CLIMATE CHANGE AND THE POULTRY VALUE CHAIN IN NIGERIA: ISSUES, EMERGING EVIDENCE, AND HYPOTHESES

Awa Sanou[1], Bukola Osuntade[2], Saweda Liverpool-Tasie[1,*], Thomas Reardon[1]
[1]Michigan State University
[2] Livelihood Support and Development Centre for Africa (SLIDEN) Nigeria

*Corresponding author. E-mail address: lliverp@msu.edu
Tel.: +1 (517) 432-5418

Abstract
The Nigerian poultry value chain is growing fast and transforming alongside increased climate variability. However, despite its importance for livelihoods in Nigeria, there is limited information about how the Nigerian poultry subsector is affected by climate change. We use the conceptual framework of Reardon and Zilberman (2017), regarding climate shocks and change on transforming food supply chains to examine how climate change will affect Nigeria's food economy. We propose hypotheses of the interactions between climate shocks and change and the dimensions of the poultry subsector. This exercise reveals that climate change will have heterogeneous effects on the different nodes of the country's poultry value chain.

Key words: Climate change, Value chain, Maize, Poultry, Nigeria
JEL classifications: Q54, R11

Introduction

The Nigerian poultry value chain is growing fast and transforming. This is linked to Nigerian diets including more eggs and poultry meat as incomes rise and urbanization occurs. Poultry are important for nutrition as well as incomes in Nigeria. But the poultry value chain is complex – varying over parts of the country in how modern or traditional it is. Really very little has been known about that value chain, as its rapid emergence as an important domestic commercial supply chain is recent. Climate change is also a recently emerging problem and little is known about how it will affect Nigeria's food economy. These two gaps make it especially unknown what is occurring from the combination of climate change and poultry value chain growth and transformation. How will climate change affect feed supply chains? Poultry farming and supply chains? How will poultry farming itself perhaps affect climate change?

We explore these questions in this article. We proceed as follows. Section 2 summarizes the conceptual framework regarding climate shocks and change on transforming food supply chains (based on Reardon and Zilberman (2017)) as a basis for the subsequent discussion. Section 3 first shows emerging evidence and discusses hypotheses for climate change on maize farming in Nigeria. Then, it takes the next step down the poultry chain by discussing potential climate change impacts on maize wholesale and feed milling and feed wholesale. This is supplemented by a discussion of the potential direct effects of climate change and shocks on poultry farming – and vice versa, poultry farming eventually on climate change (such as from effluvia). Lastly, we move further midstream and downstream to think about climate change potential impacts on poultry and egg wholesale and processing and retail. Section 4 concludes.

Methodology

Reardon and Zilberman (2017) lay out two categories of effects of climate shocks and change on supply chains. We use maize and poultry value chain examples to illustrate their points. The first category of effects on the value chains are short-term climate shocks. Examples of these are big rain years, heat waves, droughts, flash floods washing out roads, big fires caused by dry and hot conditions, and so on. These shocks can disrupt every segment of the supply chain both directly and in a cascade of linkages:

a. inputs such as fertilizer and feed may not reach maize and chicken/egg farms or be expensive;
b. farming of maize can be hurt by heat waves and floods and droughts;
c. farming of chickens may then be affected by shortage of feed from (a) and (b), and heat may hurt chickens and increase disease;
d. (b) might affect feed mills;
e. floods and other shocks along supply chain routes of inputs and of outputs of chicken and eggs may disrupt transport and wholesale.
f. (e) might affect chicken processors with costs and disruptions and diseases;
g. a-f then affect chicken retail and consumption and/or competitiveness with imports.
h. feedback from any downstream back up on upstream segments too; if floods or heat cause chicken disease that hurts feed mill industry etc.

The second category of effects is medium-long term where climate change (and or repeated short term shocks) force supply chains to reconfigure. This can happen in several ways:

a) geographic shifts (e.g., if the area feed mills were getting maize from goes dry or wet so maize becomes harder to grow then buyers may have to redirect procurement routes of maize to other zones or imports to keep feeding mills; the same goes for chickens and egg buyers);

b) temporal shifts (e.g., if there is a change in how long the season runs or what the seasonality of the product or input is; buyers might have to shift from two to one season).

