

# **Hot Times Ahead: The Effects of Climate Change on Agriculture in India and Nigeria**

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## ***Abstract***

*India and Nigeria are developing countries that are already suffering from the negative effects of climate change. Both countries have huge agricultural sectors that are vital to their economies. India has the second largest farm output in the world. In Nigeria, 70 percent of its population is employed in the agricultural sector. This article compares and contrasts how climate change is affecting the essential food production in both India and Nigeria and the efforts each country is taking to minimize the negative effects of climate change.*

## **I. Introduction**

India and Nigeria are developing countries in which agriculture is a staple of their economies. Both countries are highly vulnerable to climate change effects such as higher temperatures and extreme variations in precipitation, which will have drastic effects on their economies and the livelihoods of their citizens. The agricultural sector in both India and Nigeria absorbs a significant portion of their labor forces and still constitutes a considerable share of their gross domestic product (GDP). A large portion of those employed in the agricultural sector live below the international poverty line (\$1.25 per day in PPP), and therefore the effects of climate change will have a serious impact on the daily lives of these individuals.

With the effects of climate change worsening, India and Nigeria are anticipating declines in crop production and value, increased imports, increased debt, and ultimately a decline in GDP and a decrease in the livelihoods of the citizens of these countries. The effects will be felt by all sectors of the population as well as by countries trading with them. Efforts are being made to alleviate these effects in both countries. However, due to the urgency of this issue, more extensive projects and an increase in awareness are essential in lessening the negative impacts of climate change.

This article provides first a brief review of the literature and then some empirical background on the socio-economic development of India and Nigeria. The discussion examines (1) the carbon dioxide emissions, (2) the effects of climate change on agriculture, and (3) the efforts to alleviate the effects of climate change. The last section draws conclusions on measures both governments can take.

## II. Brief Literature Review

Given the severe impact climate change has had on the agricultural sectors of India and Nigeria, it is not surprising that there is an array of scientific articles and reports. Some of the more recent publications are summarized as follows:

- Panda (2009) assesses the vulnerabilities of climate change in India. The effects of climate change are severely impacting food production around the world because of its effect on natural ecosystems and socio-economic systems. In its fourth assessment report, the Intergovernmental Panel on Climate Change claimed that the global mean temperature will increase anywhere between 1.4°C and 5.8°C by 2100. This will be detrimental to many countries around the world, especially India, a developing country in which agriculture is a staple of the economy. It was calculated that a 2°C rise in mean temperature and a 7 percent increase in mean precipitation will reduce the net revenue of the whole country of India by 12.3 percent. This is a very serious issue for India, as agriculture provides employment for two-thirds of its total workforce. Climate change is also likely to cause more cyclones, monsoons, droughts, and floods, which will greatly affect India's crop yields in coastal cities that are at or slightly above sea level. The vulnerability of India's economy and the effects of climate change on its people need to be evaluated further.
- Thaker and Leiserowitz (2014) examine the shifting discourses of climate change in India. India has 17 percent of the world's population and is the world's third largest emitter of greenhouse gases (GHGs). India's carbon dioxide emissions from fuel combustion tripled between 1990 and 2011; and these emissions are estimated to increase 2.5 times between 2008 and 2035. Unfortunately, developing countries, including India, have refused to sign a legally binding treaty to lower GHG emissions because of issues of equality, low per-capita emissions, and the demand that the responsibility to lower emissions first rests with the developed countries. However, in 2007, it appeared that India shifted its stance on addressing climate change issues when its prime minister created a Council on Climate Change and authorized eight national missions to address energy security as part of the Nation Action Plan on Climate Change. Two of the main issues that have been the source of debate for Indian negotiators are increasing energy access and energy security in an environmentally friendly way. However, India is a country where 40 percent of the population does not have access to electricity and where there has been a rise in economic growth and industrial demand for energy. Its leaders are desperate for a solution that will promote its development objectives of poverty alleviation and economic growth, while also yielding co-benefits for addressing climate change effectively. It is hoped that a solution will be found in renewable energy resources.
- Bosello, Campagnola and Eboli (2013) reviews climate change and adaptation applied to Nigerian agriculture. Climate change in Nigeria will cause a decrease in crop production, GDP losses starting in 2025, an increase in crop prices, and a higher food dependency on foreign imports. By 2050, it is predicted that crop production will decline between 4.8 percent and 7.4 percent, the prices of crops will increase between 17 percent and 32 percent, and agricultural imports will increase between 13 percent and 23 percent. In order to adapt to these climate changes and to reduce their detrimental effects, a mix of "soft measures" that are inexpensive and "hard measures" that are very costly like irrigation expansion need to be implemented. However, the application of these methods needs to be highly

researched and planned carefully in order to avoid creating a costly and ineffective situation.

