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

By

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Food Security Policy *Research Papers*

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1. INTRODUCTION

The Nigerian poultry sub-sector is experiencing rapid growth and transformation. This is linked to the transformation of diets as incomes and urbanization increase. Poultry is both a protein and income source for many households and the poultry subsector in Nigeria is quite complex. This complexity has several dimensions. First, there is a plethora of segments of the supply chain from inputs to consumers (from upstream to downstream, there are the segments of maize and other ingredient farmers, feed mills, hatcheries of day-old-chicks, the poultry farmers, poultry wholesalers, processors, and retailers). Second, there is a multiplicity of scales of the firms and farms in those segments – small, medium, and large. Third, there are several crucial socioeconomic characteristics of the people managing and working for the farms and firms – the gender and age of actors. Fourth, there is great range and variation in the spatiality of the poultry and egg system, as the above segments span the zones of Nigeria, such as eggs being moved from farmers in the South to retailers in the North, maize from farmers in the north to feed mills in the South, spent layers from farmers in the Southwest to processors in the East, and so on. These four dimensions have significant implications for the dynamics and sustained growth of the subsector (Liverpool-Tasie et al., 2016).

However, despite its importance for livelihoods in Nigeria, there is limited information about how the Nigerian poultry subsector is affected by climate change. Climate short-term shocks and long term change can affect the resilience, growth, and inclusiveness of the poultry subsector, and thus its effects on Nigerian food security. The goal of this paper is to examine the issues and propose hypotheses of the interactions between climate shocks and change and the dimensions of the poultry subsector.

We approach this as an analysis of potential effects on the poultry value chain along its segments. This perspective on analysis of climate on the agriculture and food sector is rare. The examination of climate shocks and change even on poultry farming per se, however, is rare. Much rarer still is examination of climate impacts on the poultry value chain from poultry farmers to poultry distribution and processing, and climate impacts on input supply chains feeding the poultry value chain (such as the chain of maize to feed, and feed to poultry farms).

The rarity of examination of climate impacts on the poultry value chain and the inputs chains that feed it is just part of the dearth of such analysis in the general literature. We can see that from two perspectives.

On the one hand, the mainstay of the burgeoning literature on climate on agriculture and food focuses on the farm sector per se, such as how increases in rainfall variability or heat will affect yields and crop disease in various regions (e.g. Wheeler and von Braun, 2013; Adejuwon 2006; Gornall et al. 2010; Odekunle et al. 2007; Parry et al. 2004; Sultan and Gaetani 2016. Traore et al. 2017). For example, Sonneveld et al. (2012) use climate models and crop production models to predict that staple crops yields will decrease in West Africa by 2050 with the largest reduction occurring between 2030 and 2050.

On the other hand, the examination of climate impacts on agrifood value chains is just emerging in the literature. Ingram (2011) and Vermeulen et al. (2014) explore climate change interaction with farm production (both climate on farming and farming on climate), and then extend that to note that climate's effects on farming have knock-on effects on the rest of the supply chain and markets and prices and consumption. They also provide some preliminary hypotheses concerning direct climate effects on midstream segments such as transport and warehousing, concerning the disruption that excessive rainfall and so on can have. We know of only one piece that empirically digs into the potential specific effects on the midstream, and that is Stathers et al. (2013) discussion of possible vectors of climate impacts on post-harvest handling (such as storage) in traditional maize supply chains in Eastern and Southern Africa.

However, there has not to date been an exploration of a particular product all along the value chain of inputs to the product value chain, and the product value chain, exploring potential vectors of impacts of climate shocks and longer term change on the segments of those chains. We aim to do that here. We use as a conceptual framework Reardon and Zilberman (2017) which builds on the above pieces and takes a step further by laying out a conceptual framework for short term shocks versus long term changes in climate on the value chain as a chain and also its individual segments. They also examined these in the context of the kind of transformation of supply chains that poultry value chains are undergoing now in Nigeria – spatial lengthening, restructuring, and technology changes.

We proceed as follows. Section 2 summarizes the conceptual framework of Reardon and Zilberman (2017) regarding climate shocks and change on transforming food supply chains as a basis for the subsequent discussion. Section 3 shows emerging evidence and discusses hypotheses for climate change on maize farming in Nigeria. Section 4 takes the next step down the poultry chain by discussing potential climate change impacts on maize wholesale and feed milling and feed wholesale. Section 5 then discusses potential direct effects of climate change and shocks on poultry farming – and vice versa, poultry farming eventually on climate change (such as from effluvia). Section 6 takes us further midstream and downstream to think about climate change potential impacts on poultry and egg wholesale and processing and retail. Section 7 concludes.

