Nigeria's Food Prospects in 2050: A Back-of-the-Envelope Calculation

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This paper extends earlier work on Nigeria's failure to improve living standards for its population when compared with China and South Korea since 1960. With historically low rates of growth in per capita income over the 60-year interval when compared with these two countries and the elevated growth rate in Nigeria's population to 2050 projected by the United Nations Population Division and others, this paper explores the consequences of the intersection of these two important "drivers" of food consumption on Nigeria's prospects for food security. Because of Nigeria's poor growth prospects, in part the result of its fast growing population, the country's dependency on food imports is likely to increase significantly by mid-century. Allocating its scarce foreign exchange, derived mostly from oil exports, in order to feed its population will negatively impact Nigeria's ability to modernize its agricultural sector specifically, and, more generally, the country's physical and social infrastructure that would improve living standards and growth prospects.

Keywords: Nigeria, food security, economic development

INTRODUCTION

This is the final paper of a trilogy (Sohn, 2020; Sohn, 2022) on the Nigerian economy and the prospects for improving living standards in Nigeria—Africa's most populous country and largest economy. The focus is specifically on the position of energy and food in Nigeria's national economy, two of the principal components of economic well-being, and the prospects for continuing to deploy revenue from exports of the former to secure adequate and nutritious supplies of the latter in light of the country's rapidly growing population to mid-century.

Because of the volatility in international commodity prices, for example, the spike in global energy and food prices in 2021-2, and the longer-term uncertainties regarding the future global demand for oil in light of the increasingly aggressive global agenda to phase out carbon-based energy feedstocks over the next 30-50 years, Nigeria's over-reliance on oil in its export structure and for financing government expenditures exposes the country to considerable risks in its ability to import critical goods for economic development and everyday life. Also, allocating scarce foreign exchange for its growing bill for food imports reduces resources available to enhance food security by investing in critical agricultural infrastructure such as irrigation and water management systems, as well as investing in vital transport and electricity infrastructure that would benefit the economy at large. In addition, the volatility in international oil prices also contributes to fiscal stress since government revenue is so dependent on oil exports. Nigeria currently produces approximately 1.1 million barrels a day (m/b/d) of crude oil, well below its OPEC-administered quota of 1.8 m/b/d, and while the oil sector accounts for 10% of GDP, revenues from oil and gas exports constitute

more than half of total government revenue and more than 90% its export revenue (Munshi, 2021, Pilling, 2022c). Consequently, Nigeria's repeated failure over many years to diversify its exports is an issue of continuing concern among policy-makers and advisors, both in the country and in multilateral organizations such as the International Monetary Fund and the World Bank (Selassie, 2021).

With a projected doubling of Nigeria's population by mid-century from its 2020 level of 206 million people (United Nations Population Division, 2022), providing food security for its expected 401 million people—with 34% of its current population currently experiencing moderate-severe food insecurity, 57% living below the poverty line (Olowe, 2020), and more than 40% living in absolute poverty, that is, earning less than $1.90 per day (Pilling, 2022c)—is likely to present a serious challenge to the country, especially in light of the fact that Nigeria's import bill of food in 2020 (mostly for wheat, rice, poultry, fish, food services, and consumer-oriented foods) exceeded $10bn according to the United States Department of Commerce (International Trade Administration, 2021). Depending on the level of volatile international oil prices, according to the World Bank Nigeria's food import bill over the last decade absorbed between 10-25% of total export revenue (Exports of goods and services, 2021) of which, as mentioned above, more than 90% is derived from oil and gas exports. The growth in oil export revenue over the next 30 years is highly uncertain because of technical reasons in the field, mounting domestic social tensions, the increasingly rigorous climate-related constraints on carbon-based energy sources orchestrated and monitored by the international community, and, of course, the perennial fluctuations in international oil prices.

The performance of Nigeria's economy in particular, and Sub-Saharan Africa in general, also has consequences for neighboring and distant countries, both rich and poor. In part because of the increasing lack of both personal security and economic opportunity, African refugees account for a third of the world's population that is displaced abroad, and since 2010 more than one million Sub-Saharan Africans have migrated to Europe (Financial Times, 2019). Recent Pew and Gallup surveys reported that more than 40% of Sub-Saharan Africans—and almost 75% of Nigerians polled—said they would live in another country if they had the means and opportunity to do so, with the share of Nigerian adults who want to emigrate increasing from 41% in 2012 to 48% in 2018, with 45% planning to emigrate within five years (The Economist, 2018; The Economist, 2021; Adeoye, 2022).

Remittances to Nigeria from abroad have averaged about 6% of annual GDP over the last 15 years, according to the World Bank (Personal Remittances Received as a Percent of GDP - Nigeria, 2022). Any significant increase in emigration from Nigeria over the coming decades is likely to increase the flow of remittances into the country, curiously relieving some of the pressure on Nigeria's current account balance. A short section below, largely reproduced from Sohn (2020), provides some background information about Nigeria and lists the reasons for the poor performance of Nigeria's economy since gaining independence in 1960.

BACKGROUND INFORMATION ABOUT NIGERIA

Known as "the Giant of Africa," Nigeria is the world's 20th largest economy and—since overtaking South Africa in 2014—is the largest economy in Africa. Nigeria's population grew by approximately 2.6% per year over the six decades since gaining independence in 1960, 1% more per year than world population growth over the same interval. By mid-century, Nigeria's population—which is likely to exceed the population of the US—is projected to increase by about 2.2% per year, from 206 million people in 2020 to approximately 400 million (United Nations Population Division). In its reference scenario, a recently published study by the University of Washington's Institute for Health Metrics and Evaluation (IHME, 2021) projects that Nigeria's mid-century population will exceed 490m, more than 22% above the UN's projected level

Nigeria—one of 51 countries classified by the International Monetary Fund as "resource-rich"—has an abundance of oil and gas reserves, fertile soil, and untapped mineral wealth. At the same time, according to the World Bank, in 2019, more than 40% of the country's population was living on less than $1.90 a day of income (Population living in extreme poverty, 2020) and the most recent data from the World Bank

report an increase to 43% of the population, reflecting some of the effects of the Covid pandemic on the poverty rate (Financial Times, 2022; Pilling, 2022c), a number likely to increase as a result of the grain and fertilizer crisis triggered by Russia's invasion of Ukraine in February 2022 that has exacerbated Africa's ongoing, drought-induced food production problems. Nigeria has more poor people than India, a country with more than six times its population (The Economist, 2019a).

While Nigeria currently produces (and exports about) 1.1m/b/d, only about half the population has access to electricity (Pilling, 2022b), and only about a third to *reliable* electricity. According to the UN Food and Agriculture Organization (FAO), agricultural activities represent approximately 20% of Nigeria's annual GDP, and employ more than 70% of the labor force (Nigeria Agriculture at a Glance (FAO)). Though the oil sector accounts for only about 10% of annual GDP, Nigeria's earnings from oil represent about 50% of government revenue and between 85-90% of total merchandise export revenue (Akwagyiram, 2022; Fuel Exports, 2022), greatly exposing Nigeria's economic stability to volatile international oil prices. Even though life expectancy in Nigeria increased by 42% from 1960 to 2019 (from 37.2 years to 54.7 years), it is still about 18 years below the world average.

As a student of long-term issues for over 50 years I can argue with a reasonable degree of confidence that a country's long-term economic prospects are predominantly driven by demographic and technological parameters, along with a country's institutional and political environment. For example, the level of corruption in Nigeria—both in the State and private sectors—is almost without parallel in its dimensions: the funds plundered between independence in 1960 and 1999—the end of military rule—is estimated at more than $400bn (Time, 2007), and in 2015, President Muhammadu Buhari stated that between 2005 and 2015 corrupt officials stole $150bn of state revenue (BBC News, 2015). Most recently, the daily theft of crude oil was estimated at 400,000 barrels a day (Adeoye and Pilling, 2022). According to Transparency International (2021), a non-governmental organization (NGO) dedicated to fighting corruption around the world, Nigeria is among the most corrupt countries in the world, listing at 154 out of 180 countries in the organization's 2021 ranking. Needless to say, over the years, these diverted funds could have been used to reduce poverty levels and to finance development projects in the country that would have improved living standards significantly.

Readers interested in a summary of the views of scholars of African history and economics "explaining" the reasons for the relative lag in economic development in Sub-Saharan Africa, most of which are also shared by Nigeria, along with a brief review of Nigeria's pre- and post-independence history, are referred to Sohn (2020). The main focus of the 2020 paper was to enumerate, describe, and analyze the current long-term issues that are adversely impacting the growth in living standards in Nigeria: demography and urbanization; insufficient infrastructure (including roads, access to clean water and sanitation, communications, and electricity); regional, ethnic and religious stresses that are contributing to the rising tide of violence and insecurity in the country and the region; the over-reliance on oil revenue to finance indispensable government services such as education and health; and the widespread level of public and private corruption. Readers interested in a more in-depth description and analysis of the critical issues facing Nigeria over the next 30 years are referred to Sohn (2020).