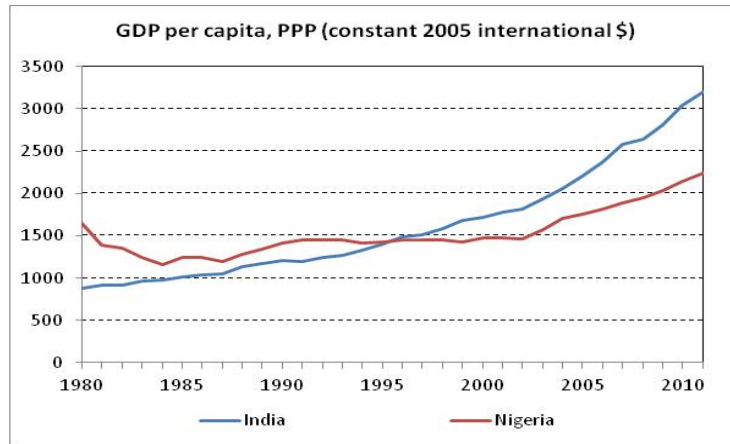
- Apata, Samuel and Adeola (2009) analyze the perception of and adaptation to climate change among arable food crop farmers in South Western Nigeria. Nigeria as a country is very vulnerable to climate change since its economy is agriculture-based. Because of its location in Sub-Saharan Africa, which already has characteristically high temperatures, an increase in the mean temperature and varying extremes of precipitation due to global warming will have detrimental effects on the Nigerian economy. The coastal regions of Nigeria are also susceptible to severe storms and sea-level rise caused by climate change, which would drastically affect agriculture yields in these areas. The Niger-delta wetlands have experienced significant damage due to climate change already, as the salt from the coastal waters has increased soil salinity, thus making it impossible to grow crops on this land. Logit regression analysis was used to analyze how farmers in this area are adapting to climate change. It was found that multiple and mixed crop-livestock was the most common practice, diverging away from the typical mono-cropping used by most farmers. In order to enhance the current adaptation to climate change, there needs to be easily accessible information on the causes and effects of global warming, and a credit or grant facility needs to be established to empower the farmers.
- A World Bank (2013a) report reviews the risks a warming climate poses to agriculture, water resources, and health in India. In India, over 60 percent of crops are rain-fed, which makes these agricultural areas very vulnerable to changes in precipitation due to climate change. With 15 percent of India's groundwater tables already overexploited, changes in precipitation will further affect the water supply. It has been predicted that the mean temperature will rise by 2°C globally by 2040; if this happens, crop production in South Asia is expected to drop by 12 percent. This will then cause a decline in food availability, which will cause severe health problems, including an increase in childhood stunting by 35 percent by 2050. As a result, the World Bank is supporting projects to help communities conserve their watersheds better, and it is sponsoring groups that are developing environmentally sustainable hydropower in India. However, if the warming is held below 2°C, there is a chance that the worst effects stemming from climate change can be avoided. Action on climate change needs to happen fast, though, because this window of opportunity to stabilize the global warming is closing quickly.

### **III. Empirical Background**

India is the world's third largest economy if GDP is measured in purchasing power parity (PPP), and it is home to nearly 1.3 billion people. Nigeria is considerably smaller; it is the world's 20<sup>th</sup> largest economy if measured by the same parameter, and it is home to nearly 170 million people. As shown in Figure 1, Nigeria's GDP per capita decreased from 1980 to 1984 and then stagnated during most of the 1990s and early 2000s. It is only in the last ten years that Nigeria made significant progress in increasing income per capita. India's GDP per capita grew moderately during the 1980s and more rapidly since India's economic reforms went into effect in 1991. India's GDP per capita in 2011 was 3.6 times its GDP per capita in 1980, while that of Nigeria has only increased 1.6 times during the same period, as seen in Figure 1 below. Although India's GDP per capita was about half of Nigeria's GDP per capita in 1980, today, India's GDP per capita is about 70 percent higher than that of Nigeria. In both cases, these countries have made significant progress

in increasing their GDP per capita during the last decade. However, due to the detrimental effects caused by climate change, these countries' economies are expected to be hit hard in the coming years and it will be very difficult to maintain these high growth rates.

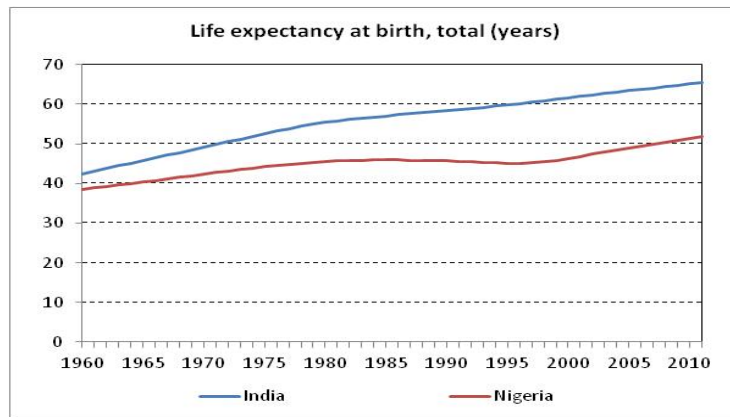
**Figure 1: GDP per capita (in PPP) for India and Nigeria, 1980-2011**



Source: Created by author based on World Bank (2013b).