Note that climate shocks and changes have parallel manifestations to sociopolitical risks and shocks, energy cost shocks and long term changes, disease introduction, and so on.

In turn, shocks or long term changes in climate can affect the structure, conduct, and performance of the overall value chain. Reardon and Zilberman (2017), discuss the value chain actors as strategizing actors who address their vulnerabilities by adjusting their sourcing and marketing activities, as well as technologies and institutions. For example, the greater risk or requirements of threshold investments to mitigate or cope with the shocks can lead to concentration of the structure of the supply chain either spatially for the overall chain or in terms of the "industrial organization" of the chain's segments. Or, shocks can lead to conduct changes such as alteration of technologies (such as addition of binders in stored maize by feed mills to mitigate aflatoxins spawned by hot and wet conditions of maize production and transport). These conduct changes can in turn affect the structure of the chain. Finally, the changes can affect the performance, such as increasing costs to mills of maize, or of chicken to consumers.

Discussion

Potential and Emerging Impacts of Climate on Nigeria Maize Farming

Climate change is often reflected in rising temperatures, changing rainfall and seasonal trends, and the frequent occurrence of extreme weather events such as droughts and floods (Asfaw & Lipper, 2016). Weather related shocks will have different effects in Nigeria. Southern Nigeria has irregular and excessive rainfall patterns while the North is characterized by a reduction in water availability (Onyekuru and Marchant, 2014).

Other studies in Nigeria have linked the variability in rainfall in recent years to several dry spells during rainy seasons and increased frequency of the little dry season (Adejuwon & Odekunle, 2006; Odekunle, Balogun, & Ogunkoya, 2005)[1]. Using a Just-Pope Stochastic Production Function of maize, millet and sorghum, Boubacar (2010) estimated the impact of drought on the agricultural sector in eight countries in the Sahel from 1970 to 2000. He found that an increase in daily temperature (degree-days) has a negative effect on crop yield. Based on historical maize-trial data in Africa, it is expected that each day above 30C reduces maize yield by 1% on average and by 1.7% under drought conditions (Lobell *et al.,* 2011).

[1] The little dry season is a terminology associated with a "decline in both the frequency and amount of daily rainfall for a number of weeks, hallway through the rainy season" (Odekunde *et al.*, 2005)

Second, the vector of effect on maize farming of climate change can be via the encouragement of maize disease. This in turn can affect the safety of food and feed for consumers. This is a concern because the types and distribution of pests and diseases are expected to be conditioned by changing climatic conditions (Jarvis *et al.*, 2012). In a European study, Miraglia et al. (2009) found that a major food safety issue is the incidence of mycotoxins on various crops while on the field or during storage. The incidence of aflatoxin is high under conditions of wet spells and hot spells at harvest time (Paterson & Lima, 2010). In a study to detect aflatoxin levels in maize storage systems in Nigeria, (Udoh, Cardwell, and Ikotun, 2000) found that 33% were contaminated. In general, one would expect that the probability of adoption of adaptive technologies (such as aflasafe and maize drying) is increasing under hot and humid weather conditions.

The above discussion of climate shocks is particularly relevant to Northern Nigeria. That region is the maize production basket. In the context of the poultry value chain, it caters to feed mills across the entire country. The sector is characterized by smallholders typically operating on farm sizes of less than two hectares (Liverpool-Tasie *et al*., 2017). In addition, there are distinct socio-economic differences between Northern and Southern Nigeria with the North being more rural and traditional with larger household sizes and exhibiting less education and higher poverty rates on average (Adjognon, Liverpool-Tasie, and Reardon, 2017; Kuku *et al.*, 2013). Consequently, there is significant heterogeneity in production and socio-economic characteristics in the North and South.

