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Alexandra T. Tapsoba
Pascale Combes Motel
Jean-Louis Combes

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CERDI
POLE TERTIAIRE
26 AVENUE LÉON BLUM
F- 63000 CLERMONT FERRAND
TEL. + 33 4 73 17 74 00
FAX + 33 4 73 17 74 28
http://cerdi.uca.fr/

The authors

Alexandra T. Tapsoba, Researcher, Institut Supérieur des Sciences de la Population, Université Joseph Ki-Zerbo, Ouagadougou, Burkina Faso.
Email address: atapsoba@issp.bf

Pascale Combes Motel, Professor, Université Clermont Auvergne, CNRS, CERDI, F-63000 Clermont-Ferrand, France.
Email address: pascale.motel_combes@uca.fr

Jean-Louis Combes, Professor, Université Clermont Auvergne, CNRS, CERDI, F-63000 Clermont-Ferrand, France.
Email address: j-louis.combes@uca.fr

Corresponding author: Pascale Combes Motel

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Abstract

This paper assesses the impact of remittances and climate variability on the food security of households in Burkina Faso. It draws from the World Bank 2010 survey on migration and remittances in Burkina Faso and uses a database from Burkina Faso's Department of Meteorology regarding rainfall recorded in the ten weather stations throughout the country between 2001 and 2010. We build a food security index using principal component analysis that encompasses the accessibility and utilization dimensions of the concept. We also compute an inter-annual rainfall index and the latter is found to have a negative impact on food security. After controlling for potential endogeneity issues using distance variables and migrant characteristics as instruments, remittances are found to enhance food security. Results are robust to alternative measures of food security and alternative calculations of rainfall variability. The paper also highlights that remittances dampen the negative effect of rainfall variability on food security.

Keywords

Food security, Climate variability, Remittances, Burkina Faso.

JEL Codes

D13, F24, Q54, N57.

1 Introduction

Drastic changes in rainfall and temperature have dramatically affected agricultural production in Sub-Saharan Africa (SSA) (Barrios, Bazoumana, & Strobl, 2008). Climate variability has also adversely impacted farmers' incomes, especially for dryland crops and livestock (Kurukulasuriya, et al., 2006). In 2014, the Intergovernmental Panel on Climate Change (IPCC)'s fifth assessment report on adaptation highlighted key risks related to increased stress on water resources, as well as reduced crop productivity, which may have strong adverse effects on the welfare of rural and urban households for developing countries. In this context, climate variability is expected to further shape future food security in African countries (Intergovernmental Panel on Climate Change, 2014). Climatic failures will arguably produce the most significant consumption shocks (Porter, 2012) Indeed, environmental disasters have been shown to be one of the major underlying drivers of food insecurity, as well as of poverty and conflict in African countries (Misselhorn, 2005).

Food security therefore remains at the top of development policy agendas in SSA, where the proportion of undernourished people reached a 26.8% average between 2010 and 2012 (Porter, et al., 2014) and where the share of income spent on food is particularly high, especially for poor households (Chauvin, Mulangu, & Porto, 2012). Changes in rainfall and temperature patterns are expected to affect all dimensions of food security, which are food availability, food access, food use and price stability (Schmidhuber & Tubiello, 2007). Crop losses due to climate variability critically affect food availability, especially when households depend on rain-fed agriculture. The destabilizing effect of extreme climate events, which are expected to become more frequent, exacerbate the vulnerability of all food-insecure people. In terms of food utilization, people may not be able to get the necessary diversity of food nutrients as they will be rationing their consumption to prioritize calorie-rich but nutrient-poor foods (Bloem, Semba, & Kraemer, 2010). Finally, climate variability may also contribute to increases in food commodity prices (Niang, et al., 2014).

Adaptation strategies, therefore, play a crucial role in preventing further detrimental effects of climate change on food security in Africa. Adaptation targets help lowering risks and vulnerability and contribute to the search for diversification opportunities. For African populations who mostly depend on subsistence or rainfed agriculture, crop diversification is a widespread adaptation practice (Harrower & Hoddinott, 2005). In a context characterized by rising temperatures, declines in rainfall and more frequent extreme climate events, a significant number of African farmers have already changed their agricultural practices while diversifying crop varieties, changing dates of planting, increasing water conservation and using shading and sheltering techniques (Maddison, 2007). Differences in the ability of individual farmers to adapt may, however, be significant due to the existence of material constraints. Indeed, farmers willing to adapt their farming practices may face numerous impediments related to their poverty and liquidity constraints. Relaxing the latter may, therefore, be critical for successful adaptation to climate change (di Falco, Veronesi, & Yesuf., 2011).

In this paper, we argue that remittances support farmers' adaptation strategies, which in the end strengthen food security in developing countries, especially in SSA. Migration, both cross-border and internal is the primary income diversification strategy practiced in developing countries and especially in SSA. Remittances have increased at an impressive rate since the beginning of the 2000s and now represent a major source of foreign inflows in developing countries (Yang & Choi, 2007). A large body of the literature has already provided empirical evidence of the dampening effect of remittances on consumption instability (Combes. & Ebeke, 2011), income inequalities (Chauvet & Mesplé-Somps, 2007) (Koechlin, & Leon, 2007), and poverty (Adams & Page, 2005) (Acosta, Calderon, Fajnzylber, & Lopez, 2008), (Gupta, Pattillo & Wagh,2009). Though SSA countries do not rank among the top remittance-receiving countries, worker's remittances more than doubled between 2000 and 2006 (Mohapatra, Joseph, & Ratha, 2012). Personal remittances grew at an impressive 20% per annum over the 2001 to 2010 period, which is the highest average annual growth rate among developing regions (World Bank Indicators). Remittances arguably play a key role in dampening the effects of a large variety of risks, both, ex-ante or ex-post. For instance, the dampening effect of remittances on adverse shocks in SSA has been documented in several studies (Combes, Ebeke, Ntsama Etoundi, & Yogo, 2014), (Azam & Gubert, 2006). Remittances have also buttressed ex-ante household preparedness for natural disasters and provided resources in their aftermath (Mohapatra, Joseph, & Ratha, 2012).