Both countries also made progress in increasing their life expectancy, though similar to the differences in GDP per capita, Nigeria's progress has been uneven. As seen in Figure 2 below, between 1960-2011, India increased its life expectancy by 23 years, while Nigeria's increased by only 13.4 years. Hence, there is now a large difference between the life expectancy in India and Nigeria.

**Figure 2: Total Life Expectancy at Birth (years), 1960-2011**

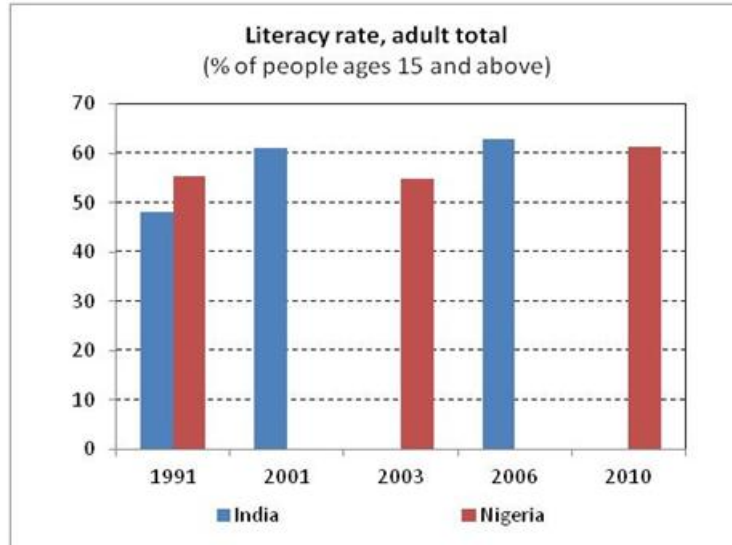


Source: Created by author based on World Bank (2013b).

Even though the data are very limited for adult total literacy rates, some interesting observations can be made. As shown in Figure 3, while Nigeria's literacy rate was 7 percent higher than that of India in 1991, by the early 1990s, India's literacy rate surpassed Nigeria's by about 6 percent. However, the data seem to indicate that India has not made much progress in terms of literacy between 2001 and 2006 (literacy rates increased by only 1.7 percent), while Nigeria has made

considerable progress during 2003 and 2010, increasing its literacy rates by 6.6 percent. In both of these countries, the total literacy rate of adults is still only about 60 percent, a little over half of these populations. Therefore, these countries still have a long way to go to improve their education systems and thus the livelihoods of their citizens.

**Figure 3: Literacy Rate, Adult Total in India and Nigeria Between 1981-2010**



Source: Created by author based on World Bank (2013b).

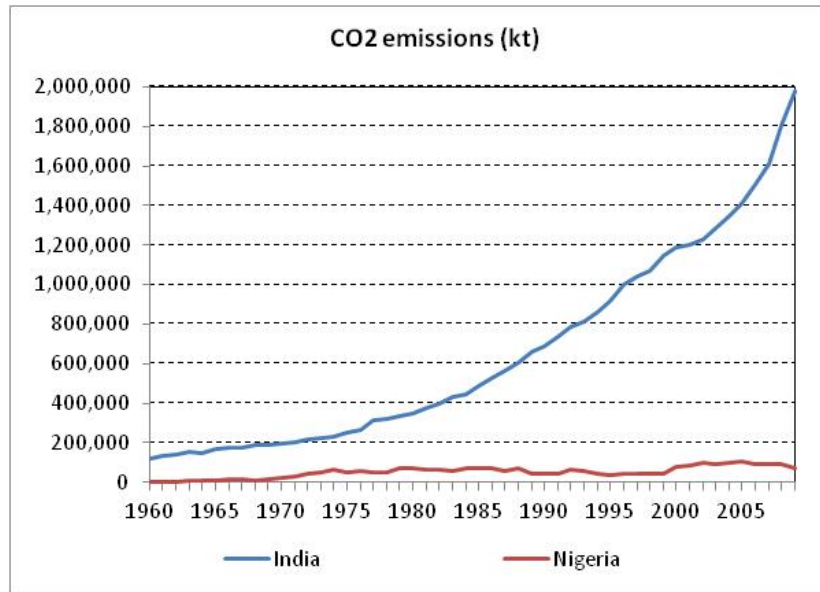
## IV. Discussion

### IV.1. Carbon Dioxide (CO<sub>2</sub>) Emissions in India and Nigeria

Climate change is affecting countries around the world, but it poses the greatest threat to developing countries, like India and Nigeria, whose economies are based on agriculture and to those countries already in high-temperature areas. India supports 17 percent of the world's population and was the world's third largest emitter of GHGs in 2010 (Thaker and Leiserowitz, 2014). India's GHG emissions have increased since 1992, when India was ranked the world's sixth largest emitter (U.S. Energy Information Administration [USEIA], 2011). Its CO<sub>2</sub> emissions from fuel combustion alone tripled between 1990 and 2011, and they are estimated to increase by 2.5 times between 2008 and 2035 (Thaker and Leiserowitz, 2014).

