Climate change, agricultural output, household income and policies in Senegal

Khady Yama SARR, WASCAL PhD in Economy of climate change
khadyyama@gmail.com

Abstract

The Senegalese agricultural sector shows low production level over the last decades. This study assesses the impact of climate change on crop production, household income and also tests policies instruments through a national static computable general equilibrium (CGE) model. The main results show that the local impacts of climate change (through declining yields) are likely to affect Senegal beyond the agricultural sector and farmers. The results show also after testing different policies instruments in the worst climate scenario for Senegal that decreasing the rice import tariff by 20% and subsidizing fertilizers are the most suitable policies instrument that can help to mitigate the negative effects that climate change has on agricultural sector in Senegal.

Résumé

Le secteur agricole sénégalais affiche un faible niveau de production au cours des dernières décennies. Cette étude évalue l'impact des changements climatiques sur la production agricole, le revenu des ménages et teste également les instruments de politique à travers un modèle d'équilibre général calculable (MEGC) statique national. Les principaux résultats montrent que les impacts locaux du changement climatique (à travers la baisse des rendements) sont susceptibles d'affecter le Sénégal au-delà du secteur agricole et des agriculteurs. Les résultats montrent également qu'après avoir testé différents instruments de politique dans le pire scénario climatique pour le Sénégal, la réduction de 20% des droits de douane sur les importations de riz et la subvention des engrais sont les mesures les plus appropriées qui peuvent aider à atténuer les effets négatifs des changements climatiques sur les secteurs agricoles au Sénégal.

This paper was presented at the Conference on Climate Change and Food Security in West Africa co-organized by Université Cheikh Anta Diop de Dakar (UCAD) and Center for Development Research (ZEF), University of Bonn, on 17-18 November 2019 in Dakar, Senegal.

Introduction

Senegalese agriculture is mainly rain-fed for more than 94% of the area planted. It is one of the main economic activities and the engine of growth in the framework of the implementation of the Senegal Emergent Plan (PSE) (Rapport revue conjointe agriculture, MAER, 2016). Agriculture is a key sector in Senegal economy and it is mainly the backbone of rural economy: 55% of the population lives in rural areas, 49.5% of these households have farming as main activity, 60% of these latter engage on rainfed agriculture (ANSD, 2014). Agriculture employs more than 70% of the Senegalese workforce. Most household cultivate on plots of 1 to 5 ha. Cereals like rice, millet and sorghum are key subsistence crops, while groundnuts, a main cash crop, are grown on 40% of cultivated land and employ up to 1 million people (USAID, 2017).

However, it is clear that climate change such as extreme weather events, increased incidence of droughts and floods, variability in rainfall and degradation of marginal lands will affect the agricultural sector and its many workers. Climatic projections of average (RCP 4.5) and extreme (RCP 8.5) scenarios indicate a general downward trend in rainfall by 2035 throughout the country. As for temperatures, for both scenarios (RCP 4.5 and RCP 8.5), there is a general upward trend. Temperatures would increase on average between 1.17 and 1.41 degrees Celsius by 2035 (NDC, 2017). This increase in temperature combined with a rainfall deficit could lead to a deterioration of the agricultural productive base resulting in: the reduction of the vegetation cover; a process of water and wind erosion leading to encrusting and degradation of soils; salinization related to saltwater invasion and poor drainage of land; loss of soil fertility and more specifically nutrient loss ((Crasswell et al., 2004 in Edward R. et al, 2004). All these forms of land degradation will result in a reduction of cultivated areas. The reduction in farmland could reduce cereal production by 20% in 2025 (Funk et al., 2012 in Edward R. et al, 2004).

Smallholder agriculture, which is predominantly rainfed, is already stressed by overexploitation of land, soil degradation, conflicts between herders and farmers, and limited access to extension services. Climate change is expected to amplify most of these challenges.