This paper investigates whether remittances help improve food security threatened by climate risk, using Burkina Faso as a case study. To the best of our knowledge, little research has been done on the impact of remittances in Western African countries and Burkina Faso in particular. Some exceptions include a study that found that off-farm income, including remittances, improved food security in the Kwara state of Nigeria (Babatunde & Qaim, 2010). Remittances were also found to have a positive impact on the probability of rural Malian households to improve their food security levels (Generoso, 2015). Existing studies on Burkina Faso that focus on consumption and income smoothing were mostly made in the aftermath of the 1980s droughts. For instance, (Kazianga & Udry, 2006) questioned the consumption smoothing properties of livestock (Reardon, Peter Matlon, & Christopher Delgado, 1988). (Barbier, Hamma Yacouba, Harouna Karambiri, Malick Zoromé, & Blaise Somé, 2009) highlighted that rural households from the Sudanian and Sahelian zones were strongly involved in income diversifying strategies in order to ensure food security. Interestingly, (Kazianga & Udry, 2006) pointed out that in Burkina Faso transfers are rooted in a complex gift exchange system. Insurance motives were not always the main motive for transfers. There is, therefore, room for new investigations on the role of remittances on household welfare measured under pervasive climate variability. This paper empirically innovates in several aspects. First, a food security index is built in order to encompass its multidimensional character. Second, an original dataset of meteorological recordings gathered at a fine level allows us to construct an index of climate variability. Third, the potential endogeneity of remittances is also addressed.

The rest of the paper is organized as follows. Section 2 sketches out the context of the study. Section 3 focuses on the construction and description of the food security index. Section 4 presents our empirical framework, the main results, and robustness checks.

2 Remittance patterns in Burkina Faso

This study takes advantage of the 2010 Migration and Remittances household survey conducted under the auspices of the World Bank in Burkina Faso as part of the Africa Migration Project. This survey aimed to contribute to the improvement of migration and remittance impact on development in SSA. [1] The dataset used in this study is based on the answers collected on 2,102 rural and urban households in 7 regions, 10 districts and 77 villages surveyed in 2010 in Burkina Faso. It focuses on the southern parts of the country, which hosts the most intense migration provinces (Banwa, Boulgou, Boulkiemdé, Kadiogo, Namentenga, Passoré, Sanmatenga, Sourou, Tuy, Yatenga).

In Burkina Faso, most migration is internal and moves toward Ouagadougou and Bobo-Dioulasso, which are the country's largest cities. International migrants, however, made up at least 28.9% of the migrants in 2006 (Ministry of Economy and Finance, 2006). According to the Central Bank of West African States, remittances represented 1.3% of the country's GDP in 2013, which is in line with the 2001-2010 personal remittances average calculated from the World Bank Indicators. One-third of this amount accrued to rural communities, which are the poorest and most vulnerable. Yet the majority of international remittances (30.9% of the total) come from Ivory Coast (Table 1). The 2009 survey on household living conditions undertaken by the National Institute of Demography of Burkina Faso showed that men, who mainly migrate for economic reasons, sent back the majority of remittances (87.4%).

Remittances are a critical source of income in Burkina Faso, especially for poor households. The majority of the money received is used to cover household consumption and investment expenses (Table 2). These expenses generally relate to education and housing. Remittances from workers located in Ivory Coast were correlated with the rise of poverty in Burkina Faso over the 1998-2003 period (Lachaud, 2012). This evidence is somehow in contradiction with previous results based on surveys conducted in the Central Plateau region, which concluded that the effect of remittances on poverty and income diversification was conditional on the destination countries of migrants

[1] Other countries surveyed by the World Bank are Ethiopia, Kenya, Nigeria, Senegal, South Africa, and Uganda.

(Wouterse & Taylor, 2008) and (Wouterse, 2010). One may therefore further inquire about the role of remittances while looking at food security, which is a critical dimension of household welfare.

Table 1. International remittances, by origin countries in 2009

Origin	Amount (in FCFA)	% of total remittances
Côte d'Ivoire	17 108 661 241	30.9
West African Economic and Monetary Union Countries	4 595 530 366	8.3
Ghana	609 046 193	1.1
ECOWAS countries	332 207 014	0.6
France	5 204 576 559	9.4
Italy	6 367 301 109	11.5
USA	8 360 543 195	15.1
Rest of the world	12 789 970 054	23.1
Total	55 367 835 730	100.0

Source: (Central Bank of West African States, 2011)

Table 2. Remittance spending by households

	Amount (F CFA)	% of total remittances
Consumption	9 210 882 416	37,3
Health	543 269 204	2,2
Education	3 704 108 210	15,0
Property investment	6 346 372 067	25,7
Other investment	4 025 130 922	16,3
Savings	370 410 821	1,5
Family events	419 798 931	1,7
Other	74 082 164	0,3
Total	**24 694 054 736**	**100,0**

Source: Central Bank of West African States (2011)

3 Stylized facts on food security and climate variability

The database gathered by the World Bank's Migration and Remittances household survey also allows us to build a food security index which is detailed in Section 3.1. What is original here is that the information on migration and food security is connected to a database on local climatic conditions. Weather centers across the country regularly record various rainfall and temperature parameters, which are then compiled by the General Meteorological Department of Burkina Faso (Direction Générale de la Météorologie). This rich data set is available from 2000 onwards and serves as a basis for various climate variability indices, which are presented in Section 3.2.

