POLICY BRIEF

Impact of Climate Variability on Crop Diversification in West African countries

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Abstract

This paper analyses the impact of climate variability on cereal, root, and tuber crops diversification for selected West Africa countries during the period 1965-2014. Crop diversification index, lumping together cereal, root and tuber crops, was calculated through the Composite Entropy Index. Climate variability is measured by the coefficient of variation of temperature and precipitation. A

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Seemingly Unrelated Regression was used to estimate the relationship between climate variability and crop diversification by controlling for supply and demand side factors of crop diversification. Overall, the results reveal that variability in temperature and precipitation over decades did not have an adverse effect on cereal root and tuber crops diversification. A detail analysis showed that Niger and Togo have been the most adapted to climate variability while Ghana was the most affected, mainly by precipitation variability. The results also indicated that, on the supply side, the availability of agricultural land contributed to crop diversification. Productivity, which is expected to increase crop diversification, was positive and significant in very few countries. In the others, it was not enough to improve crop diversification. On the demand side, population growth and consumption led to crop diversification, particularly in consumption of roots and tuber crops. This study suggests that greater diversification would mitigate the negative impact of climate variability. Therefore, regional, and national agricultural policies aimed at increasing productivity are necessary to encourage farmers to diversify food crops under climate variability.

Introduction

Literature related to the impact of climate change in West Africa shows that for some years, there have been signs that temperature and rainfall have changed significantly (De Bruijn and Van Dijk, 2006; FAO, 2008; Brown and Crawford, 2009; Jalloh et al., 2013). A substantial body of empirical research reveals that climate change and variability threaten agriculture and food production (Parry et al., 2004; Lobell et al., 2008; Schlenker and Lobell, 2010; Müller et al., 2011). Reviewing these studies and other country-specific studies, Roudier et al. (2011) found that the negative impact of climate change results mainly from temperature, and it is much larger relative to change in precipitation. Furthermore, the predicted potential impact of climate change showed that the median values of country-average yield loss of cereal crop would be 13% and 18% in the southern (Guinean countries) and northern (Sudano-Sahelian countries) parts of West Africa, respectively. Consequently, regions most vulnerable to food insecurity will be affected by a severe food deficit. To address this situation, farmers need to find solutions to enable them to produce enough food for their home consumption or even for the market. One possible solution is crop diversification.

Crop diversification is about crop area allocation and cropping pattern (FAO, 2001). In the context of growing uncertainties, crop diversification is a potential strategy to cope with weather, market, and environmental risks. Crop diversification can improve yield stability and crop resilience under changing climatic conditions (Bradshaw et al., 2004; Seo, 2010; Lin, 2011, Bezabih and Sarr, 2012; Njeru, 2013; Huang et al., 2014; Roesch-McNally et al., 2018). Indeed, as climate variability increases, the value of resilience will also increase, especially in production systems sensitive to climate variation. A farmer's decision to move towards diversified agricultural systems will be highly influenced by the ability of the diversification strategy to support the economic resilience of farms (Lin, 2011). Crop diversification can also manage market risks (McGuire, 1980; Dilley et al., 2005; Kahan, 2008; Mukherjee, 2010). Price variability strongly influences an individual farmer's planting decision. They diversify their production to reduce the risk of income volatility. Moreover, climate change is likely to reduce food safety due to environmental risks resulting from increased temperatures or weather events (Miraglia et al., 2009; Tirado et al., 2010; Liu et al., 2013; Hammond et al., 2015; Campbell et al., 2016). In such situations, farmers may diversify crops to mitigate potential losses due to climate change.