Without coordinated and appropriate policy measures shares these challenges jeopardize the prospects of the country achieving the Sustainable Development Goals. Not acting quickly can lead to a significant increase in the number of people needing assistance.

The objective of this paper is to assess the impact of climate change on the production volume of some crops (maize, millet/sorghum, groundnut) in Senegal, household income and to test alternative policies instrument that can help to mitigate fluctuations of quantities through a national static computable general equilibrium (CGE) model. The rest of the paper is organized as follow: section 1 presents the literature related to climate change and the general equilibrium model, section 2 described the model, the data and calibration issues; the climate scenarios and the different simulations are dealt with in section 3 and finally, the results are presented and discussed in section 4.

1. Literature related to climate change and the general equilibrium model

As climate change affects various sectors of the economy directly or indirectly, interactions between different sectors must be studied to assess the impacts of climate change on agriculture and productivity. CGE models are well suited to depict interactions between agriculture and other sectors in the economy.

Two broad approaches have been used to assess the impact of climate change on agriculture within the CGE framework. The first approach is to develop an integrated assessment model, which couples a CGE model with a partial equilibrium agricultural land use model. The second approach is to develop climate scenarios to determine the different changes in yields and introduce these changes to the production function of the CGE model.

There has been much development in "macro-micro CGE models" during the last decade. The application of CGE to assess the impact of global climate change on a national economy has been conducted in several research projects. There has been an explosive growth in analyses of developing countries' vulnerability to climate change, including its economy-wide impacts.

Breinsinger and al., (2008) use the Dynamic Computable General Equilibrium (DCGE) model to capture the growth and poverty linkages of the agricultural sector in Ghana. This model explicitly captures the following: agricultural production technology at the sub-sector level across agro-ecological zones; agricultural input demand, including demand for factors and intermediates; output distribution, i.e. for exports and domestic markets; and incomes from agricultural production. They found that agriculture accounted for about 39 percent of national GDP in Ghana in 2005. Although the 4.2 percent average agricultural annual growth is lower than those of the two nonagricultural sectors in the base-run, the size of agriculture in the economy only falls slightly to 38 percent by 2015. . In the face of slightly slower agricultural growth, agricultural prices rise for some products produced for domestic markets, especially those that are income elastic, such as rice, high-value products and poultry.

Pauw, Thurlow, and Van Seventer (2010) use stochastic hydrometeorological crop-loss models with a regionalized CGE model to estimate losses for the full distribution of possible weather events (drought and floods) in Malawi. Results for Malawi indicate that, on average, droughts and floods together reduce total GDP by about 1.7 percent per year. However, damages vary considerably across weather events, with total GDP declining by at least 9 percent during a severe 1-in-20-year drought. Smaller-scale farmers in the southern regions of the country are especially vulnerable to declining agricultural revenues and increasing poverty during drought and flood years.

Zhai et al., (2009) examined the potential long-term impacts of global climate change on agricultural production and trade in the People's Republic of China, using an economy-wide, global CGE model, as well as simulation scenarios of how global agricultural productivity may be affected by climate change up to 2080. This study suggested that, with a declining share of agriculture in GDP, the impact of climate change on the overall macro economy may be moderate. Food processing sectors carry the burden of some crop sectors (wheat, in particular) that are likely to expand due to increased demand.

Octaviani and al., (2011) measure the impact of climate change on the Indonesian economy using a combination of the partial equilibrium model and the CGE model as the main analytical tool. To analyze in detail the impact on the agricultural sector and macroeconomic conditions in Indonesia, they link IMPACT with the national Indonesian general equilibrium model (Indonesian CGE Model for Climate Change), which has different agricultural product aggregations and also includes labor aggregations.