3.1 Food security

The literature includes several definitions of food security, as the concept itself has evolved through time and across socio-economic conditions since its first introduction in the early 1940s (Hassan, 2016). In the early 1970s, hunger and food shortages in SSA and Asia led to a focus on Malthusian preoccupations, which relate food crises to the food supply. Later, the 1974 World Food Conference (Food and Agriculture Organization of the United Nations) defined food security as the "availability at all times of adequate world supplies of basic foodstuffs… to sustain a steady expansion of food consumption…. and offset fluctuations in production and prices". Accessibility issues arose in the 1980s with Sen's vision developed in *Poverty and Famines* (Sen, 1981). This work highlighted the fact that the capacity of people to have access to food is as important as food availability. In 2002, the (Food and Agriculture Organization of the United Nations) stated that food security occurs, "When all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life." It is now generally accepted in the literature that food security refers to four main dimensions: availability, accessibility, utilization, and stability. [2]

[2] Interested readers can refer to (Barrett, 2010) or (Pinstrup-Andersen, 2009) for an extensive presentation of methodological issues pertaining to food security or insecurity measurement.

The World Bank household survey on Migration and Remittances covers several dimensions of food security. In the present case, two pillars are taken into account. They are food accessibility and utilization. [3] A synthetic index is calculated using principal component analysis (PCA), which combines discrete and continuous variables. The World Food Program often applies PCA to generate food security indexes and draw household profiles. PCA is also used in case studies in Ethiopia (see e.g. (Demeke, Keil, & Zeller, 2011)).

In our case, accessibility and utilization of food could be referred to by the same variables. Detailed information is available about household expenditures for cereals, legumes, oleaginous, tubers, fruits, meat, chicken and eggs. As food expenditures also reflect the accessibility and dietary diversity of the eight major food groups[4] and their uses [5], we capture both dimensions in these variables. Utilization also refers to the optimal use of food and is captured here by the presence in a given household of a room reserved for cooking and the presence of an internal faucet.

The results of the principal component analysis are reported in Table 3. They indicate that the first component explains 30.9% of the total variance within the data and that the second component explains only 25.7% of the variance. Table 3 also shows the variable loadings in the components. We kept the first component that is positively correlated with food expenditures: the possession of an internal faucet and the existence of a separate room for cooking. We then consider this first component to be our index of food security. The value of the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is 0.53, showing relatively compact patterns of correlations between the variables and justifying the use of principal component analysis.

[3] We tried to catch the availability dimension with a dummy pertaining to the possession of agricultural land. However, calculations did not give satisfactory results. The stability dimension refers to the term "at all times" of the FAO definition. It refers to the stability of the three dimensions cited above over time. Since our data has no time dimension, this aspect is not taken into account.

[4] Cereals, milk, meat, sugar, vegetable oils, fruits, vegetables, starchy roots (Pangaribowo, Gerber and Torero, 2013).

[5] FAO (2008) stated "Utilization is commonly understood as the way the body makes the most of various nutrients in food. Sufficient energy and nutrient intake by individuals is the result of good care and feeding practices, food preparation and diversity of the diet and intra-household distribution of food. Combined with good biological utilization of food consumed, this determines the nutritional status of individuals."

Table 3. Results of the principal component analysis

No Rotation		
	Component 1	Component 2
Internal Faucet	0.4763	0.4120
Existence of a separate room for cooking	0.4763	0.7959
Cereal /Tuber / Vegetable expenditures	0.6162	-0.3048
Meat/Fish/Egg expenditures	0.22.62	-0.3223
Eigen Values	1.23662	1.02804
Explained Variance	0.3092	0.2570

Source: 2010 World Bank Survey on Migration and Remittances in Burkina Faso and authors' calculations

3.2 Climate variability

Burkina Faso is characterized by tropical and mainly Sudano - Sahelian weather. The country can be divided as presented in the introduction into three main regions: the Sahel region, which averages less than 600 mm of rainfall per year, the north Sudanian region, which averages between 600 mm 900 mm of annual rainfall, and a south Sudanian region, which averages more than 900mm of rainfall annually.

Temperatures have risen globally in the country over the past years, and according to the Department of Meteorology of Burkina Faso (Permanent Secretary of the National Council for Environment and Sustainable Development, 2007) a rise of 0.8° C is expected by 2025 and of 1.7°C by 2050 that will mainly contribute to evapotranspiration levels across the country. The Department of Meteorology actually states that the country records 206.9 billion cubic meters of rain every year. From this amount, 15.66% infiltrates the soil, and 80.18% evaporates. These figures highlight the importance of understanding climate variability's impact on food security in a country, which is highly dependent on subsistence and rain-fed agriculture. It is also important to note that the years 2009 and 2010 were critical years for the country, as it experienced some highly destructive floods.

An inter-annual rainfall variability index, based on the definition of (Nicholson, 1989) is constructed. Data used are precipitations (mm) measured by 10 stations[6] across the

[6] Bobo-Dioulasso, Bogandé, Boromo, Dedougou, Dori, Fada N'Gourma, Gaoua, Ouagadougou, Ouahigouya, Po.

country and provided by the National Institute of Meteorology of Burkina Faso. The index is basically the absolute value of a reduced central variable calculated on annual precipitation (Servat, 1997).

Following (Mohapatra, & Ratha, 2012), we also compute this index using further historical data that are available on rainfall records since 2001.[7] The computed index is then assigned to households according to the geographical proximity of their village to the weather station in the database[8]. We compute further down the line another index referring only to the number of months of the year with rainfall, which corresponds to the cropping season. This season generally goes from June to September and climate conditions during this time determine household harvests for the coming year.

