probability of intending to migrate or having a temporary migrant, the opposite is true here. For instance, the dryer the area, the higher the probability the household intents to migrate in case of a seasonal drought. It shall be mentioned that the significance level is low, at 10%, and that this is observed only for models 3b and 4b.
Here again, the perceived evolution of rainfall has the most influence within the variables of perception of environmental change. For instance, when looking at model 4b which has the highest R^2 of McFadden, a perceived decrease in intensity of the rains decreases the probability of intending to migrate. This is in contradiction with what has been observed in previous models. A possible explanation might be that other adaptation measures are preferred in case of a short-term change. Akinnagbe & Irohibe (2014) showed that on-site adaptations are more common, as a first step in the adaptation process. In addition, an increase in the duration of rain breaks during the rainy season increases the likelihood to intent to migrate.
Particularities are also observed regarding the perception of change in daily life. A perceived decrease in land accessibility reduces the likelihood of intending to migrate. As for previously, this might be explained by the implementation of other adaptation strategies in such a punctual change scenario or by the decrease in income reducing the capacity to migrate. Nevertheless, a perceived decreased access to compost and the market increases the likelihood of intending to migrate. Thus, some aspects of daily life seem more important in triggering the intention to migrate. Finally, mixed effects are observed concerning the pastoral area. One explanation might be the community dimension of pasture. The different level of impact resulting in a mixed effect on the household level.

To summarize, the perception of change in daily life and the perception of environmental change have a greater explanatory power in the scenario of a permanent aridification than in the scenario of a seasonal drought. This might be related to the fact that in the scenario of a seasonal drought, crucial variables have been omitted to better understand the intention. Another explanation might be that other forms of adaptations are preferred. As a matter of fact, in the AMMA survey, the number of households indicating the intention to migrate in case of a seasonal drought are inferior to those indicating the intention to migrate. The next section will help confirm or infirm these hypotheses.

b. Other intention of adaptation: selling of animals

Table 3 and 4 present the results of the logistic regressions concerning the intention to sell animals in the same scenarios presented in the previous section. No distinction was made on the number of animals sold or the type of animals according to the scenario. The explanatory power is higher in model 4c than in model 4d, including both types of perceptions, indicating that the intention of selling animals is better understood in the case of a aridification scenario. On the opposite, only looking at one type of perception, the explanatory power is greater in the scenario of a seasonal drought. These observations suggest that the combination of both types of perceptions is crucial to reveal the relationship between the independent variables and the dependent variable when considering the scenario of a permanent aridification and to a lesser extent in the scenario of a seasonal drought. Surprisingly, in both scenarios the contextual variables seem to have little to no impact on the intention

to sell animals. Only the localization in a dryer zone has an influence. Overall, the value of the R^2 of McFadden suggests that perception variables help explain the intention of selling of animals, but not as much as for the intention to migrate. Adding other independent variables in future research would be of relevance to have a more thorough view on which factors influence the intention of selling animals in the adaptation to environmental change.

Table 3

Logistic regression models, contextual, environmental change perception and change in daily life perception effects on the intention to sell animals in case of an aridification

Explanatory variables		Modalities	Model 1c	Model 2c	Model 3c	Model 4c
	INTERCEPT		-1.38***	-1.21**	-1.99***	-7.97***
Contextual	PERS_ACTAGRI					-0.09
Contextual	GROUP_RAIN	> 700mm (R)				
Contextual		500 – 700mm				2.25***
Contextual		< 500mm				1.37
Environment	RAIN_BREAK	Decrease/Stable (R)				
Environment		Increase				1.39*
Environment	RAIN_INTEN	Increase/Stable (R)				
Environment		Decrease		1.09*		2.75***
Environment	TEMP_COLD	Increase/Stable (R)				
Environment		Decrease		-1.27**		-2.92***
Daily life	LAB_FORCE					1.04
Daily life	LAND_ACCESS	Stable (R)				
Daily life		Decrease			-1.03	
Daily life		Increase			1.13*	
Daily life	AGRI_EQUIP	Increase/Stable (R)				1.36
Daily life		Decrease				
Daily life	MARK_ACCESS	Increase/Stable (R)				
Daily life		Decrease				2.11**
Daily life	PAST_CORR	Increase/Stable (R)				
Daily life		Increase				0.44
Daily life		Decrease				2.13***
Daily life	PAST_PASTURE	Increase/Stable (R)				
Daily life		Decrease			0.88*	
R^2 McFadden			0	0.05	0.08	0.26
AIC			116.64	114.36	113.8	109.05