They discovered that the impact on domestic prices, measured by the consumer price index (CPI), is expected to increase from –2.37 percent change in the baseline to –2.08 and –

2.17 percent change in Sims 2a and 2b, respectively, worsening the deflation of the baseline scenario. Prices increase particularly for paddies and rice under the MIROC A1B scenario, which shows higher impacts for Indonesia. Real household consumption is expected to slightly decrease because of climate change due to the decrease in average real wages in most labor classifications. Furthermore, operator and professional labor will suffer from the highest negative impact under the climate change scenario. They also found that there is a reduction in capital rental. Net export performance worsens because Indonesia has to focus on allocating resources to provide adequate supply in response to domestic demand of strategic food commodities (rice and maize).

2. Description of the model, data and calibration

To highlight the effects of climate change on the volume of production and household income in Senegal and to test alternative policies instruments, the methodology used in this study is based on a static computable general equilibrium (CGE) because it has the ability to analyze the interactions among different sectors. In this study, the model has four agents (government, firms, households and the rest of the world), two factors of production (labor and capital) and fourteen branches. The model structure is based on five blocks of equations describing the production, income and savings, demand, prices and trade with the outside; the balance is achieved in factor markets and commodity markets. Equality between savings and investment is realized.

2.1. The Representative Household

Households aim to maximize their utility function under the constraint of their budget. Their
income consists of the remuneration received from their supply of production factors namely labor and capital. In addition, households receive transfers from the Government and the rest of the world. Household preferences regarding their demand for consumer goods are represented using a linear expenditure system from the maximization of a Stone-Geary (SG) utility function.
The maximization program of the household h utility is as follows:
Max Π(Ci,h,t – CMINi,h,t)yi,h

$\sum_i Pci,h,t\ Ci,h,t = Rht$ With the following restrictions:

CMINi,h,t < Ci,h,t and $\sum_i Pmci,h,t = 1$

Pmci,h,t is the marginal consumption of good I; **CMINi,h,t** is the minimal consumption (in volume) of good i by the household h at time t.

The production process

Production activities are represented by branches of the national accounts system whose organization is based on the NAEMAS nomenclature. In the basic model, each activity j (j = 1, .., J) is the production of a single good noted i (i = 1, .., I).
In general, each producer aims to minimize costs, with a constraint production technology available according to the structure described in Annex. The technology is such that the production is a Leontief function of value added and a composite measure of inputs. Value added is, in turn, specified as a Cobb-Douglas function of labor and capital in non-agricultural sectors, while in the agricultural sector, it aggregates a composite of the primary factors that are labor and capital.
As for the composite measure of inputs, it includes disaggregated intermediate consumption

of the activity, according to a Leontief function.
The factors of production are labor and capital. It is assumed that there is a perfect segmentation of the labor market. In this market the supply of labor will be assumed exogenous while the wage rate will adjust to clear the market in response to changes in the demand for labor.
The supply of capital is supposed to be specific to sectors. The annual change in the capital stock is endogenous and determined by the following equation:

KDjt= (1- ¢(j)) KDjt-1 + INVjt-1

KDjt is the capital stock of the sector j at time t ; ¢**(j)** is the depreciation rate of capital of the sector j and **INVjt** represents the investment volume of sector j at period t.

The Final Demand

Final demand for each commodity i is formed by the sum of domestic and import demand of this commodity. Once incorporated, the final demand for any good i is the sum of final consumption, government consumption, investment and intermediate goods industries, following the traditional script of the equilibrium equation on goods and services.

Trade

The **foreign trade block** comes from export activities and the import of goods from the Senegalese economy. World prices of imports and exports will be assumed exogenous in that the analysis is conducted in the context of a small open economy. In general, for each product, export supply will be determined by arbitration between exports and supply on the domestic market, through a constant elasticity of transformation function (CET). In contrast, imports will come from the arbitration between the demand for locally produced goods and those addressed to the "rest of the world," according to a constant elasticity of substitution function (CES) or Armington function.