The index is calculated as $\frac{Z_i - \bar{Z}}{\sigma}$ where Z_i represents the 2010 precipitation highs for each station indexed by i. $\bar{Z}$ is the annual rainfall average between 2007 and 2010, and σ is the standard deviation of annual precipitations over this period. It is worth noting that the rainfall variability index can also be interpreted as an indicator of perceived variability. Field surveys conducted in the Central Plateau of Burkina Faso provided evidence that perceptions on the amount or frequency of rainfall were closely correlated with rainfall records (West, Roncoli, & Ouattara, 2008).

[7]The choice of the years to compute this index is based on the availability of the data. Therefore, the height of rain in 2001 is represented by the mean amount of rain since 1971.
[8] There is approximately one weather station for each region in Burkina Faso. This allowed us to assign the rainfall variability index to households, according to the region they are located in.

4 Econometric analysis

4.1 Empirical framework

The basic econometric specification used to capture the impact of remittances on food security is the following:

$$Y_i = \alpha_0 + \alpha_1 R_i + \alpha_2 RainVar_i + \mathbf{X'_i\beta} + \varepsilon_i \quad (1)$$

Where Y represents the food security index, R is the amount of remittances received by the household in FCFA divided by 1000, $RainVar$ is the index of rainfall variability and **X** is a vector of other explanatory variables including province dummies, a list of which is available in Appendix 1.

αs and βs are coefficients to be estimated. It is expected $\alpha_1 > 0$ and $\alpha_2 < 0$. ε is the error term. i is a household index, with $i = 1, \ldots, 2{,}102$, which is the maximum number of households. Other explanatory variables pertain to household human capital such as the number of people who can read and write in French and the head of household characteristics such as gender and age. Having a male head of household can have a positive impact on food security, given the fact that in some developing countries, men are often the household breadwinners. The potential labor force available in the household, measured by the number of male teenagers is also included and is expected to have a positive impact on food security. Lastly, a dummy variable taking the value of 1 if the household is in a rural area, and 0 otherwise, as well as the number of children in the households are also included and expected to have a negative impact on food security. This result is expected given that rural areas are commonly poorer and can be expected to be less food-secure than urban areas. Many children in the household can lower expenditures on food to the benefit of expenditures on health, education and so on and therefore lower food security levels.

Descriptive statistics of these control variables are reported in Table 4 below.

Table 4. Descriptive statistics

Variable	Mean	Std.dev	Nb of HH	Measurement	Data Source
Remittances	25.98	107.09	2,102	Amount of remittances received by HH (divided by 1000) in CFA Francs	World Bank Survey on Migration and Remittances in Burkina Faso (2010)
Rural	94%	0.25	2,102	Equals 1 if the HH lives in a rural area, % of total population in the region	World Bank Survey on Migration and Remittances in Burkina Faso (2010)
Rainfall Index (2007)	0.57	0.40	2,102	Rainfall Variability since 2007	Department of Meteorology
Rainfall Index (2001)	0.87	0.57	2,102	Rainfall Variability since 2001	Department of Meteorology
Rainfall Season Index	0.69	0.28	2,102	Rainfall Variability during the raining season since 2007	Department of Meteorology
Food Expenditures	3 793.59	4 318.40	2,102	Per capita expenditures in food per month in CFA Francs	World Bank Survey on Migration and Remittances in Burkina Faso (2010)
HH Head Gender	93%		2,102	Equals 1 if the Head of HH is a man, % of the total population in the region	World Bank Survey on Migration and Remittances in Burkina Faso (2010)
HH Head Age	49.50	15.89	2,099	Household Head Age, in years	World Bank Survey on Migration and Remittances in Burkina Faso (2010)
Literacy	1.45	1.87	2,069	Number of literate people in the HH	World Bank Survey on Migration and Remittances in Burkina Faso (2010)
Teenagers	1.00	1.30	2,069	Number of teenagers (15 years or older)	World Bank Survey on Migration and Remittances in Burkina Faso (2010)
Children	1.52	1.46	2,069	Number of children under 5	World Bank Survey on Migration and Remittances in Burkina Faso (2010)
Luminosity Intensity	2.68	10.15	1,913	Night-time luminosity intensity	National Centre for Environmental Information
Poverty Incidence	46.18%	15.07	2,102	Population share under the poverty line between 2008 and 2010 by region	Reports of the « Institut National de la Statistique et de la Démographie » of Burkina Faso
Migrant' Education Level	26.39%	0.44	2,102	Percentage of migrants with at least a primary education	World Bank Survey on Migration and Remittances in Burkina Faso (2010)
Distance to Railway	64.05	57.91	2,102	Distance between households' geographical location and the railway in kilometers	World Bank Survey on Migration and Remittances in Burkina Faso (2010) and authors' work

The basic specification can be augmented in the following manner:

$$Y_i = \alpha_0 + \alpha_1 R_i + \alpha_2 RainVar_i + \alpha_3 R_i \times RainVar_i + \mathbf{X'}_{\mathbf{i}}\boldsymbol{\beta} + \varepsilon_i \qquad (2)$$

It is still expected that $\alpha_2 < 0$ while $\alpha_3 > 0$ so that remittances improve household food security in a context of climate variability. This specification allows determining the value of remittances, which significantly dampens the negative effects of rainfall variability on food security. It is calculated as follows: $\frac{\partial Y}{\partial RainVar} = \alpha_2 + \alpha_3 R_i$. Solving for $\frac{\partial Y}{\partial RainVar} = 0$ allows us to calculate the amount of remittances that cancels out the effect of climate variability on food security.

We begin by providing OLS estimates, which will be completed by a series of robustness checks, and lastly the use of instrumental variables.

4.2 Results

OLS results of the baseline specification (equation 1) are presented in Table 5. Control variables are gradually included so as to check the sensitivity of the effect of remittances to additional control variables. Results show that remittances have a positive impact on household food security. Climate variability, on the other hand, significantly and negatively affects food security. As expected, living in a rural area has a negative impact, somehow validating our hypothesis that rural households are poorer. Having a man as head of household as well as having a certain amount of male teenagers, significantly and positively impacts food security. Other variables such as children and the head of the household's age do not seem to have any robust impact on food security.