(R) – Reference category; Results expressed as coefficients; *** p < 0.01; ** p < 0.05; * p < 0.10; – not significant but included in the model.

In case of a permanent aridification, contextual variables do not seem relevant to explain the intention to sell animals. Only when considering all the variables, the localization seems to play a role (see model 4c). For instance, households living in the area receiving between 500 and 700mm of rainfall have an increased chance of intending to sell animals compared to households living in an area receiving more rainfall (over 700mm). The R^2 of McFadden only slightly increases when adding the variables of perception separately. Only when adding all the variables, the value of the R^2 of McFadden indicates an interest of considering the perceptions in studying the intention to sell animals if a permanent aridification is forecasted. Therefore, focus is led on model 4d.

Concerning the perception of environmental change, rainfall seems to have the greatest importance, as could be observed previously, when considering intentions to migrate. In the present case, an increase in the duration of rainfall breaks and a decrease in the intensity of the rainfall increases the

likelihood of intending to sell animals in case of a permanent aridification. In addition, a decrease in the duration of cold spells decreases the probability of intending to sell animals for the households.
Looking at the variables of perception of change in daily life, two variables are of interest. A decrease in the accessibility to the market increases the probability of intending to sell animals. The same is true for the decrease of the corridor pastoral area.
All things considered, the perception of a degradation of the environment and a perceived deterioration in daily life increases the likelihood of a household considering to sell animals in case of a permanent aridification. Nevertheless, these variables of perception do not give a thorough look, and other variables should be investigated to have a more complete view on the matter, as the R^2 of McFadden is rather small.

Table 4

Logistic regression models, contextual, environmental change perception and change in daily life perception effects on the intention to sell animals in case of one seasonal drought

Explanatory variables		Modalities	**Model 1d**	**Model 2d**	**Model 3d**	**Model 4d**
	INTERCEPT		0.76*	2.13**	-1.02	0.86
Contextual	PERS_ACTAGRI				-0.08*	
	NUMB_HH		0.04	0.04		
	GROUP_RAIN	> 700mm (R)				
		500 – 700mm	-1.00**	-1.25***	-1.04**	-1.24**
		< 500mm	-1.31***	-1.69***	-0.22	-0.80
Environment	RAIN_HEUG	Increase/Stable (R)				
		Decrease		-1.55**		-1.86***
	RAIN_FLOOD	Increase/Stable (R)				
		Decrease		0.62		0.31
		Don't know		-0.97		-1.38*
Daily life	LAB_FORCE	Increase/Stable (R)				
		Decrease			1.10**	1.02**
	LAND_ACCESS	Stable (R)				
		Decrease			1.02*	0.77
		Increase			1.33**	1.60***
	AGRI_EQUIP	Increase/Stable (R)				
		Decrease			1.25**	0.92
	PAST_CORR	Increase/Stable (R)				
		Increase			-0.43	-0.62
		Decrease			0.79*	0.75
R^2 McFadden			0.07	0.14	0.19	0.24
AIC			189.91	181.69	180.07	172.57

(R) – Reference category; Results expressed as coefficients; *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$; – not significant but included in the model.