GLOBAL MODELING AND FOOD PROJECTIONS

Forty years ago, a three-day symposium organized by the Norwegian Nobel Institute convened at Noresund, near Oslo, where several of the world's then leading experts in the fields of demography (Paul Demeny, Rafael Salas, Rodney Shaw, and Leon Tabah) and food, agriculture, and oceanography (Norman Borlaug, Nural Islam, and Roger Revelle) assembled to explore the "long-term perspectives of world demographic and economic growth ... on resources and food supplies" (Faaland, 1982, p. vii). In addition to these "area" specialists, four prominent economists (Ester Boserup, Kenneth Boulding, Robert Heilbroner, and Wassily Leontief) whose research focused on long-term issues of economic development and improved living standards in the national—and by-then the global—-economy also participated in this symposium. (Full disclosure: I accompanied Professor Leontief at the symposium as his *aide-de-camp.*)

While global economic models embedded with detailed resource sectors was still a relatively new tool of economic analysis in the late 1970s and early 1980s, the Norwegian Nobel Committee enlisted Professor Leontief to prepare alternative projections of global food and energy levels to 2030 that would reflect alternative global levels of projected population and income growth—the two main "drivers" of the demand for food and energy—using his United Nations-commissioned World Input-Output Model that was completed in the mid-1970s (Leontief, Carter and Petri, 1977; Leontief and Sohn, 1982).

Leontief, who was awarded the 1973 Nobel Prize in Economic Sciences in part for his work in developing input-output analysis, designed the World Model to be "resource intensive" with the incorporation of three fuel minerals, six non-fuel minerals, and four agricultural commodities whose demand and supply could be tracked beginning with the model's 1970 base-year, decade by decade, to the year 2000. In the study undertaken for the Norwegian symposium the terminal year of the model's projections was extended to 2030. Assessments of the model's projections of non-fuel minerals (Sohn, 2005), energy resources (Sohn, 2007), and agricultural commodities (Sohn, 2013) were compiled for the halfway mark of the projection interval—to the year 2000—and are available for review.

With the steady advances over the last half century in computer software, hardware, information technology, and the rapid development of on-line databases (and their inter-connectivity generally referred to as Big Data), beginning in the mid-1970s long-term global projections of food and agriculture became the "business" of a number of international organizations and research institutes such as the United Nations' Rome-based Food and Agriculture Organization (FAO); the International Institute for Applied Systems Analysis (IIASA) based in Schloss Laxenburg just south of Vienna; and the International Food Policy Research Institute (IFPRI) headquartered in Washington, DC. (FAO has since discontinued its program of providing long-term food projections.) In addition, other institutes engaged in long-term global food projections include the following modeling teams: the Global Trade Analysis Project (GTAP), the Joint Research Centre of the European Commission (JRC), the National Institute for Environmental Studies (NIES, Japan), the PBL Netherlands Environmental Assessment Agency (PBL), and the Potsdam Institute for Climate Impact Research (PIK).

Arguably, IFPRI has the most robust and comprehensive model that provides long-term projections to 2050 of 62 agricultural commodities in 158 countries. IFPRI's IMPACT model is considered the "gold standard" for modeling food and agricultural projections, consequently, some of their assumptions and projections are used in this study as the "point of departure" for a scenario of mid-century Nigeria that is considerably less optimistic than IFPRI's but more in concert with Nigeria's historical economic and demographic trends. Therefore, a short digression on the structure, the assumptions, and the projections from one of IFPRI's recent iterations is provided below.

According to (the median variant of) projections made by the United Nations Population Division (UNPD, 2022) almost half the growth in the world's population to 2050 is expected to take place in Africa, with the continent's population swelling from 1.34 billion in 2020 to 2.49 billion people by mid-century, or, from 17.2% of the world's population today to 25.6% in 2050. Regarding Nigeria, its 2020 population of 206m is expected to increase to 401m by mid-century, an annual rate of growth of 2.2%.

According to the World Bank (World Bank Open Data, 2021) from 1960-2020, *global* Gross Domestic Product (GDP) per capita (in constant 2010 US dollars) —the most widely used metric in economics for measuring material well-being—increased by 1.75% per year, while the increase in Sub-Saharan Africa was 0.6% per year, less than 40% of the world growth rate. For Nigeria, annual per capita GDP grew at a rate of 0.9%, slightly more than half of the world's annual growth rate. The relatively poor performance of Nigeria in particular, and Sub-Saharan Africa in general, is in stark contrast with the more successful economic performance experienced by other extremely poor countries at that time, such as China and South Korea, over a similar interval. (Please see Table 1 in Sohn (2020)).

Given some of the alternative population projections for Nigeria in 2050 and a number of alternative assumptions regarding Nigeria's growth in per capita income to mid-century (including its historical long-term growth rate cited above)—the main drivers of the demand for food—what are the prospects for achieving food security in Nigeria at mid-century? The objective of this paper—by utilizing, as a point of departure, some of the assumptions about Nigeria regarding population and income growth to the year 2050

employed in the IMPACT model developed by IFPRI—is to shed some light on Nigeria's prospects to provide adequate amounts of nutritional food for its rapidly growing population to mid-century.

A DIGRESSION ON IFPRI'S "IMPACT" MODEL

"The International Food Policy Research Institute (IFPRI) is an international agricultural research organization founded in the early 1970s whose mission is to improve the understanding of national agricultural and food policies and to promote the adoption of innovations in agricultural technology. IFPRI is part of a network of 15 international research institutes funded in part by the Consortium of International Agricultural Research Centers (CGIAR), which in turn is supported by governments, private businesses and foundations, and the World Bank" (International Food Policy Research Institute). IFPRI's goal is to provide research-based sustainable policies for agriculture to the end of reducing poverty and eliminating hunger and malnutrition.

The IMPACT model (International Model for Policy Analysis of Agricultural Commodities and Trade) was developed at IFPRI at the beginning of the 1990s to engage in medium to long-term scenario analysis. The first results using the IMPACT model were published in a 1995 study which analyzed the effects of population, investment, and trade scenarios on food security and nutrition status, especially in developing countries (Rosegrant, Agcaoili-Sombilla, and Perez, 1995). The modeling framework links climate, crop, water, and economic models to analyze scenarios of future change in agricultural production, consumption, prices, and trade at national, regional, and global levels. The IMPACT model continues its role as the principal methodological tool for research at IFPRI, examining the links between the production of key food commodities and food security at the national level in the context of developing scenarios based on future trends regarding economic growth, demographic change, and current global issues such as climate change.

Since its inaugural study in 1995 the model's reach has been expanded both in its coverage of agricultural products and the number of countries tracked. In addition to new components and modules that have been added, advances in data collection and dissemination, with increased computing capacity the model's coverage of the commodity markets has increased from the original 17 commodities to 62 commodities and from the initial 35 countries to the current 158 countries (Robinson et al., 2015).

With climate change currently one of the most important long-term issues facing the global community, its potential effect on agricultural productivity—and as a consequence, on food production and food security in vulnerable regions of the world—has led to the IMPACT model being enlisted "to produce reference scenarios to 2050 assuming no climate change as well as different levels of climate change and socioeconomic assumptions, capturing a wide range of possible climate and socioeconomic futures" (Sulser et al., 2021). According to Sulser "many complex connections exist between climate change and hunger," but the basic problem can be summarized easily: "climate change, by and large, negatively affects agricultural production by reducing yields. This reduced productivity then reduces availability and drives prices upward, ultimately resulting in increased hunger" (Sulser et al., 2021). The discussion that follows below uses, as a point of departure, selected socioeconomic assumptions (such as population and per capita GDP levels) and climate change assumptions from IMPACT's alternative projections of six categories of agricultural commodities (production, consumption, and trade) in 2050 for Nigeria. As needed, other less optimistic socioeconomic assumptions—arguably more in line with Nigeria's historical long-term economic and demographic trends—are also included to develop a more complete range of Nigeria's constraints and opportunities in order to determine its future food requirements and to secure its mid-century food supplies.

ECONOMIC DEVELOPMENT AND FOOD SECURITY: THE CASE OF NIGERIA

As mentioned earlier, the provision of adequate amounts of food is one of the principal components and metrics of economic well-being. To highlight the importance of national and global programs for ensuring adequate food supplies and their distribution, the *first* three of the 17 components that comprise

the 2015 United Nations' "blueprint to achieve a better and more sustainable future for all"—officially known as the Sustainable Development Goals that are intended to be achieved by 2030—are directly or indirectly linked to food: eliminating poverty, eliminating hunger, and ensuring good health and wellbeing (United Nations, 2015).