Table 5. Impact of remittances and climate variability on food security - OLS results

	All HH							
Dependent Variable:	Food security							
Remittances R	0.00100** (0.000504)	0.00103** (0.000516)	0.00103** (0.000513)	0.000998** (0.000500)	0.000980** (0.000497)	0.000975** (0.000496)	0.000975** (0.000496)	0.000975** (0.000496)
Rainfall Variability $RainVar$	-0.152*** (0.0537)	-0.156*** (0.0534)	-0.150*** (0.0534)	-0.169*** (0.0525)	-0.161*** (0.0512)	-0.161*** (0.0513)		
Rural	-1.558*** (0.129)	-1.574*** (0.131)	-1.585*** (0.131)	-1.553*** (0.132)	-1.559*** (0.132)	-1.551*** (0.132)	-1.551*** (0.132)	-1.551*** (0.132)
HH Head Gender		0.260*** (0.0837)	0.266*** (0.0844)	0.260*** (0.0864)	0.258*** (0.0863)	0.261*** (0.0862)	0.261*** (0.0862)	0.261*** (0.0862)
HH Head Age			0.00226 (0.00145)	0.00228 (0.00147)	0.00198 (0.00146)	0.00199 (0.00146)	0.00199 (0.00146)	0.00199 (0.00146)
Literacy				0.0349*** (0.0133)	0.0224 (0.0138)	0.0234* (0.0140)	0.0234* (0.0140)	0.0234* (0.0140)
Teenagers					0.0478*** (0.0182)	0.0497*** (0.0182)	0.0497*** (0.0182)	0.0497*** (0.0182)
Children						-0.0111 (0.0144)	-0.0111 (0.0144)	-0.0111 (0.0144)
Rainfall Variability $RainVar_i$ (2001)							-0.943*** (0.301)	
$RainSeasonVar$								-0.720*** (0.230)
Observations	2,102	2,102	2,099	2,066	2,066	2,066	2,066	2,066
R-squared	0.150	0.153	0.156	0.158	0.161	0.161	0.161	0.161

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Equation 2 introduces the interactive term of the remittances crossed with the rainfall variability index. The results of this estimation are presented in Table 6. It should be noted that the coefficient associated with the interaction between remittances and the rainfall index is positive and significant, while the rainfall index introduced additively has a negative impact on food security, as expected. Remittances then significantly dampen the negative effects of rainfall variability on food security.

Table 6. The role of remittances in the context of climate variability - OLS results on interactive term

	All HHs				
Dependent Variable	Food Security				
Remittances R	0.00118** (0.000502)	0.00122** (0.000511)	0.00122** (0.000508)	0.00118** (0.000503)	0.00115** (0.000503)
Rainfall Variability $RainVar$	-0.171*** (0.0547)	-0.176*** (0.0544)	-0.169*** (0.0544)	-0.187*** (0.0538)	-0.179*** (0.0527)
$R \times RainVar$	0.00121* (0.000705)	0.00128* (0.000718)	0.00127* (0.000714)	0.00121* (0.000706)	0.00119* (0.000704)
Rural	-1.531*** (0.128)	-1.547*** (0.129)	-1.558*** (0.129)	-1.529*** (0.131)	-1.528*** (0.131)
HH Head Gender		0.282*** (0.0789)	0.287*** (0.0798)	0.281*** (0.0819)	0.281*** (0.0818)
HH Head Age			0.00222 (0.00145)	0.00225 (0.00147)	0.00197 (0.00146)
Literacy				0.0329** (0.0130)	0.0217 (0.0138)
Teenagers					0.0480*** (0.0182)
Children					-0.0102 (0.0143)
Observations	2,102	2,102	2,099	2,066	2,066
R-squared	0.155	0.159	0.161	0.163	0.166

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

4.3 Robustness checks

The robustness of the results is assessed in different ways. First, we check whether the results are affected by the definition of the rainfall variability index. We consider (i) a broader temporal range of coverage with rainfall variability computed starting in 2001 instead of 2007, and (ii) a rainfall variability index accounting for the cropping season, due to the population's practice of subsistence agriculture. Second, we consider that the food security index is measured as per capita food expenditures. Third, we try to check whether the results are affected by the magnitude of remittances received by households and consider the 50% of households that receive the highest amounts in remittances.

Table 7 shows that previous findings are accurate, even when the year of the rainfall index calculation is changed. In addition, food expenditures react similarly to remittances.

When we look at the 50% of households that receive the highest amounts in remittances, we find that this source of income still has a positive impact on food security.

Table 7. Impact of remittances and climate variability on food security - Robustness checks- OLS results