However, behavioral effects of climate change may be different between the North and the South depending on the prevailing weather conditions. For example, more droughts in the North potentially affect yields there which increase the price of maize generally with reduced supply. This might encourage the adoption of drought resistant or early maturing varieties of maize, where possible. However, with increasing spells of unpredictable weather alongside high transportation costs to secure maize from the North, the expected price of maize produced in the South could also increase, as the South becomes increasingly a potential source of maize for feed in the South. This could induce investments in modern technologies such as maize dryers to reduce the moisture content of maize produced in the South (one reason for the observed preference of maize from the North by most feed mills). On the other hand, it is also possible that flooding becomes an issue for maize production in the South. This would further reinforce the North’s comparative advantage in maize production and even allow its farmers to avail of higher maize prices.

In addition, while we expect high variability in growing conditions (rainfall and germination temperature for instance) to be negatively correlated with marketed surplus, this might vary between the North and the South. Since the majority of the maize in Nigeria is produced in the North, it is not unlikely that this region has developed adaptive practices to maintain marketed surplus in the face of weather shocks. However, as mentioned above, we might expect to see the adoption of other types of technologies such as drought resistant or early maturing varieties with the changing unpredictable weather patterns.

Potential and Emerging Impacts of Climate on Feed Mill and Maize Wholesalers

Maize wholesalers are likely to develop innovative responses to increased variability in growing conditions: Climate change will initially disrupt and eventually force to adaptation food supply chains (Reardon and Zilberman, 2017; Stathers *et al.*, 2013). Maize wholesale is the first point of entry in the post-harvest value chain of maize. Wholesalers buy where the maize and chickens are – and that will be conditioned by weather. They will set up warehouses and seek transport links to where they think the likeliest sourcing points are and will be. The more cash and trucks and information a trader has, the easier it is for him to work around weather shocks and still source his needed product. That means smaller traders will be at a relative disadvantage in coping with weather change. We also think that climate getting worse or more variable in the North will mean that traders will need to work out ways to source more from the South to spread their risks. That might mean they will set up contracting with farmers in the South, and set up transport hubs and warehouses to handle these new flows.

Actors engaged in feed milling and feed wholesale are likely to adopt institutional arrangements that guarantee consistency in quality and delivery of maize: With climate variability translating into price fluctuations and supply shorts, feed mills might try to reduce uncertainty by moving from buying from the spot market to increasingly trying to tie down their maize supply via contracting with farmers. Maybe they will even grow some of their own maize to make sure of a minimum supply, as low capacity utilization kills a mill. Mills might pay more for dried maize especially to minimize fungus problems. Mills might even shift somewhat beyond maize to some substitutes (such as High Quality Cassava Grits or sorghum. Again, as with the traders, mills might shift from sourcing only or mainly in the North to also sourcing from the South. Mills might also have to manage wider sales networks as bird producers in some areas might reduce demand as climate shocks cause disease in their stocks so they buy less feed.

Potential and Emerging Impacts of Climate Directly on Poultry Farming and Vice-Versa

Although the existing literature highlights the indirect effects of climate change on the poultry sector, the direct effects of climate on poultry farming can be important: Heat spells slow bird growth, reduce the quality of their meat, and increase their likelihood of disease (Gous, 2010; Gregory, 2010). Poultry farmers might have to vaccinate the birds more to control disease. That can be costly for small farmers. Bird farming in Nigeria is already stressed by heat, and even more heat from climate change will make it necessary for farmers to invest in cooling practices to keep the birds alive.

The structure and trajectory of growth in the poultry subsector could have significant effects on the environment at home and abroad: Bird farming practices might even feed climate change through generating more greenhouse gas. Osuntade (2014), found that the average gas in the poultry area in Southwest Nigeria fall between 2.4 and 3.2ppm for methane and ammonia, respectively. The gas density declines with distance from the farms (Osuntade, 2014). Although this is well below the IPCC threshold, it could change if the appropriate measures are not put in place. The daily production of wastes is essentially equal to the amount of feed used as the quantity of feed brought into a poultry house amounts to the quantity of wastes generated on the same farm (Bell, 1990). There is room for bird farmers to reduce GHG emissions by sustainable practices (Foster, Green, and Bleda, 2007; Osuntade, 2014).