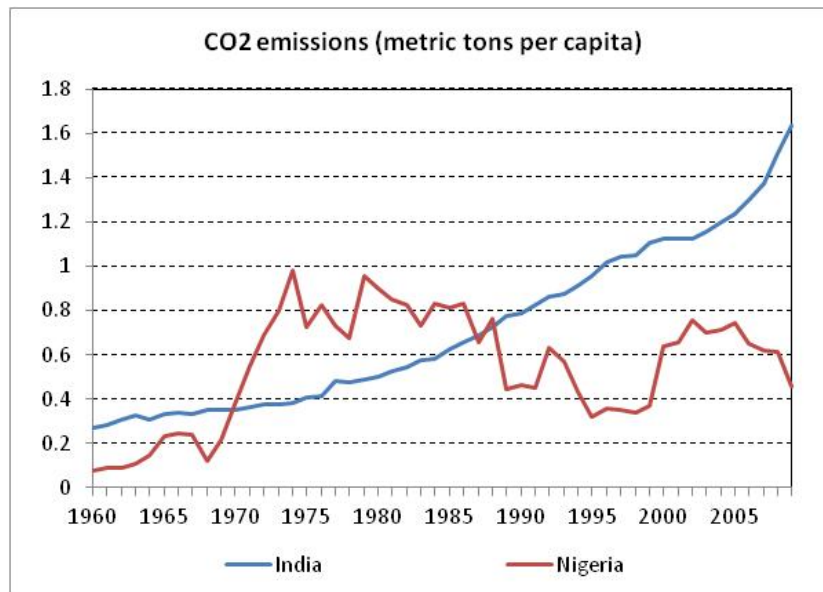
Nigeria is the world's 44<sup>th</sup> largest emitter of GHGs (USEIA, 2011). In 1992, it was ranked as number 35 (USEIA, 2011). This reduction in emissions is due to several programs that the Nigerian Government has implemented to reduce CO<sub>2</sub> emissions. As seen in Figure 4 below, while Nigeria's CO<sub>2</sub> emissions have been stagnating overall since the mid-1970s, India's CO<sub>2</sub> emissions have been steadily increasing since 1960. As shown in Figure 5, these different trends are (despite a more visible volatility for Nigeria) the same if looking at CO<sub>2</sub> emissions per capita. Hence, if provisions and regulations on these emissions are not put in place and monitored, India's contribution to global climate change is only expected to become more significant and problematic.

**Figure 4: CO<sub>2</sub> Emissions (in thousands of metric tons), 1960-2009**



Source: Created by author based on World Bank (2013b).

**Figure 5: CO<sub>2</sub> Emissions per capita (in metric tons), 1960-2009**



Source: Created by author based on World Bank (2013b).

## IV.2. Effects of Climate Change on Agriculture

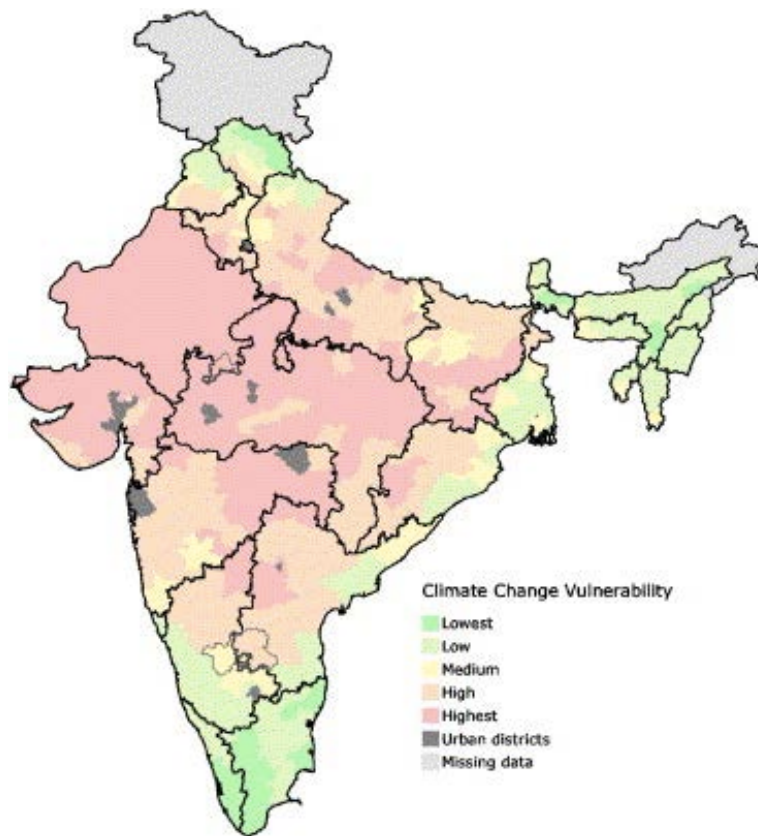
India is very vulnerable to climate change as the average annual temperature in the majority of India is between 25°C and 27.5°C or 77°F and 87°F.<sup>1</sup> The World Bank (2013a) has predicted that by 2040, the mean global temperature will increase by 2°C. A rise of 2°C in India would make the