	All HHs					50% of HHs receiving highest amount in remittances	
Dependent variable:	Food Security	Food Security	Food Security	Food Expenditures	Food Expenditures	Food Security	Food Security
Remittances R	0.00115** (0.000503)	0.000810** (0.000349)	0.00155*** (0.000288)	19.96** (9.493)	25.88*** (9.934)	0.000940* (0.000526)	0.00115*** (0.000227)
Rainfall Variability $RainVar$	-0.179*** (0.0527)			-840.3** (345.4)	-853.0** (351.7)	-0.168** (0.0779)	-0.207* (0.112)
$R \times RainVar$	0.00119* (0.000704)				27.50* (16.10)		0.00124*** (0.000370)
Rural	-1.528*** (0.131)	-1.535*** (0.131)	-1.531*** (0.109)	-3,658*** (406.2)	-3,818*** (404.1)	-1.653*** (0.215)	-1.582*** (0.160)
HH Head Gender	0.281*** (0.0818)	0.279*** (0.0825)	0.277*** (0.0937)	-1,324*** (350.7)	-1,288*** (348.3)	0.108 (0.130)	0.164 (0.127)
HH Head Age	0.00197 (0.00146)	0.00199 (0.00146)	0.00193 (0.00144)	-15.25*** (5.386)	-16.27*** (5.416)	0.00262 (0.00268)	0.00258 (0.00221)
Literacy	0.0217 (0.0138)	0.0226 (0.0139)	0.0216 (0.0133)	39.61 (50.00)	xx	-0.0192 (0.0215)	-0.0193 (0.0210)
Teenagers	0.0480*** (0.0182)	0.0477*** (0.0181)	0.0487** (0.0192)	22.57 (71.98)		0.0841*** (0.0282)	0.0819*** (0.0287)
Children	-0.0102 (0.0143)	-0.0101 (0.0143)	-0.0106 (0.0161)	-37.69 (60.51)		-0.00658 (0.0212)	-0.000896 (0.0238)
$RainVar$ (2001)		-0.907*** (0.305)					
$R \times RainVar$ (2001)		0.000856* (0.000476)					
$RainSeasonVar$			-0.857** (0.415)				
$RainSeasonVar \times R$			0.00122*** (0.000416)				

Observations	2,066	2,066	2,066	2,066	2,099	853	853
R-squared	0.166	0.165	0.165	0.165	0.190	0.215	0.220

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The last column presents estimates on the half of households that received the highest amount in remittances.

4.4 Instrumentation

The main concern for identification concerning remittances is their potential endogeneity. The first source of potential endogeneity can come from the non-inclusion of some omitted variables that can bias the relationship between remittances and food security. Also, there is a high probability that remittances and food security influence each other (Gupta, Pattillo, & Wagh, 2009). On the one hand, migration (leading to remittances) can constitute an adaptive strategy for households that experience food insecurity. On the other hand, remittances can influence food security, as they constitute an important source of income for poorer and less food-secure households. In order to tackle the potential endogeneity of remittances, we proceed to instrumentation using two variables.

Table 8 shows the results of instrumenting with one variable (IV1) and with two variables (IV2), as well as the statistics of Wald and Sargan, accordingly. Column (IV1) therefore presents the results when the model is perfectly identified, and column (IV2) when the model is overidentified.

The first instrument accounts for the migrant level of education and is a variable that takes the value of 1 if the migrant has at least a primary level of school, and 0 otherwise.[9]. The relationship between a given migrant's education and remittances is ambiguous. Early literature tends to conclude that migration of the skilled, or the brain drain has a negative impact on potential remittances in the home country (Bhagwati, 1976). However, today the literature is less clear-cut. On the one hand, more skilled migrants can remit less as they often come from richer families and are more likely to migrate with their entire household (Faini, 2007). In this case, sending remittances back to the origin country does not really make sense. On the other hand, migrants can remit more as they are more educated and less likely to be illegal (Docquier, Rapoport & Salomone, 2012). Hence, they can have access to banks and cheaper transfers, and can consequently remit more. (Docquier, Rapoport,& Salomone, 2012) also theoretically and empirically investigate the relationship between remittances and migrant education using several databases on migration, accounting for a large panel of origin countries. Their model suggests that a migrant's education has a positive impact on remittances

[9] As households can have more than one migrant, we took the mean level of schooling for all migrants in the household.

when the immigration policy of the destination country is more restrictive and less skill-selective. In a cross-country macroeconomic work (Niimi & al 2010) find that remittances decrease with the share of migrants with tertiary education. The authors argue that this might be a reason why source countries may prefer unskilled migration. In a theoretical and empirical work on developing countries (Faini, 2007) shows that skilled migrants have a lower propensity to remit from a given flow of earnings.

Table 8 allows us to understand that for this specific case study, migrants with at least a primary school level remit more.

Our second instrument is inspired by (Christopher & Zenteno, 2007) and (Asli, Córdova, Pería & Woodruff, 2011), who use distance from migrants' households to railway lines to explain migration and remittance patterns in Mexico. We believe that using this instrument allows us to capture a historical pattern of migration, in order to explain more recent and current patterns and therefore use the distance between the households and the sole railway, leading to Ivory Coast, to capture the flow of migration and remittances. Using distance to railway can be a good way to do so in Burkina Faso, as the history of this railway infrastructure is linked to the population's migration and movement across the country.

This railway, which spans 1,260 km today, was constructed between 1904 and 1954 and connects Abidjan in Ivory Coast to Ouagadougou in Burkina Faso. The construction reached Ferkessedougou, a city at the border between the two countries in 1926 and the first city of Burkina Faso, Bobo Dioulasso in 1934. Burkinabe men who were seen as a source of labor force in sub-Saharan Africa during colonial times, were the main builders of the railway (Coulibaly, 1986).

The work of (Piché & Cordell, 2015) on migration patterns in West Africa shows that nearly 61,000 Burkinabe migrants, half of them originating from the central part of the country, worked on the railway which was called "the railway of the Mossi" after the main ethnic group of Burkina Faso originating from the central regions. Piché and Cordell also describe how internal and international migration was facilitated by the extension of the railway to Ouagadougou in 1954.

It is well recognized that in developing countries internal migration moves from rural areas toward the largest and major cities, as migrants hope to find better economic opportunities in cities. According to (Coulibaly, Desrosiers, Gregory & Piché, 1980), the most dynamic cities in 1975 in terms of migration were Koudougou for its textile industry, and Banfora, mainly because of the trade generated by the railway via Ivory Coast.