Climate on Wholesale, Chicken and Egg Processing, Retail of Poultry

The potential effects of climate shocks and change on maize wholesale and feed mills are transmitted to subsequent segments: Climate shock "upstream" affects the midstream. For example, shocks to climate can affect egg delivery from South to North Nigeria (as that is an important flow at present) and from Southwest to the East delivery of "spent layers" (old hens) to freezing facilities there who sell to the oil sector. Moreover, the flow of birds and eggs within these segments will be affected by the throughput from the chicken and egg production areas. Reardon and Zilberman (2017), emphasize that companies in the wholesale, processing, and retail sector are not passive to these changes, but take active strategic steps and make investments to mitigate the effects of climate induced upstream and downstream changes on them. In the Nigeria case these could take a wide variety of directions. One could be that there will be a concentration in poultry operations with advantage going to larger firms who can set up geographically broader and more flexible sourcing systems, refrigerated warehouses, and freezing facilities.

Conclusion and Policy Implications

For a sustainable growth of the poultry sector in Nigeria, it is crucial to gain a better understanding of the interaction of climate change and shocks, and the different segments of the value chain. This would ultimately guide policy makers in their work to stimulate the subsector for inclusive participation.

- Higher temperatures, and the increased incidence of disease are likely to alter the investment and technology requirements of poultry farmers. Thus, it is important to understand why and how some operations remain viable overtime, and how that is potentially related to the ability of different demographic groups to invest in adaptation strategies.
- Cognizant of the disparities in high moisture in maize between the South and the North, it is worthy to understand how the structure, conduct and performance of the value chain will likely be altered.

- There is a need to understand the link between different poultry management practices and key meteorological variables, including GHG, to promote those which are less harmful to the environment

- The intensity and extent of transmission of shocks across different segments of the poultry value chain is also a worthy empirical undertaking

References

Adejuwon, J. O. and Odekunle, T. O. (2006). Variability and the Severity of the “little Dry Season” in southwestern Nigeria. *Journal of Climate, 19*(3), 483-493.

Adjognon, S. G., Liverpool-Tasie, L. S. O. and Reardon, T. A. (2017). Agricultural input credit in Sub-Saharan Africa: Telling myth from facts. *Food Policy, 67*, 93-105.

Asfaw, S. and Lipper, L. (2016). Managing climate risk using climate-smart agriculture. *FAO, Rome*.

Bell, D. (1990). An egg industry perspective. *Poultry Digest*.

Boubacar, I. (2010). *The effects of drought on crop yields and yield variability in Sahel*. Paper presented at the The Southern Agricultural Economics Association annual meeting. The Southern Agricultural Economics Association, Orlando.

Foster, C., Green, K. and Bleda, M. (2007). Environmental impacts of food production and consumption: Final report to the Department for Environment Food and Rural Affairs.

Gornall, J., Betts, R., Burke, E., Clark, R., Camp, J., Willett, K. and Wiltshire, A. (2010). Implications of climate change for agricultural productivity in the early twenty-first century. *Philosophical Transactions of the Royal Society of London B: Biological Sciences, 365*(1554), 2973-2989.

Gous, R. (2010). Nutritional limitations on growth and development in poultry. *Livestock Science, 130*(1), 25-32.

Gregory, N. (2010). How climatic changes could affect meat quality. *Food Research International, 43*(7), 1866-1873.

Hassan, S., Ikuenobe, C., Nelson, G. and Thomas, T. (2013). Nigeria. In A. Jalloh, G. C. Nelson, T. S. Thomas, R. B. Zougmoré, & H. Roy-Macauley (Eds.), *West African agriculture and climate change: a comprehensive analysis* (pp. 259-290). Washington, DC: IFPRI.

Ingram, J. (2011). A food systems approach to researching food security and its interactions with global environmental change. *Food Security, 3*(4), 417-431.

Jarvis, A., Ramirez-Villegas, J., Campo, B. V. H. and Navarro-Racines, C. (2012). Is cassava the answer to African climate change adaptation? *Tropical Plant Biology, 5*(1), 9-29.