In West Africa, agriculture plays a key role in the national economies and is the major source of livelihood (Jalloh et al., 2013). Several cereal, root and tuber crops are widely grown in the region. The major crops grown and consumed are sorghum, millet, maize, rice and fonio (cereals), cassava, sweet potato, yams, and taro (roots and tubers). They are the most important staple crops and are rich sources of protein, minerals, and vitamins. Therefore, the abundance and diversification of these crops are essential for ensuring food security and improving nutrition. Moreover, cereal-root crops mix is one of the dominant systems farming in West Africa (Dixon et al., 2001; World Bank, 2009; Callo-Concha et al., 2012; Benin, 2016). At the production level, the total areas harvested for cereal, root and tuber crops have grown. From the 1960s to the 2010s, the area harvested increased from 20 million hectares to more than 50 million hectares for cereals and from 2.7 million hectares to more than 20 million hectares for roots and tubers.[2] Furthermore, area allocation (i.e. the share of area harvested of individual crop to total harvested area of crop category) changed during this period.[3] The share of areas harvested of some major food crops decreased to the benefit of some minor food crops. These changes occurred from the 1980s, when the total areas harvested have also increased. At the same time, it is known that the climate has varied significantly. These observations lead us to ask the following questions: Does climate variability adversely affect the diversification of cereal, root, and tuber crops? If yes, what is the strength of the relationship?

Recent studies in West Africa (Parry et al., 2004; Lobell et al., 2008; Schlenker and Lobell, 2010; Müller et al., 2011; Roudier et al., 2011) have analyzed the long-term impact of climate variability on individual crops. They found that climate variability negatively affected crop yields. However, the exploitation of food crop diversification as a strategy to adapt to long-term climate variability has not been critically examined. This study intends to show whether climate variability influences crop diversification in West Africa, particularly for cereal, root and tuber crops. The aim of this study is

2 Figure 2 (FAO data).

3 Table 1 & 2 (FAO Data).

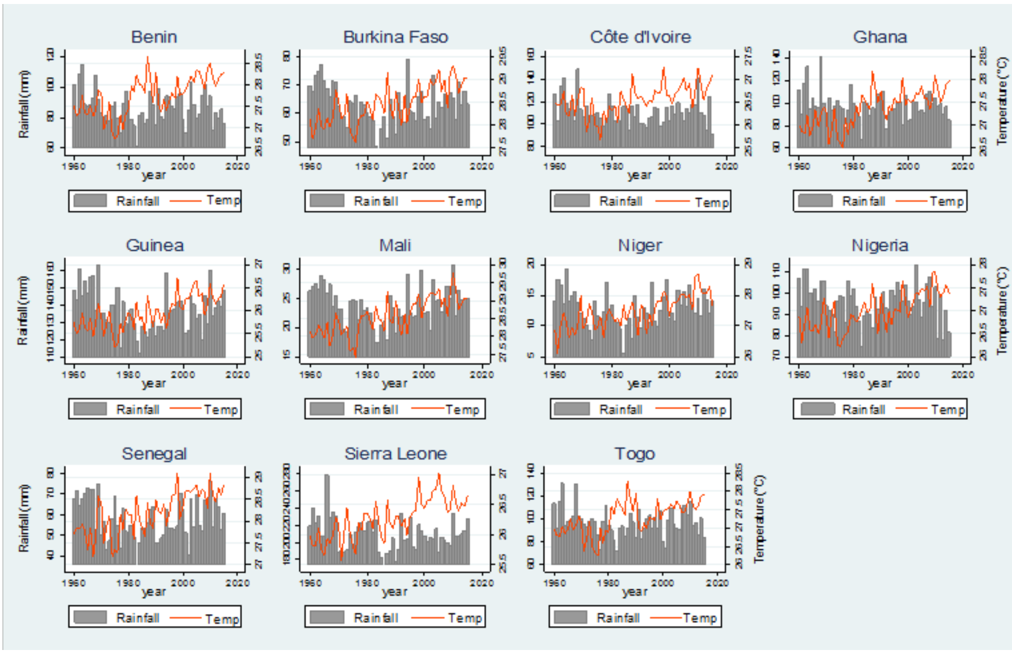
to investigate the link between climate variability and crop diversification, lumping together cereal, root and tuber crops in eleven countries of West Africa using dynamic panel data model. Specifically, land allocated to each individual crop is aggregated to calculate the level of crop diversification by country using the Composite Entropy Index (CEI). Secondly, the strength of the relationship between interannual variability of temperature and precipitation and crop diversification are estimated by controlling for supply and demand side factors of crop diversification. We also take account of the interaction between temperature and precipitation variabilities to capture a simultaneous long-term change in these two climatic variables. Having a long panel data with small cross section units and large time, we applied a Seemingly Unrelated Regression (SUR) technique that is more appropriate than fixed or random effects panel data. Indeed, the SUR method proposed by Zellner (1962) is a way of estimating panel data models that are long (large T) but not wide (small N). It enables an efficient joint estimation of all the regression parameters and accounts for heteroskedasticity and contemporaneous correlation in the errors across equations.