2. CONCEPTUALIZING CLIMATE SHOCKS AND CHANGE ON THE SUPPLY CHAIN

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 greater than normal rainfall or heat or drought, 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 when get there;

(b) farming of maize may be affected by heat drought floods and have losses disease and yields;

(c) farming of chickens may then be affected by lack of or expensive feed from (a) and (b), and heat may hurt chickens and increase disease incidence;
(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.
g) 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 alfatoxins 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.

3. POTENTIAL AND EMERGING IMPACTS OF CLIMATE ON NIGERIA MAIZE FARMING (AS KEY INPUT TO FEED AND THUS POULTRY)

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 and 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).

There is emerging evidence of this climate change on cropping in Nigeria, or at least evidence that points to eventual and potential effects. Using crop modelling techniques to map crop yields in

2050 with climate change against a 2000 climate scenario, Hassan et al. (2013) show that the yield losses for rainfed maize are negligible compared to yield gains across all production zones in Nigeria. They attribute this overall gain to increases in rainfall in some parts. In contrast, the models predict a loss of yield for sorghum (a substitute for maize in feed) in the Northern Sahelian zone due to higher temperatures. These results demonstrate that hotter temperatures and reduced water availability have differential impacts depending on the crops and location.

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 and Odekunde 2006; Odekunde et al. 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).

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. 2010). 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 and Lima 2010). In a study to detect aflatoxin levels in maize storage systems in Nigeria, Udoh et al. (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. 2016). 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 et al. 2016; Kuku-Shittu et al. 2015). 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

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[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)

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.

4. POTENTIAL AND EMERGING IMPACTS OF CLIMATE ON UPSTREAM FROM POULTRY FARMING: SOURCING INPUTS (HENCE FEED MILL SEGMENT AND WHOLESALE LOGISTICS TO FARM)

4.1. Climate on maize wholesalers (midstream in feed value chain between maize farmers and feed mills and then to poultry farmers)

Climate change and associated increased variability will have an impact on postharvest systems (Stathers et al. 2013; Reardon and Zilberman 2017). As a result, maize wholesalers, for example, are likely to develop innovative responses to increased variability in growing conditions (e.g. late onset of rains, variability in precipitations and germination temperatures). Their behavior may depend on actual weather forecast information (where available) or their perceptions of climatic changes. The likelihood of investments in warehouses for storage might increase with unpredictable weather events capable of disrupting both yields and maize transportation logistics. In terms of the decision to own a warehouse for storage or a truck for distribution, it is possible that the occurrence of extreme weather conditions will increase the probability of ownership for large and medium wholesalers. The size of the warehouse (truck) will most likely be positively correlated with the occurrence or frequency of occurrence of such events for large wholesalers while it is unclear how medium actors will adjust. They might be forced to adopt different strategies if such investments are not possible or profitable. For small scale wholesalers, the effect of such events on the decision to own a warehouse (truck) is ambiguous. They are likely to be vulnerable to extreme weather due to their limited ability to invest in adaptive technologies (Vermeulen et al. 2012). But large scale wholesalers might have the necessary financial capital, or have access to loans to invest in adaptive technologies such as larger warehouses. Additionally, it is possible that increased variability in growing conditions in one part of the country might affect the logistical arrangements for securing grain. We hypothesize an increase in the use of contractual arrangements or investments in storages and other technologies for large scale wholesalers capable to fulfill large orders.

Maize wholesalers can be adversely affected in the event of heavy rains that make farming communities inaccessible. Wholesalers make their procurement decisions based on profit maximization. If a period of hot spell results in a high incidence of fungal or bacterial disease in maize (thus reducing the quality), the wholesaler maybe reluctant to engage in trading relationships with the concerned farming community in the future. Higher incidences of such diseases may also create investment opportunities for technologies (such as aflasafe for aflatoxin free maize) among maize farmers in the event that maize wholesalers are willing to pay higher prices for this attribute. Increased frequencies of droughts in the North for instance can shift wholesalers' demand to production areas in the South.

4.2. Climate on feed mills

With increased climate variability and its effect on maize availability and prices, one would expect feed mills to move away from spot markets arrangements for the procurement of maize toward informal contracting agreements (or other strategies) to reduce high fluctuation in supply. Since a significant number of the large size feed mills are located in the South, a weather induced reduction in maize supply in the North could encourage a higher proportion of maize to be sourced in the South or for feed mills to vertically integrate maize production into their portfolio of activities. In the event of warehouse destruction due to extreme weather events such as floods or droughts in the North, a larger quantity of maize is likely to be sourced from the South. In contrast if the shock were to hit the South, then the quantity of maize sourced from the North could go up.