The Global Hunger Index (GHI), developed by IFPRI, provides a comprehensive index to measure and track the progress of countries in reducing hunger and malnutrition. The index combines the four indicators of malnutrition—undernourishment, child wasting, child stunting, and child mortality—into a single metric. Needless to say, these four indicators are strongly correlated with adequate daily food intake levels (daily kcal per capita) and improved nutrition (increased daily protein levels in national diets), central components of this study.

Before turning to the description of the scenarios that inform on the prospects for food security in Nigeria at mid-century it is important to provide a working definition of food security. As described at the 1996 World Food Summit, food security refers to conditions in which "all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO,1996). The FAO identified "the four pillars of food security as availability, access, utilization, and stability. Food security is measured by caloric intake levels per person per day. In general, the objective of food security indicators and measurements is to capture some or all of the main components of food security in terms of food availability, accessibility, and utilization/adequacy" (FAO,1996).

A corollary—and more precisely, the obverse—of food security is food "insecurity," which is defined by the FAO as the "situation when people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active and healthy life" (FAO et al., 2017). FAO observes that food insecurity "can be caused by a number of factors, including the unavailability of food, unaffordable food, and unequal distribution of food between household members. Food insecurity is one of the major causes of poor nutrition" (Hunger and Undernourishment).

Furthermore, the FAO has developed measures to gauge the intensity of food insecurity in nations: "Moderate food insecurity is generally associated with the inability to regularly eat healthy, nutritious diets. High prevalence of moderate food insecurity is therefore an important indicator of poor dietary quality, and the development of health outcomes such as micronutrient deficiencies. Severe food insecurity is more strongly related to insufficient quantity of food (energy) and therefore strongly related to undernourishment or hunger" (Hunger and Undernourishment). Readers interested in a more complete understanding of the measurement of food insecurity are referred to FAO's Food Insecurity Experience Scale (FIES) global reference scale. This scale measures the percentage of individuals in the population who have experienced food insecurity at moderate or severe levels at any particular point in time (Hunger and Undernourishment).

Regarding the prevalence of food insecurity the FAO reported that in 2017 about 25% of the world's population—approximately 1.9b people—experienced moderate or severe food insecurity. With respect to Nigeria, the FAO reported that more than 36% of Nigeria's population—about 68m people—suffered from food insecurity in 2016, the most recent year reported (Hunger and Undernourishment).

A PORTRAIT OF NIGERIA AT MID-CENTURY: THREE ALTERNATIVE FUTURES

To inform on the prospects for food security (or insecurity) in Nigeria, this section identifies—and provides alternative quantitative estimates of—the values of the major "drivers" of national food requirements: the size of Nigeria's population and its economy at mid-century. Even with the short time horizon to 2050—only 40 years, using 2010 as the base year—the size of Nigeria's projected mid-century population can vary considerably. Ditto for the projected size of its economy, measured by Gross National Product (GDP), and for future living standards, represented by a combination of these two main "drivers," resulting in hypothetical mid-century per capita income levels. The contours of the *very* pessimistic scenario, (PP), described below are shaped by the assumptions employed for these main "drivers". In addition, assumptions regarding other variables that contribute to the discussion of food security in Nigeria—such as future oil and food prices, the degree of dependency on imported food, diet changes,

etc.—are also incorporated in the (PP) scenario, which relies on the socio-economic assumptions and food balance results (demand and supply projections) in IFPRI's optimistic and pessimistic scenarios for Nigeria as a "point of departure." Other factors—such as a country's changing urbanization rate—that alter food demand patterns, particularly through changes in "national diets", are not included in any of the scenarios in this study.

The scenarios are identified as optimistic (O), pessimistic (P), and very pessimistic (PP). In the first two scenarios, (O) and (P), the 2050 population and GDP levels are identical to the levels assumed in the "SSP1-NOCC" (the most optimistic scenario), and "SSP3-RCP8.5-HGEM" (the most pessimistic scenario), respectively, for Nigeria in a recent IFPRI study using their IMPACT model (Sulser et al., Extended Results, 2021). The 2050 population level assumed for scenario (PP), the most pessimistic scenario in this paper (and the paper's *raison d'etre)*, is the "slower progress" ("highest population growth") variant projected for Nigeria reported in the study by the Institute for Health Metrics and Evaluation (IHME, 2021). That study projects Nigeria's mid-century population at 548m, 37% higher than the UN's median projection. The 2050 GDP level in the (PP) scenario is generated by calculating the historical GDP growth rate in Nigeria from 1960-2020 (GDP-Nigeria, 2021), and applying this annual growth rate to the 2010 base-year GDP to generate a level of GDP in 2050. Beginning with the 2010 base-year, the population and GDP levels assumed in the three scenarios, along with their respective GDP per capita levels and annualized growth rates over the 40-year interval to 2050, are presented in Table 1 in the Appendix. (The GDP and GDP per capita levels are valued in 2005 dollars, ppp).

Because of the critical role played by hard currency revenue from oil exports in Nigeria's economy (that was mentioned above), assumptions regarding oil prices and the level of Nigeria's oil exports (in m/b/d) are also included in the three scenarios. It is important to note that the oil prices and export volumes included in the (O) and (P) scenarios are included here only to accentuate the optimism and pessimism of the IFPRI-based model's scenarios, since they do not play a role in IFPRI's 2050 projections. Needless to say, the optimistic scenario, (O), assumes a relatively high price and level of oil exports, and the very pessimistic scenario, (PP), assumes, intentionally, a low oil price and a low level of oil exports. The middle scenario, (P), reflects Nigeria's recent levels of oil exports and an oil price that is an average of the oil prices assumed in the (O) and (PP) scenarios. Based on oil prices (valued in "then" current dollars and 2021$US) reported by British Petroleum (2022), the 2010 base year price was set at $80 a barrel. Since IFPRI's food prices in Table 6 are reported in $2005US, the assumed 2050 prices (in $2005US) per barrel in 2050 for the alternative scenarios ($40 (PP), $70 (P), and $100 (O)) appear to be reasonable values given BP's historical price data for crude oil. These values need not be adjusted for inflation over the 2005-2010 period because of the benign annual rate of inflation of 2.2% over this five-year interval reported by the U.S. Bureau of Labor Statistics (2022). The rate of inflation over this interval paled with respect to the "normal" volatility of oil prices.

Regarding the 2050 level of Nigeria's oil exports assumed in the (PP) scenario, according to the global database of CEIC Data (2022) over the last 40 years, Nigeria exported "an all-time high of 2,464,120 b/d/ in 2010 and a record low of 935,200 b/d in 1983", and has, until recently exported about 1,800,000 b/d. Using these historical benchmarks to develop the 2050 export levels in the three scenarios, the daily level of oil exports in the very pessimistic scenario (PP) was set at 1 m/b/d, at 1.8 m/b/d—until very recently, the level of Nigeria's exports that is roughly equal to the country's OPEC-administrated *production* level—for the pessimistic scenario (P), and at 3.75 m/b/d for the optimistic scenario (O). This value was set at 50% above the 2.5 m/b/d of oil exported in 2010, the base year of this study. Finally, the $80 a barrel price of Nigerian oil in the base year, 2010, combined with the export level of 2.5m/b/d, generated approximately $73bn of revenue for Nigeria in 2010, a value closely aligned with data on oil and gas export revenue of Nigeria from the International Monetary Fund (IMF, 2011). These assumed oil-related data (daily export volumes, oil prices, and annual export revenue from oil) are included in Table 1.

In a recent interview Mele Kyari, the managing director of the state-owned Nigerian National Petroleum Corporation, NNPC, said that he "intends to double production to 4m barrels a day" by 2030, a wildly ambitious target given current daily production levels (Pilling, 2022a). According to the International Energy Agency's "Stated Policies Scenario", global demand for oil in 2050 is projected to reach 103 m/b/d

(IEA, 2021). Therefore, setting Nigeria's oil exports at 3.75 m/b/d in 2050 in the optimistic scenario (O) would constitute a very generous level of production and exports, characteristic of an "optimistic" scenario, since it would nearly double Nigeria's current two percent share of global oil supply.

It is important to note that the ongoing program to decarbonize the global energy system, likely by 2100, could result in Nigeria's "crown jewel," its endowment of oil, becoming a "stranded"—and possibly a "wasted"—asset by the end of the century. Second, until decarbonization is realized, because of its topography and latitudinal position, the conventional wisdom is that Sub-Saharan Africa—including Nigeria—will be one of the regions hardest hit by global warming (Sengupta, 2019.) For those countries situated "in temperate zones, rising temperatures may bring milder weather and a longer growing season". But for countries like Nigeria "in the tropics, the effects are not likely to be so benign" (The Economist, 2019b.)