Kuku, O., Mathiassen, A., Wadhwa, A., Myles, L. and Ajibola, A. (2013). *Comprehensive food security and vulnerability analysis: Nigeria*. Retrieved from

Liverpool-Tasie, L. S. O., Omonona, B., Sanou, A., Ogunleye, W., Padilla, S. and Reardon, T. A. (2017). *Growth and Transformation of Food Systems in Africa: Evidence from the Poultry Value Chain in Nigeria* (25). Retrieved from Feed the Future Innovation Lab for Food Security Policy: http://foodsecuritypolicy.msu.edu/resources/growth_transformation_of_food_systems_in_africa_evidence_from_the_poultry_v

Lobell, D. B., Bänziger, M., Magorokosho, C. and Vivek, B. (2011). Nonlinear heat effects on African maize as evidenced by historical yield trials. *Nature Climate Change, 1*(1), 42-45.

Miraglia, M., Marvin, H., Kleter, G., Battilani, P., Brera, C., Coni, E., . . . Dekkers, S. (2009). Climate change and food safety: an emerging issue with special focus on Europe. *Food and chemical toxicology, 47*(5), 1009-1021.

Odekunle, T., Balogun, E. and Ogunkoya, O. (2005). On the prediction of rainfall onset and retreat dates in Nigeria. *Theoretical and applied Climatology, 81*(1), 101-112.

Odekunle, T., Orinmoogunje, I. and Ayanlade, A. (2007). Application of GIS to assess rainfall variability impacts on crop yield in Guinean Savanna part of Nigeria. *African Journal of Biotechnology, 6*(18).

Onyekuru, A. N. and Marchant, R. (2014). Climate change impact and adaptation pathways for forest dependent livelihood systems in Nigeria. *African Journal of Agricultural Research, 9*(24), 1819-1832.

Osuntade, O. B. (2014). *Influence of Intensive chicken management practices on climate change in the rainforest of southwest Nigeria.*

Parry, M. L., Rosenzweig, C., Iglesias, A., Livermore, M. and Fischer, G. (2004). Effects of climate change on global food production under SRES emissions and socio-economic scenarios. *Global Environmental Change, 14*(1), 53-67.

Paterson, R. R. M. and Lima, N. (2010). How will climate change affect mycotoxins in food? *Food Research International, 43*(7), 1902-1914.

Reardon, T. and Zilberman, D. (2017). Climate smart food supply chains in developing countries in an era of rapid dual change in agrifood systems and the climate. In L. Lipper, N.

McCarthy, D. Zilberman, S. Asfaw, and G. Branca (Eds.), *Climate Smart Agriculture: Building Resilience to Climate Change*. Rome: Springer International Publishing.

Sonneveld, B., Keyzer, M., Adegbola, P. and Pande, S. (2012). The impact of climate change on crop production in west Africa: An assessment for the oueme river basin in Benin. *Water resources management, 26*(2), 553-579.

Stathers, T., Lamboll, R. and Mvumi, B. M. (2013). Postharvest agriculture in changing climates: its importance to African smallholder farmers. *Food Security, 5*(3), 361-392.

Sultan, B. and Gaetani, M. (2016). Agriculture in West Africa in the Twenty-first Century: climate change and impacts scenarios, and potential for adaptation. *Frontiers in plant science, 7*.

Traore, B., Descheemaeker, K., Van Wijk, M. T., Corbeels, M., Supit, I. and Giller, K. E. (2017). Modelling cereal crops to assess future climate risk for family food self-sufficiency in southern Mali. *Field Crops Research, 201*, 133-145.

Udoh, J., Cardwell, K. and Ikotun, T. (2000). Storage structures and aflatoxin content of maize in five agroecological zones of Nigeria. *Journal of Stored Products Research, 36*(2), 187-201.

Vermeulen, S. J., Campbell, B. M. and Ingram, J. S. (2012). Climate change and food systems. *Annual Review of Environment and Resources, 37*.

Wheeler, T. and Von Braun, J. (2013). Climate change impacts on global food security. *Science, 341*(6145), 508-513.