Furthermore, assuming that feed mills care about their reputation on the feed market (and as such pay attention to the safety of the feed they supply), an increased frequency of hot spells and wet spells means that the supply of maize with lower moisture content might fall and thus attract a price premium. This could encourage feed mills to adopt institutional arrangements that guarantee a consistent supply of the desired maize quality. However, given the history of high moisture content prevalent in the South, feed mills in the South might already have strategies in place to address moisture content such as the use of binders. Thus this is ultimately an empirical question worthy of further exploration.

Feed mills are directly linked to poultry farmers who are their primary customers. Thus, a shock of avian flu at the poultry farmer node implies a reduction in demand for feed for poultry. The size of the feed mill will likely impact its aptitude to survive and/or respond to such a shock in terms of diversification strategies. Larger feed mills might be able to diversify to other types of milling activities (e.g. milling grain for consumption) at a much faster rate than smaller ones. Additionally, a shock on production, climate related or not, translates into higher maize prices for feed mills. If the shock happens to be region specific, then feed mills would turn to the region capable to supply the quantity of maize they need at the price they are willing to pay. Alternatively, mills might incorporate different levels of substitutes to maize (such as High Quality Cassava Grits or sorghum), as necessary to profitably meet the demand of their customers while maintaining their reputation.

An increase in the price of maize due to low production in the North for instance, may result in the use of alternative sources of feed. Moreover, a shock of avian flu will equally decimate all infected farms regardless of size. However medium and large farms will probably recover more rapidly compared to smaller operations owing to their larger asset base. Some small farms might even exit the sub sector if they lose all their stock of birds to the disease. This means that there might exist a minimum stock of birds to be resilient to avian flu.

5. POTENTIAL AND EMERGING IMPACTS OF CLIMATE DIRECTLY ON POULTRY FARMING... AND VICE VERSA

5.1. Climate directly on poultry farming

Most studies on climate change and food systems focus almost exclusively on the likely effects of climate change on crop systems. Very few studies have looked at animal systems despite their increasing importance as food systems transform and households in developing countries increasingly demand animal based proteins (Ayanlade et al. (2016) is an exception). Even within animal production, poultry production has not received much attention.

The vector of effect of climate on poultry production has probably most been thought of in the indirect channel of climate induced shocks such as higher frequency and variability in the occurrence of floods and droughts that have detrimental effects on feed from their effects on the production of maize (and other cereals) which are key ingredients in poultry feed.

In Nigeria, much less attention has been given to the direct effects with more attention focused on the indirect effects through climate induced effects on maize supply. But the direct effects of climate shocks on poultry farming can be important. Higher temperatures linked to changing weather patterns affect the growth rate of birds, the quality of meat and the frequency of disease outbreak (Gous 2010; Gregory 2010). One key channel by which climate change or shocks can affect poultry farming is via increasing disease incidence. Similarly, shocks such as avian influenza affect the supply of chicken which affects the activities of bird and egg sellers, processors as well as feed mills which cater to the needs of poultry producers. The link between climate and animal disease has been analyzed. A study in Europe used climate data and model simulations to show that the increased probability of bluetongue (a viral disease of ruminants transmitted by biting midges) among ruminants is linked to changing climatic conditions (Guis et al. 2012). Besides ruminants, poultry will also be adversely affected by changing temperatures. These insights are particularly relevant to the Nigerian context as heat related stress is already prevalent. In a study comparing farmers' perception of climate change with meteorological data in southwestern Nigeria. Ayanlade et al. (2016) found that livestock farmers perceived climate change impact to be the highest on chickens compared to small ruminants due to their sensitivity to higher temperatures.

Higher temperatures linked to changing weather patterns are likely to impact production practices. Poultry farmers might need technologies to keep temperatures bearable for birds so as to maintain optimal growth rates and reduce mortality. Since higher risks of diseases have been associated with climate change, poultry farmers might require a larger set of health practices, expanding the already large number of vaccinations needed for birds. This may significantly increase the investment threshold required to engage in the activity. The adoption of various practices and technologies might require some minimum size of operation to make them viable. This implies that abilities to adjust to these climate-induced effects will vary across different kinds of poultry farmers. Differentiated impacts of shocks on the ability of different demographic groups involved in the subsector (such as women and the youth) to invest in adaptation strategies has also been largely ignored.

