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Department of Geopolitical Studies

Master's Thesis

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By

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Geopolitics of Global Food Supply - An analysis of Nigeria, China, and the United States

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Year of Defense: 2021

Declaration of Authorship

1. The author hereby declares that he compiled this thesis independently, using only the listed resources and literature.

2. The author hereby declares that all the sources and literature used have been properly cited.

3. The author hereby declares that the thesis has not been used to obtain a different or the same degree.

Prague, 27.07.2021

Olav M. Eeg-Henriksen

References

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Abstract

This thesis examines the functioning and implications of the food supply chain on countries food security by investigating one low, one middle, and one high-income country, represented by the Federal Republic of Nigeria, People's Republic of China, and the United State of America. While it is well understood that a high-income country has a more secure food supply chain than a low-income country, the multitude of reasons affecting this difference, and the severity of the difference is less clearly framed in literature. The first part explores and lays out the factors influencing all the key aspects of the food supply chain, and the second part then analyzing the selected countries through those. The third part explores some geopolitical trends of importance to the food supply chain. Through the analysis, the differences between the countries becomes apparent, and the results show a strong difference in food security for low income countries, compared to middle and high-income. The difference between middle and high-income countries is not as prevalent, but still meaningful.

Keywords

Agriculture, Food security, Food Supply, National security, Africa, Nigeria, China, United States of America.

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List of Acronyms and Abbreviations

BCE = Before Common Era

Co2 = Carbon Dioxide

CPC = Communist Party of China

FMARD = Federal Minister of Agriculture and Rural Development

GDP = Gross Domestic Product

GPP = Gross primary productivity

GPS = Global Positioning Systems

IPCC = International panel on climate change

KG = Kilogram

NPA = Nigerian Port Authority

MoU = Memorandum of Understanding

SSA = Sub Saharan Africa

USD = United States Dollar

USDA=. U.S. Department of Agriculture

WFP = World Food Programme

ZAPZ = Special Agro-Industrial Zones

Master Thesis Proposal

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Proposed Topic:

Geopolitics of Global Food Supply

Registered in SIS: Yes/NO - No **Date of registration:**

Topic Characteristics:

My master thesis will analyze the geopolitics of global food supply. To better compare how this global issue affects countries of different economic development, I will do deeper analyzes of one country of low income status, one of middle income status and one of high income status. These are; Nigeria, China, and The United States. China, though vast, has a relatively constrained arable land mass, and will in the future have to import more food as well as try to buy land or crop facilities in other countries. Nigeria, as most of Sub Saharan Africa see huge population growth. Heavy investment and modernization is required into the country and continents farm sector to secure food supply and relative price stability. The United States have a strong, diversified and highly technological agricultural sector and high exports. However, the rapidly increasing average age of farmers means that prices need to rise to attract young ones to the agricultural sector. This, combined with their changing stance on global issues, in turn will impact the rest of the world.
There are many examples of correlation between food prices/availability and civil unrest going back. Either looking at Greek city states, or the French revolution it becomes clear that food is a major trigger. We have enjoyed a long period of very stable food prices, and stable availability in the vast majority of countries. However, now we are seeing signs of this changing due to several factors. There are long term developments such as a changing climate and population growth, medium term changes such as trade policies, protectionism and transport solutions, and lastly shorter-term changes such as the current covid-19 crisis. All of these are now seemingly coming together to create a perfect storm, with the consequence potentially being sharply rising food prices and strong geopolitical tensions over the availability and security of food.

Hypotheses:

2.6. The changing geopolitical framework towards a more multipolar world decreases the stability of food supply.

2.6. The higher up on the income scale a country is, the safer is their food supply.

2.6. Sub Saharan Africa have the agricultural potential and capability to feed themselves, and also support China with food.

2.6. Food prices need to rise to attract young farmers.

Methodology:

To test the hypotheses, I will use both quantitate and qualitative methods of analysis. I will do numerical analysis of where the breaking point in terms of food prices are for the different countries. This will influence how prone they are to civil unrest and instability. I will analyze historical events where food prices have raised sharply, and investigate how that impacted the states and people within it at the time. I will compare local agricultural production capabilities, import power, and political approaches to food supply in the three case countries.
I will analyze the current supply and demand for different key agricultural products how they affect the countries differently. I will look at what measures and geopolitical tools the countries use to secure their agricultural supply chains and production for the future. I will also look into how more protectionist policies may impact the stability of the global food supply chain.

Outline:

1. *Introduction*
2. Theoretical background
    a. History of global food supply and food crisis
    b. Impact of globalization and modern supply chains
    c. Demographical changes impacting production and consumption

3. *Global trends*
    a. Decreasing globalization and less trade
    b. Changing climate – Harder to produce?
    c. Aging farmers – prices need to rise.

4. *Implications in different regions – The case of Nigeria, China, and the U.S*
    a. Key figures on the analyzed countries
    b. Huge populations – Limited arable land mass
    c. The lack of technology and capital
    d. Import power and currency situations.

5. *Potential solutions*
    a. Sub Saharan Africa as the worlds food basked
    b. Local farming
    c. Smarter supply chains

6. Conclusions
7. References / Bibliography

References/bibliography

BELLEMARE, M. F. (2014). *Rising food prices, Food price volatility, and Social unrest .* American Journal of Agricultural Economics.

de Ridder, M., de Jong, S., Selleslaghs, J., Achterbosch, T., Jongeneel, R., Berkhout, P., & van der Heide, M. (2013). *The Emerging Geopolitics of Food.* The Hague Centre for Strategic Studies (HCSS). 2514 EE The Hague: The Hague Centre for Strategic Studies.

Rayner, V., Laing, E., & Hall, J. (2011). *Developments in Global Food Prices.* Reserve bank of Australia.

Roseboom, J., Beintema, N., Lynam, J., & Badiane, O. (2016). *Agricultural Research in Africa.* INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE.

Toshichika Iizumi, N. R. (2015, 4). How do weather and climate influence cropping area and intensity? *Global Food Security*.

Westhoff, P. C. (2010). *The Economics of Food: How Feeding and Fueling the Planet Affects Food Prices.* 07458, New Jersey, USA: Pearson Education, Inc.

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Author Supervisor *

Table of Content

1 Introduction

Food is the cornerstone of any society and is the most important commodity for any country to secure stable, reliable and affordable supply of to their population. Agriculture and food supply have played an extremely important part in societal development throughout history and has led to the rise of some societies and, when supply has been lacking, the fall of others. Small and large conflicts have been fought throughout history over the access to this one group of commodities we cannot live without. This research aims to analyze the geopolitics of global food supply in the modern world in order to better understand the challenges that states are facing in order to obtain and distribute enough food to its people. To better compare and understand the challenges of this global issue, countries of different economic development will be analyzed, those being one country of low-income status, one of middle-income status and one of high-income status. The selected countries are respectively; Nigeria, China, and The United States. Nigeria, as most of Sub Saharan Africa faces huge population growth. Heavy investment and modernization are required into the country's agricultural sector in order to secure food supply and relative price stability. China, though vast, and with a considerable agricultural land mass, have been increasingly reliant on imported food and the acquiring of land or crop facilities in other countries. The United States has a modernized, diversified and highly technological agricultural sector and is a net exporter of food. However, although different, all countries face challenges in the food supply chain, from the rapidly increasing average age of farmers, through infrastructure and finance, to climate change. There are many examples of correlation between rising food prices and lack of availability with civil unrest going back in history. Either looking at Greek city states, or the French revolution it becomes clear that food is a major trigger for revolution or collapse.

There are also many more modern examples of this, among them the influence on the Arab Spring.[12]We have enjoyed a long period of very stable food prices and stable availability in the vast majority of countries. However, since 2008 we have been seeing signs of this changing due to several factors. There are long term developments such as a changing climate and population growth, medium term changes such as trade policies, protectionism and transport solutions, and lastly shorter-term changes such as the current covid-19 crisis and weather. All of these are now seemingly coming together to create a perfect storm, with the consequence potentially being sharply rising food prices and strong geopolitical tensions over the availability and security of food. The importance of food, and the link to conflict and peace was stated clearly when the Nobel Peace Price of 2020 was given to the World Food Programme (WFP). The committee referred to the efforts of programme as… *"bettering conditions for peace in conflict-affected areas and for acting as a driving force in efforts to prevent the use of hunger as a weapon of war and conflict."* [3]

1.1 Research goals

The aim of this thesis is to analyze the food supply chain through what influences availability and price stability in Nigeria, China and the United States. As the states all are in very different positions when it comes to demographics, technology, productivity, land utilization, infrastructure, climate and purchasing power, I am hoping to explain the different approaches and challenges the countries have when approaching this issue. Global food supply, security, and prices are highly complex and are interconnected to a long list of factors that impact each other over time and on a global scale. Predicting exact developments in availability or prices

[1] (Barbet-Gros & Guesta, 2020)
[2] (Smith, 2014)
[3] (The Nobel Prize, 2020)

for a time horizon longer than a few months (if even that) is therefore both an impossible task, and also one without any real value as it will be based on too many unreliable assumptions. The aim of this research analysis is therefore not to accurately predict a detailed future, but rather to build an understanding of how the agricultural supply chain have implications the analyzed countries and the geopolitical implications that can cause.

1.2 Research questions/hypotheses

1. The changing geopolitical framework towards a more multipolar world decreases the stability of food supply.
2. The higher up on the income scale a country is, the safer is their food supply.
3. Sub Saharan Africa have the agricultural potential and capability to feed themselves, and also support China with food.
4. Food prices need to rise to attract young farmers.

1.3 Methodology & Structure

The methodology of this work is built around creating a framework of understanding of the many key factors influencing the food supply chain, from production to the end consumer, and this is content of the first part. Is will go through the theoretical background of what is the main factors impacting a county's food security. The second part will be analyzing the selected countries using the factors form the first chapter.

1.4 Literature review

This thesis is based on second hand date collected from the most reliable and descriptive sources I was able to find on the different subjects. The quality of data published is varying between the analyzed countries. Most of the numbers and figures supporting this paper are collected from solid source such as the World Bank, The United Nations, and the USDA. The figures for each country are as far as possible collected from the same source to make an equal comparison, but in some instances other supplementary sources were needed. The book; The Economics of Food, by Patrick Westhoff[4] is key source of theoretical information as it is a comprehensive work into the dynamics of what drives food prices around the world, from weather to politics. To make this work more up to date, the numbers are used when applying the theory of this book is mostly replaced by more updated data.

1.5 Potential flaws and limitations to this research

Due to the complexity of the food supply chain and the many factors influencing it, I will not claim to be an expert on all of these. Therefore, I am sure some important factors have been left out, while some factors have been given too much or too little importance. Although mentioned, the influence of insurgencies, other non-state actors, or war could have been more researched as a part of this paper.

[4] (Westhoff P. , 2010)

2 Theoretical background

The aim of this chapter is to provide the theoretical background that builds the framework of understanding of the factors comprised within the research topic.

2.1 History of agriculture and global food supply

During most of human history, we have been hunter-gatherers, living of what nature naturally provided without any input from us. From around 11,000 BCE, a gradual transition into cultivating crops and breeding animals started due to a range of plausible factors from change in climate conditions and technology to increasing population density and overhunting. By 5000 BCE, agriculture had reached every major continent apart from Australia, and eventually it spread to all corners of the globe. Agriculture became the force driving the extreme growth in societies all around, and global population numbers quickly increased. Agriculture tied people to a specific area of land, which meant that what was earlier small settlements that would usually move around when local food resources were depleted, turned into towns and eventually cities with surrounding farmland attached. This switch into agricultural societies changed the world into a place where not all our time and energy were spent on survival and gathering food, but people also had time to pursue other tasks leading towards the development of the modern system. Although agriculture facilitated civilizations to grow, it has not made those civilizations safe from crises or collapse but has rather often been a major factor in their downfall. Technological innovations have increased productivity enormously over time and improved stability of supply but has also caused depletion on the fertility of the soil, as was the case in the Roman empire. However, with continued research into productivity increasing technologies and soil preservation methods, we are able to

produce enough food even with the extreme rise in population that has occurred since the beginning of the 20th century.[5]

2.2 Agricultural landmass

There are significant differences in landmass suitable for agricultural production between different countries and regions. This can be caused by both climate factors such as temperatures or rainfall, and it can be caused by lack areas covered with fertile soil. In certain places, these factors can be changed over time by doing land conversion. This involves cutting trees, rerouting of waterways (irrigation) or other landscape changes, however, many places are just not suitable for agriculture regardless what will be done to change them. Examples of this is heavily mountainous countries like Norway, or countries comprised mostly by desert, such as Libya. Some countries are "luckier" then others on this aspect and will therefore have a much better starting point for sufficient production of food internally. As examples of neighboring countries with extreme differences in agricultural land area is the United States with over 44 percent and Canada with only 6.5 percent of total land area, or Denmark and Norway (although not land neighbors) with 65.8 percent and 2.7 percent respectively. There are also different types of agricultural areas with different properties and contributions to food production capabilities. The most valuable is arable land which is land used (or suitable) for crop rotation. Secondly, there is land under permanent crops, which is land that is planted with long term crops such as fruit trees and coca plants.[6] Thirdly, there is pasture land, which is land used for grazing by livestock, typically situated in areas not suitable for arable land as it is hilly, has thin soil, or is scattered with trees or other obstacles.[7]

[5] (John Hopkins Center for A Livable Future, 2021)
[6] (United Nations, 2021)
[7] (United Nations, 2021)

The mixture of different types of farmland is important for a country, and especially the level of arable land per capita. Globally, there is about 5 billion hectares, which is about 38 percent of total land surface. About two-thirds of this area is pasture land and one third is crop land including both arable land and permanent crops. With the global population having more than doubled during the last half a century, farmland per capita has decreased from 0.45 hectares in 1961 to 0.21 hectares in 2016.[8] This speaks to the challenges faced, but also the enormous productivity gains achieved in the industry.