In addition, the Sustainable Development Goals loom large in IFPRI's research, and assumptions about climate change are embedded in the (O) and (P) scenarios, whose socio-economic assumptions and food demand-supply balances are deployed in this study. Therefore, the socio-economic assumptions, that is, population and per capita GDP levels—the major "drivers" of food demand—are complemented in the optimistic scenario (O) with a "no climate change" assumption, while the pessimistic (P) scenario incorporates a "climate change" assumption. Readers interested in the nature and impact the climate change assumptions have on agricultural output and other indicators for Sub-Sahara Africa in 2050 are referred to (Sulser et al., 2021.)

FOOD-RELATED DEFINITIONS AND ASSUMPTIONS

The FAO publishes, and periodically updates, country data on the *actual* daily supply of calories per capita and the *minimum* daily requirement of calories per person that is considered adequate to ensure the maintenance of a minimum weight for health. S*upply* implies the *delivery* of calories to households, though not necessarily the *consumption* of calories by households. Table 1 presents the "*daily delivery, or availability of calories*" under the Indicator called "Macro-Food Related Data", for the base year (2010) and the 2050 (O) and (P) IFPRI-based scenarios for Nigeria.

Across a population (country), this minimum is dependent on age, gender, height and the activity levels of the population. To provide readers with a sense of the range of the *actual* daily per capita caloric supply (in 2018) and the *minimum* daily requirements (in 2020), the following countries serve as extreme examples: Central African Republic, 1786 and 1713, respectively; Madagascar, 1938 and 1692, respectively; the United States, 3782 and 1951, respectively; and Ireland, 3885 and 1909, respectively. As can be observed from these numbers, since the *minimum daily requirements* are influenced mostly by physiological rather than economic factors, the range of the *minimum requirements* is much more contained than the *actual daily supply of calories*, whose range is well correlated with country-specific per capita income, that is, living standards (Daily per capita supply of calories vs GDP per capita, 2022; Daily per capita caloric supply, 2022).

Diets—and, of course, changing diets over time—also play a critical role in determining the level of food demand in a country. Diet changes, too, are addressed in IFPRI's IMPACT model. Table 2 in the Appendix presents the projected changes in the diets of Nigerians for 2050 compared to the 2010 base year, where food availability of their six aggregate commodity categories is represented by kilograms per capita, per year. The conventional wisdom regarding diet changes—confirmed by FAO (Food Balance Sheets)—is that the category with the largest increase in consumption with rising per capita income is meat (along with eggs and milk products), followed by more modest increases in per capita consumption of fruits and vegetables, oils and fats, and pulses, then finally with cereals, and roots and tubers consumption increasing the least, if at all (Fruit Consumption vs GDP per Capita; Share of Energy from Cereals, Roots, and Tubers vs GDP per Capita; Share of Calories from Animal Protein vs GDP per Capita).

This is borne out in the data presented in Table 2 in the optimistic (O) and pessimistic (P) scenarios, which are replicas of the diets in the IFPRI-based (O) and (P) scenarios cited in Sulser et al. (Extended Results, 2021). The numbers that appear in the cells of the left-hand side of this table present daily per

capita "food availability" for Nigerian consumers in the 2010 base year, the 2050 (O) and (P) scenarios along with the more pessimistic (PP) scenario developed for this study. The data in Table 2 are expressed in kilograms per year per person. Readers should recall that the (PP) scenario, which assumes very pessimistic—though historically well-founded—socio-economic assumptions, displays no diet change from 2010 since the assumed per capita income growth is only about 43% above its 2010 base-year, amounting to growth of only about 0.9% per annum, approximately equal to Nigeria's historical growth rate in per capita income over the 1960-2020 interval (Sohn, 2022). On the right-hand side of Table 2, the diet changes for the three scenarios for 2050 are expressed as ratios to the 2010 base year, along with the relative changes in per capita GDP, the main driver of diet changes.

It is worth noting the changes in the composition of the daily diets (in percent of total calories) for different countries in the same year (in this case, the base year 2010) as represented by FAO data (Dietary Compositions by Commodity Group). Table 3 presents this data for eight commodity groups and seven countries (in order of ascending annual per capita incomes): Nigeria, China, Peru, Venezuela, South Korea, France, and the United States. Readers should take special note of the changing composition of daily diets represented by the per capita daily consumption of the eight categories of commodities in the same year by these seven countries in terms of daily kcal per person and the proportion of total daily calories consumed in each category. The national per capita incomes in 2010 ranged from $2,280 (Nigeria) to $48,467 (United States) are also included in Table 3. Particular attention should be paid to the large reduction of cereals and grains in the daily diet of consumers in France and the United States, the two richest OECD countries included in Table 3. Also, there are notable differences in the daily consumption of animal-based proteins (represented by consumption of meat, eggs, and dairy products) in poor countries such as Nigeria and rich countries such France and the United States. Table 3 also highlights some of the *negative* dietary effects of increased living standards—the percentage of daily caloric intake of "junk food" (alcoholic beverages, sweeteners, and sugary foods, etc.)—doubling or even tripling in rich countries from the 6% or 7% proportion of daily calories that is characteristic of poorer countries, such as China and Peru. It is also important to note that national food demand profiles are affected not only by the degree of urbanization, but also by cultural and religious norms.

From the data in Table 2, it appears that the "cereals" component changes only modestly for Nigeria in the (O) and (P) scenarios compared with the changes in meat availability. This can be explained by the 2050 levels of GDP per capita in the (O) and (P) scenarios, $15,338 and $5,165, respectively, which approximately correspond to the per capita income levels of Venezuela and Peru in Table 3, where caloric percentages of daily meat in the diet are four and two times as great, respectively, as in Nigeria, while the percentage of cereals in the daily diet for Nigerians in Table 2 is only slightly different in the three scenarios, and similar to the percentages in the daily diets of Venezuelans and Peruvians that are associated with their respective per capita incomes in Table 3.

In addition, IFPRI's IMPACT model also tracks the number of people (and the percentage of the population) confronting hunger under alternative scenarios. (Please see Table 1). For example, in the 2010 base year, 9.7 million people (constituting about 6% of Nigeria's population) were considered hungry, and the *absolute* number of people projected as "hungry" in 2050 increased in both the optimistic (O) and pessimistic (P) scenarios (to 10.3 million and 30.1 million, respectively). However, under the optimistic scenario—as a result of much lower population growth and much higher economic growth—only 3.1% of the population is projected to be "hungry," a decline of almost 50% from the base year percentage. Alternatively, under the pessimistic scenario—with higher population growth and lower economic growth over the 40-year interval—the percentage of the population projected as "hungry" increases to 7% of the population from 6% in 2010. Needless to say, under the much more pessimistic assumptions that characterize the (PP) scenario in this paper (see Table 1), both the number and the percentage of the population that would be defined as "hungry" will certainly be higher.

"BACK-OF-THE-ENVELOPE" PROJECTIONS FOR NIGERIA IN 2050: A MORE PESSIMISTIC FUTURE

This section presents the "back-of-the-envelope" calculations that were generated by the alternative socioeconomic assumptions described in Table 1 which, together, constitute the very pessimistic scenario, (PP). The projections for the two IFPRI-based scenarios are provided alongside the calculations for the (PP) scenario. It is important to recall that the domestic demand projections in scenario (PP) in Table 4 in the Appendix reflect much higher population growth and much lower income growth over the 40 year interval than the IFPRI-based scenarios assume. The justification for this was provided earlier. The projected domestic production data for the six commodity groups reflect the application of the approximate historical annual growth rates from 1961-2018 calculated from FAO's food balance sheets (Food Balance Sheets, FAO, 2022). The justification for using these historical annualized growth rates in the (PP) scenario to project future levels of domestic production of the six categories of food lies with the underlying socio-economic assumptions of the (PP) scenario that result in only very modest improvements in living standards over the next 40 years. Therefore, in addition to unchanged diets from the base year (the demand side), the inability to modernize the farm sector and the lack of sufficient investment in civilian infrastructure—that is, not only inside the farm gate but also from the farm gate to the table, ie, water and irrigation systems, roads, electricity, etc. (the supply side)—because of the assumed poor performance of the economy, along with the demographic time bomb over the 40-year time interval—condemns output in the six agricultural sectors, at best, to their historical growth rates over the 1961-2018 interval.