Government

The function of government is to collect indirect taxes on production, the components of final demand, direct taxes on incomes of households and enterprises and, finally customs duties and taxes on exports. It receives transfers from the "rest of world" and conducts itself in transfers to households, as well as subsidies to enterprises. Moreover, the government has resources in respect of capital remuneration. Its income thus formed is then used for its spending. Public resources are intended, first, for the consumption of goods (public consumption) and, on the other hand for investment (public investment). The difference between the state resources and its expenditures (current and investment) constitute the budgetary balance.

The market equilibrium, the model assumptions and mechanisms of closure

In terms of **macroeconomic closure of the model**, foreign savings will be assumed to be exogenous. The balance of the external account will be realized on the basis of the assumption of exogeneity of the trade balance and therefore, the adjustment process will be achieved through the real exchange rate. The meaning of this assumption is that the Senegalese economy cannot adjust to the external debt to cover internal imbalances, but should generate sufficient export earnings to proceed to the purchase of imported goods and services. In other words, any increase in imports of certain goods will be systematically offset by lower imports of other goods or by an equivalent increase in exports, to meet the constraint. In general, the prices of different goods adjust to balance the relevant markets. (Equations are in annexes)

2.2. Data and Calibration

The model is calibrated using the 2010 agricultural accounting matrix for Senegal (DPEE,
2010). DPEE is one component of the Senegalese ministry of economy.
The social accounting matrix (SAM) is a summary table that outlines the structure of
production in an economy through the use of production and operating accounts and the
interactions between the economic agents.

3. Brief description of the Climate Scenarios

To assess the impacts of climate change on agricultural output and household income, we used the results of the study of Dering (2015) on the impacts of climate change on crop productivity in semi-arid economies (Senegal, Burkina Faso, Kenya, etc.).

In the study, the author presents a comprehensive assessment of climate change impacts on crop productivity in semi-arid croplands in the world for the 2030s relative to the 2000s under a business-as- usual greenhouse gases (GHGs) emissions scenario (all results are shown for the emission rates associated with Radiative Concentration Pathway (RCP 8.5). Simulated changes in the extent of semi-arid areas and impacts on crop yield are presented. The geographical focus of the analysis is global, with a particular emphasis on six Pathways to Resilience in Semi-Arid Economies (PRISE) countries: Senegal, Burkina Faso, Kenya and Tanzania in Africa and Pakistan and Tajikistan in Central Asia. Results are shown with changes in climate (temperature, precipitation and radiation) from five different global climate models (GCMs) and crop yield impacts simulated by six different global gridded crop models (GGCMs) (an ensemble of 30 simulations). The results are sourced from a global climate impact assessment programme (Inter-Sectoral Impact Modelling Intercomparison Project (ISI-MIP)).

The study focuses also on 13 crops including maize, wheat for the full ensemble of GGCMs, as well as millet, groundnut, sorghum and peanuts for a subset of two GGCMs. Results take into account effects of elevated atmospheric CO2 concentrations under a business-as-usual GHGs emissions scenario (i.e. RCP 8.5). According to the study, In Senegal three climate models (HadGEM2-ES, IPSL-CM5A-LR and GFDL-ESM2M) project a drier climate, and two climate models (MIROC-ESM-CHEM and NorESM1-M) simulate a wetter climate.

The results show that in Senegal average crop yield by the 2030s decreases by 7.5 to 16.7% under Climate Change: yields of groundnut, millet, sorghum and maize decrease between 5.4% and 12.3% in the ensemble median. Under RCP 8.5 scenario with positive effects of CO2 concentration on crops, average crop yield decreases by 8.5 to 9.9%,groundnut, millet/sorghum fall respectively by 8.5% and 6% with maize experiencing the largest decrease (-8.8 to 14.7%)

Tableau 1: Climate change induced yield effects by crop, % change from yield with 2000 climate to yield with 2030 climate

	Scenario without CO2 effects on crops	RCP 8.5 scenario (with CO2 effects on crops)

Mais	Fall of 5.4% to 12.3%	Fall of 8.8% to 14.7%
Arachide	Fall of 5.4% to 12.3%	Fall of 8.5% to 9.9%
Mil	Fall of 5.4% to 12.3%	Fall of 8.5% to 9.9%
Sorgho	Fall of 5.4% to 12.3%	Fall of 8.5% to 9.9%

Source: Deryng (2015)

The RCP 8.5 scenario (2006–2300) assumes high population growth and high energy demand without climate change policies.