Climate variability in West Africa

Several studies (De Bruijn and Dijk, 2006; FAO, 2008; Brown and Crawford, 2009; Jalloh et al, 2013; Riede et al., 2016) and climate data in West Africa (Figure 1) reveal that temperature and rainfall have changed considerably. The period 1930-1960 was characterized by a wet climate, followed by droughts in 1970-1980 and a return of rainfall in the 1990s and 2000s, affecting Sahel's population (FAO, 2008). De Bruijn and Dijk (2006) found that climate variability is the most significant problem in the region. The variability of rainfall is enormous, sometimes up to 40-80% and increases with decreasing annual rainfall totals and especially in marginal areas such as the Sahara Desert where unpredictability of rainfall poses enormous threats to food security.

Brown and Crawford (2009) revealed that at the end of the century, global temperature in the region will rise by around 1.8°C, which will lead to a 20-30% decrease in water availability in some vulnerable regions of the world. Countries such as Côte d'Ivoire, Ghana, Guinea, Nigeria, and Togo have experienced a reduction of at least 50-100 millimetres of rainfall per year, whereas rainfall is predicted to increase substantially in the Sahelian countries such as Burkina Faso, Niger and Senegal. Moreover, temperature increases by an average of 2°C in the region. The 5th Intergovernmental Panel on Climate Change report warns that West Africa is expected to be strongly impacted by temperature increase ranging between 3 and 6°C above the late 20th century baseline (Riede et al., 2016). Figure 1 confirms these observations; it shows that the average annual rainfall and temperature in West Africa countries have changed over the last 50 years (1960-2015). Over this period, temperature has shown an upward trend while up and down situations were observed for rainfall in the countries. The consequences are that climate vulnerability has negatively affected food crops and food security, as it has been demonstrated in some studies (Parry et al., 2004; Butt et al. 2005; Lobell et al., 2008; Paeth et al., 2008; Müller et al., 2011; Schlenker and Lobell, 2010; Roudier et al., 2011).

Figure 1: Average annual temperature and rainfall for 11 West African countries, 1960-2015