<sup>1</sup> <http://www.weatherbase.com/weather/city.php3?c=IN>

average annual temperatures in most areas range from 80.6°F to 90.6°F. However, according to Panda (2009), the Intergovernmental Panel on Climate Change (IPCC) claimed that the global mean temperature will increase anywhere between 1.4°C and 5.8°C by 2100 in its fourth assessment report, predicting an even higher potential temperature increase. In a climate with these temperatures and varied precipitation, agriculture will no longer be able to provide the important resources for the country. Figure 6 below demonstrates the vulnerabilities of districts in India to climate change based on their adaptive capacity and climate sensitivity. A large portion has the highest possible climate change vulnerability, indicated by a reddish color in Figure 6. With 54 percent of India's population depending on agriculture for their livelihoods, the effects of climate change will be detrimental to India as a whole (Birthal, Joshi, Roy and Thorat, 2007).

**Figure 6: District-Level Mapping of Climate Change Vulnerability**

(measured as a composite of adaptive capacity and climate sensitivity under exposure to climate change)



Source: <http://www.sciencedirect.com.proxyau.wrlc.org/science/article/pii/S095937800400010X>.

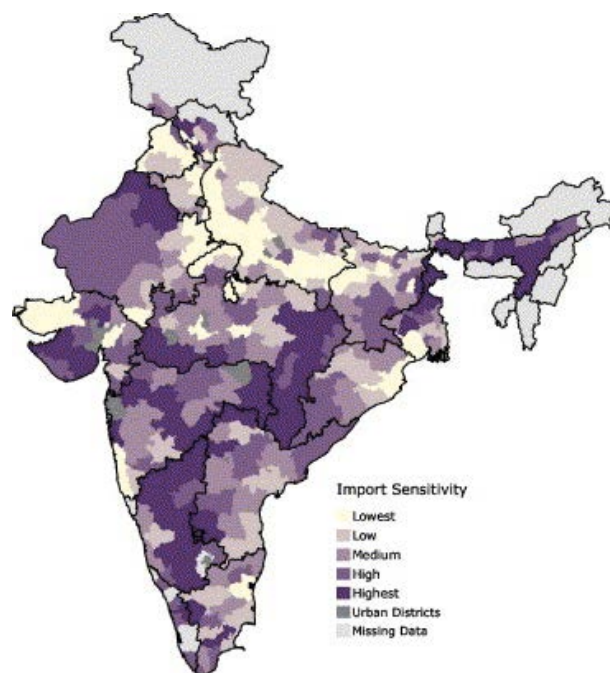
The percentage of agriculture that makes up India's GDP has declined from 40 percent in 1980/1981 to 18 percent in 2012 (Birthal et al., 2007; World Bank, 2013b). However, agriculture remains an important sector for India. The agricultural sector provides 60 percent of the labor workforce, making agriculture a very important sector to sustain (World Bank, 2011). India has 116 million farms, most of which are small (less than 2 hectares), and most of these farms belong to households below the poverty line (World Bank, 2011). As of 2007, 72 percent of India's

population lived in these rural areas, and three-fourths of these rural households rely on agriculture for their livelihoods (Birthal et al., 2007).

India is among the top three global producers of a broad range of crops, including wheat, rice, pulses (chickpeas, pigeon peas, lentils, dry peas, etc.), cotton, peanuts, fruits, and vegetables.<sup>2</sup> In 2011-12, India produced 104 million mega-tons of rice, making up 22.88 percent of the global rice production. This is the highest rice production for India since 2001/2002 (Government of India, 2012). However, India's food imports are expected to increase in the coming years. Figure 7 below depicts the import sensitivity of districts in India. It shows that a significant portion of India is ranked to have the highest import sensitivity (in dark purple), meaning that these places have a high competition from other country suppliers of the same goods (O'Brien et al., 2004). With the effects of climate change becoming more noticeable all over the world, the crop supply other countries are able to export will diminish and will leave countries like India struggling to find the goods they need to feed their populations.