2.3 Demographical changes impacting production and consumption

The demand for food quite naturally correlates with the human population and will therefore in the long term follow the trend of population growth or decline. Not only does total world population affect demand, for several reasons it also matters where this change happens, and how quickly.[9] First of all, as diets differ in different parts of the world, the demand will therefore be for some products in some areas of the world, and others in another area. This can be because of religious reasons, cultural reasons, or economic reasons. Secondly, since landmass suitable for agriculture, and especially arable land varies significantly in different regions, it is impacting the ability to produce food locally, which in turn brings up the third point; infrastructure and trade matters to demographics. If population grow in regions not well connected to the global supply chains, and especially if combined with bad internal infrastructure, it can cause a major lack of stable food supply in that region or country. All of the factors above, like every aspect of human life, changes over time, both within countries and on a global scale. Currently, populations are quite stable in the western world, while SSA

[8] (Food and Agriculture Organization of the United Nations , 2020)
[9] (Westhoff P. , 2010, p. 5)

is experiencing a rapid population increase. This dynamic will cause challenges to the food supply chain.

2.4 Economic, religious, and cultural reasons

Different economic development levels of countries impact the types of food that are in demand. As meat is typically expensive, it is a small part of the diet in less developed countries, and a large part of the diet in developed countries. For basic foods, such as grain, the picture is opposite.[10] This however, gets more complicated as grains is the main feed for livestock and poultry production, and is therefore still in high demand even in countries with relatively low levels of grain in the diet of the human population. Religion impacts what kind of food that is in demand as it often dictates certain food types that are not allowed or not common to eat, as for example pork in Muslim countries/areas, or most meat types in general for many in Buddhist areas. Culture also impacts food demand, but this historically usually comes from a combination of economic and/or religious reasons that created the local food preferences. Over time these factors change as countries develop economically, and food culture is impacted. The religious component can also change and become more or less prevalent over time as countries develop. Overall, the clear general rule is that countries shift their consumption away from a grain-based diet, towards a high protein value diet of more meat combined with rising share of vegetables and fruits when income levels rise.[11]

2.5 Infrastructure, globalization, and trade

[10] (Westhoff P. , 2010, p. 98)
[11] (Gerbens-Leenes, Nonhebel, & Krol, 2010)

As global trade started to escalade, the food marked changed and opened the opportunity for countries to import both more of the food they already produced if there was a demand for it, as well as new products that previously was not available to them. The international trade of food both increases and decreases food security for a country depending on their situation. If there is a decline in local production due to a season or two of unfavorable weather conditions, established import systems will quickly make up for the loss in harvest and stabilize food availability and prices. It can however, also make a country too reliant on imports and put them in a situation where a disruption in the supply chain for whatever reason may cause severe lack of availability since there is almost no local production left.[12] Countries with a high import share of consumption therefore needs to plan for a potential disruption in supply by having backup solutions, currency reserves, and potentially also in-country food reserves. The Covid-19 pandemic has shown the modern world what can happen when a major shock occurs that impacts the global supply chain. The complexity and fragility of the systems that supplies the world with everything from energy to food became visible and the impacts have been felt at some level for every person on the planet; that being lack of parts availability for their car, long waiting time to receive some goods, increasing prices of goods including food, or complete lack of certain food products in the supermarket or local food market. The impact of this has hit countries differently depending on their internal production and supply, import volumes, internal transport mechanisms and restrictions on labor caused by the pandemic. The FAO Food Price Index showing commodity prices of Sugar, Vegetables Oils Cereals, Dairy, and Meat has been rising dramatically from June 2020, when the index stood at 93.1 to May of 2021 at 127.8. The first drop came in June of 2021 when it went back down to 124.6. This is still significantly higher than the 2019 level of 95.[13]

[12] (Westhoff P. , 2010, p. 91)
[13] (Food and Agricultural Organization of the United Nations, 2021)

The highest the index has been was in 2011 at 131.9, following the severe drought in Russia.[14] A recent reminder what can occur in global trade is the blockade of the Suez Canal that occurred at the end of March 2021 showed the fragility of the global shipping industry. The 1,300-foot-long containership, named Ever Given got stuck sideways in the canal for six days stopping all the traffic passing through this extremely important shipping route. As food products generally are more time sensitive on time, some of the shipments could have been completely destroyed by the delays.[15]

Not only is global shipping infrastructure important, so is internal infrastructure in a country. It is crucial, and ensures a well-functioning society as well as economy, and the agricultural sector is no exception to this. It facilitates inputs and outputs to move where needed, ensures efficiency, cost reductions as well as energy and environmental effectiveness. Infrastructure is very broad and covers everything from internet connection to ports and everything in between including roads networks, train connections, inland waterways and lakes, airports, drinking water and sewerage systems (including irrigation), phone networks, and more. Maintenance and appropriate capacity of all of these is a key factor to keep the agricultural sector functioning well. The productive time of a tractor is going to be much lower if spare parts take weeks to arrive or fertilizer is delayed due to inefficient logistics. Similarly, if a load of wheat takes days or weeks to arrive at the mill, or to a ship for export, it adds costs to the process, or can cause loss of product if it goes bad during this time period. In countries with bad infrastructure and/or long distances, prices can vary significantly between different regions of the country.[16] The location of agricultural land within a country itself and the infrastructure available in and to these locations are also crucial. If the main agricultural land area is located far form population centers, it creates a substantial logistical problem.

[14] (Welton, 2011)
[15] (Rich, Reed, & Ewing, 2021)
[16] (Westhoff P. , 2010, p. 46)

This problem can, at least to a certain level be overcome over time by building new infrastructure, but this usually involves huge investments that might not be justifiable. The often better and cheaper solution is to instead import the food due to the efficiency and availability in the global food supply chain. Another factor of a globalized economy is the amount seasonal and /or foreign workers in agriculture. While developing countries usually have a large amount of their workforce involved in the agricultural sector, more develop countries usually are heavily reliant on seasonal foreign workers to sustain their production levels, at least for certain produce. This is typically to do tasks related to harvesting of fruits and vegetables, which are labor intensive compared to the otherwise heavily mechanized agricultural sector of developed countries.[17]

2.6 Policies

Governments tend to have the ability to influence availability and food prices with both broad and targeted policies, some of which decreases prices and some of which increase prices. Due to the global nature of the food supply chain, there are almost always intended or unintended transmission effects of policies in other countries outside of where the policies are implemented. The most common policies, especially in developed countries is import tariffs and farm subsidies which both are meant to support local farming, and therefore quite obviously will have an effect on other countries due to a shift in competitiveness. In developing countries, input based subsidies are more common. These can be systems of subsidized fertilizer or seeds and help to access or buy equipment. Another policy with a significant impacting is biofuel regulation. The use of corn and other grains in the production of biofuels increased demand for these products a lot. This contributed to the rise of food

[17] (Augère-Granier, 2021)

prices between 2005 and 2008 and continues to be an important factor as governments are regulating required levels of biofuel in petrol and diesel fuels.[18] The impact from biofuels production on food prices are still significant, however, the developing technology of synthetic fuels combined with increased electrification will potentially within the coming decades decreases the need for and usage of biofuel substantially.

Due to the need of seasonal workers mention above, immigration policies are important to the agricultural sector. Farmers in countries that are relying on foreigners to arrive for the harvest season expect it to be relatively easy for the workers to enter the country for the season. This is usually the case, but with situations such as the Covid-19 pandemic, we learn that this can change quickly. Many countries have experienced the negative effects of this over the last two seasons, leading to loss of revenue, rising costs, and food going to waste due to inability to harvest in time. This is among the contributions to the increased prices of food over the last year and a half.[19]

2.7 Price sensitivity

There are many inputs influencing the final price of the food at the end consumers table. The value chain starts with inputs and cost of the farming itself, onto the several steps of logistics and transport to packaging, marketing, supermarkets or vendors, and lastly the cost of the consumer to get the food to their home. On a global average, the share of food prices that is linked to the farm level is 27 percent for food at home (for food in restaurants, cafes and other venues, this share is at 7 percent) that is consumed in the country of production. In the period from 2005-2015 this share fell consistently in middle and high-income countries. For food that that is internationally traded, this share is very likely to be even lower as additional

[18] (Westhoff P. C., 2010, pp. 10-12)
[19] (Weinraub & Ingwersen, 2020)

transport, financing and marketing costs occurs. In the United States over the period from 1947 to 2017, farm share of total food expenditures went from 46 percent to 15 percent.[20] The same trend of falling farm share is consistent for every country where incomes and agricultural productivity rises. For every doubling of per capita real incomes, there is a 5.4 percent reduction in farm share of consumer food expenditures. Due to the low percentage of farm share in developed countries, rising costs at this level of the supply chain does not impact the final cost of food for the consumer that much. Take a period of increased farm prices of 50 percent due to bad weather conditions or a disease influencing output. This will lead to a 7.5 percent increase in final price if farm share is 15 percent (all else equal). However, in a less developed country where farm share is 60 percent, the final price would increase by 30 percent. This would be a significant rise in cost of living, and especially in a country where incomes are low and many already struggle to buy food. Also, the assumption that all else will be equal when farm level costs rise is rarely the case in reality as usually energy prices are also higher, leading to higher transport costs, packaging costs, etc.

When prices for food changes, it impacts people in countries of different levels of development very differently. In a high-income country, people spend a far smaller percentage of their incomes on food, while in low-income countries, this share is a lot higher.[21] The result of this is that a price increase will have a much greater impact on the affordability of food in a lower income country than a high-income country, often leading to malnutrition and hunger for parts of the society. Although the price impact is overall stronger in lower income countries, there is a factor that tend to balance this impact which is the percentage of the workforce employed in agriculture. This share again is much higher in low-income countries then in high-income countries.[22] As international prices for agricultural

[20] (YI, et al., 2021)
[21] (Gray, 2016)
[22] (The World Bank, 2021)

products rise, consumers have to spend more, however, in a country where a large share of the population work on farms, the nominal price increase does not impact them as they produce all or at least the majority of the food they consume on their own farm, or barter with neighboring farms. Some might even be better off, as the price they can charge for excess produce they sell will be higher than before.[23]

2.8 Technology and innovation

Technological improvements have dramatically changed the agricultural sector and increased the productivity levels and yields enormously. Technology involves among other factors; machines and equipment, fertilizers and pesticides, GPS technology, internet and data, biotechnology, and irrigation systems. Education and training are also needed to get the most out of the technological advancements, especially when it comes to the use of fertilizer and pesticides use. Labor productivity and land utilization is extremely different between countries with high and low levels of agricultural technology available. Top 10 percent of countries produce 9.2, 8.1, and 4.9 tons of maize, rice, and wheat per hectare respectively while for the bottom 10 percent the numbers are 2, 2.9, and 2 for the same crops. Hectares farmed per worker is for the same groups of countries are 44.6 and 1.4 respectively.[24] Taking the difference in productivity of labor and land utilization together, the countries utilizing modern methods and technology produces about 100 times as much per worker then the once that do not.