Total Domestic Demand in 2050 for the Six Aggregate Food Groups

Total domestic demand for agricultural output is the sum of food delivered to households and demand for agricultural products that includes feed and other demand. The data for 2010, and the projected levels for 2050 (O) and 2050 (P) are from IFPRI (Sulser et al., Extended Results, 2021). Table 4—the food balance sheet—incorporates the "back-of-the-envelope" data for the 2050 (PP) scenario, whose entries were calculated using the daily diets from 2010 (please see Table 2) and Nigeria's projected population in 2050 reflecting the assumption of much higher population growth to 2050, much lower economic growth and, as a result, very low growth in living standards, hence maintaining the 2010 diet in 2050. (Please see Table 1). "Other demand" for the agricultural output for 2050 (PP) was calculated by using the same proportion of "other demand" in total domestic demand as in the 2010 base year. IFPRI's proportions for "other demand" for 2050 in the (O) and (P) scenarios differ, though not significantly, from the 2010 base year ratios. In addition, Table 4 reports the annual percentage change of food availability over the 40-year interval for the six food categories in the three scenarios.

Total Domestic Supply in 2050 for the Six Aggregate Food Groups

Total domestic supply is the sum of output produced domestically plus imports. The base-year data for 2010, and the projected 2050 (O) and 2050 (P) levels are from IFPRI (Sulser et al., Extended Results, 2021). The domestic output levels for 2050 (PP) were calculated by applying Nigeria's approximate historical annual growth rate (from FAO's data base from 1961-2018 (Food Balance Sheets, FAO, 2022) to these six categories of agriculture. Import (or export) levels for 2050 (PP) were the residual after subtracting total domestic demand from domestic output. Changes in import dependency—the ratio of import levels divided by total domestic demand—are also included in Table 4 for the six commodity groups under the three scenarios for 2050. Finally, Table 4 reports the annual percentage change in domestic output from 2010 to 2050 for each of the six food categories for the three scenarios.

The Consequences of Rapid Population Growth and Anemic Economic Growth on Nigeria's Food Sectors: The 2050 (PP) Projections in the Context of IFPRI's 2050 (O) and (P) Scenarios

From the data in Table 2, the favorable socio-economic assumptions embedded in scenario (O)—a much lower growth rate in population and a much higher growth rate in income—propel annual Nigerian

diets into much higher consumption levels of meat, followed by increased annual consumption of fruits and vegetables, oil crops, and pulses, and slower growth in annual consumption of roots and tubers, and cereals.

With respect to the IFPRI-based more pessimistic scenario (P), with per capita incomes rising by a more moderate 2.2% per year over the 40-year interval, growth in per capita meat consumption increases by 1.3% per year, followed by lower annual growth in per capita consumption of fruits and vegetables, and, finally, lower annual per capita consumption of cereals and roots and tubers in 2050 than annual consumption in the 2010 base year. This result invites the view that meat and other animal-based proteins foods, and fruits and vegetables should be considered "superior goods", while roots and tubers and cereals could possibly be relegated to the status of "inferior goods".

Turning to the "nightmare" scenario, (PP), with annual population growth dwarfing annual per capita income growth by 2.3% from 2010-2050 (Table 1)—and with diets and total daily calories unchanged from the base year— the food available for households mirrors population growth, since income growth is so weak, increasing at only 0.9% annually over the 40-year interval. Therefore, the prospects for improved diets—reflected by higher annual consumption of "superior foods" such as animal-based proteins and fruits and vegetables—recede because of this very unfavorable socio-economic environment. While it is clear that annual food availability will have to increase by at least 3.2%—equal to the assumed annual growth rate population to 2050—in order to maintain the 2010 daily per capita caloric levels, domestic output levels were determined by their historical growth rates (please see the 2050 (PP) cells in Table 4), with import levels calculated as the residual between total domestic demand and domestic output. Similarly, if the calculated domestic output—after applying Nigeria's historical annual growth rates—exceeded total domestic demand, the surplus was recorded as exports, as in the case of pulses.

Can Nigeria Pay Its Food Import Bill in 2050?

As mentioned above, Nigeria currently produces 1.1m/b/d of crude oil (and exports between 85-90 percent of production), and since the country's refining capacity is well below its level of daily oil consumption, according to Nigeria's finance minister Zainab Ahmed "oil export revenues were barely covering the cost of fuel imports" (Cotterill, 2022). If oil export revenue maintains its share of approximately 85-90 percent of Nigeria's total export revenue to mid-century, how much pressure will Nigeria be under to pay for its projected food import bill, particularly if the very pessimistic assumptions in the (PP) scenario described above prevail? This issue is addressed by employing the alternative levels of 2050 food imports presented in Table 4, and attaches assumed food prices projected from Sulser et al. (Extended Results, 2021) to provide context, in order to generate Nigeria's 2050 food bill for imports (net of exports).

First, a short discussion regarding the volatility of commodity prices over the long term is useful. All prices are expressed relative to an index, set at 100 for 1900 (Commodity Price Index of Cereal Crops and Petroleum, 1850-2015; Real Commodity Price Index Food Products). Table 5 in the Appendix presents a subset of the historical data that begins in 1850: real commodity prices for five food categories from 1960-2015. The data include the beginning- and end years, as well as the low and high values (and years) for five commodities. In addition, to inform readers about the wide range of commodity prices over long intervals—1960-2015—the last column of Table 5 presents the ratio of the highest to the lowest price for the five commodities. These ratios, ranging from 4.3 for beef to 7.3 for wheat, are used to provide context for the prices applied to Nigeria's 2050 food import levels for the very pessimistic (PP) scenario presented below.

The wide ranges in prices over long intervals of time are characteristic of the volatility in commodity prices that are strongly affected by changing demand patterns, weather, technological breakthroughs, government policies, disruptions resulting from industrial and transport glitches, and, of course, from conflict. For example, according to the United Nations' FAO, in May 2022 international wheat prices rose 56.2% above their value last year (World Food Situation, 2022), with most of the increase attributed to the conflict in Ukraine as a result of the suspension of sea-borne grain and fertilizers transported from the region. The outsized run-up in world petroleum prices, another by-product of Russia's invasion of Ukraine in February 2022, is, in part, the result of the decision by oil-importing NATO and NATO-affiliated countries to begin severing their economies from Russian energy flows. According to the AAA

(Automobile Association of America, 2022) US gasoline prices in June 2022 averaged about $5 a gallon compared to $3 a gallon a year earlier.

Table 6 in the Appendix presents the prices of the six groups of agricultural commodities in the base year (2010) and for the (O), (P) and (PP) scenarios for 2050. The prices for the base year and for the first two scenarios for 2050 are from Sulser et al. (Extended Results, 2021). Given Nigeria's increasing dependence on imports of meat, cereals, fruits and vegetables, and oil crops, the prices assumed for the 2050 (PP) were the 2010 food prices stepped up by a common scaler, equal to 1.75. In this very pessimistic scenario—high population growth rates, low economic growth rates, low oil prices and export levels—these elevated food prices are well within the ranges of the long-term commodity price indices, presented in Table 5, though, of course, above the 2050 prices in scenarios (O) and (P) in Table 6, which correspond to the low (scenario (O)) and high (scenario (P)) prices projected by the IFPRI model (Sulser et al., Extended results, 2021).

Table 7 in the Appendix presents the food import and export values for the six food groups in the 2010 base year and for the three scenarios in 2050. (The Table 7 values are based on the data in Tables 5 and 6). Also included in this table are Nigeria's approximate recorded oil revenues in 2010, and the projected oil revenues under the three scenarios for 2050 that appear in Table 1. It appears that when the most pessimistic assumptions regarding the major "drivers" of food demand are in play— much higher population growth and much lower economic growth—along with increased pessimism regarding the prices of food imports, i.e., higher prices, and lower oil export revenue (resulting from the assumptions of both lower oil prices and lower export levels), by mid-century Nigeria's ability to pay for its food imports with its revenue from oil exports will be increasingly unattainable.

When applying IFPRI's (modestly) pessimistic values to the "drivers" and food prices that are embedded in IFPRI's pessimistic scenario—represented by scenario (P) in this study (please see Tables 1 and 6)—and assuming an oil price of $70 a barrel applied to daily crude oil exports of 1.8 m/b/d, Nigeria's projected food import bill will also exceed projected revenue from oil exports in 2050. Curiously, even under the most favorable conditions in this study for Nigeria, scenario (O), Nigeria's projected import bill for food in 2050 will absorb almost 25 percent of Nigerian export revenue—at the upper range of Nigeria's import bill of food as a percentage of total exports of goods and services over the last decade (Exports of goods and services)— assuming Nigeria's current export structure is maintained in 2050.

IMPROVING THE PROSPECTS FOR HIGHER LIVING STANDARDS IN NIGERIA TO 2050: WHAT CAN BE DONE?

"Hope for the best but prepare for the worst". (Attributed to many)

Averting the "worst case" scenario for Nigeria, scenario (PP), depends on altering some key parameters, some of which are not entirely controlled by Nigerian politicians and policy-makers—such as future international oil prices—and on others that can be altered only through deliberate policy actions by Nigeria's various levels of government and national institutions, along with technical support from multilateral institutions such as the World Bank, the International Monetary Fund, various United Nations agencies, and many international research centers such as IFPRI and CGIAR.