### Figure 7: Import-Sensitivity Map

(measured as a composite of distance to ports, cropping patterns, and crop productivity)



Source: <http://www.sciencedirect.com.proxyau.wrlc.org/science/article/pii/S095937800400010X>

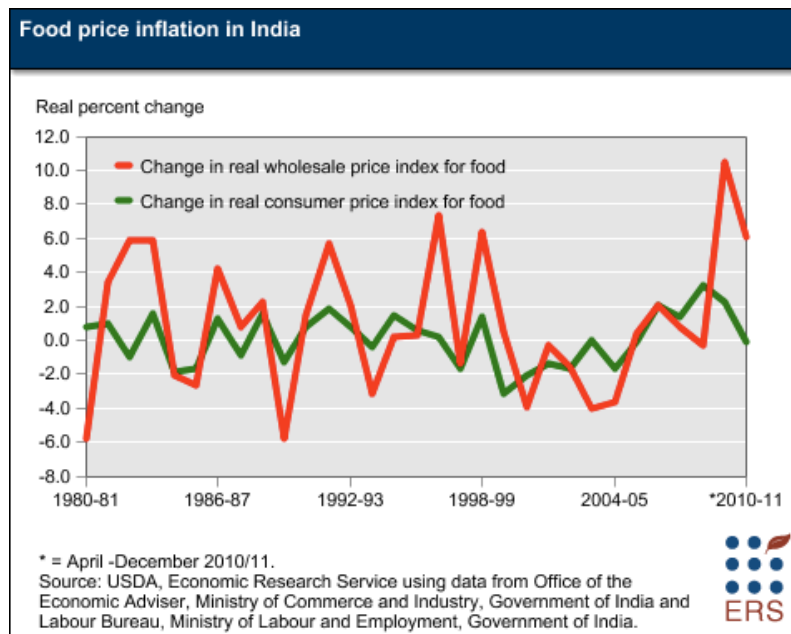
One key supporting fact of India's increased food insecurity is rising food prices. As seen in Figure 8 below, the food price inflation in India has fluctuated since 1980, but it was the highest for consumers in 2010/2011, with a jump in wholesale prices as well.

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<sup>2</sup> United States Department of Agriculture (USDA), Economic Research Service (2013).



**Figure 8: Food Price Inflation in India, 1980-81 to 2010-11**



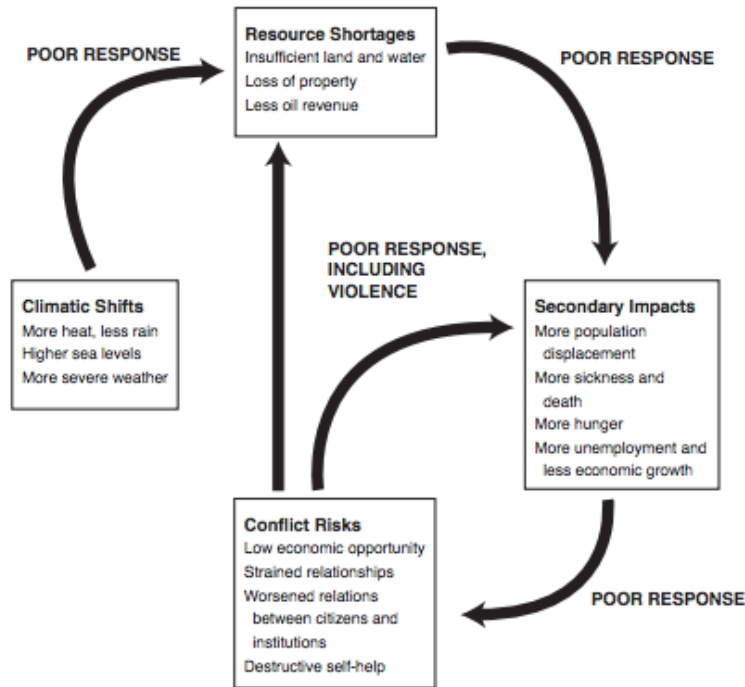
Source: United States Department of Agriculture (USDA), Economic Research Service (2012).

In India, over 60 percent of crops are rain-fed, which makes these agricultural areas very vulnerable to changes in precipitation due to climate change (World Bank, 2013a). It was calculated that a 2°C rise in mean temperature and a 7 percent increase in mean precipitation will reduce the net revenue of the whole country of India by 12.3 percent (Panda, 2009). Changes in precipitation will also affect the water supply, as 15 percent of India's groundwater tables are already overexploited. It has been predicted that the mean temperature will rise by 2°C globally by 2040 and if this happens, crop production in South Asia is expected to drop by 12 percent. This will then cause a decline in food availability, which will cause severe health problems including an increase in childhood stunting by 35 percent by 2050 (World Bank, 2013a).

