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Potential socio-economic implications of future climate change and variability for Nigerien agriculture: A countrywide dynamic CGE-Microsimulation analysis

Jean-Marc Montaud[a,*], Nicolas Pecastaing[a], Mahamadou Tankari[b]

[a] CATT, Université de Pau et des Pays de l'Adour (UPPA), 8 allées des platanes, 64100 Bayonne, France
[b] International Food Policy Research Institute (IFPRI), Dakar, BP 24063, Senegal

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ABSTRACT

This study explores the potential economic and social effects induced by a possible future deterioration of weather conditions on Niger's agriculture. Our scenarios over a 25 year period rely on both long term climate change deterministic features and climate variability stochastic features which take into account a higher than normal frequency of severe droughts. Using a microsimulated Dynamic Recursive Computable General Equilibrium model, we show how a long run mean decrease in main crop yields could adversely affect growth, poverty and food security in the country and how more severe drought would worsen these negative effects. However, we also show that there would appear to be some room for manœuvre for coping strategies for Niger such as improving the rural road network, adopting modern crop varieties or, to a lesser extent, extending irrigation capacity.

1. Introduction

The Nigerien economy depends strongly on its agricultural sector, a sector that occupies more than 80 percent of the workforce and contributes to more than 40 percent of GDP. However, this agriculture is handicapped by its low productivity and its exposition to a number of risks. Among the latter, the adverse climatic conditions are often considered to be the most severe (World Bank, 2013). Over the last few decades, the Sahel region has indeed been hit by rising temperatures, reduction in average rainfall and higher climate variability reflected, in particular, in more frequent major droughts (Druyan, 2011; IPCC, 2013). Within this context, the living conditions of the fast-growing population are particularly precarious, especially in rural areas where agriculture is the main source of income but also the main source of food. In 2010, 48,2% of Nigerien households were poors and rural areas contributed 90% to total poverty with a poverty rate of 54.6%; 48.1% suffered chronic malnutrition and more than 20% were affected by lack of food security and identified as being in a severely vulnerable situation (Herderschee et al., 2014). Noting the apparent consensus in agro-climate literature that Niger's future weather conditions could deteriorate and be characterized by both a drier climate and a higher frequency of severe droughts (Sylla et al., 2010; Mohino et al., 2011; Roudier et al., 2011; IPCC, 2013; Sultan 2013; Niang, 2014), the present study seeks to assess the risk that these possible deteriorations might entail for the Niger's economy and the welfare of its population. We draw here on several ways on the studies attempting to assess developing countries' vulnerability to possible changes in weather conditions.

First, regarding the modelling framework, we chose to build a Dynamic Recursive Computable General Equilibrium (DRCGE) model for the Nigerien economy. This framework seems indeed better suited to an economy-wide analysis of the potential effects of future agro-climatic shocks than others approaches in the literature (relying on Ricardian or partial equilibrium analysis). On the one hand, because the general equilibrium logic does not restrict the effects of the shocks to agriculture alone but also captures explicitly all the linkages between prices, income, supply and demand in the whole economy. On the other hand, because the use of a dynamic specification enables to generate time paths of the evolutions of the country's economic variables under different hypotheses for potential shocks over a given period. In the recent economic literature CGE studies on developing counties climate's vulnerability have known a rapid growth, either in a global or national framework (see for instance Gebreegziabher et al., 2016, for a review). However, to our knowledge, such analysis has never been

* Corresponding author.
E-mail addresses: jean-marc.montaud@univ-pau.fr (J.-M. Montaud), nicolas.pecastaing@univ-pau.fr (N. Pecastaing), M.Tankari@cgiar.org (M. Tankari).

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conducted for Niger. Our DRCGE model involves fairly standard general equilibrium assumptions for low income countries (Decaluwé et al., 2013). But, unlike the majority of other CGE studies, we also chose to consider some specific features of the Nigerien economy, particularly its dual nature, both in rural areas and urban areas (Stifel and Thorbecke, 2003). Moreover, using a top-down approach, we chose to link this model to a dynamic microsimulation (DMS) model in order to also assess the potential social outcomes of the future adverse climatic conditions at the micro level.

Second, regarding the nature of the climatic shocks simulated with the models, we chose here to use a three-pronged approach in order to isolate the respective potential effects of climate change and climate variability. In a first step, as with a majority of CGE studies (see for instance, Juana et al., 2008; Reid et al., 2008; Bezabih et al., 2011; Hertel et al., 2010; Bosello et al., 2013; Calzadilla et al., 2013; Gebreegziabher et al., 2016), we adopt a deterministic approach of climate change by considering solely the potential effects of long-run mean changes in agriculture (mainly crop yields reductions). We thus define a first group of agro-climatic scenarios over the next 25 years for Niger, on the basis of the main forecasts of average yield evolutions found in the agro-climate literature. However, limiting the agro-climatic shocks to average changes clearly underestimates their potential effects. In the literature, whenever possible, other CGE studies thus try to include some climate variability features using stochastic or probabilistic scenarios (see for instance, Thurlow et al., 2009; Yu et al., 2010; Arndt et al., 2011; Arndt et al., 2012; Sassi and Cardaci, 2013; Arndt et al., 2015; Arndt and Thurlow, 2015). Others, though in limited number, focus even more on future changes in extreme events and the disaster risks that they could represent for a country (see for instance World Bank, 2008; Pauw et al., 2011; Al-Riffai et al., 2012 or Zhong et al., 2014). In a second step, we therefore chose to focus on the risk of a potential future greater climate variability by defining a second group of agro-climatic scenarios including more frequent and more intense drought events for the next 25 years in Niger. These scenarios rely here on stochastic annual weather sequences including drought events with sizeable one-off impacts on yields, rainfed land depreciation or livestock capital. Finally, in a last step, we combine previous analyses in a range of scenarios including both climate change and climate variability features.