Similar to the permanent aridification scenario, in case of a seasonal drought, only the localization variable is of interest among the contextual variables. Nevertheless, the strength of the relation is higher for the latter scenario and the effect is opposite. Indeed, living in an area receiving less rainfall decreases the likelihood of intending to sell animals, suggesting that households living in dryer regions only consider selling part of their cattle when more long-term changes occur. In addition, very different variables of perception are of interest when switching to the scenario of one seasonal drought. Only variables concerning rainfall are significant regarding the perception of environmental change. A decrease in the Heug or Mangue rains decreases the likelihood of intending to sell animals. Not knowing if the number of floods during the rainy season is increasing or decreasing has the same effect.

Within the variables of perception of change in daily life, the accessibility of the labor force and the access to land have their importance. A decrease in the accessibility of labor force and the increase in the access to land increases the probability of intending to sell animals. An increased access to land could result in the agricultural activity taking more importance and therefore resulting in a reduction of cattle to have more labor force and resources to invest in agriculture, in order to increase the food production that season and sustain the household.
Here again the value of the R^2 of McFadden is not very important and contextual variables combined to perception of environmental change, and perception of change in daily life do not give a complete view on the matter.

Both types of perception have their relevance when studying the intention of households to sell animals in case of an aridification or in case of one seasonal drought. Nevertheless, among these types of perception, different variables are of interest. This observation suggests a very different approach by the population to act upon temporary change and more permanent change.

VII. Discussion and conclusion

A new theoretical framework was developed, based on the ones defined by Black *et al.* (2011) and Abid *et al.* (2019), linking perception of environmental change and perception of change in daily life to the intention and actual adaptation strategies. Perception of change in daily life being newly introduced, its relevance has been tested through a case study. According to the findings, there is a clear interest in introducing the perception of change in daily life when studying adaptation to environmental change, as the explanatory power of the logistic regression is significantly increased. The combination of both types of perception seems to help overcome some of the limits regarding the perception of environmental change, to know the social desirability (Félonneau & Becker, 2008), and the indirect impact of environmental change on adaptation (Koubi *et al.*, 2016).

This research took as a starting point the idea that the perception of change in daily life would increase the understanding of the adaptation process of households facing environmental change. This newly introduced type of perception not only is expected to increase the understanding on which households use migration as an adaptation strategy, but also on which households intend to adapt in different scenarios and how. As opposed to what was expected, models only including the perception of change in daily life, did not have a much higher explanatory power than the models considering the perception of environmental change, suggesting both types of variables bring different and relevant information. This is confirmed with the models combining both types of perceptions. The explanatory power of such models largely increased compared to models only including one type of perception. Therefore, different and complementary information is brought by both types of perceptions. Such observation is not surprising, as authors have shown the complexity of adaptation processes, in particular migration, and the need to consider a multiplicity of factors (Black *et al.*, 2011; Thober *et al.*, 2018).

The highest value of R^2 was found for the model linking the intention of migrating in the scenario of an aridification to all the independent variables, reaching a value of 0.60. This value being very high, this could suggest that intention can be better explained than facts (in this case the presence of temporary migrants), in line with the results obtained by Niles *et al.* (2016). Indeed, if compared to pseudo R^2 values found in other research considering actual adaptation to environmental change, these values are rarely over 0.20 (e.g. Fosu-Mensah *et al.*, 2012). A comparison to actual migration and actual selling of animals could help confirm this observation in the present study.

As expected, rainfall variables were the most relevant within the variables of perception of environmental change. Nevertheless, different rainfall variables were relevant in each case. Rain intensity was significant in all cases except for the model considering the intention to sell animals in

the scenario of a seasonal drought. Therefore, a distinction between intensity, quantity, floods, and so on is relevant and provide very specific information. Temperature and wind however are barely ever significant and could therefore easily be neglected. This is in line with other studies, where rainfall is one of the most important environmental factors influencing adaptation decision and often even the only environmental factor considered (de Longueville *et al.*, 2020; Afifi *et al.*, 2016; Borderon *et al.*, 2018).