A changing climate poses new challenges for the agricultural sector, and technology is helping reduce this impact. There are many ways of adapting to a changing climate and still be able to produce food. In fact, the variation in production is much lower than historically, as

[23] (Westhoff P. , 2010)
[24] (Gollin, Lagakos, & Waugh, 2014)

we with new technology has been able to overcome many of the impacts of weather and climate events, as well as learnt do predict and deal with it.[25] There is also continuously a lot of research going into ways of limiting the future change, like seeds that are more tolerant to higher temperatures unstable weather conditions.[26] Expansion and improvement of irrigation systems to modernized pressurized systems will also become necessary in certain areas where extended periods of drought are likely to occur.[27]

2.9 Currencies and finances

The economic situation of a country substantially impacts its ability to secure food supply, especially if it is heavily reliant on imports. Price of food commodities in different countries is priced in local currency, while internationally traded food commodities is priced and traded (most commonly) in U.S. Dollars. This means that the value of a country's currency in relation to the U.S. Dollar plays a significant role in their ability to import. Food prices measured in dollars increase when the dollar weakens against other currencies and decrease when the dollar strengthens, so the relative currency value is of importance.

Financial resources and access to capital and credit internally in a country is an important factor in the functioning and development of the agricultural sector. To invest in expansion or productivity increasing equipment, a farmer needs to be able to access financing, especially since farm equipment is typically very expensive, long-lasting investments. Lack of a well-functioning financial system is typically seen in low-income countries and is leading to a situation where there is no way for farmers to expand their production capabilities. Some countries work more on increasing the access then others, and some create government

[25] (Westhoff P. , 2010, p. 82)
[26] (Muhumuza, 2018)
[27] (Climate Adapt, 2015)

support or loan systems to facilitate investments. Just 4.7 percent of adults living rural areas of developing countries has a bank account, and even though about 55 percent of the workforce in Africa is employed in agriculture, only 1 percent of bank lending goes to the sector.[28] New financial technology, like phone payment solutions and online banking is helping to solve this problem in many parts of the world.

2.10 Energy prices

The price of energy is significant for the price of food as it is a major input in every aspect of the food supply chain from pre-production to the plate. Crude oil and oil derivatives are the most important one of the energy sources, and particularly diesel fuel as it is the main fuel for both farm machinery and in the transportation sector. As oil is also used for plastic production, packaging becomes increasingly expensive with rising oil prices. On the input side has the efficiency of synthetic fertilizers production has improved tremendously since it was introduced and is now about three times as efficient as it was back then. Never the less, it still requires huge amounts of natural gas for its production and prices therefore are very reliant on the natural gas price.[29] Another very important factor, is the previously discussed use of biofuel. As oil prices rise, the incentive for increased use of biofuel comes along with it which means that biofuel producers will start buying up grains, putting an upwards pressure on prices. The producers will continue to expand production until it is no longer profitable and biofuel prices are equal to conventional fuel or demand is fully met. The government regulated required minimum levels and allowed maximum levels of biofuel mixed into gasoline and diesel at the pump is therefore important for grain prices. Historically, the

[28] (World Bank Group, 2014)
[29] (Huang, 2007)

general rule has been that food prices tend to move in correlation with oil prices.[30] However, after the oil price collapse in 2014, this correlation has weakened, and this trend is likely to continue with increased electrification and renewable energy production.[31]

2.11 Weather

Food prices has a strong correlation with weather conditions, and farmers often use the phrases *"rain makes grain",* or *"no rain, no grain".* The total global average production tends to be relatively stable, but regional weather differences are very common and is the single most important factor that impacts production output.[32] However, even if world production is relatively stable, it matters to prices where in the world production happens. If weather conditions decrease output in a country that in integrated into the worlds agricultural market and usually exports big volumes, the local consumption will not be impacted, but the reduced amount available for export will put an upwards pressure on prices. If, on the other hand production output falls in a country that is not connected to the world market. It will have a significant impact on their local consumption, possibly even leading to hunger, while world prices will not be affected much. Following this, the risk of bad weather conditions is more prevalent for countries that are not involved, or very lightly involved in agricultural trade as they will then have a much harder time importing food to balance the lack of local production.[33]

[30] (Westhoff P. , 2010, p. 35)
[31] (Roman, Górecka, & Domagała, 2020)
[32] (Westhoff P. , 2010, p. 82)
[33] (Westhoff P. , 2010, pp. 90-91)

2.12 Impacts of climate change

The impacts on food production caused by climate change are very complex and very hard for scientists to model and understand. The amount of research on this topic is rising, however, due to the complexity the question, the total effect on the ability of the world to feed itself is not clear as effects are both negative and positive. The effects will also impact different regions very contrastingly, causing further complications. Some areas might turn out not to be suitable for almost any farming anymore, others might need to change their crops to some that grows better in a warmer, dryer of wetter climates, while some areas might also greatly prosper from longer growing seasons, higher Co2 concentrations, or other positive trends. This will likely lead to a stronger decoupling of where food is produced and consumed. Estimations show that by 2050, between 4 and 51 percent of the world's population will require non-domestic resources to produce crops. The limiting resources influencing this is are the resources of water and land. The estimates use the IPCCs data on climate and population expectations, and show the broad spectrum of potential outcomes.

The most obvious impact on agriculture from climate change is the impact on weather conditions. It is expected that a large part of the world will see more fluctuating weather and longer periods of extreme weather phenomena, typically floods or droughts which will directly impact the growth environment for crops. However, the more invisible factors such as amount of Co2 in levels, insects, diseases, weeds, solar radiation, precipitation and average temperature range, which all are connected and have adverse effects depending on region, type of crop, and applied technology. Research suggests that there are negative impacts for increased average temperature, and increased length of droughts. Increased levels of co2 in the air shows positive results in stimulating growth and yield.[34][35]

[34] (LI, 2018)
[35] (Chandio, Jiang, Rehman, & Rauf, 2020)

Agriculture is in itself a huge contributor to greenhouse gas emissions, accounting for 24 percent globally not detracting from carbon sequestering from the sector. Carbon sequestering in plants and soil offsets about 20 percent of the sectors emissions.[36] Utilizing new technology and methods for efficiency increases, the sector can contribute immensely to decreasing its environmental impact, improve soil health, improve yields, and possibly also help take carbon out of the atmosphere. The technique is called regenerative agriculture and involves sequestering carbon back into the soil while farming through replacing plowing with drilling seeds into the soil and utilizing cover crops to cover the soil when the main crops are harvested.[37]

[36] (epa.gov, 2014)
[37] (Ranganathan, Waite, Searchinger, & Zionts, 2020)

3 Implications in different regions – The cases of Nigeria, China, and the United States

3.1 Overview of the key figures for each state.

	Year	Unit	Nigeria	China	United States
Total land area	2018	Square Kilometers	910,770	9,424,702.9	9,147,420
Agricultural land	2018	Square Kilometers	691,234.5	5,285,287	4,058,103.538
Agricultural area	2018	% of total land	75.9	56.08	44.36
Arable land	2018	Hectares	34,000,000	119,488,700	157,736,800
Arable land	2018	% of ag.land	49.19	22.61	38.87
Arable land	2018	Hectares per capita	0.174	0.086	0,483
Number of farms	2016	Million	100 (est)	231	2.055
Average farm size	2016-2019	Hectares	0.83276	0,96	444
Fertilizer use	2015-2019 avg/year	Avg. Kg/Ha	19.737	393.215	128.765
Pesticides use	2015-2018 avg/year	Avg. Kg/Ha	N/A	13.06	2.55
Food supply	2015-2018 avg	Avg/Capita/day	2563.25	3180.50	3763.75
Renewable water resources	2017	Cubic meters/Capita	1,157.836	2,029.003	8,667.512
Ag. Government exp.	2015-2019 avg/year	Million U.S. dollar	318.09	10,756.74	25,160.00
Workers in agriculture	2019	Percent	34.97	25.33	1.36

Sources: Food and Agricultural Organization of the United Nations and The World Bank data.[3839404142]

[38] (World Bank, 2021)
[39] (The World Bank, 2019)
[40] (The World Bank, 2021)
[41] (Food and Agricultural Organisation of the United Nations, 2018)
[42] (Food and Agricultural Organization of the United Nations, 2020)

4 Federal Republic of Nigeria

Nigeria is located on the west coast of Africa by the Gulf of Guinea. With a population of 211 million people[43], it is the most populous country on the African continent. After the oil industry, agriculture is the second most important part of the Nigerian economy and the sector employs about 35 percent of the labor force in the country. The rapidly growing population challenges the ability of local farmers to produce enough food, and the country is therefore heavily reliant on imports to meet the ever-growing demand. A challenging economic situation hampers the ability of the country to import enough to cover their food needs, and undernourishment is rising among the population. This section will analyze the factors of production available, the policies implemented to support food production, societal factors influencing consumption, and the external factors influencing food availability and security of the nation.

4.1 Agricultural landmass

The country is among the largest in Sub-Saharan Africa with a total area of 923,769 square kilometers. The agricultural land area is close to 76 percent of the total at 691,234,5 Sq.km and is comprised by is comprised of 37.3 percent arable land, which is among the highest share in the world.[44] However, soil fertility is very low in most parts of sub-Saharan Africa, including Nigeria due to bad farming practices and long-term underutilization of fertilizers.[45] The government has not been interested in making sure soil qualities were maintained or improved. In some areas, wind is the main cause of soil erosion via dune remobilization, and attempts are made by locals to construct barriers, but these rarely succeed in protecting the

[43] (United Nations Population Fund, 2021)
[44] (The World Bank, 2021)
[45] (Akinde, Olakayode , Oyedele, & Tijani, 2020)

land.[46] Government investment and incentives, education of farmers, and developing support systems for fertilizers can give huge increases in soil fertility and following yield increases. There is a potential for huge increase in yields from today's very low levels. The average farm size in Nigeria is extremely small, at only 0.83 hectares, posing a problem for efficiency and ability to modernize the sector. Theoretical Nigeria has enough land area, fertile soil and climate to grow enough food for their population, however both increase in productivities and expansion of productive arable land area is necessary to achieve this.[47]

4.2 Demographical changes

The already large population of Nigeria is the most rapidly growing country in the world and is expected to grow at a record pace over the next decades and by 2050 surpass the population of the U.S. making them the third most populous in the word (currently 7th).[48] As most other countries, Nigeria is experiencing rapid urbanization rates. In 1990, 70 percent of the population lived in rural areas, while the number is now at 48 percent.[49] The population in Nigeria, as in most of Sub-Saharan Africa is very young, and while farmers follow the trend of the rest of the world of being old, the average age is significantly lower than in developed countries. Due to very family-oriented labor structures of Nigerian farms, the average age is a bit more of a complicated number. The average farm owner, or head of the farm is 53 years old, while the average person working on the farms is 33 years old.[50] Even though this is younger than most parts of the world, the picture looks different if considering the average age of the population of just over 18, and that life expectancy is only 54.7 years, farmers are

[46] (Mortimore, 1993)
[47] (Fader, Gerten, Krause, Lucht, & Cramer, 2013)
[48] (UN Department of Public Information, 2017)
[49] (World Bank, 2021)
[50] (Arslan, 2019)

old on a relative basis.[51] The attractiveness of farming needs to increase, and this mainly includes increased salaries, which means prices therefore need to rise at the farm level.[52] As mentioned, about 35 percent of the workforce are involved in agriculture which is a very significant amount of people, and that that both speak to both the importance, but also the inefficiency of the agriculture sector in the country. However, the number has gone down significantly from more than 50 percent over the last three decades,[53] indicating a gradual transition towards higher factor productivity of labor in the sector.

4.3 Infrastructure and trade

Infrastructure is among the top challenges for the Nigerian economy in general, and also for the agricultural sector. Long distances, bad road quality and lack of access to vehicles makes it hard to both acquire farm inputs such as fertilizer and seed, and transport/sell outputs. Farmers typically walks and takes busses for hours each way to acquire fertilizer or other inputs to production, and finished goods takes long to reach markets and consumers. There is also a high rate of lost and damaged products during transport due to bad infrastructure systems. The value of lost agricultural produce is estimated to be as much as $8.9 billion annually in the full post-harvest value chain.[54][55] This is a huge amount, and points to the importance of improving the infrastructure in the country.

Nigeria runs a deep trade deficit on agricultural products every year with imports being about three and a half times higher than exports.[56] They are typically importing food at a value of about $10 billion a year, however, after what is an outlier in this analysis, which is

[51] (The World Bank, 2019)
[52] (Leavy & Hossain, 2014)
[53] (The World Bank, 2021)
[54] (Bello, 2018)
[55] (This Day, 2021)
[56] (Oyaniran, 2020)

the impact of insurgencies on the agricultural sector imports has risen dramatically. In 2019 Nigeria closed its land boarders to limit the treat of insurgencies, which lead the flow of goods to stoop as well. Additionally, production has been impacted heavily in the northern regions, leading to low levels of wheat output.