We introduce the different changes of yields in the production function of the CGE model by using minimum, mean and maximum of the ranges. The production volume is in tons.

4. Results and discussion

The results of the CGE model show that under climate change scenario without the positive effects of CO2 on crops, the production of all the crops (maize, millet/sorghum and groundnut) falls: 30.7% for maize, 29% for groundnut and 11.5% for millet/sorghum. The impact of climate change on the production volume is different between crops. The decline is much less important for millet / sorghum.

The household demand decreases due to higher prices resulting from the lower level of crop production. This is also explained by the reduction of the household income by 26%. This reduction of household income is due to the drop of salary rate in the agricultural activities sectors and also in the others economic sectors. The results of the CGE model show also that the climate projected in 2030 will lead to a decrease in agricultural value added by 11.5%

Under RCP 8.5 scenario including the positive effects of CO2 on crops, we noted a drop of the production volume of all the crops: 21% for maize, 17.5% for groundnut and 8.5% for millet/sorghum. The negative effects of climate change on crops are less important under RCP 8.5 scenario including the positive effects of CO2 than under climate change scenario without the positive effects of CO2. The household demand for millet and sorghum and maize decreases respectively by 12% and 16.5% due to the increase in their prices. The household income falls by 17% and the agricultural value added also decreases by 8%.

In conclusion, we can say that the projected climate in 2030s in Senegal will lead to a decrease in the production of the top four most produced crops (groundnut, millet, sorghum and maize), even when including positive effects of CO2. As a result, the productivity of the agricultural sector and the workforce will decrease. The fall in the household income due to the reduction of salary rate will lead to a deterioration of household welfare because of the increase in prices. Therefore, a decrease in agricultural value added is noted that will slow down the sector's activities.

4.1. Results and discussion after testing the policies

The agricultural policy of Senegal is defined in many strategies formulated at regional, sub-regional and national levels. Given the multiplicity of the agricultural policy documents, it is convenient to focus on the projects and agricultural programs which are in the National Agricultural Investment Program (PNIA). Then, for this study we focus on some policy types which are in this program namely: the adjustment of import taxes for agricultural products, an increase in investment in capital and subsidy fertilizers.

- **Decrease in the rice import tariff by 20%**

In the worst climate scenario for Senegal, a decrease in rice import tariff by 20% leads to an increase in agricultural value added by 0.21%. Productions of maize, millet and sorghum are intensified and this leads to prices lowering. Groundnut production decreases. More value added can allow more workers to be employed in the agricultural sector. This can be helpful for rural households who rely on agriculture as their main source of food and income. But we remarked that the household income falls by 0.2% which can be compensated by lower prices. Senegal is a country already open to imports, especially to rice imports. The country imports a lot of rice and has opened his frontier for the rice imports. Although this reduction of rice imports tariff does not help local producers, but it can help to reduce the negative effects of climate change on production and prices. According to Fall (2005), we import much quantities of rice than we produce cereals. Rice imports positively affect the production volume and prices of millet, maize and sorghum. So, the decrease in the price of imported rice is spread on the prices of other agricultural products namely millet, maize and sorghum.

- **Increase in the capital stock (10%)**

An increase in the capital stock by 10%, boosts the value added of the agricultural sector by 8%. This jump is more significant than the changes that occur when the import tariff for rice is decreased. The production volume of maize, millet, sorghum and groundnut rises. This leads to a loss of profit for farmers, except for groundnut which is compensated by its good domestic price. The greater capital stock contributes to alleviating the food expenses of the urban household who also benefit from the increase in income. The downside of an increase in capital stock is that it simultaneously leads to lower labor volume. In fact, the increase in these stocks results in higher prices relative to labor, which in turn leads to lower demand for labor. This substitution effect reduces the expected benefits of the increase in capital stocks.