Among the variables of perceived change in daily life, some had more importance than others, suggesting some aspects of life are more important in influencing adaptation. For instance, the market accessibility was significant in all case but the intention of selling animals in the scenario of a seasonal drought. At least one aspect of the evolution of the pastoral area is significant in all models, expect again in the model concerning the intention of selling animals in the scenario of a seasonal drought. Household size evolution, and agricultural equipment availability were significant in only one case each. Were significant, a perceived decrease in accessibility to the market increases the likelihood of adaptation or intended adaptation, highlighting the importance of this factor in studying adaptation to environmental change. The mixed effect of the evolution of the pastoral area suggests its overall relevance in the study, but shall be investigated more in detail in future research.

As a last observation on the logistic regressions, the models looking at the effect of the contextual, environmental change perception and change in daily life perception on the intention to sell animals in case of one seasonal drought, are very different of all other models. First, the number of variables significant in the models is inferior and do not include the variables of rainfall intensity, market accessibility and pastoral area evolution variables, which are included in all other cases. Furthermore, the R^2 of McFadden is the lowest, suggesting that these variables only give a very partial explanation on the intention of selling animals and other factors should be included. Thus, in order to study different types of adaptation strategies, weather it be intentions or implemented, contextual and perceptions variables are not sufficient.

The results of this paper should not be taken as an absolute truth, but should be seen as a starting point for future research. The AMMA database included 169 households which does not allow for any generalization and only give an exploratory insight on the subject. Furthermore, Senegal was used as a case study, but the theoretical framework should be confronted to other contexts and situations to evaluate its overall relevance. Mainly the relevance of the perception of change in daily life should be further investigated as its interest is only suggested in this research. Furthermore, the difference in factors influencing actual adaptation and different intentions to adapt could suggest a chronology in the adaptation. Unraveling a chronology would be of great interest in order to develop tailored policies that respond to concrete demand and evolve according to the situation. Migration, as one adaptation strategy should be at the core of future research as it impacts not only the area of departure, but also the arrival place. More in dept testing requires data that is not readily available, but would continue our efforts to better understand how people adapt to the environmental changes they experience.

References

Abid, M., Scheffran, J., Schneider, U. A., & Elahi, E. (2019). Farmer perceptions of climate change, observed trends and adaptation of agriculture in Pakistan. *Environmental management*, *63*(1), 110-123.

Adams, H. (2016). Why populations persist: mobility, place attachment and climate change. *Population and Environment*, *37*(4), 429-448.

Adger, W. N., Crépin, A. S., Folke, C., Ospina, D., Chapin III, F. S., Segerson, K., ... & Wilen, J. (2020). Urbanization, migration, and adaptation to climate change. *One Earth*, *3*(4), 396-399.

Afifi, T., Milan, A., Etzold, B., Schraven, B., Rademacher-Schulz, C., Sakdapolrak, P., ... & Warner, K. (2016). Human mobility in response to rainfall variability: opportunities for migration as a successful adaptation strategy in eight case studies. *Migration and Development*, *5*(2), 254-274.

ANSD (Agence Nationales de la Statistique et de la Démographie) (2009). Situation economique et sociale du Sénégal en 2008.

ANSD (Agence Nationales de la Statistique et de la Démographie) (2006). Résultats définitifs du troisième recensement général de la population et de l'habitat – (2002). *RGPH III*.

Azadi, Y., Yazdanpanah, M., & Mahmoudi, H. (2019). Understanding smallholder farmers' adaptation behaviors through climate change beliefs, risk perception, trust, and psychological distance: Evidence from wheat growers in Iran. *Journal of environmental management*, *250*, 109456.

Beine, M., Docquier, F., & Özden, Ç. (2011). Diasporas. *Journal of Development Economics*, *95*(1), 30-41.

Belay, A., Recha, J. W., Woldeamanuel, T., & Morton, J. F. (2017). Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. *Agriculture & Food Security*, *6*(1), 1-13.

Black, R., Adger, W. N., Arnell, N. W., Dercon, S., Geddes, A., & Thomas, D. (2011). The effect of environmental change on human migration. *Global environmental change*, *21*, S3-S11.