4.4 Government policies

The Nigerian government seems to understand the importance of the agricultural sector, and that policies and plans are needed to increase productivity and output in order to meet future demand from an ever-growing population. The government has implemented a long list of different policies targeting all different sides of the agricultural sector, but the success has been limited and the sector is still underdeveloped. While government support systems in developed countries typically is structured as area payments, it is usually structured as subsidies of inputs in developing countries. This mostly is the case in Nigeria as well, where several input programs have been implemented, among them a fertilizer subsidy under the new structure called Growth Enhancement Support, which has increased usage dramatically.[57] Other programs include the Anchor Borrowers Programme meant to give access to credit, and the Green Imperative plan meant to accelerate mechanization of the agricultural sector. The main challenge for Nigeria is in the infrastructure space, both to facilitate trade and to have facilitate local transport of agricultural inputs and finished products. The government is implementing policies to increase the capacity and efficiency of the infrastructure through a list of initiatives. Development of railway, road, and port infrastructure, as well as creating special Agro-Industrial zones.[58] Railways are planned to be built across the country uniting the agricultural areas with areas of consumption as well as seaports for export. Today there

[57] (Michael, Tashikalma, & Maurice, 2018)
[58] (Oyaniran, 2020)

are six seaports in Nigeria, and to increase capacity, another two is planned in Lagos and in Akwa Ibom. In 2019 The Nigerian Port Authority (NPA) signed a Memorandum of Understanding (MoU) with the Port of Antwerp with the goal of increase operational efficiency through technical and practical skills and knowledge.[59] Road infrastructure is also a strong focus, as railroads only will cover main transportation routes. A good road network with a capacity for trucks to travel efficiently is essential to achieve a well-functioning agricultural sector and reduce damage of goods due to delays or bad road quality between producer and consumer. To help boost the productivity of the agricultural sector the Federal Ministry of Agricultural and Rural Development (FMARD) and Federal Ministry of Finance is developing a project of Special Agro-Industrial Zones (ZAPZs) that contains four different state clusters. The first cluster is comprised of the five states of Katisina, Kano, Jigava, Kaduna, and Gombe,[60] the second of the six states of Ogun, Lagos, Ondo, Oyo, Osun and Ekiti.[61] The third cluster is the six states of Niger, Kogi, FCT, Kwara, Kebbi and Sokoto,[62] and the last one is the four states of Anambra, Benue, Cross River and Ebony.[63] This project is financed by the African Development Bank (AfDB) and International Fund for Agricultural Development (IFAD). It contains three main components; (a) Support the development of climate-resilient enabling infrastructure and management of Agro-Industrial zones; (b) Enhance climate-smart agricultural production and productivity in proximity to Agro-Industrial zones; (c) Support enabling institutional capacity, policy, regulatory and business environment for agribusiness and project management. It aims to increase food and nutritional security, enhance productivity of the farming sector, encourage long-term investments from the private sector, promote investments into climate-smart and green technologies,

[59] (Nigerian Ports Authority , 2019)
[60] (Rigasa, 2021)
[61] (Itua, 2021)
[62] (Badamasi, 2021)
[63] (Ebigwai, 2021)

economically develop the rural areas, and increase tax revenues. This kind of full-scale plan for boosting the agricultural sector is strongly needed in the country, and the enormity of it shows that it is now high on the political agenda. The initiative will not be rolled out in all states simultaneously due cost and logistical challenges of doing so. The first phase will start with seven states, among them Ogun which is an ideal candidate as its landmass consists of about 74 percent arable land and it is a major agricultural state already. It also has several other positive factors for industrialization such as a deep-sea port, good road and rail infrastructure, a gas pipeline, and a powerplant. Additionally, as it is the neighboring state to Lagos, it has close proximity to the main consumption area of the country.

4.5 Economic, religious and cultural

The economic situation of Nigeria is a key factor for food demand in the country. Consumption of cereals is at very high levels, which is typical for a low-income country, while shares of meat and dairy remains low. As the economy grows to an expected GDP per capita of more than $7000 by 2050, while also urbanizing, the demand for higher value proteins will increase leading to a need for more livestock production. The demand for all livestock products is estimated to triple until 2050, which means demand will grow at an annual rate of about 3.3 to 3.8 percent.[64] Some of the growth in demand will be met by increased productivity, while most will have to be met by increasing animal stock. This increase will lead to a rising demand of animal feed in order to facilitate the rising number of animals, leading to increased pressure on the agricultural sector and likely increased imports.

[64] (Food and Agricultural Organisation of the United Nations, 2018)

4.6 Price Sensitivity

Price sensitivity is extremely high in Nigeria as incomes are low and share of income spent on food (food consumed at home) is the highest in the world at 56.4 percent. This is almost a full 10 percent above the country with the second highest share, which is in Kenya at 46.7 percent (most countries in sub-Saharan Africa is lacking data, but several of these is likely to be in the same range)[65] As farm share of food prices is also high, any factor changing costs at the farm level will have a substantial effect on the affordability of food for the Nigerian consumer. With a high share of import in the food mixture as well, the country is exposed to international food commodity prices, and price changes will drastically influence the consumer prices in the internally.

4.7 Technology, innovation and water management

Adaption and utilization of technology and machinery is going to be essential for the development of the agricultural sector in the country. It is needed in order to increase productivity and output, reduce the risks posed by climate change, and reduce wrong use of inputs and wasteful handling of outputs. At the level of development the sector is at currently, the most important is to start with the basics of technology, while also focusing on training farmers on using those, and on how to better manage their land. Even if advanced technology will eventually play a role, it will have to be a gradual process.

There is a need for more research and development spending to understand and develop agriculture, however the earmarked budget was only about 40 billion Nigerian Naira

[65] (Gray, 2016)

in 2019, which is less than 100 million USD.[66] This is very little considering the population of the country and the agricultural land area and potential they have.

With renewable water resources of only about 1.158 cubic meters per capita, development of efficient water management systems and irrigation technology will likely be needed in the parts of the country most exposed to climate risks and droughts.

4.8 Currencies and finance

The financial situation of Nigeria is not strong, and the currency is continuously devaluing against the U.S. dollar. This poses a risk to the purchasing power of imported food products, as well as agricultural inputs and machinery. There is very little, or no local production capacity for equipment, meaning the modernization of the agricultural sector has to be done with imported machinery and equipment. This is a huge investment that will require a lot of foreign currency, which the country already is lacking. To facilitate the investments needed to modernize the agricultural sector, access to credit is needed. The financial system in Nigeria is developing, but it still has huge ways to go before credit is readily available. This is a major challenge holding back the development of both the agricultural sector, supporting sectors and the rest of the economy. The previously mentioned Anchor Borrowers Programme is meant to give farmers and companies involved in the agricultural sector access to cheap and long-term credit in order to invest into development of their businesses. One of the sectors targeted by the programme is rice production, which was targeted by the government to be fully supplied by internal production by 2018. They are still importing about half, but even if prices still are higher than for imports, the local production is increasing due to the program.[67] A start-up

[66] (Oyaniran, 2020)
[67] (International Trade Administration, 2020)

called Farmcrowdy, which is a crowdfunding app aimed at financing small Nigerian farms has gained popularity and has funded more than 7.000 farmers.[68]

In June of 2015, the Central Bank of Nigeria issued a ban on the use of foreign exchange markets for importers of certain products in an effort to sustain the stability of the currency. Among the 41 products on the list, many food items were included. The policy also aimed to incentivize the expansion of production of these items in the local market leading to improved employment.[69] The previously mentioned rise in imports due to production issues in the north caused by insurgencies has led to a situation where the bad state of the currency reserve situation became very visible. As imports started rising dramatically in 2020, Nigeria saw their reserves dwindle leading them to impose further limitations of the use of foreign exchange for import of additional products. In April of 2021, this ban has been extended to include wheat and sugar as well.[70] Although there is a ban of accessing the foreign exchange market for importers of these goods, import is not illegal. As the local market is far from being able to supply enough, importers therefore have to find alternative ways of acquiring foreign exchange. Mostly, this happens through the currency black market which is trading about 20% over the closely protected and managed official rate.[71] From 2012 to 2020, the proportion of undernourished in the population has gone from 7.6 percent to 12.6 percent according to the global hunger index,[72] indicating that there is a large group of the population who is not able to acquire enough food with these limitations in place.

[68] (Unah, 2018)
[69] (Gbadamosi, 2015)
[70] (Ohuocha, 2021)
[71] (Alake, 2021)
[72] (Global Hunger Index, 2021)

4.9 Energy prices

Energy prices have a relatively small impact on direct production costs in Nigeria as the majority of farms are still utilizing conventional manual equipment. As the price of fertilizers correlates strongly with the price of energy, it will play a stronger role then diesel prices currently do. With the agricultural sector modernizing, prices of both will continue to increase as a share of total costs, and therefore impact final prices more than today. At the same time, farm share of final cost will likely decline simultaneously. Nigeria as a huge food importer will be influenced by energy prices through increasing production costs in the exporting country as well as rising cost of transportation and shipping. As a major oil producing nation, Nigeria has an advantage of being less impacted by rising oil prices as acquiring fuel would not put a huge strain on the foreign exchange reserves.

4.10 Impacts of weather and climate change

Weather conditions in Nigeria are not ideal in many parts of the country, with short growing seasons in many regions of the country.[73] Average annual rainfall is about 300mm in the north and 2500mm in the coastal areas in the south, creating significantly different growing potentials. As mentioned, Nigeria has the smallest amount of renewable water resources of the analyzed countries at just over one thousand cubic meters per capita, potentially posing a threat to the sector and increasing the risk of warmer climates and prolonged droughts. Climate change will contribute to a change in the agricultural sector of Nigeria, however according to climate science, most of the impact on the African continent will be in the north and south while central regions will be less affected. [74] Similar as with energy prices, Nigeria

[73] (Odekunle, 2003)
[74] (Woetzel, et al., 2020)

being a huge food importer, are exposed to changing climate or weather in a main exporting country of grains. A significant impact there, will impact the country's ability purchase imported food commodities.

5 People's Republic of China

With a population of 1.41 billion people, China is currently the most populous country in the world. [75] Feeding a population of that size creates many challenges. The Great Chinese Famine of the late 1950s and early 1960s is a clear example of a long list of failed policies leading to a devastating result in the country. Millions died, and it is a situation that the Chinese Communist Party will do everything in their power to avoid a repeat of. Therefore, they are working hard to secure the food supply to the country by a diversity of means, from increasing internal production capabilities, leasing of land in other countries, to imports from abroad. Great strives have been done to increase production levels, increase production levels, and lift the rural population out of poverty. However, there are still challenges ahead, and this chapter will discuss those. This section will analyze the factors of production available, the policies implemented to support food production, societal factors influencing consumption, and the external factors influencing food availability and security of the nation.

5.1 Agricultural land

As the third largest country on earth with a total area of 9,424,703 square kilometers (including Taiwan), China is not lacking space. They have huge amounts of total agricultural land mass with a total area of 5.285.287 sq.km.[76] However, their huge population needs even more. In 2015, China had 18.9 percent of the world's population and 8.5 percent of the worlds arable land area.[77] This means that they have a significant amount of people to feed per hectare of arable land creating a need for increased efficiency. The composition of farms in china is mainly small family farms rather than large industrialized farms, and average farm

[75] (statistia, 2021)
[76] (The World Bank, 2021)
[77] (Hayes, Li, & Zhang, 2019)

size is only slightly larger than in Nigeria, at just 0.96 acres. Privat land ownership is not allowed in China and all rural land is therefore owned by rural collectives organized by the Household Responsibility System (HRS) who allocates right of use to eligible households. With the 2002 Land Contract Law of China the right of farmers to transfer their land rights was confirmed. This has led to the increasing trend of farmers letting friends or family in the area farm their land, usually for a small rent, while they, themselves move to work in a factory job in an urban area. Even though this trend still only accounts for a small share of Chinese farmland, it helps to increase the size of farms. The central government has extended the HRS tenure until 2057 and while so also issued updated certificates that are more accurate on size and location of the plots. This is expected to increase land rental and is likely to incentives a larger share of firms to start renting the land for industrialized agriculture. Rental of land has shown to increases productivity by as much as 60 percent. The increased productivity is caused mainly by economics of scale as mentioned earlier and the fact that it is usually the struggling, less productive farmers who choose to rent/let out their land and move to a city.[78] Chinese are acquiring millions of hectares of farmland in foreign countries around the globe to secure food supplies.[79] The land purchases were previously mostly targeting developing countries, however lately they have increased purchases in countries like Australia and the U.S.[80]

5.2 Demographical changes

The demography of China is among the worst in the world with extremely few young people. The population is set to decline dramatically over the coming decades, falling about one

[78] (Hayes, Li, & Zhang, 2019)
[79] (Smaller, Wei, & Yalan, 2012)
[80] (Mccrimmon, 2021)

billion people by the turn of the century.[81] This means that the total amount of people requiring food will be decreasing, easing up the challenges faced by the agricultural sector in the country. However, this is counterbalanced by the rapidly aging population, which includes the farmers. With the big move to cities and very few young people wanting to farm, the production capability of the Chinese agricultural sector is heavily reliant on a successful modernization and industrialization of the sector, including dramatic reduction in numbers of farms and rising farm sizes. There are currently 231 million farming households in the country and about 27 percent of Chinese are employed in agriculture. This leads to a problem when young people do not want to continue running the farm, and rather relocate to a city. A huge number of farmers would be needed to sustain production within the current farm structure. The problem of the small farm sizes is its implications on the investment rate and productivity increases of agriculture. Small farms do not have any ability or capital to invest into modern equipment that would increase the output of labor. For a very small farm, the investment needed may changing from manual equipment and investing in a tiny tractor, while for a bigger farm that could be investing into a combine harvester, a bigger tractor or a new drill.