These policy actions include micro-economic and macro-economic reforms as well institutional and political changes. Examples of the former would include ramping up Nigeria's oil output and exports within the constraints dictated by Nigeria's membership in OPEC and with its commitments agreed in the 2021 COP26 Glasgow Climate Pact, and/or moving aggressively to reduce food imports to be replaced with increased domestic agricultural production. It is worth noting that until the 1960s, Nigeria was a net exporter of food. Examples of the latter— macroeconomic reforms—would include a determined policy to reduce the "forever" bloated position that oil represents in Nigeria's export structure. This would require massive infrastructure programs that would range from modernizing the farm sector with improvements in water management and irrigation systems to upgrading the nation's transport and electricity sectors. Also, the inclusion of Nigeria in the African Continental Free Trade Agreement, the largest free trade area in the

world measured by the number of participating countries that came into force in January 2021, could, over the coming decades, facilitate growth in intra-African trade if the group's acute infrastructure deficiencies can be remedied. Improved infrastructure in the region would promote greater intra-African trade in the Free Trade Area, enabling member countries, including Nigeria, to exploit their Ricardian "comparative advantages" in agriculture, manufacturing, and services. Regarding the "laundry list" of much-needed institutional and political reforms, readers are referred to Sohn (2020).

In addition to reducing the proportion of Nigeria's export revenues that derive from the sale of oil—an objective that has proved elusive for decades—and increasing domestic food production to lower the percentage of domestic food requirements supplied by imports, a deliberate policy of luring direct foreign investment—especially for the modernization of the agricultural, electricity, and transport sectors—can mitigate the stress on Nigeria's current account balance. Given the country's current political, social, and institutional environment, attracting large amounts of foreign private capital flows will continue to be challenging for Nigeria. Most recently, it was reported that "foreign direct investment in 2021 was just below $700mn, down from $3.1bn at the start of President Muhammadu Buhari's tenure in 2015" (Adeoye and Pilling, 2022), that was attributed to increasing fears by foreign companies regarding their ability to repatriate dollars because of government policies targeted to alleviate the growing dollar shortage.

One final component of the current account balance that can be increased is the share of foreign remittances as a percentage of GDP, but this could be achieved only with a very large out-migration of people over the coming decades, accompanied with a very large in-migration of Nigerians into host countries. For example, in 2020, according to the World Bank, personal remittances received from abroad were 4% of Nigeria's GDP, while Honduras and El Salvador, two Northern Triangle Central American states, had remittances ratios above 24% of GDP (Personal Remittances Received as a Percent of GDP, 2022). However, high remittances ratios are not usually associated with successful countries.

Policies designed to slow population growth, whose template need not necessarily be restricted to the harsh and much criticized —though successful—"one-child" policy implemented by China from 1980 to 2016, would require cultural and institutional change. Other developing countries, such as South Korea and Costa Rica, over a 60-year interval, have reduced their national fertility rates—and population growth rates with policies that are more benign—but as successful— as those adopted by China (Sohn, 2020). These and the other major issues, enumerated above, that have been retarding Nigeria's growth trajectory for decades are more fully articulated in Sohn (2020).

CONCLUSIONS

"*Never say never*," Charles Dickens, *Pickwick Papers* (1837).

The assumptions regarding population and income growth, food and oil prices, export and import levels of oil and food that underpin this paper's very pessimistic scenario for Nigeria in 2050 are within the ranges of past data and are anchored in historical precedent. Admittedly, it would be highly unlikely for these assumptions to converge simultaneously and develop into the "perfect storm" that is represented by scenario (PP). That said, over the last ***three*** years the world economy has been subjected to, not one, but ***two*** "once-in-a-century" events: a global health pandemic that is being managed and mitigated but not eliminated, and a land war in Europe that threatens the well-being of hundreds of millions of people who are not a party to the Russia/Ukraine dispute due to the war's disruption of the global food and energy markets, not to mention the loss of life, serious injury, and displacement sustained by Ukrainians, and the ongoing physical devastation of Ukraine's land, infrastructure, and capital stock. Hence the quotation that begins this section.

This partly explains the justification to assume the "mix" in scenario (PP) of *low* international oil prices with *high* global food prices, when the historical data generally show positive correlation between the two. It is important to note, that even with less extreme assumptions than those employed in scenario (PP), that is, scenario (P), which applies IFPRI-based socio-economic assumptions and projected food prices to average oil prices and prevailing Nigerian oil export levels, the calculations sow doubts whether the

Nigerian economy can be propelled into a higher growth orbit that would simultaneously modernize the country's economy, increase living standards, and reduce food insecurity.

As the middle of the 21st century becomes more visible on the radar screen, the hope is that the crude, "back-of-the-envelope" calculations performed in this study that incorporate a set of very pessimistic assumptions that constitute scenario (PP) will encourage a full-bodied study—along the lines of IFPRI's IMPACT model—of Nigeria's prospects for improving not only the state of food security for its growing population but, along with that, an increase in overall living standards, similar to the impressive performance recorded by China and South Korea over the last six decades (Sohn, 2020).

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REFERENCES

Adeoye, A. (2022, September 27). Can Nigeria's middle-class brain-drain be reversed? *Financial Times*.

Adeoye, A., & Pilling, D. (2022, September 20). Nigeria dollar shortage batters economy. *Financial Times*.

Akwagyiram, A. (2022, February 15). From crude oil to palm oil: Nigeria strives to diversify. *Financial Times*.

Automobile Association of America (AAA). (2022). Retrieved from https://gasprices.aaa.com

BBC News. (2015, July 28). *Nigerian former minister "stole $6bn of public money"*.

British Petroleum (BP). (2022). *British Petroleum Statistical Review of World Energy 2022* (24). Retrieved July 11, 2022, from https://https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf

Census and Economic Information Center Data. (2022). *Nigeria Crude Oil: Exports*. Retrieved from https://www.ceicdata.com/en/indicator/nigeria/crude-oil-exports

Cookson, C. (2019, June 18). Africa to propel world's population towards 10bn by 2050. *Financial Times.*

Cotterill, J. (2022, June 6). Fuel crisis exposes Africa's energy vulnerabilities. Lack of refining capacity means crude-producing continent relies on oil imports. *Financial Times*.

Faaland, J. (Editor). (1982). *Population and the World Economy.* Oxford: Basil Blackwell, p. vii.

FAO. (2022, May). *World Food Situation.* Retrieved from https://www.fao.org/worldfoodsituation/foodpricesindex/en/

FAO. (n.d.). *Nigeria Agriculture at a Glance*. Retrieved from https://www.fao.org/nigeria/fao-in-nigeria/nigeria-at-a-glance/en/

Financial Times. (2019, June 17). *Datawatch: Africa's Refugees.*

Financial Times. (2022, February 9). *Nigeria needs a new kind of politics*.

Food and Agriculture Organization et al. (2017). *The State of Food Security and Nutrition in the World 2017: Building Resilience for Peace and Food Security*. (Jointly prepared by the Food and Agriculture Organization of the United Nations (FAO), the International Fund for Agricultural Development (IFAD), the United Nations Children's Fund (UNICEF), the World Food Programme (WFP) and the World Health Organization (WHO), Rome.

Food and Agriculture Organization. (FAO). (1996). World Food Summit Plan of Action, (Paragraph 1 in Rome Declaration on World Food Security). *World Food Summit.* Retrieved from http://www.fao.org/docrep /003/w3613e/w3613e00.HTM