In Nigeria, climate change will also cause a decrease in crop production, GDP losses (projected to start in 2025), an increase in crop prices, and a higher food dependency on foreign imports (Bosello, Campagnola, and Eboli, 2013). By 2050, it is predicted that crop production will decline between 4.8 percent and 7.4 percent, the prices of crops will increase between 17 percent and 32 percent, and agricultural imports will increase between 13 percent and 23 percent (Bosello et al., 2013). It is also predicted that by 2050, the GDP of Nigeria could drop by 4.5 percent (Cervigni, Valentini, and Santini, 2013).

Climate change in Nigeria is not only causing increased temperatures and less precipitation, but the poor response to these issues is causing conflicts to break out (Figure 9). As seen in Figure 8 below, the poor responses to these issues are creating resource shortages, more sickness and death, more hunger, more unemployment, and low economic opportunity among many other problems. The result of this is an ever-worsening cyclical pattern, and therefore not addressing these problems only creates more problems. In order to mitigate these conflicts, dealing with the effects of climate change needs to become a priority of the Nigerian Government (Sayne, 2011).

**Figure 9: Climate Change and Conflict in Nigeria: A Basic Casual Mechanism**



Source: [http://www.usip.org/sites/default/files/Climate\\_Change\\_Nigeria.pdf](http://www.usip.org/sites/default/files/Climate_Change_Nigeria.pdf).

Nigeria was once a great exporter of agricultural goods. Between 1962 and 1968, export crops were Nigeria’s main foreign exchange earner. Nigeria was the number one exporter in palm oil globally and the exporter of 47 percent of all groundnuts, putting it ahead of the United States (Green, 2013). Unfortunately, in the 1960s, Nigeria turned to oil, causing its agricultural sector and main source of income to dwindle (Green, 2013). Since 2012, Nigeria has imported over \$7 billion of agricultural food products and commodities per year, and it was the second largest importer of wheat from the United States in 2010/2011 (David, 2012; Nzeka, 2013).

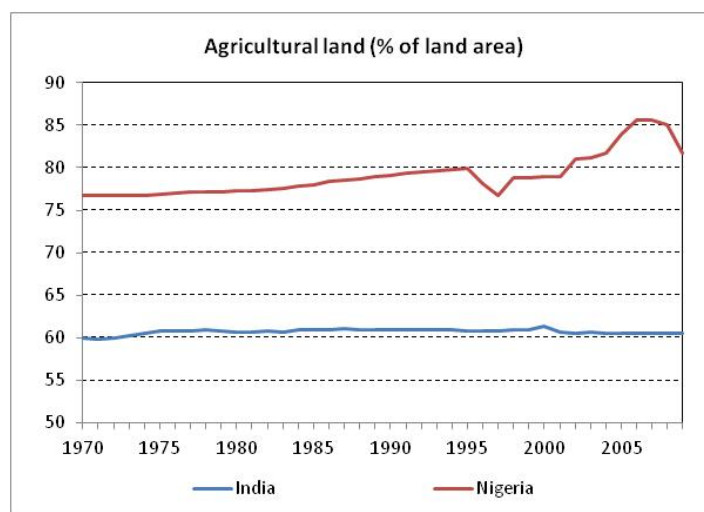
However, agriculture is still a staple of Nigeria’s economy, with mass production of maize, millet, rice, and sorghum (Osagie, 2013). Akinwumi Adesina, Nigeria’s Minister for Agriculture, stated: “Only 2 percent of all bank lending in Nigeria goes into agriculture—a sector that is 40 percent of GDP and 70 percent of employment.”<sup>3</sup> If the effects of climate change are not mitigated, the share of agriculture in GDP will decline from 40 percent to 15 percent, (Cervigni et al., 2013). However, Adesina has recently adopted reforms for agriculture, from which he is hoping to add 20 million metric tons to the domestic food supply by 2015 and create 2.5 million jobs through agriculture (Green, 2013).

In October of 2013, the International Food Policy Research Institute (IFPRI) warned Nigeria of an imminent food security threat (Osagie, 2013). Adesina’s reforms therefore need to be implemented as quickly as possible and in the most effective way to ensure that the circumstances in Nigeria do not escalate further. Figure 10 below shows just how much land is used for agriculture in India

<sup>3</sup> Green (2013), paragraph 14.

and Nigeria. In India and Nigeria, 60 and 80 percent, respectively, of the total land is used for agriculture. This shows how widespread the agriculture sector is in these countries and how important it is to maintain it. The land used for agriculture has remained about constant for India since 1975, indicating that India is likely using all the land suitable for agriculture. In Nigeria, the percentage of land used for agriculture has increased slightly during the 1980s and early 1990s, but has undergone some volatility since. The sharp decline during the last few years for which such data are available is certainly an alarming indicator, though further examination of the reasons for the decline is needed.

**Figure 10: Agricultural Land (percent of total land area), 1970-2009**



Source: Created by author based on World Bank (2013b).