5.3 Infrastructure and trade

The amount of infrastructure has increased extremely in China along with its economic development, and it is one of the main focus areas of investment and development in the country.[82] This means that the quality and ease of transport has significantly increased over the last decade. Especially rural infrastructure was a main objective in the 12th five-year plan,

[81] (United Nations, 2019)
[82] (Berreda & Wertime, 2013)

which has led to much better accessibility of the countries core farmlands.[83] The focus on infrastructure is increasing the connections in China, however there are still geographical limitation creating challenges for infrastructure development and usage of land. Certain parts of the country are located in areas that are very far from the agricultural core in the north-east.[84] In 2006 the total length of the Chinese road network was 3.457 million kilometers with 2.283 million km of paved (standard) road and 1.174 of unpaved (substandard) road. This increased to 4.339 million km of standard road and 434.91 thousand km of substandard roads.[85] This shows the rapid increase of the Chinese road network, which is now the second largest in the world after the U.S.[86] Historically China was a mainly net food exporter, but since 2004 they have been a net importer, and increasingly so until it stabilized in 2012.[87] In 2021, the trade deficit has been increasing dramatically again, reaching $28.62 billion in the first four months.[88] The U.S. is among Chinas main suppliers of agricultural products, and USDAs numbers show a 91 percent increase in exports to China from 2019 to 2020 totaling $26.435 billion for the year.[89] A huge share of the imports are livestock feed, and mostly soy beans, but also corn and wheat. The countries huge involvement in international trade, including food gives them easy and quick access to the world's food market, however, the reliance on imports is still significant and poses a threat to their food security.

Along with expanding and diversifying their investments in foreign agricultural land, China is also focusing on gaining control of trade links and logistics linked to the food supply chain in order to rely less on the laws and regulation of international food trade.

[83] (Lapehn, 2020)
[84] (Zader, 2013)
[85] (Wu, Guan, Zhang, & Xu, 2019)
[86] (CIA, The World Factbook, 2021)
[87] (Zhu, 2018)
[88] (The State Counsil, The peoples Republic of China, 2020)
[89] (USDA, Foreign Agricultural Service, 2021)

5.4 Governmental policies

In a recent government publication called "China No.1 Central Document of 2020" two main policy goals were put forward of poverty alleviation and improving rural weak links.

> "*Measures to be implemented include: (i) to control rural ecological and environmental problems, i.e. enhance the treatment and reuse of livestock manures, reduce the application of chemical fertilizers and pesticides, control soil and water pollution, conserve arable farmland, etc. (ii) ensure the land resource supply for rural and agricultural development, i.e. setting up arable land red lines, incorporating land use for constructing processing, storage and marketing facilities into land management system; etc."*[90]

The rapid urbanization China is going through is requiring a lot of land for city and infrastructure development, and some of this will have to be agricultural land. The central government is tightly controlling the amount of land converted away from farm use, and if additional land is being converted it has to be replaced by new arable land somewhere else. A commonly used policy to increase arable land in rural areas is to deconstruct the homes of the farmers and relocating them to high-rise buildings that is much less space consuming. The local governments then gain area permits to convert arable land to urban development or they can sell the urban land rights to other local governments.[91] Food security was included as a specific goal in the 14th five-year plan of the CPC and included policies to reduce reliance on imports of livestock feed, continuing the development of rural areas and setting a very strict land protection system in place that determines a minimum amount of agricultural land, called

[90] (Food and Agricultural Organization of the United Nations, 2020)
[91] (Hayes, Li, & Zhang, 2019)

the “red line”. To maintain a level of security in supply of basic foods in an emergency situation, China keeps a huge grain reserve. The history of grain storages is long, and they have invested significantly into increasing capacity and modernizing existing storage facilities.[92] In April of 2021, the amount of grains on reserve reached 650 million tons, which is enough for a year of domestic consumption.[93]

5.5 Economic, religious and cultural impacts

Rapid economic development has occurred in China over the last decades leading to a cautiously changing diet that includes more and more high protein products. Meat, vegetable, and fruit consumption have gone up significantly and rice consumption down. This trend is likely to continue, although it is probable that it will turn more gradual. In 1961, average meat consumption was 3.8 kg per capita per year, while for 2013, the number was 62 kg. Vegetable went from 79.7 kg to 348 kg, while fruit went from 4.3 kg to 94 kg.[94] Cheaper meats like pork are still the most consumed, while beef is still far below the values of the U.S. and Europe. The global trend of healthy food, vegetarianism, and veganism is also catching on in China, especially in the urban areas. The Chinese government has also implemented new dietary guidelines to curb meat consumption.[95] It is hard to predict the full and continuous effect of this trend and government guidelines, but it likely will help to slow down the growth in meat consumption.

[92] (The State Council Information Office of the People’s Republic of China, 2019)
[93] (Demaree-Saddler, 2021)
[94] (Zhu, 2018)
[95] (Milman & Leavenworth, 2016)

5.6 Price sensitivity

Price sensitivity in china is decreasing rapidly as the economic situation improves and huge amounts of the population is brought out of poverty. It is still, however, an enormous group of Chinese who lives in, or at the edge of poverty and who are malnourished.[96] Small price increases can therefore heavily impact the country and its population. An example of this is the African swine fever that hit Chinese pork production extremely hard in 2018 and into late 2019. It wiped out about 50 percent of the Chinees pork population, and prices of meat increased by more than 80 percent.[97] The disease in now again coming back, and we might see a reoccurrence of the price increases.[98]

Even though farm value has increased in China, post-farmgate value added has increased a lot more, leading to a rapid decrease in farm share of final food prices. This means that price sensitivity is decreasing for the average Chinese consumer, and ricing farm costs, or food commodity import cost will not significantly impact the them.[99]

5.7 Technology, innovation, and water management

There is a rapid development in the use of technology in China and although the farming sector is far from as advanced as in developed countries, great strives have been made. The development of alternative agriculture solutions, seeds technology, livestock improvement and modern equipment. These implementations have increased the productivity of the Chinese agricultural sector, and the momentum is strong in continuing this. However, a strong

[96] (World Food Programme, 2021)
[97] (Patton, reuters.com, 2019)
[98] (Patton, reuters.com, 2021)
[99] (YI, et al., 2021) (YI, et al., 2021)

increase in mechanization of the industry is needed to take the sector to the next level of output and technology utilization.

On the contrary to Africa, where a severe underuse of fertilizers is causing problems, China has an opposite problem of strong overuse of fertilizers. From 2004 to 2017, chemical fertilizer use has risen from 46.37 to 58.59 million tons. This overuse is the key cause of soil degradation and negative environmental impacts causing long term issues. There is also an overuse of pesticides and insecticides leading to severe negative health impacts on the population. Both of these problems are causes by a combination of government policies and by lack of education among desperate farmers trying to increase production.[100] Some of the environmental impacts might take long to balance out, but regulators have started to focus on the issue and improvements are already happening.

The amount of renewable water resource in China is at about the world average. It should not pose a significant challenge to their agricultural sector in the near future. However, water resources are spread very unevenly in China, with the whole western part having almost nothing. This combined with topographical factors is why there is almost no agricultural production in the area.

5.8 Currencies and finance

The financial situation of both the Chinese government and the population as a whole has increased dramatically. They now have the purchasing power to import huge amounts of products from abroad. They are the main importer of agricultural products from the U.S. and will likely continue to be so for a while. The currency situation therefore plays a significant part in the price of certain products related to imports. The fact that they have developed local

[100] (Hinnink, 2018)

production of many types of equipment and machinery including tractors and combine harvesters, means that technological advancement of the sector requires less use of currency reserves than it otherwise would. The access to financial resources for the Chinese agricultural sector is gaining strength every year. On December 31, 2015, the State Council of China issued Plan for Advancing the Development of Financial Inclusion.[101] In this plan, they targeted groups that typically have lack of access to loans and other financial solutions, among the farmers. By the middle of 2020, outstanding loans to agricultural areas of the country reached RMB37.8 trillion (about $5.83 trillion), accounting for 22 percent of outstanding loans of financial institutions. This does not mean all this went to firms or individuals in the agricultural sector, but it gives an indication of the size and expansion of funds. Even though this number is huge, there are still ways to go, and penetration is not good enough into certain parts of the country and among certain groups. In March of 2020, the World Bank approved a load of $300 million the help China increase green agricultural development the boos the adaption of innovative technologies. The funds were targeted towards the Henan Province, and the hope is that it will help attract and mobilize further public and private investment.[102]

5.9 Energy prices

As with Nigeria, the impact on fuel prices on direct production costs are lower than in countries with modernized agriculture as a large part of farmers till use conventional manual farming techniques. Modernization requires huge investments into new equipment and machinery which requires access to finance for farmers. However, even if it is very gradual, this transition is happening and will influence the exposure to energy prices. Similar to

[101] (Chen & Yuan, 2021)
[102] (The World Bank, 2020)

Nigeria, China, as a huge food importer is exposed to the risk of rising energy prices as it impacts production costs in exporting countries, as well as transportation costs. Opposite to Nigeria, China is a major energy importer will be more exposed to rising energy costs in the sector.[103]

5.10 Impact of weather and climate change

China has many different climate zones and therefore very varying weather depending on the part of the country. The recent flood of July 2021 in the Henan region is an example of how extreme weather can impact production. The region has the second largest grain output in the country at 68.26 million tons in 2020, accounting for more than 10 percent of the total output. This shows the potential damage extreme weather can do when such a huge agricultural area as located in a flood prone area. However, floods do not impact the total output of Chinees agricultural production significantly.[104] As the Chinese agricultural sector is the biggest in the world, any significant impact from climate change on the agricultural production in the country will strongly impact the worlds food supply, and price levels. An empirical study of the impacts of climate change in China from 1982 to 2014 showed that increased levels of Co2 has a positive impact on agricultural output both in the short and long-term. Temperature and rainfall, also had a positive impact in the short-term, however negatively impacts output in the long-term.[105] Another study, analyzing for solar radiation, precipitation, and GPP, found that the agricultural sector in the country was negatively impacted by climate change. However, this analysis did not account for Co2 concentration levels.[106] Even with slightly different results, the advice is investing in improved weather forecast, expanding and

[103] (U.S. Energy Information Administration, 2020)
[104] (Guoxiang, 2021)
[105] (Chandio, Jiang, Rehman, & Rauf, 2020)
[106] (Chen, Chen, & Xu, 2014)

modernizing irrigation systems, and construct farmland to better deal with climate change, and utilize new crop varieties. Some of these changes has already implemented with great results for increased yields.[107]

[107] (LI, 2018)

6 The United States of America

With a population of 330 million, the U.S. has far more agricultural capacity then needed, and that is likely to continue to be the case into the future. They have the second largest agricultural land area in the world after China, along with the second largest agricultural economy. On the complete contrary to China, the United States has only about 2 million farms and an average farm size of 444 acres which is in the world top. This means that the structure and factor productivity of farming in enormously different and indicates the advanced level of the sector. The U.S. grow nearly 25 percent of all grains worldwide,[108] and have for decades been the largest exporter of agricultural products in the world. This section will analyze the factors of production available, the policies implemented to support food production, societal factors influencing consumption, and the external factors influencing food availability and security of the nation.