Food Balance Sheets. FAO. (2022). Retrieved from https://www.fao.org/faostat/en/#data/FBS and https://www.fao.org/faostat/en/?#data/FBSH
Fuel Exports. (2022). *World Bank, Percentage of Merchandise Exports - Nigeria*. Retrieved from https://data.worldbank.org/indicator/TX.VAL.FUEL.ZS.UN?locations=NG
Global Hunger Index (GHI). (2020). Retrieved from https://www.globalhungerindex.org/download/all.html
Institute for Health Metrics and Evaluation (IHME). (2021). Retrieved from https://vizhub.healthdata.org/population-forecast/
International Energy Agency (IEA). (2021). Retrieved from https://www.iea.org/reports/world-energy-outlook-2021/executive-summary
International Food Policy Research Institute. (IFPRI). (2022). Retrieved from https://en.wikipedia.org/wiki/International_Food_Policy_Research_Institute
International Monetary Fund (IMF). (2011). *Nigeria: 2010 Article IV Consultation (IMF Country Report No. 11/57, p.21)*. Retrieved from https://www.imf.org/en/Publications/CR/Issues/2016/12/31/Nigeria-2010-Article-IV-Consultation-Staff-Report-Debt-Sustainability-Analysis-Informational-24673
International Trade Administration. (US Department of Commerce). (2021). Retrieved from https://www.trade.gov/country-commercial-guides/nigeria-agriculture-sector
Leontief, W., & Sohn, I. (1982). Economic Growth (Chapter 5). In J. Faaland (Ed.), *Population and the World Economy*. Oxford: Basil Blackwell.
Leontief, W., Carter, A., & Petri, P. (1977). *The Future of the World Economy: A United Nations Study*. New York: Oxford University Press.
Munshi, N. (2021, December 17). Oil price shocks test mettle of Nigerian banks, FT Special Report, African Banking and Finance. *Financial Times*.
Olowe, V. (2020). Africa 2100: how to feed Nigeria in 2100 with 800 million inhabitants. *Organic Agriculture (Official Journal of the International Society of Organic Agriculture Research)*. Retrieved from https://doi.org/10.1007/s13165-020-00307-1
Our World in Data. (2020). *Population Living in Extreme Poverty. Nigeria: 1981 to 2019*. Retrieved February 8, 2022, from https://ourworldindata.org/extreme-poverty
Our World in Data. (2022). *Commodity Price Index of Cereal Crops, 1850-2015*. Retrieved from https://ourworldindata.org/grapher/commodity-price-index-of-cereal-crops-and-petroleum-1850-2015?tab=chart&country=~OWID_WRL
Our World in Data. (2022). *Daily per Capita Caloric Supply*. (FAO). Retrieved from https://ourworldindata.org/grapher/daily-per-capita-caloric-supply?tab=chart&country=MDG~CAF~IRL~USA
Our World in Data. (2022). *Daily per Capita Supply of Calories versus GDP per Capita*. (FAO). Retrieved from https://ourworldindata.org/grapher/daily-per-capita-supply-of-calories-vs-gdp-per-capita
Our World in Data. (2022). *Dietary Compositions by Commodity Group*. Retrieved from https://ourworldindata.org/grapher/dietary-compositions-by-commodity-group?country=~USA
Our World in Data. (2022). *Fruit Consumption vs GDP-Per-Capita*. Retrieved from https://ourworldindata.org/grapher/fruit-consumption-vs-gdp-per-capita
Our World in Data. (2022). *Hunger and Undernourishment*. Retrieved from https://ourworldindata.org/hunger-and-undernourishment
Our World in Data. (2022). Real Commodity Price Index Food Products. Retrieved from https://ourworldindata.org/grapher/real-commodity-price-index-food-products?tab=chart&country=~OWID_WRL
Our World in Data. (2022). *Share of Calories from Animal Protein vs GDP-per-Capita*. Retrieved from https://ourworldindata.org/grapher/share-of-calories-from-animal-protein-vs-gdp-per-capita

Our World in Data. (2022). Share of Energy from Cereals, Roots and Tubers vs GDP Per Capita. Retrieved from https://ourworldindata.org/grapher/share-of-energy-from-cereals-roots-and-tubers-vs-gdp-per-capita
Pilling, D. (2022a, February 15). Yesterday's fuels power tomorrow's growth, Investing in Nigeria, (Special Report). *Financial Times*.
Pilling, D. (2022b, July 11). Africa: Calls for a just energy transition carry echos of elite panic. *Financial Times*.
Pilling, D. (2022c, September 20). How Nigeria's state lost the trust of its citizens. *Financial Times.*
Robinson, S., Mason-D'Croz, D., Islam, S., Sulser, T., Robertson, R., Zhu, T., . . . Rosegrant, M.W. (2015). *The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT): Model description for version 3*. International Food Policy Research Institute. Retrieved from https://ebrary.ifpri.org/digital/collection/p15738coll2/id/129825
Rosegrant, M., Agcaoili-Sombilla, M., & Perez, N. (1995). *Global food projections to 2020:Implications for investment.* 2020 Vision for Food, Agriculture, and the Environment Discussion Paper No. 5. Washington, D.C.: IFPRI.
Selassie, A. (2021, December). The African Century. *Finance & Development*, pp. 58–61.
Sengupta, S. (2019, April 23). Poor Nations Lose as Planet Warms, Study Finds. *The New York Times*.
Sohn, I. (2005). Long-term Projections of Non-Fuel Minerals: We Were Wrong, But Why? *Resources Policy*, 259–284.
Sohn, I. (2007). Long-term Energy Projections: What Lessons Have We Learned? *Energy Policy*, 4574–4584.
Sohn, I. (2013, June). Long-Term Projections of Global Food Requirements: Why Were We Wrong? *Natural Resources*, *4*, 195–20.
Sohn, I. (2020). Why Is Nigeria -- The 'Giant of Africa' -- Still Poor? *Journal of Applied Business and Economics*, *22*(5), 11–41.
Sohn, I. (2022). If Nigeria's Economic Performance From 1960-2020 Resembled China's and South Korea's: Exploring the Counterfactual and Subjunctive in Economics. *Journal of Applied Business and Economics*, *24*(1), 32–50.
Sulser, T., Wiebe, K., Dunston, S., Cenacchi, N., Nin-Pratt, A., Mason-D'Croz, D., . . . Rosegrant, M.W. (2021). Climate change and hunger: Estimating costs of adaptation in the agrifood system. *Food Policy Report*. International Food Policy Research Institute, Washington, DC. Retrieved from https://ebrary.ifpri.org/digital/collection/p15738coll2/id/134423
Sulser, T., Wiebe, K., Dunston, S., Cenacchi, N., Nin-Pratt, A., Mason-D'Croz, D., . . . Rosegrant, M.W. (2021). Climate change and hunger: Estimating costs of adaptation in the agrifood system. (Extended Results). *Food Policy Report*. International Food Policy Research Institute, Washington, DC. https://doi.org/10.2499/9780896294165
The Economist. (2018, March 31). *Returning migrants: Homeward bound* (p.50).
The Economist. (2019a, April 6). *Welfare in India: The Beauty of Breadth* (p.14).
The Economist. (2019b, April 20). *Climate change and crop disease: Blocking the road to rusty death* (p.69).
The Economist. (2021, October 23). *Nigeria: When things fall apart* (p.59).
The World Bank. (2021). *Exports of goods and services (BoP, current US$) - Nigeria*. Retrieved from https://data.worldbank.org/indicator/BX.GSR.GNFS.CD?locations=NG
Time. (2007, April 23). *A Failure of Democracy in Nigeria*.
Transparency International. (2021). *Corruption Perceptions Index*. Retrieved from https://www.transparency.org/en/cpi/2021
U.S. Bureau of Labor Statistics.(2022). Retrieved from https://www.bls.gov/data/inflation_calculator.htm
United Nations Population Division (UNPD). (2019). *9.7 billion on Earth by 2050, but growth rate slowing, says new UN population report*. Retrieved from https://www.un.org/en/academic-impact/97-billion-earth-2050-growth-rate-slowing-says-new-un-population-report

United Nations Population Division (UNPD). (2022). *World Population Prospects 2022*. Retrieved from https://population.un.org/wpp/Download/Standard/Population/
United Nations. (2015). *Sustainable Development* Goals. Retrieved from https://en.wikipedia.org/wiki/Sustainable_Development_Goals
World Bank (WB). (2021). *World Bank Open Data*. Retrieved from https://data.worldbank.org/indicator/NY.GDP.MKTP.KD? locations=1W-ZG
World Bank Open Data. (2021). *GDP-Nigeria*. Retrieved from https://data.worldbank.org/indicator/NY.GDP.MKTP.KD?locations=NG
World Bank Open Data. (2022). Personal Remittances Received as a Percent of GDP - Nigeria. Retrieved from https://data.worldbank.org/indicator/BX.TRF.PWKR.DT.GD.ZS?locations=NG
World Bank Open Data. (2022). *Personal Remittances Received as a Percent of GDP*. Retrieved from https://data.worldbank.org/indicator/BX.TRF.PWKR.DT.GD.ZS?locations=SV-HN-NG
World Bank. (2021). *World Bank Open Data*. Retrieved from https://data.worldbank.org/indicator/NY.GDP.MKTP.KD? locations=1W-ZG

APPENDIX

TABLE 1
SOCIO-ECONOMIC, MACRO-FOOD AND OIL EXPORT DATA FOR 2010 AND THE THREE SCENARIOS IN 2050

Indicator	2010	2050(O)	2050(P)	2050(PP)
Population				
Level (millions)	158.4	328.6	433.7	548.1
Annual rate of change (%)	———	1.8	2.6	3.2
Gross Domestic Product				
GDP level (billions of $2005 ppp)	338.3	5,040.7	2,237.9	1,674.4
Annual rate of growth (%)	——-	6.9	4.8	4.1
GDP per capita ($2005 ppp)	2,135	15,338	5,165	3,055
Annual rate of growth (%)	———	5.1	2.2	0.9
Macro Food-Related Data				
Daily available calories (per day/per person)	2,636	3,250	2,597	NA
Aggregate food production index (2050/2010 ratio)	1	2.35	2.13	NA
Annual percentage change from 2010	———	2.15	1.91	NA
Hunger (millions)	9.7	10.3	30.1	?
Hunger (% of population)	6	3.1	7	?
Data Related to Oil Exports				
Oil exports (m/b/d)	2.5	3.75	1.8	1
Oil price per barrel ($2005, except for 2010)	80 ($2010)	100	70	40
Annual oil export revenue (in bn of $2005 dollars, except for 2010)	73 ($2010)	137	46	15