- **Subsidize fertilizers by reducing tax on fertilizers by 50%**

When the tax on fertilizers is reduced by 50%, we notice a notable increase in the production of millet (21%), sorghum (21%), maize (45%) and groundnut (27%). The household income drops overall by 0.1%. The value added of the agricultural sector increases by 0.22%. This growth in the agricultural sector is a direct result of the lower tax rate for fertilizers.
The decline in soil fertility today prompted the Senegalese government to resume its fertilizer subsidy policy from 2003/2004. After several years of modest subsidies, GOANA was introduced in 2008 to subsidy chemical fertilizers and equipment. The return of the subsidy on fertilizers may help to fight against the impacts of climate change on crop production.

- **Increasing the maize import tariff by 50%**

Not promoting the maize importation leads to an increase in the productions of maize (49%), millet and sorghum (21%), whereas the production of groundnut decreases by 27%. We notice a higher value added for the agricultural sector by 0.20%. The labor demand increases for all the crops (maize, millet and sorghum) due to the effect that hiking the maize import tariff by 50% has on the value added for the agricultural sector. A negative consequence of this policy is that the household income is reduced by 0.18%, which is not good for the household, but this can be compensated by the lower prices. This policy also developed the Senegalese farming system by creating more jobs, as in Senegal the agricultural sector is the most important source of revenue and food for poor people.

All these policies bring positive value added for the country except for an increase in maize import tariff for which value added is negative. This positive impact on the economy is much more important for policies about the increase in capital stock (11.081% million F. CFA) and subsidizing fertilizers by decreasing fertilizers taxes by 50% (-0.39% million F. CFA). So, the financial implications of the increase in maize import tariffs are not good for the state revenues because this shock leads to a loss of value added which is not favorable for the economy. The increase in capital stock increases the value added but the problem is that it leads to decrease the labor demand.

Finally, it appears that **cutting the rice import tariff by 20%** and **subsidizing fertilizers by slashing taxes by 50%** are the most suitable policies instruments that can help to mitigate the negative effects that climate change has on agricultural sector in Senegal. Cutting rice import tariff by 20% generates agricultural value added (0.21%). Subsiding fertilizers by halving fertilizer taxes increases agricultural value added by 0.22% which is still an improvement even with an agricultural value-added loss of 0.08%. These two policies, modeled in the worst climate scenarios for Senegal can generate agricultural value added that can compensate for the losses that we have in the RCP8.5 scenario.

As in Senegal the agricultural sector employs 70% of the working population, the greater value added can provide more jobs in agricultural sector. This growth of the labor force can lead to an increase in the volume of production in the agricultural sector, which is shown by the positive results that we have for the production volume of maize, millet and sorghum. If the government applies these two policy instruments, the Senegalese farming system will be strengthened because farmers will benefit in comparison to the RCP 8.5 scenario. Even if we notice small decline in the household income, the better prices can compensate for this loss.

So, these two policies contribute to alleviating the food expenses of the urban household with cheaper food and also, they can be helpful for rural households who rely on agriculture as their main source of food and income.

Conclusion

This study aimed to assess the impact of climate change on production volume and household income and to test alternative policies instruments that can help to mitigate fluctuations of quantities. Particularly it focused on some policies that are in the Senegalese National Agricultural Investment Program (PNIA).

The level of production decreased in these last years and this is particularly due to climate change. The difficulties of the agricultural sector are mainly due to low levels of rainfall, degradation of soils, degradation of the agricultural infrastructure, seed quality etc. Consequently, the production deficit is still critical leading to higher levels of imports for agricultural products.

A static computable general equilibrium model oriented on the agricultural sector has been used to assess the impact of climate change on the level of production and to test alternative policies instrument that can help to reduce the fluctuation of quantities.