6.1 Agricultural landmass

As the third largest country in the world after China, The U.S. has a total land area of 9.147.420 square kilometers. Agricultural land mass is at of 4.058.103 sq.km.[109] The utilized land has been decreasing slightly over the past decades. Total farmed area was 964,470,000 acres in 1987, down to 900,217,576 in 2017.[110] However, they still have the largest cropland area, and arable land area in the world,[111] and they have a huge overcapacity of agricultural production. With the increase in efficiency that has occurred, land area is not a limiting factor for the sector in the country. Except for the Rocky Mountains, and deserts of Nevada and

[108] (United States Environmental Protection Agency, 2021)
[109] (The World Bank, 2021)
[110] (Hamer & Perdue, 2019)
[111] (The World Bank, 2021)

Arizona, and New Mexico, there are good agricultural land all over the country. The abundance of farmland gives technical self-sustainability in food, and the option to be self-sufficient. The diversity in landmass and climate gives the opportunity to produce most kinds of products from wheat to lemons, however focusing on less labor-intensive industries and rather importing those has been the proffered choice.

6.2 Demographical changes

On the consumer side, The United States has stable demographics without the prospects for any significant change in population numbers. This means that the requirement for food will continue to be more or less similar to today with just a slight increase, although the types of food required by the population might change based on preferences. On the farmer side of the equation the problem is different. 3.4 million producers/farmers work the about 2 million farms in the U.S. The average age of these are 57.5 years and 34 percent of these are over 65 years old. Only 8 percent is under 35 years old. Similarly, to what happens in China, young people are moving away from farms and rural areas to urban areas. This has been a trend for a long time and is posing a problem to the industry. Farming is often seen as badly payed work with long hours and a constant worry about weather and price fluctuations. To attract younger people to the industry, the attractiveness needs to improve and pay will likely have to be the main driver.

6.3 Infrastructure and trade

The agricultural areas of the U.S. are geographically very well situated for transport and logistics. The infrastructure is well built in every part of the country giving easy access for both inputs and outputs to move from farm to consumer. There are, however, a lot of need for

upgrades and maintenance of roads, bridges, and railroads in the coming years to maintain functionality, quality, and improve weight capabilities of many roads to facilitate heavier trucks.[112] As the U.S. has the largest trading volume in agricultural products, and is the biggest exporter, quick, reliable and cheap logistics and export routs are of key importance. This makes the inland waterways of the country extremely useful as they have the ability to transport goods directly from inland farming areas to wherever in the world without needing to be transported on land and then being reloaded to ships. U.S. waterways carries the equivalent of 58 million semi-truck loads every year, and 58 percent of soybean export is transported ports connected to the Mississippi river. Similar to highways and bridges, there is a substantial amount of the river systems locks and dams that are outdated and in need of maintenance. In a 2017 assessment, The American Society of Civil Engineers gave the inland waterways and river system the grade D based on age and condition. Between 2000 and 2014, the average delays due to nearly doubled, which leads to a problem as food commodities are generally time sensitive. To continue to keep U.S. agricultural exports competitive and facilitate cheap and efficient transport within nationwide, sizable investments into upgrades are needed.[113] With the small number of workers in agriculture, seasonal workers is crucial, especially for the labor-intensive fruit and vegetable sector. This means that policies regulating short-term hire as well as seasonal work visas are of importance. The United States has kept a significant trade surplus on agricultural products since 1959 until 2019,[114][115] when the balance went just slightly negative due to a significant drop in exports to China. However, the main trading partner and export market is still China, and in 2020 with a value of $26.5 billion in 2020.[116] Year to date for 2021, the surplus is back to a strong level, again much due

[112] (National Association of State Departments of Agriculture, 2016)
[113] (THE MARITIME EXECUTIVE, 2017)
[114] (Snell & Atherton, 2020)
[115] (Economic Research Service U.S. DEPARTMENT OF AGRICULTURE, 2021)
[116] (USDA, Foreign Agricultural Service, 2021)

to increasing demand from China. Even though the U.S. generally keeps a solid trade surplus on agricultural products, they are also the top importer of food in the world in total (financial) amount. Imports are mainly more exotic products such as tropical fruit, fish, wine and beer, spices, fruits and fruit juices, and nuts.

6.4 Policies influencing agriculture

Agricultural policies in the U.S. follows a 5-year cycle in most cases and is adjusted with a revision of the Farm Acts or "Farm Bills". As the farm sector is historically strong and well-functioning, no revolutionary policies are implemented. It is rather a continuous adjustment to improve and sustain the sectors productivity and competitiveness. Policies therefore focuses on adjusting farm support, incentivizing and funding research and development, development of rural areas, and increasing sustainability. U.S. farm policies is not only focused internally, but reaches far outside of the country, with measures in place to increase exports and protect nation security interests. These policies include opening up access to foreign markets through challenging unfair barriers to trade, implementing international standards for food quality and harmonizing products and coordinating response systems for food supply emergencies around the world.[117]

6.5 Economic, religious and cultural impacts

The economic purchasing power of the U.S. consumer is high and stable. In 2020, only 8.6 percent of annual disposable income were spent on food. Consequently, will changes in income not impact food demand in any significant way. Increased demand per capita is therefore very unlikely, however, changes in preferences may occur. As in China, the trend of

[117] (U.S. Department of State, 2021)

vegetarian and vegan food is increasing, putting a downwards pressure on meat consumption and demand. Organically grown food is also gaining popularity, although it is only grown at about 1 percent of farmland.[118] Changes in the diets of consumers however, will not impact the food security, as the capability of the sector to produce is there, and the import power is strong.

6.6 Price sensitivity

Price sensitivity is low in the U.S. as share of expenditures on food are the lowest in the world. An increase in costs at the production level will therefore not significantly impact most consumers. This means that prices for food is quite inelastic, so these consumers will not buy significantly more if prices fall, or less if incomes fall marginally, nor will price increases at farm level, as farm share of final price is very low. The only food product impacted by price changes was high end meat, like beef and veal.[119] However, high inequality levels mean that there is a relatively large group of people for which food prices matters more than for the average consumer. This group typically is about 10 percent of the population, but recent numbers indicates that it increased to between 20 and 30 percent during the pandemic time due to increased prices and rising unemployment.[120]

6.7 Technology, innovation, and water management

The U.S. agricultural sector has had a huge increase in productivity and output by constant adapting and utilizing modern technology all parts of their sector. Farming is heavily mechanized, and factor productivity is high. The USDA is aiming to further increase the

[118] (Cobb, 2020)
[119] (Tamin, Akhi, & Palash, 2020)
[120] (Cobb, 2020)

production by 40 percent by 2050, while also reducing the environmental footprint by 50 percent during the same period. Different technologies will be implemented in order to reach this goal, and those include genome design and the use of big data and automation. Genome design help develops crops that are more resistant to diverse weather and climate including droughts, wet-soaking and more. The use of date will continue to improve the information on what exact inputs are needed for every part of the crop cycle, leading to more resource efficient farming and cost reductions. The United states has 8,667 cubic meters of internal renewable freshwater resources per capita which is above the world average of 5,732 and is the highest level of the analyzed countries. California, which also is a major agricultural state, experiences serious water shortages caused by long draughts. This has been a feature of the area as far back as records go, and therefore something they are used to dealing with.[121] However, increased population and agricultural production has increased the pressure on the water resources available. Although it is challenging foresee changes in precipitation and therefore water availability, other areas that are likely to experience scarcity in the future is the great planes, the Southwest, and the Rocky Mountain states.[122] Improved modified crops will help overcome this, and expansion of irrigation systems might be needed in certain areas.

6.8 Currencies and finance

The U.S. is the largest economy in the world and also controls the international reserve currency in the U.S. Dollar. There are therefore no technical limitations to their ability to fund import of food in case an internal production shortcoming should occur. Access to finance is for the agricultural sector in the U.S. has historically been strong, and it generally continues to be. Private banks finance all the factions of farm operations, and there is a backing system by

[121] (California Department of Water Resources, 2021)
[122] (Brown, Mahat, & Rameriez, 2019)

the USDA, where they guarantee loans of higher-risk farmers to access finance.[123] The USDA also have their own targeted programs for loans to farmers, where they finance operations, equipment and land. U.S. farmers have been struggling with debt during the last part of the last decade with some farmers choosing to retire early and some bankrupting, but conditions are now improving, and debt is being repaid at a quick rate.[124][125]

6.9 Energy prices

Energy prices has a significant impact on production costs as the agricultural industry is heavily industrialized and mechanicalized. Although fertilizer use is carefully managed and relatively small in volume of use, it still will impact total costs if natural gas prices increase. As farm share of food prices are the among the lowest in the world, the impact on consumers will not be extremely noticeable, while food exports might drop due to increase prices.[126] With rising energy prices, demand for grains is also likely to increase due to more biofuel production, further pushing up grain prices and general food prices with it. With the size of the export sector, and the deep trade involvement, the rising grain prices will be passed on to the world market leading to increases in food prices around the globe. This means that energy prices will not significantly impact the average U.S. consumers, but the lover income countries dependent on imports will be impacted.

[123] (Huffstutter & Lange, 2019)
[124] (Huffstutter & Lange, 2019)
[125] (Kauffman & Kreitman, 2021)
[126] (YI, et al., 2021)

6.10 Impacts of weather and climate change

Weather is relatively stable in most key agricultural areas of the U.S. There are, however, extreme weather events impacting the country and also the agricultural sector. Droughts, floods, and hurricanes all occur. Hurricanes can have detrimental consequences for the area it hits, but as they are rear occurrences that hits a relatively localized geographical area and therefore poses a small risk to the nationwide agricultural output. Floods follow the same principle as they are covered by the flood usually is relatively limited, however, excessive rainfall over a long period can cause waterlogging and pest infestations. It also can cause difficulties for farm machinery to access the wet field, especially without destroying crop and soil. If the crop has to be harvested before reaching the right humidity level, it will cause additional costs from drying post-harvest. Droughts are probably the most influential as it usually causes more widespread consequences when they hit, while also increasing wind and water erosion leading to a negative impact on future crop productivity levels.[127]

Climate change will also have an impact on the U.S. agriculture sector. It has already changed some dynamics to where yields for certain produce have fallen in some areas while it has increased in others. Total yield however, is up with increased temperatures, and although some areas might have to change to different crops, significant changes to the production potential is not expected. As the U.S. has huge overproduction and exports a lot of food, they can take a huge drop in yields whiteout it being a treat to the availability of food, although prices would definitely increase from such an event. Similarly, to as for China, a significant impact on the U.S. agricultural sector caused by climate change will impact the world market. Especially their role as a key exporting country will extend this impact, and disproportionally countries food insecure nations relying on imports.

[127] (Motha, 2011)

7 Influential factors

7.1 Geopolitical trends

Outside of the in-country factors influencing food security, the global food supply chain is reliant on well-functioning and efficient international cooperation, shipping and financial systems. Rising food commodity prices in the U.S. or other significant exporting countries transmits to the world, while if it happens in Nigeria, there is almost no price transmission mechanism. This can create a feeling amount smaller countries of being the victim, and the international implications, and local importance of food policies are a major reason for their huge importance in trade negotiations.[128] The gradual shift towards more protectionist policies and shift away from globalization among many states, puts a pressure on the functioning of the systems, and its ability to provide food commodities around the world. The trade war that developed during formed president Donald Trump's time in office caused a drastic fall in U.S. agricultural exports to China and Mexico, demonstrating how quickly the effects can come.

The strong link between food security and national security becomes visible with the insurgency issue in Nigeria, causing production problems in the northern region is an example of how a changing security situation can cause severe problems for the food security of a state. It could also be argued that the insurgencies caught hold of the area exactly due to the lack of food security in the region. The reduced production further caused a sharp increase in imports, depleting currency reserves and enhancing the food insecurity of the region. This is an example of the cascading effects that can occur.

Another potential threat to stability is countries use of external water resources. As water resources become more scares in many places, agricultural production will be suffering in areas lacking water supplies. While some countries have huge reserves of renewable water

[128] (Westhoff P. , 2010)

resources, others rely heavily on external water resources such as rivers flowing in from other countries. This creates a security problem, as it is hard to control what the neighboring country will do. There are many examples of this happening, among them in Sudan and Egypt, where access and usage of the Nile river is a key conflict point.

7.2 Agricultural technologies

As seen from the evidence in this research, there is huge potential of productivity increases and yield increase of the agricultural sector all over the world, and in developing countries especially. There is technically no limitation in land capacity holing us back from producing enough food healthy food for everyone, however, to achieve this the right policies and systems has to be put in place. In order for the world to fully and sustainably feed itself, policies, technology, knowledge and capital has to work together to enhance and futureproof the sector in every country.