Third, some CGE studies (see for instance, Eboli et al., 2010; World Bank, 2010; Robinson et al., 2012; Bosello et al., 2013; Bandara and Cai, 2014; Calzadilla et al., 2014; Chalise and Naranpanawa, 2016) explore also different options for coping with future climate conditions focusing on either autonomous price-driven decisions of agents (mainly regarding primary factors-use change) or adaptation strategies that governments may promote. We thus chose to also asses the opportunity of such coping strategies for Niger. For that purpose, we selected some planned strategies specifically designed to boost agricultural productivity with a focus on improvements in the rural road network, expansions of irrigation capacity or changes in farm management practices.

The rest of the paper is structured as follows. Section 2 presents the current vulnerability of Nigerien agriculture to climate conditions and the hypotheses we selected for defining the different future agro-climatic scenarios. Section 3 describes the main features of our economic models and Section 4 presents the results of the different simulations. Finally, Section 5 explores the net impact of the coping strategies we selected in order to determine if they are capable of counterbalancing the effects of the changing weather conditions.

2. Background

2.1. Niger's current vulnerability to adverse climatic conditions

Despite the major efforts made since the 1970s by the Nigerien government to develop agriculture, this sector, which is essentially rainfed subsistence farming, is characterised by structural fragility. The decline in natural resources and in soil fertility, the traditional nature of systems of production, the lack of rural infrastructures, the weakness of state institutions or rural organizations, the low level of incomes which limit farmers' ability to invest, etc., are all handicaps which have a powerful impact on agricultural production and its ability to meet the needs of an ever-increasing population (3.5% growth per annum). But, beyond these constraints, which are relatively common in the least developed African countries, Nigerien agriculture is also constrained by particularly unfavourable climate conditions. The first reason has to do with the limit in the amount of arable land: only 12,5% of land is cultivated, mainly in the Sudan-Sahel and Sahel regions, the only areas to have rainfall in excess of 300 mm per year (FAO, 2016a). The second has to do with the detoriation of historical climate conditions over the last few decades. On the one hand, the continuous long term effects of climate change have contributed to an increase in average temperatures and a reduction in rainfall even in the more agriculturally productive southern regions on the country (see for instance Mohino et al., 2011; Druyan, 2011). On the other hand, climate conditions have also been characterised by a high inter-decadal variability as well as significant interannual variability, particularly reflected in a higher frequency and intensity of drought events (Epule et al., 2014; Masih et al., 2014). According to the World Bank (2013), there have already been three such major episodes leading to food crises since 2000 (2004/2005, 2009/2010 and 2011/2012), while only three episodes were observed between 1970 and 2000 (1973/1974, 1984/1985 and 1997/1998).

Under these adverse, changing climatic conditions, Nigerien farmers have preferred crops able to thrive despite low rainfall such as millet, sorghum or cowpea which together represent 92.7% of the harvested area and 61% of the crops' gross production value (Table 1). However their yields remain particularly low and unstable. Over the period 1980–2011, millet and sorghum yields fell 11.7% and 44.5% respectively even though an average increase (23.6% and 50.4% respectively) was observed over the period 2000–2011 (World Bank, 2013). This decade-by-decade instability has moreover been reinforced

Table 1
– Share of Harvested area, Production and Gross Production Value of major agricultural crops in Niger (in %).
Source: Own calculations based on FAO (2016a)

CROPS	Harvested area(1)	Production(1)	Gross Production Value(2)
Food crops	**62.47**	**54.59**	**41.11**
Rainfed	***62.38***	***53***	***39.74***
Millet	*42.21*	*37.65*	*29.90*
Sorghum	*20.17*	*15.35*	*9.84*
Irrigated	***0.09***	***1.59***	***1.37***
Cassava	*0.04*	*1.47*	*0.77*
Rice, paddy	*0.05*	*0.12*	*0.60*
Cash crops	**35.20**	**38.33**	**47.82**
Rainfed	***34.34***	***20.77***	***27.42***
Cowpeas, dry	*29.82*	*16.95*	*21.22*
Groundnuts, with shell	*4.52*	*3.82*	*6.20*
Irrigated	***0.86***	***17.56***	***20.40***
Fruit, fresh nes	*0.31*	*3.43*	*5.15*
Mangoes, mangosteens, guavas	*0.22*	*2.06*	*5.32*
Onions, dry	*0.14*	*4.29*	*3.88*
Cabbages and other brassicas	*0.06*	*2.44*	*1.57*
Tomatoes	*0.06*	*2.06*	*3.28*
Vegetables, fresh nes	*0.04*	*1.11*	*0.90*
Sugar cane	*0.03*	*2.17*	*0.30*

Notes: (1) Mean of 2012, 2013 et 2014; (2) Mean of 2012 and 2013.