Regarding international migration, it is necessary to understand the complex history between Burkina Faso and Ivory Coast, [10]. which has incontestably shaped the migration patterns of Burkina Faso. For instance, in the early 1930s, Burkina Faso[11] became a part of Ivory Coast as a consequence of French West African administration, while other parts of the country joined other neighboring countries (Burkina Faso subsequently recovered its original borders after independence in 1960). Between 1951 and 1955, Ivory Coast was the leading recipient country of Burkina Faso's migrants, while receiving nearly 60% of them (Piché & Cordell, 2015). After the independence of both countries in the 1960s, this pattern remained thanks, for instance, to the expansion of the railway line between Burkina Faso and Ivory Coast.

We argue that the proximity of the railway line can have an impact on the development of regions and the development of markets, inevitably impacting food security. To control for the potential impact of the development of the region, we firstly include a variable accounting for the incidence of poverty in the region [12], to take into account the development of the different regions. Secondly, we use the night-time luminosity intensity recorded between 2009 and 2010 at the household's geographical location to take into account the different levels of development within villages and more precisely among households.

Luminosity data use for social and environmental research responds to the difficulty in some developing countries to find reliable subnational socioeconomic data. Night-time luminosity data can be considered as a good proxy of economic and demographic variables. It has been shown to be highly correlated with income (Chen & Nordhaus, 2011). In the same vein, frequency of lighting can predict GDP per capita at national and

[10] Historical main destination of Burkina Faso international migrants.
[11] Upper Volta at the time.
[12] This variable is taken from the yearly reports of the « *Institut National de la Statistique et de la Démographie* » of Burkina Faso and represents the proportion of people living under the poverty line per region.

subnational levels (Ebener, Murray, Tandon, & Elvidge, 2005). This luminosity variable is computed using stable light data presented in digital numbers from 0 to 63. These digital numbers are then summed up to calculate aggregate luminosity for a 1° longitude × 1° latitude grid cell.

Results in Table 8 show that when instrumenting, remittances still positively impact food security and have a higher coefficient, while rainfall variability has a negative effect. The proportion of people living under the poverty line has a negative impact on food security, as expected.

Table 8. Impact of remittances and climate variability on food security - IV results

	All HH			
Dependent variable:	Food Security IV1.1	Food Security IV2.1	Food Security IV1.2	Food Security IV2.2
Remittances R	0.00607*** (0.00213)	0.00675*** (0.00198)	0.00612*** (0.00216)	0.00685*** (0.00201)
Rainfall Variability $RainVar$	-3.917*** (0.996)	-3.417*** (1.086)	-3.621*** (0.995)	-3.216*** (1.085)
$R \times RainVar$	0.00305*** (0.000898)	0.00331*** (0.000852)	0.00315*** (0.000919)	0.00343*** (0.000871)
Luminosity	0.00724** (0.00305)	0.00715** (0.00314)	0.00778** (0.00304)	0.00771** (0.00313)
Poverty Incidence	-0.169*** (0.0417)	-0.151*** (0.0447)	-0.156*** (0.0417)	-0.142*** (0.0447)
Rural	-1.280*** (0.151)	-1.252*** (0.150)	-1.311*** (0.150)	-1.282*** (0.150)
HH Head Gender			0.439*** (0.126)	0.460*** (0.127)
HH Head Age			0.00224 (0.00170)	0.00221 (0.00176)
First Stage Equation				
Dependent variable:	Remittances	Remittances	Remittances	Remittances
Distance to Railway		-0.355256***		-0.35299213***
Migrant Education Level	29.5104 ***	29.3557 ***	29.08247 ***	28.90084 ***
Other Controls	YES	YES	YES	YES
Wald F Test / Sargan Stat	26.621	(0.4751)	25.701	(0.4558)
Observations	1,913	1,913	1,910	1,910

Robust Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
IV1 and IV2 refer respectively to the use of 1 and two instruments. Sargan Statistic in IV2 is in parenthesis.

Based on the column IV2.1 of Table 8, we found that an amount of remittances of 1,284,262.30 FCFA, or USD 2,167 per household and USD 309.57 per capita is necessary annually to dampen the negative effect of rainfall variability on food security. In 2010, the World Development Indicators estimated the GDP per capita of the country at USD 592.61. Hence, based on this particular survey, households may need nearly half of the GDP per capita of the year to cope with the negative impact of rainfall variability on food security.

For robustness purposes, we extend results of Table 9 by introducing additional control variables. Our results are still robust, and go along with our main findings.

Table 9. Impact of remittances and climate variability on food security - Robustness checks IV results

	All HH			
Dependent variable:	Food Security IV1.1	Food Security IV2.1	Food Security IV2.2	Food Security IV2.3
Remittances R	0.00632*** (0.00222)	0.00698*** (0.00205)	0.00489* (0.00285)	0.00645*** (0.00238)
Rainfall Variability $RainVar$	-3.276*** (1.022)	-2.929*** (1.111)	-3.099* (1.709)	
$R \times RainVar$	0.00322*** (0.000960)	0.00347*** (0.000905)	0.00280** (0.00129)	
Luminosity	0.00725** (0.00326)	0.00720** (0.00335)	0.00490 (0.00421)	0.00749 (0.00483)
Poverty Incidence	-0.141*** (0.0427)	-0.129*** (0.0458)	-0.132* (0.0722)	-0.116*** (0.0280)
Rural	-1.303*** (0.150)	-1.279*** (0.150)	-1.244*** (0.313)	-1.348*** (0.170)
HH Head Gender	0.443*** (0.133)	0.464*** (0.133)	0.283 (0.194)	0.397*** (0.128)
HH Head Age	0.00210 (0.00175)	0.00208 (0.00180)	0.00530 (0.00324)	0.00214 (0.00185)
Literacy	0.00454 (0.0166)	0.00331 (0.0170)	-0.0455 (0.0296)	0.00857 (0.0152)
Teenagers	0.0330 (0.0250)	0.0305 (0.0255)	0.0513 (0.0409)	0.0353 (0.0243)
Children	0.0125 (0.0207)	0.0141 (0.0211)	0.0287 (0.0338)	0.0118 (0.0171)
Rain Season Var				-13.06*** (3.136)
First stage equation Dependent variable:	Remittances	Remittances	Remittances	Remittances
Distance to Railway		-0.3539722***	-0.6619867***	-0.3160181***

Migrant Education	28.87324 ***	28.67016***	23.10965***	31.09974***
Other Controls	YES	YES	YES	YES
Wald F test /Sargan Stat	24.545	(0.5179)	(0.7265)	(0.2659)
Observations	1,877	1,877	770	1877

Robust Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
IV1 and IV2 refer respectively to the use of 1 and two instruments. Sargan Statistic in IV2 is in parenthesis.