In addition to conventional agriculture, there are also some potential solutions that can solve many of the issues involved in the food supply chain for every country and potentially change the dynamic of food production. Among these are urban farming, artificial meat and smarter supply chains, Urban farming includes community gardens, planting areas on rooftops, and vertical farms. Singapore is among the countries on the forefront of this, and is investing heavily into development of this, and increasingly so after the pandemic demonstrated the upside of having internal supply.[129] This way of farming can reduce the stress on infrastructure, be built to better handle climate change, and create a green living environment in cities. Artificial meat has the potential to reduce carbon footprint from the

[129] (Wood, Wong, & Paturi, 2020)

increasing global meat consumption considerably. The technology is promising, but so far to expensive for mass market.[130]

[130] (Dolgin, 2020)

Conclusion

The result of this research suggest that the income and development level of a country significantly influences the level of food security. The evidence from both Nigeria and China shows that the countries are in a much more fragile position then the United States is. The different level of fragility depending on income level occurs in all the aspect of the analysis. The more advanced a country is, the more advanced is the agricultural sector, and the stronger is their ability to produce food despite adverse situations due to technological and knowledge superiority. In a situation where imports are needed, the strong financial institutions of a developed country make this task much simpler. A more advanced farming sector also generally has a lighter environmental footprint, with better productivity, soil preservation techniques, and more accurate fertilizer use. They are also less exposed to the impacts of environmental change, as better systems and techniques are already in place and under development. Neither China, nor Nigeria has had an agricultural revolution on a grand scale. They both operate mostly without modern equipment and at very low productivity levels compared to developed high-income countries. China, however, has taken enormous steps forward in the last decades to ensure food security. They have done this by a large diversity of means, including a very intense agricultural and rural development policy. Although China still relies on imports of food to sustain their supply chain, internal production levels are increasing to meet the need. This, combined with securing supply abroad, and the huge emergency grain supplies they have, there is little risk of a major food crises in the country. With the decrease and rapid ageing of the population that is happen over the next decades, the main threat is lack of willing farmers if their policies of increasing farm sizes do not work quickly enough. Nigeria has a huge potential in their advantageous young demography, which in the future will give them an advantage when it comes to labor needs. The same strong demography, however, will give them a rapidly increasing amount of mouths to feed.

Government policies meant to increase the efficiency of the agricultural sector so far has not worked out as well as hoped, and if we should go by this history, prospects do not look great. Never the less, the broad scale and share size of the current agricultural policies, almost resembling the policies of China about two decades ago is promising. However, this change will take time, and as the country is, and will continue to be very reliant on imports for the coming decade at a minimum, the extremely weak currency situation and import power is a major treat to the food security of the nation.

Based on the evidence from Nigeria, the premise that Sub-Saharan Africa has the potential and capability to feed themselves, while also supplying China (or other countries) with food seems very unlikely. First of all, the significant expected population increase will put a strong upward reassure on internal demand on the continent, along with changing diets that comes with expected increases in GDP per capita. This means that even with significant productivity gains in the sector, it is very unlikely that Nigeria, or any other country in SSA will be a net contributor of any significance to Chinese food supply, or the world market overall. Although Nigeria has the largest arable land area of any SSA country, some other countries have better prospects due to their more advanced agriculture and better practices. Some of these might be able to be net exporters of food, but the net supply of the region overall is likely to stay negative.

The trend of aging farmers is percent in all the countries analyzed and shows that something needs to happen to attract new young blood to this extremely important sector. As farmers retire, and supply decreases, prices at the farm level will have to increase in both low, medium and high-income countries in order to attract new people. Along with this, governments need to focus on policies that make rural areas attractive for people to live, and the main one of these are infrastructure. As the research show, it is essential for the food supply chain itself, but also for the people living there. A simple thing as lack of a good

internet connection can deter the younger generations form living in rural areas, but the key most important is transportation, which has to be cheap and accessible.

Common areas of focus for all the countries to ensure food security and a functioning food is infrastructure is their infrastructure situation, even if they are all at very different stages. The U.S. has "all" the infrastructure needed, but due to old age and lack of maintenance, huge investments are needed to ensure continuous functionality and competitiveness. China has been increasing the amount of infrastructure enormously over the last decade, but due to the distances and geographical challenges, there is still a need to continue the efforts. Nigeria is, like most low-income countries simply lacking well-functioning infrastructure, and enormous investments are required on every level. Measures for weather and climate adaptation is also a common need for all the countries.

The functioning of the global food supply is intricated and complex creating a risk of supply shortages for a huge group of countries and millions, if not billions of people if it stops flowing. The Covid-19 pandemic has shown the world the fragility of closed boarders, leading to problems for goods and people to move around. The trends towards a more multipolar world, that is likely to involve more protectionist measures and rising trade barriers can change the functioning of food supply chain and decrease food security.

To conclude, the Research confirms that countries income level is a determining factor for the security of its food supply chain, and its ability to prepare for unforeseen occurrences, long term trends, and global geopolitical instability.

Bibliography

Akinde, B. P., Olakayode , A. O., Oyedele, D. J., & Tijani, F. O. (2020, 09 28). Selected physical and chemical properties of soil under different agricultural land-use types in Ile-Ife, Nigeria. *Heliyon, Volume 6, Issue 9*.

Alake, T. (2021, 04 21). *bloomberg.com*. Hentet fra https://www.bloomberg.com/news/articles/2021-04-21/nigeria-dollar-ban-for-wheat-and-sugar-may-add-to-food-scarcity

Arslan, A. (2019, 07 01). *ifad.org.* Hentet fra https://www.ifad.org/en/web/latest/-/blog/how-old-is-the-average-farmer-in-today-s-developing-world-

Augère-Granier, M.-L. (2021). *Migrant seasonal workers in the European agricultural sector.* European Parliamentary Research Service.

Badamasi, M. M. (2021, 01 15). *afdb.org.* Retrieved from https://www.afdb.org/en/documents/nigeria-special-agro-industrial-processing-zone-sapz-cluster-3-niger-kogi-fct-kwara-kebbi-and-sokoto-states-p-ng-aaa-002-executive-summary-esmf

Barbet-Gros, J., & Guesta, J. (2020, 12 15). *worldbank.org.* Retrieved from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjmpav7_YLyAhXRk4sKHUgcCpIQFjABegQIDhAD&url=http%3A%2F%2Fwww.worldbank.org%2Fcontent%2Fdam%2FWorldbank%2Fdocument%2FPoverty%2520documents%2FIntroduction%2520Guide%2520

BELLEMARE, M. F. (2014). *Rising food prices, Food price volatility, and Social unrest .* American Journal of Agricultural Economics.

Bello, A. A. (2018, 09 13). *dailytrust.com*. Retrieved from https://dailytrust.com/nigeria-loses-8-9bn-agro-produce-to-poor-transportation

Berreda, D. M., & Wertime, D. (2013, 08 12). *theatlantic.com*. Hentet fra https://www.theatlantic.com/china/archive/2013/08/chinas-great-infrastructure-binge-in-charts/278597/

Brown, T. C., Mahat, V., & Rameriez, J. A. (2019, 02 05). Adaptation to Future Water Shortages in the United States Caused by Population Growth and Climate Change. *Earth´s Future, 7*.

California Department of Water Resources. (2021, 07 08). *water.ca.gov*. Retrieved from https://water.ca.gov/water-basics/drought

Chandio, A. A., Jiang, Y., Rehman, A., & Rauf, A. (2020, 01 21). Short and long-run impacts of climate change on agriculture: an empirical evidence from China. *International Journal of Climate Change Strategies and Management*, ss. 201-221.

Chen, S., Chen, X., & Xu, J. (2014, 07). Impacts of Climate Change on Agriculture, Evidence from China. *Environment for Development*.

Chen, W., & Yuan, X. (2021, 03 22). Financial inclusion in China: an overview. *Frontiers of Business Research in China*.

CIA, The World Factbook. (2021, 05 12). *cia.gov*. Retrieved from https://www.cia.gov/the-world-factbook/field/roadways/

Climate Adapt. (2015). *climate-adapt-eea.europe.eu.* Retrieved from https://climate-adapt.eea.europa.eu/metadata/adaptation-options/improvement-of-irrigation-efficiency/#

Cobb, K. (2020, 12 04). *chicagofed.org.* Retrieved from https://www.chicagofed.org/publications/blogs/chicago-fed-insights/2020/how-are-consumers-food-preferences-changing

de Ridder, M., de Jong, S., Selleslaghs, J., Achterbosch, T., Jongeneel, R., Berkhout, P., & van der Heide, M. (2013). *The Emerging Geopolitics of Food.* The Hague Centre for Strategic Studies (HCSS). 2514 EE The Hague: The Hague Centre for Strategic Studies.

Demaree-Saddler, H. (2021, 05 04). *world-grain.com*. Retrieved from https://www.world-grain.com/articles/15103-china-achieves-ample-grain-reserve

Dolgin, E. (2020, 12 09). *nature.com*. Retrieved from https://www.nature.com/articles/d41586-020-03448-1

Ebigwai, J. (2021, 01 15). *afdb.org.* Retrieved from https://www.afdb.org/en/documents/nigeria-special-agro-industrial-processing-zone-sapz-cluster-4-anambra-benue-cross-river-and-ebonyi-states-p-ng-aaa-002-executive-summary-esmf

Economic Research Service U.S. DEPARTMENT OF AGRICULTURE. (2021, 07 06). *ers.usda.gov.* Retrieved from https://www.ers.usda.gov/data-products/foreign-agricultural-trade-of-the-united-states-fatus/us-agricultural-trade-data-update

epa.gov. (2014). Retrieved from https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data

European Commission. (2011, 06 06). Hentet fra https://ec.europa.eu/home-affairs/what-is-new/news/news/2011/20110606_en

Fader, M., Gerten, D., Krause, M., Lucht, W., & Cramer, W. (2013, 26 03). Spatial decoupling of agricultural production and consumption: quantifying dependences of countries on food imports due to domestic land and water constraints. *Enviromental Resarch Letters, 8*.

Food and Agricultural Organisation of the United Nations. (2018). *Transforming livestock sector Nigeria: What do long-term projections say.* The United Nations.

Food and Agricultural Organization of the United Nations. (2020, 01 02). *fao.org.* Retrieved from http://www.fao.org/faolex/results/details/en/c/LEX-FAOC192850/

Food and Agricultural Organization of the United Nations. (2021, 07 08). *fao.org.* Retrieved from http://www.fao.org/worldfoodsituation/foodpricesindex/en/

Food and Agriculture Organization of the United Nations . (2020, 05 07). *fao.org.* Retrieved from http://www.fao.org/sustainability/news/detail/en/c/1274219/

Gbadamosi, O. I. (2015, 06 23). Inclusion of some imported goods and services on the list of items not valit for foreign exhage in teh Nigerian foreign exhange markets. Abuja, Nigeria: Central Bank of Nigeria.

Gerbens-Leenes, W., Nonhebel, S., & Krol, M. S. (2010, 12). Food consumption patterns and economic growth. Increasing affluence and the use of natural resources. *Appetite*, pp. 597-608.

Global Hunger Index. (2021, 06 29). *globalhungerindex.org*. Retrieved from https://www.globalhungerindex.org/nigeria.html

Gollin, D., Lagakos, D., & Waugh, M. E. (2014, 05). Agricultural Productivity Differences across Countries. *The American Economic Review*, pp. 165-170.

Gray, A. (2016, 12 07). *weforum.org*. Retrieved from https://www.weforum.org/agenda/2016/12/this-map-shows-how-much-each-country-spends-on-food/

Guoxiang, L. (2021, 07 21). *globaltimes.cn*. Retrieved from https://www.globaltimes.cn/page/202107/1229259.shtml

Hamer, H., & Perdue, S. (2019). *2017 Cenesus of Agriculture.* Jeffersonville, IN, USA: United States Department of Agriculture.

Hayes, D., Li, M., & Zhang, W. (2019, 03 26). Can China's Rural Land Policy Reforms Solve its Farmland Dilemma? *Agricultural Policy Review*.

Hinnink, N. (2018, 06 17). *earth.stanford.com.* Retrieved from https://earth.stanford.edu/news/overuse-fertilizers-and-pesticides-china-linked-farm-size#gs.7hp9ne

Huang, W.-y. (2007). *Influence of the Natural Gas Price on the Ammonia Price, 2000 to 2006.* Mobil, Alabama: Economic Research Service U.S. Department of Agriculture.