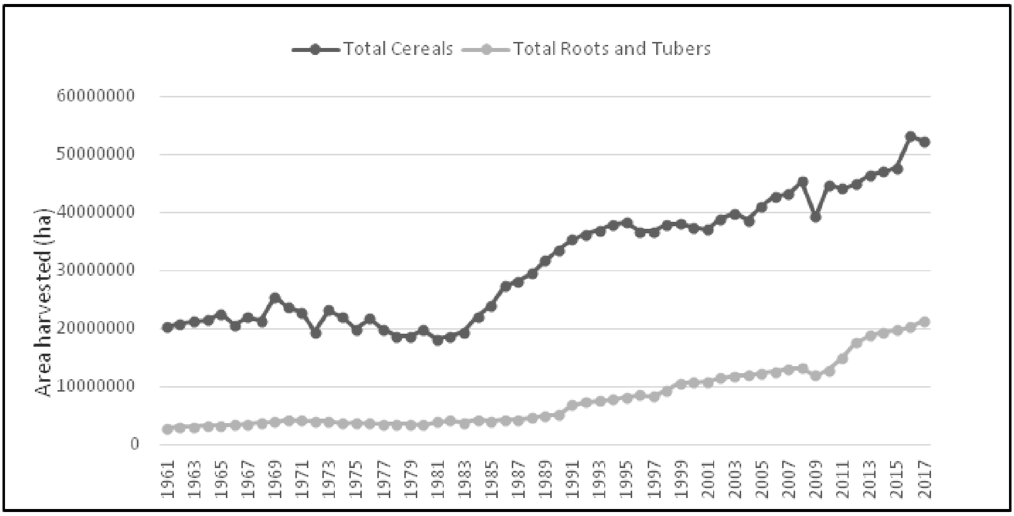


Source: Elaborated by author from Climatic Unit Research (CRU) database

Changing land use pattern among cereal, root and tuber crops in West Africa

West Africa has an advantage of growing diversified food crops in view of its land availability. First, the FAO's data show that over the period 1961-2017, the areas harvested for cereal and tuber crops have grown (Figure 2). The harvested area more than doubled from 20 million hectares to more than 50 million hectares, while that of root and tuber crops has increased almost tenfold from 2.7 million hectares to 20.0 million hectares. The trends show that during the 1960s and 1970s, the harvested area of cereal crops has evolved into a saw tooth trend while the harvested area of root and tuber crops remained constant. It is from the 1980s that the areas harvested of both groups of crops increased sharply. However, the area of cereal crops showed a more rapid growth than that of roots and tubers.

Figure 2: Trend of total area harvested for cereal, root, and tuber crops from 1961-2017



Source: Elaborated by author from FAO database

Secondly, the distribution of individual cereal, root, and tuber crops (i.e. the share of area harvested of individual crop in total harvested area of crop category) changed during 1961-2017. Table 1 shows that in the 1960s, millet and sorghum occupied about 41.8% and 36.8%, respectively, of total harvested area under cereals, while maize and rice represented only 12.7% and 7.3%, respectively. The share of area harvested for millet and sorghum decreased from about 41.8% to 27.8% and 36.8% to 29.3% during the 1960s and 2010s, respectively, while in the same period, the share of area for maize and rice increased from about 12.7% to 23.9% and 7.3% to 17.1%, respectively. The figures point out that the cropping pattern for cereals tend to diversification.

Conclusion and policy implications

In this paper, we have examined the impact of climate variability on cereal, root, and tuber crops diversification for eleven (11) selected countries in West Africa over the period 1965-2014. Indeed, cereal, root and tuber crops are the most important staple crops grown and consumed in the region. They are not only essential to food security, but are a rich source of proteins, minerals and vitamins needed to ensure children's nutrition. Over the last decades, there is evidence that climate variability adversely affected crop yield, and the negative impact results mainly from temperature.

In this paper, we have shown that climate variability characterized by long-run change interannual temperature and precipitation negatively affect cereal, root, and tuber crop diversification. A seemingly unrelated regression was used to estimate a dynamic panel data. The results reveal that, in many cases, variability in temperature and precipitation over decades did not have an adverse effect on cereal root and tuber crops diversification. The results also indicate that an increase in demand for cereals, roots and tubers, and population, are positively associated with crop diversification in most countries. However, the productivity of these crops is not yet sufficient to promote great diversification.

One of the limitations of the study is that it did not consider prices. Price variability can influence the farmer's decision to diversify or not. We wanted to include producer prices, but the data is not available over a long period. This study suggests that greater diversification would mitigate the negative impact of climate variability. Therefore, regional, and national agricultural policies aimed at increasing productivity are necessary to encourage farmers to diversify food crops under climate variability. It is necessary to invest in research to promote new varieties and ensure access to fertilizers and irrigation.

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