Borderon, M., Sakdapolrak, P., Muttarak, R., Kebede, E., Pagogna, R., & Sporer, E. (2018). A systematic review of empirical evidence on migration influenced by environmental change in Africa.

Castells-Quintana, D., del Pilar Lopez-Uribe, M., & McDermott, T. K. (2018). Adaptation to climate change: A review through a development economics lens. *World Development*, *104*, 183-196.

Chepkoech, W., Mungai, N. W., Stöber, S., Bett, H. K., & Lotze-Campen, H. (2018). Farmers' perspectives: impact of climate change on African indigenous vegetable production in Kenya. *International Journal of climate change strategies and management*.

Codjoe, S. N. A., Atidoh, L. K., & Burkett, V. (2012). Gender and occupational perspectives on adaptation to climate extremes in the Afram Plains of Ghana. *Climatic Change*, *110*(1), 431-454.

Concato, J., Peduzzi, P., Holford, T. R., & Feinstein, A. R. (1995). Importance of events per independent variable in proportional hazards analysis I. Background, goals, and general strategy. *Journal of clinical epidemiology*, *48*(12), 1495-1501.

Cordell, D. D., Gregory, J. W., & Piché, V. (1996). *Hoe and wage: a social history of circular migration system in West Africa, African modernization and development series*. Oxford: Westview Press.

De Groot, C., Mulder, C. H., Das, M., & Manting, D. (2011). Life events and the gap between intention to move and actual mobility. *Environment and planning A*, *43*(1), 48-66.

De Longueville, F., Ozer, P., Gemenne, F., Henry, S., Mertz, O., & Nielsen, J. Ø. (2020). Comparing climate change perceptions and meteorological data in rural West Africa to improve the understanding of household decisions to migrate. *Climatic Change*, *160*(1), 123-141.

DeMaris, A. (1995). A tutorial in logistic regression. *Journal of Marriage and the Family*, 956-968.

Deressa, T. T., Hassan, R. M., & Ringler, C. (2011). Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. *The Journal of Agricultural Science*, *149*(1), 23-31.

Faye, B., Webber, H., Diop, M., Mbaye, M. L., Owusu-Sekyere, J. D., Naab, J. B., & Gaiser, T. (2018). Potential impact of climate change on peanut yield in Senegal, West Africa. *Field Crops Research*, *219*, 148-159.

Félonneau, M. L., & Becker, M. (2008). Pro-envonmental attitudes and behavior: Revealing perceived social desirability. *Revue internationale de psychologie sociale, 21*(4), 25-53

Ferris, E. (2020). Research on climate change and migration where are we and where are we going? *Migration Studies*, *8*(4), 612-625.

Fielding, K. S., Terry, D. J., Masser, B. M., & Hogg, M. A. (2008). Integrating social identity theory and the theory of planned behaviour to explain decisions to engage in sustainable agricultural practices. *British journal of social psychology*, *47*(1), 23-48.

Fosu-Mensah, B. Y., Vlek, P. L., & MacCarthy, D. S. (2012). Farmers' perception and adaptation to climate change: a case study of Sekyedumase district in Ghana. *Environment, Development and Sustainability*, *14*(4), 495-505.

Grothmann, T., & Patt, A. (2005). Adaptive capacity and human cognition: the process of individual adaptation to climate change. *Global environmental change*, *15*(3), 199-213.

Hathie, I., Wade, I., Ba, S., Niang, A., & Niang, M. (2015). Emploi des jeunes et migration en Afrique de l'Ouest (EJMAO): rapport final-Sénégal.

Henry, S., Boyle, P., & Lambin, E. F. (2003). Modelling inter-provincial migration in Burkina Faso, West Africa: the role of socio-demographic and environmental factors. *Applied Geography*, *23*(2-3), 115-136.

Henry, S., Schoumaker, B., & Beauchemin, C. (2004). The impact of rainfall on the first out-migration: A multi-level event-history analysis in Burkina Faso. *Population and environment*, *25*(5), 423-460.