5 Conclusion

In this paper, we investigated ed the effect of remittances on food security for the year 2010 while matching data from the World Bank survey on migration and remittances in Burkina Faso and rainfall data recorded by the ten weather stations across Burkina Faso.

We demonstrate that remittances had a positive and significant impact on household food security, while rainfall variability affected food security negatively. These results are robust to the inclusion of several control variables as well as alternative measures of climate variability, subsampling of the data, and instrumentation. We also show the role of remittances in dampening the negative effect of rainfall variability on food security and calculate the amount necessary to cancel the negative effect of climate variability.

Our results indicate that migration can be considered as a viable strategy for coping with food insecurity. It is therefore important to encourage any policy that aims to improve the ease of sending this important source of income back to migrants' origin countries. In addition, Burkina Faso is likely to experience more episodes of climate disorder in the near future. Helping populations to invest remittances in activities other than agriculture can be a risk management, strategy and a way of reducing dependence on rain-fed agriculture, which is highly sensitive to climate conditions.

Though remittances have been shown helpful in enhancing food security, they should be complementary devices in a broader set of national and international assistance initiatives. As the IPCC's fifth assessment on adaptation points out, "Across the continent, most of the adaptation to climate variability and change is reactive in response to short-term motivations, is occurring autonomously at the household level, and lacks support from government stakeholders and policies". Given the intensification of climate variability and natural disasters, it may well be necessary to focus on ex-ante adaptation strategies, targeting the most vulnerable populations, who are usually also the poorest.

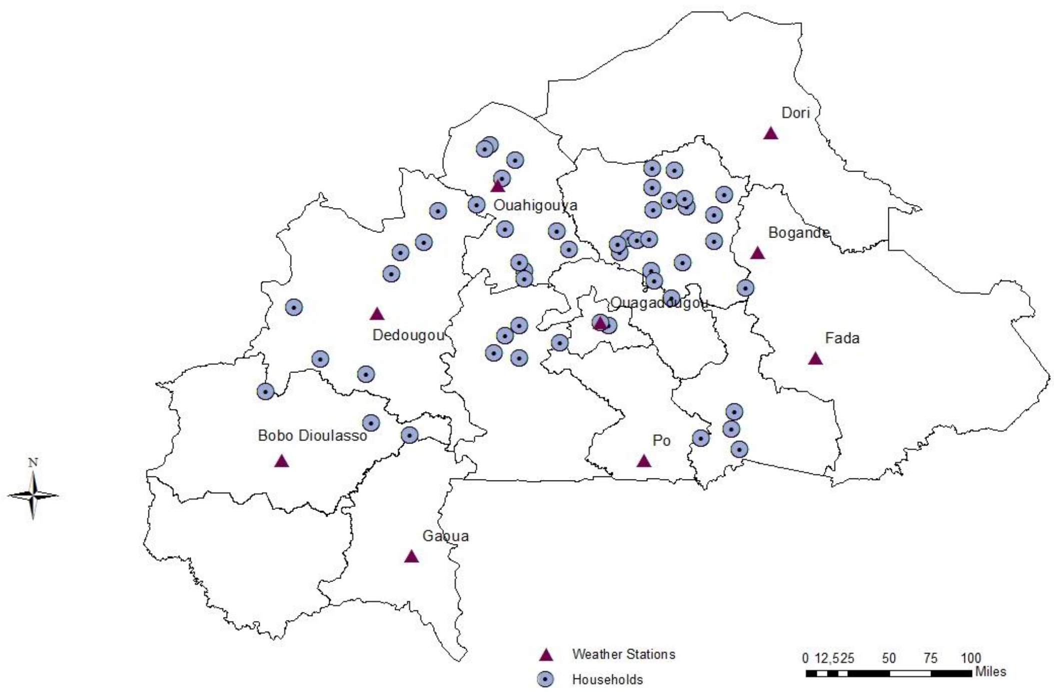
Such strategies should, therefore, be financed by government initiatives with the aid of migrant input, through remittances. Policies and initiatives that can foster the facility of remittances should, therefore, be encouraged.

Appendix

Appendix 1: Localization of surveyed villages and weather stations.

Burkina Faso is divided into 13 administrative regions, which encompass 45 provinces. The regions observed in this survey are: Boucle du Mouhoun, Center-Est, Western-Center, Center, North-Center, North, Hauts Bassins. Provinces observed in the survey are: Banwa, Sourou, Kadiogo, Namentenga, Sanmatenga, Boulkiemde, Boulgou, Tuy, Passoré, Yatenga.

Carte 1 Surveyed households and weather stations



Source: The World Bank and authors' work

Appendix 2: An overview of the rainfall variability per region and per weather station

Region of Surveyed Households	Rainfall Variability	Nearest Weather Station
Boucle du Mouhoun	1.19258	Dedougou
Centre	0.47455	Ouagadougou
Centre Nord	0.51869	Dori
Centre Ouest	0.47455	Ouagadougou
Centre Est	0.66824	Fada N'Gourma
Hauts Bassins	1.39412	Bobo Dioulasso
Nord	0.00657	Ouahigouya

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