Huffstutter, P., & Lange, J. (2019, 07 11). *reuters.com*. Retrieved from https://www.reuters.com/article/us-usa-farmers-lending-insight-idUSKCN1U618F

International Trade Administration. (2020, 09 14). *trade.gov.* Hentet fra https://www.trade.gov/country-commercial-guides/nigeria-agriculture-sector

Itua, E. (2021, 01 15). *afdb.org.* Retrieved from https://www.afdb.org/en/documents/nigeria-special-agro-industrial-processing-zone-sapz-cluster-2-ogun-lagos-ondo-oyo-osun-and-ekiti-states-p-ng-aaa-002-executive-summary-esmf

John Hopkins Center for A Livable Future. (2021, 04 24). *foodsystemprimer.org.* Hentet fra https://www.foodsystemprimer.org/food-production/history-of-agriculture/

Kauffman, N., & Kreitman, T. (2021, 05 27). *kansancityfed.org.* Retrieved from https://www.kansascityfed.org/agriculture/agfinance-updates/regional-improvements-in-farm-credit-conditions/

Lapehn, A. (2020, 03 24). *1421.consulting.* Retrieved from https://www.1421.consulting/2020/03/agricultural-industry-in-china/

Leavy, J., & Hossain, N. (2014, 03). Who Wants to Farm? Youth Aspirations, Opportunities and Rising Food Prices. *IDS Working Paper 439*.

LI, M. (2018, 02 13). *ifpri.org.* Retrieved from https://www.ifpri.org/blog/climate-change-adversely-impact-grain-production-china-2030

Mccrimmon, R. (2021, 07 19). *politico.com*. Retrieved from https://www.politico.com/news/2021/07/19/china-buying-us-farms-foreign-purchase-499893

Michael, A., Tashikalma, A. K., & Maurice, D. C. (2018, 11 3). Agricultural Inputs Subsidy in Nigeria: An overview of the Growth Enhancement Support Scheme (GESS). *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, pp. 781-789.

Milman, O., & Leavenworth, S. (2016, 06 20). *theguеardian.com*. Retrieved from https://www.theguardian.com/world/2016/jun/20/chinas-meat-consumption-climate-change

Mortimore, M. (1993). Northern Nigeria: Land Transformation Under Agricultural Intensification. In M. Mortimore, *Population and Land Use in Developing Countries* (pp. 53-55). Washington, DC: The National Academies Press.

Motha, R. P. (2011). The Impact of Extreme Weather Events on Agriculture in the United States. *University of Nebraska - Lincoln*.

Muhumuza, J. R. (2018, 04 25). *allianceforscience.cornell.edu.* Retrieved from https://allianceforscience.cornell.edu/blog/2018/04/agricultural-technology-can-help-curtail-climate-change/

National Association of State Departments of Agriculture. (2016, 09). *nasda.org*. Retrieved from https://www.nasda.org/policy/nasda-policy-statements/agriculture-infrastructure

Nigerian Ports Authority . (2019, 11 27). *nigerianports.gov.ng.* Retrieved 05 20, 2021, from https://nigerianports.gov.ng/2019/11/27/press-release-npa-port-of-antwerp-sign-mou-towards-operational-efficiency/

Odekunle, T. (2003, 12 16). RAINFALL AND THE LENGTH OF THE GROWING SEASON IN NIGERIA. *INTERNATIONAL JOURNAL OF CLIMATOLOGY, 24*, pp. 467-479.

Ohuocha, C. (2021, 04 16). *reuters.com*. Hentet fra https://www.reuters.com/world/africa/nigeria-halt-foreign-currency-sugar-wheat-imports-central-bank-2021-04-16/

Olayide, O. (2011, 03). Agricultural Trade Balance and Food Self-Sufficiency: Implications for Sustainable Development in Nigeria. . *World Rural Observations, 3*.

our world in data. (2021, 04 12). *ourworldindata.org*. Hentet fra https://ourworldindata.org/grapher/daily-per-capita-fat-supply?tab=chart&country=NGA~CHN~USA~GBR~OWID_WRL

Oyaniran, T. (2020). *Current State of Nigeria Agriculture and Agribusiness Sector.* Lagos, Nigeria: PwC Nigeria.

Patton, D. (2019, 10 15). *reuters.com*. Retrieved from https://www.reuters.com/article/us-china-swinefever-pork-prices-idUSKBN1WU1EQ

Patton, D. (2021, 04 1). *reuters.com*. Retrieved from https://www.reuters.com/article/us-china-swinefever-resurgence-analysis-idUSKBN2BO5AV

Patton, D. (2021, 04 01). *reuters.com*. Retrieved from https://www.reuters.com/article/us-china-swinefever-resurgence-analysis-idUSKBN2BO5AV

Ranganathan, J., Waite, R., Searchinger, T., & Zionts, J. (2020, 05 12). *wri.org.* Retrieved from https://www.wri.org/insights/regenerative-agriculture-good-soil-health-limited-potential-mitigate-climate-change

Rayner, V., Laing, E., & Hall, J. (2011). *Developments in Global Food Prices.* Reserve bank of Australia.

Rich, M., Reed, S., & Ewing, J. (2021, 03 31). Clearing the Suez Canal Took Days. Figuring Out the Costs May Take Years. *New York Times*.

Rigasa, A. Y. (2021). *Nigeria - Special Agro-industrial Processing Zone (SAPZ) cluster 1.* Abuja, Nigeria: Federal Ministry Of Agriculture and Rural Development.

Roman, M., Górecka, A., & Domagała, J. (2020, 12 11). The Linkages between Crude Oil and Food Prices. *Energies*.

Roseboom, J., Beintema, N., Lynam, J., & Badiane, O. (2016). *Agricultural Research in Africa.* INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE.

Smaller, C., Wei, Q., & Yalan, L. (2012). *Farmland and Water: China invests abroad.* Winnipeg, Manitobo, Canada: the International Institute for Sustainable Development.

Smith, T. G. (2014, 11 06). Feeding unrest: Disentangling the causal relationship between food price shocks and sociopolitical conflict in urban Africa. *Journal of Peace Research, vol 51*, pp. 679-695.

Snell, W., & Atherton, N. (2020, 10). U.S. Agriculture Flirting with an Annual Trade Deficit – First Time in 60 years? *Economy & Policy Update*.

statistia. (2021, 04 01). *sttistia.com*. Hentet 06 16, 2021 fra https://www.statista.com/statistics/263765/total-population-of-china/

Tamin, K., Akhi, K., & Palash, S. (2020, 03 31). Empirical evidence of changing food demand and consumer preferences in the USA. *Journal of Bangladesh Agricultural University*.

THE MARITIME EXECUTIVE. (2017, 07 13). *maritime-executive.com*. Hentet fra https://www.maritime-executive.com/article/us-agriculture-challenged-by-aging-infrastructure

The Nobel Prize. (2020, 10 09). *nobelprize.org*. Retrieved from https://www.nobelprize.org/prizes/peace/2020/press-release/

The State Council Information Office of the People's Republic of China. (2019, 10). *scio.gov.cn.* Retrieved from http://www.scio.gov.cn/m/zfbps/32832/Document/1666228/1666228.htm

The State Counsil, The peoples Republic of China. (2020, 06 06). *english.gov.cn*. Retrieved from http://english.www.gov.cn/statecouncil/ministries/202006/06/content_WS5edb95edc6d066592a448f9e.html

The World Bank. (2019). *data.worldbank.org*. Retrieved from https://data.worldbank.org/indicator/SP.DYN.LE00.IN?locations=NG

The World Bank. (2020, 03 26). *worldbank.org.* Retrieved from https://www.worldbank.org/en/news/press-release/2020/03/26/china-developing-green-finance-in-agriculture

The World Bank. (2021, 01 29). *data.worldbank.org*. Retrieved from https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=NG

The World Bank. (2021, 01 29). *data.worldbank.org*. Retrieved from https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS

The World Bank. (2021, 06 25). *data.worldbank.org*. Hentet fra https://data.worldbank.org/indicator/AG.LND.ARBL.ZS?view=map

The World Bank. (2021, 06 21). *data.worldbank.org*. Hentet fra https://data.worldbank.org/indicator/AG.LND.AGRI.K2?view=map

The World Bank. (2021, 05 18). *data.worldbank.org.* Retrieved from https://data.worldbank.org/indicator/AG.LND.ARBL.HA?locations=US&view=map

This Day. (2021, 07 06). *thisdaylive.com*. Retrieved from https://www.thisdaylive.com/index.php/2021/07/06/pessu-nigeria-records-50-post-harvest-losses-annually/

Toshichika Iizumi, N. R. (2015, 4). How do weather and climate influence cropping area and intensity? *Global Food Security*.

U.S. Department of State. (2021, 05 19). *state.gov.* Hentet fra https://www.state.gov/agricultural-policy/

U.S. Energy Information Administration. (2020, 03 23). *eia.gov.* Retrieved from https://www.eia.gov/todayinenergy/detail.php?id=43216

Unah, L. (2018, 05 04). *devex.com*. Retrieved from https://www.devex.com/news/agritech-startups-aim-to-lift-nigerian-smallholder-farmers-out-of-poverty-92646

UN Department of Public Information. (2017). World population projected to reach 9.8 billion in 2050.

United Nations. (2019). *population.un.org*. Retrieved from https://population.un.org/wpp/Graphs/Probabilistic/POP/TOT/156

United Nations. (2021, 06 19). *knowledge.unccd.int.* Hentet fra https://knowledge.unccd.int/knowledge-products-and-pillars/best-practices-sustainable-land-management/slm-different-land-use-1

United Nations. (2021, 06 25). *un.org.* Hentet fra https://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets/land/arable_crop land_area.pdf

United Nations Population Fund. (2021). *unfpa.org*. Hentet fra https://www.unfpa.org/data/world-population/NG

United States Environmental Protection Agency. (2021, 04 10). *climatechange.chicago.gov.* Retrieved from https://climatechange.chicago.gov/climate-impacts/climate-impacts-agriculture-and-food-supply

USDA, Foreign Agricultural Service. (2021, 05 11). *fas.usda.gov.* Retrieved from https://www.fas.usda.gov/china-2020-export-highlights

Weinraub, M., & Ingwersen, J. (2020, 07 02). *reuters.com*. Retrieved from https://www.reuters.com/article/us-health-coronavirus-usa-wheat-idUSKBN2431BQ

Welton, G. (2011, 06 28). The impact of Russias 2010 grain export ban. *Oxfam Research Report*.

Westhoff, P. (2010). The Economics of Food. In P. Westhoff, *The Economics of Food* (p. 57). New Jersey: FT Press.

Westhoff, P. C. (2010). *The Economics of Food: How Feeding and Fueling the Planet Affects Food Prices.* 07458, New Jersey, USA: Pearson Education, Inc.

Woetzel, J., Pinner, D., Samandari, H., Engel, H., Krishnan, M., McCullogh, R., . . . Boettiger, S. (2020, 05 18). How will African farmers adjust to changing patterns of precipitation? *McKinsey Global Institute*.

Wood, J., Wong, C., & Paturi, S. (2020, 12 21). Vertical Farming: An Assessment of Singapore City. *Electronic Journal of Studies in the Tropics, 19 (2)*, ss. 228-248.

World Bank. (2021, 05 21). *data.worldbank.org*. Hentet fra https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS?end=2020&locations=NG&start=1990

World Bank Group. (2014). Access to Finance for Smallholder Farmers. Washington DC: International Finance Corporation, The World Bank Group. Retrieved from https://openknowledge.worldbank.org/bitstream/handle/10986/21679/949050WP0Box3800English0Publication.pdf?sequence=1&isAllowed=y

World Food Programme. (2021, 05 11). *docs.wfp.org.* Retrieved from https://docs.wfp.org/api/documents/WFP-0000130185/download/?_ga=2.94303581.1594683398.1627239649-665961836.1627239649

Wu, Q., Guan, X., Zhang, J., & Xu, Y. (2019, 09 19). The Role of Rural Infrastructure in Reducing Production Costs and Promoting Resource-Conserving Agriculture. *International Journal of Environ Research and Public Health.*

YI, j., Meemken, E.-M., Mazariegos-Anastassiou, V., Liu, J., Gómez, M. I., Cannign, P., & Barret, C. B. (2021, 06 07). Post-farmgate food value chains make up most of consumer food expenditures globally. *Nature Food*, pp. 417-425.

Zader, A. (2013, 04 22). *oxforbibliographies.com.* Retrieved from https://www.oxfordbibliographies.com/view/document/obo-9780199920082/obo-9780199920082-0054.xml

Zhu, J. (2018). *Contributions and Challenges of Agro-trade to Food Security in China.* Ninjing, P.R. China: Nanjing Agricultural University.