### IV.3. Efforts to Alleviate Effects of Climate Change

In 1985, India introduced the Comprehensive Crop Insurance Scheme (CCIS) to provide insurance to farmers due to the extreme weather conditions (like droughts and monsoons) they already faced at that time. In 1999, the National Agricultural Insurance Scheme, an updated risk management tool, replaced CCIS, and now insurance is provided by the Agriculture Insurance Company of India (AICI), which is a public crop insurance firm. AICI offers insurance on food crops, oilseeds, and specific commercial crops based on an area yield. AICI is the only company providing such a service to Indian farmers (World Bank, 2011).

Before 2013, India was unwilling to set forth efforts to reduce its GHG emissions because poverty eradication and social and economic development were considered to be first and over-riding priorities (Worldwatch Institute, 2013). However, if the drastic impacts of climate change are not addressed, poverty will only become a more difficult problem to fix. Luckily, in July 2013, India announced that, along with 16 other countries, it would prevent the global average temperature from increasing by 2°C (Worldwatch Institute, 2013). India has also presented 20 initiatives to address at a domestic level, which are a part of India's "National Action Plan on Climate Change" (Worldwatch Institute, 2013). This action plan also includes eight national missions (the solar mission, mission for enhanced energy efficiency in industry, mission on sustainable habitat, water mission, mission for sustaining the Himalayan ecosystem, mission for a "green India," mission for

sustainable agriculture, and a mission on strategic knowledge for climate change) to lessen India's impact on climate change (Government of India, 2013).

Nigeria, a large importer of agricultural products, especially wheat, is about to sign a bio-safety bill, which will allow for the managing and controlling of agricultural biotechnology in Nigeria in order to guarantee safety for the environment and human health. This bill will also make it possible to assess the risk of genetically engineered (GE) organisms before the release, including Living Modified Organisms (LMOs) like food products. In anticipation of this bill being signed, field trials are being conducted for cow pea, sorghum, and cassava varieties of wheat, in order to increase the domestic production of wheat and to decrease the country's imports (Nzeka, 2013).

Another program Nigeria has implemented is called *Vision 20:2020*, within which Nigeria has set out to become one of the world's 20 largest economies by 2020 (Cervigni et al., 2013). This plan will implement irrigation systems applied to 0.6 to 1 million hectares, which will reduce the effects of climate change in the short run but will not eliminate its long-run effects (Cervigni et al., 2013). Therefore, irrigation expansion will be coupled with improving the management of 13 to 18 million rain-fed harvested areas, which will alleviate the spending on irrigation (Cervigni et al., 2013).

Another project being carried out to help Nigeria with the effects of climate change is called Build Nigeria's Response to Climate Change (BNRCC), which started as the Canada-Nigeria Climate Change Capacity Development Project (C-NCCCDP). It had a substantial effect on raising awareness of climate change effects and by gathering a group of individuals willing to work on these issues (BNRCC, 2008). The new project intends to increase the awareness by enhancing the capacity at the individual, corporate, and state levels to implement effective adaptation strategies, policies, and actions (BNRCC, 2008).

All of the above initiatives that Nigeria has set fourth will aid in the effort to mitigate the effects of climate change. However, these projects and programs need to be widespread in order to make any significant changes in Nigeria's agricultural sector. Nigeria also needs to implement a credit system for agriculture and an insurance program for farmers, such as that in India, in order to sustain its agricultural sector.

## **V. Conclusion**

Agriculture plays a large role in the economies of both India and Nigeria, making up a significant portion of their GDPs and labor work forces. In fact, it plays a large role around the world, as 40 percent of the Earth's land is used for agriculture (Owen, 2005). However, due to the increasingly evident effects of climate change, such as extremes in temperature and precipitation, both India and Nigeria are now very vulnerable. Both of these countries have created programs to alleviate these effects before they become irreversible. However, between 2000 and 2010, CO<sub>2</sub> emissions were the highest they have ever been. According to the IPCC, in order to not surpass the inevitable 2°C rise in global temperature, GHG emissions need to be reduced by 40 to 70 percent from the 2010 recorded emissions and to near-zero by 2100 (United Nations, 2014).

There is hope, though, that new technologies combined with a new sense of global cooperation will stop, not turn back, the clock that spells disaster. This can happen, but only if countries join together and make it a common goal combined with the implementation of their own domestic programs. Providing renewable energy and reducing air pollution are only two ways to create a sustainable environment (United Nations, 2014). There also needs to be increased bank lending to

the agricultural fields to enhance this sector. Not only will reducing the effects of climate change maintain India's and Nigeria's economies, but it will eventually improve the education, poverty, and livelihoods of the individuals in these developing countries. As stated by Hugh Sealy, Chair of the Executive Board that oversees the Clean Development Mechanism (CDM), "when emission reductions come with other benefits, such as technology transfer, sustainable energy, increased household prosperity, clean air, education, or spur other types of sustainable development, then clearly this is in the best interest of everyone, in developed and developing countries."<sup>4</sup>

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<sup>4</sup> United Nations (2014), paragraph 9.

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