Source: BP(2022); CEIC Data (2022); IHME(2021); IMF(2011), Sulser et al. (Extended Results, 2021)

TABLE 2
CHANGES IN NIGERIAN DIETS, 2010 AND 2050: AVAILABILITY OF FOOD
(KG PER CAPITA PER YEAR)

Indicator	Kilograms per year per person				Ratios of 2050/2010			
		2050 (O)	2050 (P)	2050 (PP)	2010 Level	2050 (O)/2010	2050 (P)/2010	2050 (PP) /2010
Food Category								
Meat	8.5	24.6	14.1	8.5	8.5	2.89	1.66	1
Cereals	144.5	156.8	132.6	144.5	144.5	1.09	0.92	1
Fruits & Vegetables	135.5	218.2	161.2	135.5	135.5	1.61	1.19	1
Oils & Fats	8.4	11.8	8.7	8.4	8.4	1.4	1.04	1
Pulses	8.8	11.9	9.1	8.8	8.8	1.35	1.03	1
Roots & Tubers	231.6	256.7	220.6	231.6	231.6	1.12	0.95	1
Per Capita GDP (2005$, ppp)	2,135	15,338	5,165	3,055	2.14	7.18	2.42	1.43

Source: Sulser et al. (Extended Results, 2021) for 2010, 2050(O), and 2050(P)

TABLE 3
DAILY DIETARY COMPOSITION BY COMMODITY CATEGORY IN 2010

Country	Nigeria		China		Peru		Venezuela		South Korea		France		United States	
	kcl/p/c	%	kcl/p/c	%	kcl/p/c	%	kcl/p/c	%	kcl/p/c	%	kcl/p/c	%	kcl/p/c	%
Commodity														
Meat	66	2.4	501	16.5	137	5.2	268	9.6	364	11.1	552	15.6	469	12.9
Eggs & Dairy Products	25	1	130	4.3	122	4.7	210	7.5	77	2.3	390	11	425	11.6
Cereals	1225	45.3	1420	46.7	1114	42.6	1093	39	1414	43.1	972	27.5	807	22
Fruits & Vegetables	126	4.7	306	10	235	9	132	4.7	236	7.8	175	5	181	5
Oils & Fats	410	15.2	338	11	219	8.4	446	16	621	18,9	776	22	870	23.8
Pulses	95	3.5	11	-0-	74	2.8	61	2	13	-0-	17	0	38	1
Roots & Tubers	566	20.9	152	5	374	14.3	76	2.7	34	1	100	3	91	2.5
Alcohol & Sugary Beverages	193	7.1	186	6.1	464	13.1	729	18.5	522	15.9	554	15.7	769	21.1

Totals (incl. waste)	2706	100	3044	100	2617	100	2805	100	3281	100	3536	100	3650	100
GDP per capita (2010 $)	2,281		4,551		5,100		13,800		23,087		40,600		48,467	

Source: Our World in Data (2022)

TABLE 4
FOOD BALANCE SHEET: 2010 AND 2050 (COMMODITY LEVELS ARE IN TMT)

Commodity / year & scenario	Domestic production	Annual percent-age change	Imports	Imports/ total domestic demand	Domestic supply	Food availability	Annual percentage change	Other demand	Exports	Total domestic demand
Meat										
2010	1290	—	59	4.4	1349	1349	—-	——	——-	1349
2050(O)	5214	3.6	2854	35.4	8068	8068	4.6	——-	——-	8068
2050(P)	4699	3.3	1418	23.2	6117	6117	3.9	———	———	6117
2050(PP)	4048	2.9	611	13.1	4659	4659	3.2	———	———	4659
Cereals										
2010	27359	—-	6361	18.9	33720	22888	——	10832	———	33720
2050(O)	48283	1.4	40802	45.8	89085	51514	2.1	37571	———	89085
2050(P)	49306	1.5	39779	44.7	89085	57501	2.3	31584	———	89085
2050(PP)	67675	2.3	49004	41.9	116679	79201	3.2	37478	———	116679
Fruits & Vegetables										
2010	24095	—-	——	—-	24095	21460	——-	2566	69	24026
2050(O)	71107	2.7	10082	12.4	81189	71702	3.1	9487	——-	81189
2050(P)	54499	2.1	24088	30.7	78587	69908	3	8679	——-	78587
2050(PP)	62041	2.4	21107	25.4	83148	74268	3.2	888	———	83148
Oils & Fats										
2010	32479	—	——	—-	32479	1336	——-	30941	12	32277
2050(O)	81974	2.3	3284	3.9	85258	3867	2.7	81391	——-	85258
2050(P)	59289	1.5	3645	5.8	62934	3789	2.6	59145	———	62934
2050(PP)	98023	2.8	13861	12.4	111884	4604	3.1	107280	—-	111884

Pulses										
2010	3350	—-	——-	——	3350	1400	—-	1723	227	3123
2050(O)	9670	2.7	———	——-	9670	3919	2.6	5641	109	9560
2050(P)	9691	2.7	———	———	9691	3958	2.6	4983	750	8941
2050(PP)	11810	3.2	———	———	11810	4823	3/1	5936	1051	10759
Roots & Tubers										
2010	96678	—-	——	——-	96678	36689	——-	58003	1986	94692
2050(O)	218169	2.1	10414	2.1	228583	84346	2.1	144237	——-	228583
2050(P)	215552	2.1	7162	2.1	227714	95662	2,4	132052	——-	227714
2050(PP)	315367	3	12257	3.7	327624	126940	3.1	200684	——-	327624

Source: FAO (2022); Sulser et al. (Extended Results, 2021) for 2010, 2050(O), and 2050(P)

TABLE 5
REAL COMMODITY PRICE INDEX (SELECTED FOOD PRODUCTS AND PETROLEUM): 1960-2015 (1900=100)

Commodity	**1960**	**2015**	**Low (year)**	**High (year)**	**Ratio H/L (column4/ column 3)**
Beef	271	204	115 (1998)	493 (1973)	4.3
Corn	83	33	21 (2005)	142 (1974)	6.8
Palm oil	68	24	21 (1986)	123 (1974)	5.9
Petroleum	147	300	122(1970)	673 (1974)	5.5
Wheat	77	22	15(1999)	109 (1974)	7.3

Source: Our World in Data (2022)

TABLE 6
COMMODITY PRICES IN 2010 AND 2050 FOR SCENARIOS O, P, AND PP
($2005 PER METRIC TON)

Commodity	2010	2050 (O)	Ratio 2050(O)/2010	2050 (P)	Ratio 2050 (P)/2010	2050 (PP)	Ratio 2050 (PP)/2010
Meat	2320	2322	1	3368	1.45	4063	1.75
Cereals	217	256	1.18	338	1.56	380	1.75
Fruits & Vegetables	870	1033	1.19	1406	1.62	1523	1.75
Oil crops	438	496	1.13	679	1.55	767	1.75
Pulses	943	1060	1.12	1216	1.29	1650	1.75
Roots & Tubers	341	417	1.22	524	1.54	597	1.75

Source: Sulser et al. (Extended Results, 2021) for 2010, 2050(O), and 2050(P)

TABLE 7
VALUE OF FOOD IMPORTS AND EXPORTS AND OIL EXPORT REVENUE, 2010 and 2050

	2010 Imports	2010 Exports	2050 (O) Imports	2050(O) Exports	2050 (P) Imports	2050 (P) Exports	2050 (PP) Imports	2050 (PP) Exports
Commodity (Valued in Billions of $2005)								
Meat	0.14		6.63		4.78		2.48	
Cereals	1.38		10.45		13.45		18.62	
Fruits & Vegetables		0.06	10.42		33.87		32.15	
Oil crops		0.005	1.63		2.47		10.63	
Pulses		0.21		0.12		0.91		1.73
Roots & Tubers		0.68	4.34		3.75		7.32	
Total Value	1.52	0.96	33.47	0.12	58.32	0.91	71.2	1.73
Balance of Trade (Food): (X-M)	-0.56		-33.35		-57.41		-69.47	
Oil revenue from Exports ($2005)		73.0 ($2010)		137		46		14.6

Sources: Commodity export and import values are based on data in Tables 5 and 6; Values of oil exports are from Table 1