The results show that the projected climate in 2030s in Senegal will lead to a decrease in the production of the top four most produced crops (groundnut, millet, sorghum and maize), even when including positive effects of CO_2. As a result, the productivity of the agricultural sector and the workforce will decrease. The fall in the household income due to the reduction of salary rate will lead to a deterioration of household welfare because of the increase in prices.

The results show also after testing different policies instrument in the worst climate scenario for Senegal that cutting the rice import tariff by 20% and subsidizing fertilizers are the most suitable policies instruments that can help to mitigate the negative effects that climate change has on agricultural sector in Senegal. With these two policies the level of production rises as well as the agricultural value added. These two policies generate agricultural value added that can compensate for the losses that we have in the RCP 8.5 scenario. Also, the improvement of agricultural performance can significantly reduces the poverty in urban and rural areas. This requires seed quantity and of good quality, modernization of technical production, in particular through the training of rural stakeholders, encouraging innovation and research development; strengthening production diversification policies (especially in areas where traditional farming is experiencing a decrease in production and yield) and improved access to credit for farmers. Emphasis should also be placed on policies that enable the poorest people to carry out and go beyond subsistence agriculture, especially in areas where the severity of poverty is the most significant.

References

Breinsinger, C. and X. Diao. (2008). Economic transformation in theory and practice: What Are the messages for Africa? *IFPRI Discussion Paper 797.* Washington, D.C: International Food Policy Research Institute.

Crasswell, E.T., Grote, U., Henao, J. and Vlek, P.L.G. (2004) Nutrient Flows in Agricultural Production and International Trade: Ecological Policy Issues. Discussion Paper No. 78, Bonn, Germany: ZEF Center for Development Research, University of Bonn

Dering, D. (2015). Climate change impacts on crop productivity in global semi-arid areas and selected semi-arid economies. Small Grant Programme Working Paper, Overseas Development Institute (ODI), London. Available online at http://prise.odi.org/research/small-grant-programme-climatechange-impacts-on-crop-productivity-in-global-semi-arid-areas-andselected-semi-arid-economies

Fall, A.A. (2005). Impact économique de la recherche sur le riz au Sénégal et en Mauritanie. In : Revue Agronomie Africaine, CORAF, Numéro Spécial (5), ISSN n°1015-2288, 53-6, décembre.

Funk, C., J. Michaelsen, and M. Marshall. (2012). Mapping recent decadal climate variations in precipitation and temperature across Eastern Africa and the Sahel. In: Remote Sensing of Drought: Innovative Monitoring Approaches [Wardlow, B.D., M.C.Anderson, and J.P.Verdin (eds.)]. CRC Press, Boca Raton, FL, USA, pp. 331-358.

MAER. (2016). Rapport sur la revue conjointe du secteur agricole.

MEDD (2016). Contributions Déterminées au niveau National (CDN)- volet adaptation secteur de l'agriculture.

Oktaviani, R., E. Puspitawati, and Haryadi. (2008). Impacts of ASEAN Agricultural Trade Liberalization on ASEAN-6 Economies and Income Distribution in Indonesia. *Working Paper* series no. 51 Bangkok: .Asia-Pacific Research and Training Network on Trade, United Nations of Economic and Social Commission for Asia and the Pacific (UNESCAP).

Pauw, K., J. Thurlow, M. Bachu, and D.E. Van Seventer. (2011). 'The Economic Costs of Extreme Weather Events: A Hydro-Meteorological CGE Analysis for Malawi'. Environment and Development Economics, 16: 177-98. US EPA. (2009). *Opportunities to Reduce Greenhouse Gas Emissions through Materials and Land Management Practices*, September 2009.

USAID (2017). Finding the best fit: Naatal Mbay case study, Christina Manfre

Zhai, F., and J. Zhuang, (2009), 'Agriculture impact of climate change: A general equilibrium analysis with special reference to Southeast Asia', *ADBI Working Paper Series* 131.