Huong, N. T. L., Bo, Y. S., & Fahad, S. (2017). Farmers' perception, awareness and adaptation to climate change: evidence from northwest Vietnam. *International Journal of Climate Change Strategies and Management*.

Ianos, I. (1998). The influence of economic and regional policies on migration in Romania. *Romania: migration, socio-economic transformation and perspectives of regional development. Sudosteuropa-Studie*, *62*, 55-76.

Mastrandrea, T.E. Bilir,M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy,S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge UniversityPress, Cambridge, United Kingdom and New York, NY, USA, 1132 pp.

Juana, J. S., Kahaka, Z., & Okurut, F. N. (2013). Farmers' perceptions and adaptations to climate change in sub-Sahara Africa: A synthesis of empirical studies and implications for public policy in African agriculture. *Journal of Agricultural Science*, *5*(4), 121.

Klepp, S. (2017). Climate change and migration. In *Oxford research encyclopedia of climate science*.

Koubi, V., Spilker, G., Schaffer, L., & Bernauer, T. (2016). Environmental stressors and migration: Evidence from Vietnam. *World Development*, *79*, 197-210.

Lustgarten, A. (2020). *The great climate migration*. New York Times Magazine.

McLeman, R., & Smit, B. (2006). Migration as an adaptation to climate change. *Climatic change*, *76*(1), 31-53.

Menard, S. (2000). Coefficients of determination for multiple logistic regression analysis. *The American Statistician*, *54*(1), 17-24.

Mendelsohn, R. (2000). Efficient adaptation to climate change. *Climatic Change*, *45*(3), 583-600.

Mertz, O., Mbow, C., Reenberg, A., Genesio, L., Lambin, E. F., D'haen, S., ... & Sandholt, I. (2011). Adaptation strategies and climate vulnerability in the Sudano-Sahelian region of West Africa. *Atmospheric Science Letters*, *12*(1), 104-108.

Morrissey, J. (2012). Rethinking the'debate on environmental refugees': from'maximilists and minimalists' to'proponents and critics'. *Journal of Political Ecology*, *19*(1), 36-49.

Neter, J., Wasserman, W., & Kutner, M. H. (1989). Applied linear regression models.

Nielsen, J. Ø., & Reenberg, A. (2010). Cultural barriers to climate change adaptation: A case study from Northern Burkina Faso. *Global Environmental Change*, *20*(1), 142-152.

Niles, M. T., Brown, M., & Dynes, R. (2016). Farmer's intended and actual adoption of climate change mitigation and adaptation strategies. *Climatic Change*, *135*(2), 277-295.

Peduzzi, P., Concato, J., Kemper, E., Holford, T. R., & Feinstein, A. R. (1996). A simulation study of the number of events per variable in logistic regression analysis. *Journal of clinical epidemiology*, *49*(12), 1373-1379.

Perch-Nielsen, S. L., Bättig, M. B., & Imboden, D. (2008). Exploring the link between climate change and migration. *Climatic change*, *91*(3), 375-393.

Pohar, M., Blas, M., & Turk, S. (2004). Comparison of logistic regression and linear discriminant analysis: a simulation study. *Metodoloski zvezki*, *1*(1), 143.

Ranganathan, P., Pramesh, C. S., & Aggarwal, R. (2017). Common pitfalls in statistical analysis: logistic regression. *Perspectives in clinical research*, *8*(3), 148.

Salack, S., Muller, B., & Gaye, A. T. (2011). Rain-based factors of high agricultural impacts over Senegal. Part I: integration of local to sub-regional trends and variability. *Theoretical and Applied Climatology*, *106*(1), 1-22.

Salack, S., Saley, I. A., Lawson, N. Z., Zabré, I., & Daku, E. K. (2018). Scales for rating heavy rainfall events in the West African Sahel. *Weather and climate extremes*, *21*, 36-42.

Schuman, S., Dokken, J. V., Van Niekerk, D., & Loubser, R. A. (2018). Religious beliefs and climate change adaptation: A study of three rural South African communities. *Jàmbá: Journal of Disaster Risk Studies*, *10*(1), 1-12.