5.2. Poultry farming on climate

Most of the limited attention of climate change studies focused on poultry have been on the effects of climate induced factors on poultry production with limited attention on how activities in the subsector could also affect climate change. Currently Nigeria's contribution to greenhouse gas emissions might be very small. However, the structure and trajectory of growth in the subsector could also have a significant effect on the Nigerian environment and future contribution to greenhouse gas emissions.

Agriculture contributes to global Greenhouse Gas (GHG) emissions due to constant production of methane (CH4); ammonia (NH3) and Nitrous oxide (N20) that are major contributors to changes in climate. A number of governments are seeking to involve the livestock sector in policies to curb issues of GHG as a result of the projection of increase in the global consumption of livestock products and demand for meat and milk as incomes increase (FAO, 2006; USEPA; 2016).

Most poultry farmers are unaware of the impact of their activities on climate change. Oduntade (2014) found for Southwest Nigeria highlighted that most poultry farmers are not aware of the influence of poultry management practices on climate change due to inadequate access to extension and research services. Furthermore, the few farmers that have benefitted from climate change interventions tend to be more conversant with the effect that changes in climate could have on their production and not vice versa. 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).

Compared to other animal rearing activities, poultry production has multiple streams, including egg and meat production, breeder stock and hatchery activities and the use of waste for manure (which is not always exhausted) varies with scale. Irrespective of the size of bird holdings, there are basic management practices, amongst which proper feeding; good housing management. and sanitation. Other management practices include the utilization of various equipment, production of egg and table birds, brooding practices, incubation practices, housing, vaccinations, management of administration of drugs, slaughtering practices, management of unused feeds and marketing of poultry products. All these have their contribution to issues of climate change especially in the emission of GHG. Studies have shown that livestock industries are GHG intensive compared with other food industries. Most emissions occur at the farm stage where most of the management practices are handled extensively (Osuntade 2014; Foster et al 2006). The commonly used practices that are of interest are incubation practices; brooding practices; housing; management of waste from dung and unused feed; management of feed mills; management of the administration of drugs and vaccinations; bird dressing management which includes slaughtering; draining; defeathering; evisceration; washing; chilling; refrigeration; packaging and the management of wastes at sales point (Garnett, 2007). Consequently, there is a need to really understand, the extent to which changes in the trend of key meteorological variables are attributable to widespread use of selected poultry management practices.

In addition, the impact of pollution from poultry production depends on a number of factors; among which are farm size, production system (such as deep litter or cage systems and the extent of integration of activities with a particular farm), diet composition, and so on. Caged animals tend to contribute more to GHG than free range which is mostly for broiler production in chicken. There is need to consider other environmental burdens of different poultry systems as cited by Williams et al. (2006) reiterating that there are alternative practices useful in reducing the effects of poultry production on climate and other environmental degradations.

GHG emitted on intensively managed poultry farms in the rainforest of Southwest Nigeria are methane and ammonia. The gas density declines with distance from the farms. Constraints faced in using alternative practices are financial (incentives as well as capacity), technical knowhow, lack of expertise, increase in the cost of production, intermittent and irregular power supply, non-introduction of new innovation from the extension services, lack of space and time, availability of the equipment to be used and inability to adapt to changes.

IPCC 2007 reports that the GHG become hazardous to human health when these gases fall between 10-25ppb for CH4 and NH3. It was observed by Osuntade (2014) that the average gases in the poultry area fall between the averages of 2.4 and 3.2ppm for the two gases in the nine points observed. This is still well below the IPCC threshold and thus is not at the hazardous stage, but could be in the future.

6. CLIMATE ON WHOLESALE, CHICKEN AND EGG PROCESSING, RETAIL OF POULTRY

Above we discussed potential effects of climate shocks and change on shifts of the geography of maize and feed sourcing, as well as transaction costs for feed and maize wholesalers and logistics companies. These same points spill over to the parts of the supply chain post farm gate of poultry farms and poultry processing firms. These can affect for example the logistics of 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 (2007) 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.

7. CONCLUSION

There is limited information on the link between climate change and food value chains in Nigeria. Using the poultry value chain in Nigeria as a case in point, this paper is a first step in thinking about the potential links between climate change and food systems in Nigeria. The paper shows how climate change effects likely vary across and within each segment of the poultry value chain. The paper stresses the need for a much broader framework of thinking about climate change and the poultry value chain as well as the importance for thinking more about how chicken management practices among producers, processors and distributors also affect climate change.
A better understanding of these effects is necessary in order to uncover which adaptive technologies and institutions will be most conducive for the sustainable growth of the poultry sector in Nigeria. This would also guide policy makers as they develop strategies to stimulate the sub-sector and ensure active participation among a broad set of actors.

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