Simelton, E., Quinn, C. H., Batisani, et al. (2013). Is rainfall really changing? Farmers' perceptions, meteorological data, and policy implications. *Climate and development*, 5(2), 123-138.

Smith, P. J. (2007). Climate change, mass migration and the military response. *Orbis*, *51*(4), 617-633.

Smith, T. J., & McKenna, C. M. (2013). A comparison of logistic regression pseudo R2 indices. *Multiple Linear Regression Viewpoints*, *39*(2), 17-26.

Thober, J., Schwarz, N., & Hermans, K. (2018). Agent-based modeling of environment-migration linkages. *Ecology and society*, *23*(2).

Van Dalen, H. P., & Henkens, K. (2008). Emigration intentions: Mere words or true plans? Explaining international migration intentions and behavior. *Explaining International Migration Intentions and Behavior (June 30, 2008)*.

Van der Land, V. (2015). *The environment-migration nexus reconsidered: why capabilities and aspirations matter*. Verlag nicht ermittelbar.

Van der Land, V., Romankiewicz, C., & van der Geest, K. (2018). Environmental change and migration: A review of West African case studies. *Routledge handbook of environmental displacement and migration*, 163-177.

Warner, K. (2011). Environmental change and migration: methodological considerations from ground-breaking global survey. *Population and environment,* 33(1), 3.

Wheeler, S., Zuo, A., & Bjornlund, H. (2013). Farmers' climate change beliefs and adaptation strategies for a water scarce future in Australia. *Global Environmental Change*, *23*(2), 537-547.

Wiederkehr, C., Beckmann, M., & Hermans, K. (2018). Environmental change, adaptation strategies and the relevance of migration in Sub-Saharan drylands. *Environmental Research Letters*, *13*(11), 113003.

Yaro, J. A. (2013). The perception of and adaptation to climate variability/change in Ghana by small-scale and commercial farmers. *Regional Environmental Change*, *13*(6), 1259-1272.

Appendix 1: List of variables used

Table X: Definitions of the explanatory variables

Variable name	Variable description
Social, economic, demographic, and localization variables	
NUMB_HH	Number of members in the household
PERS_ACTAGRI	Number of members active in agricultural activities
PERS_INACT	Number of inactive members
NUMB_RAIN_PLOTS	Number of rain plots owned or rented
GROUP_RAIN	Localization of the village according to the average rainfall (little: <500mm, intermediate: 500-700mm, much: >700mm)
Perception of environmental change variables [a]	
RAIN_QUANTRS	Amount of rainfall during the rainy season
RAIN_DURRS	Duration of the rainy season
RAIN_HEUG	Heug/Mangue rains
RAIN_BREAK	Duration of rainfall breaks
RAIN_INTEN	Rainfall intensity
RAIN_FLOOD	Floods during the rainy season
TEMP_INTENRS	Temperature intensity during the rainy season
TEMP_INTENDS	Temperature intensity during the dry season
TEMP_WARM	Duration of hot spells
TEMP_COLD	Duration of cold spells
WIND_RS	Frequency and duration of strong winds during the rainy season
WIND_DS	Frequency and duration of strong winds during the dry season
WIND_SAND	Dust and sand wind intensity
Perception of change in daily life variables [a]	
INCOME	Income of the household
EXPENSES	Expenses of the household
HH_SIZE	Household size
LAB_FORCE	Labor force availability
LAND_ACCESS	Land accessibility
SEED_ACCESS	Seed accessibility
COMP_ACCESS	Accessibility of manure/compost
FERT_ACESS	Fertilizer accessibility
SOIL_FERT	Soil fertility
AGRI_EQUIP	Agricultural equipment availability
MARK_ACCESS	Accessibility to the market
PAST_CORR	Pastoral area: corridor
PAST_PASTURE	Pastoral area: pasture
PAST_REST	Pastoral area: rest

[a] Perception variables can have the following answers: *increase*, *decrease*, *stable*, or *I don't know*