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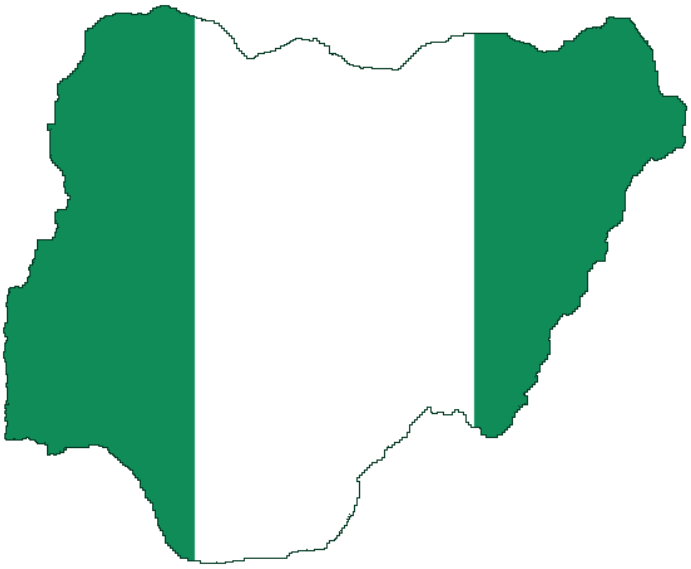
Innovation for Sustainable Agricultural growth in Nigeria



PARI
Program of Accompanying Research for Agricultural Innovation

OCTOBER 2017
research4agrinnovation.org

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SUGGESTED CITATION:

ZEF, FARA, ARCN (2017). *Country Dossier: Innovation for Sustainable Agricultural Growth in Nigeria.* Program of Accompanying Research for Agricultural Innovation. Bonn, Accra and Abuja: Center for Development Research, Forum for Agricultural Research in Africa and Agricultural Research Council of Nigeria.

ACKNOWLEDGEMENTS

The paper was developed within the project "Program of Accompanying Research for Agricultural Innovation" (PARI), which is funded by the German Federal Ministry of Economic Cooperation and Development (BMZ).

Federal Ministry
for Economic Cooperation
and Development

About this study

In 12 African countries and India Green Innovation Centers (GICs) have been established under the ‘‘One World, No Hunger’’ Initiative (SEWOH) of the German government and other investors. The aim of the GICs is to promote agricultural innovation, improve food and nutrition security and build sustainable value chains in the agri-food sector of these countries. The Program of Accompanying Research for Agricultural Innovation (PARI) has been providing independent research to the SEWOH since 2015. PARI is led by the Center for Development Research (ZEF) at the University of Bonn in close collaboration with the Forum for Agricultural Research in Africa (FARA) and its network of national and regional partners in Africa, the African Growth and Development Policy Modeling Consortium (AGRODEP) facilitated by the International Food Policy Research Institute (IFPRI, Africa Office) and other partners in Germany and India. This country dossier offers a situation analysis of the current state of the agri-food sector, related policies and existing agricultural innovations. It thereby provides basic background knowledge necessary to make fruitful investments in line with the country‘s policies and its potentials, and to find promising partners for development cooperation.

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Acronyms/Abbreviations

ADP	Agricultural Development Project
ARCN	Agricultural Research Council of Nigeria
ATA	Agricultural Transformation Agenda
CAADP	Comprehensive Africa Agriculture Development Program
CBN	Central Bank of Nigeria
CGIAR	Consultative Group International Agricultural Research
CMD	Cassava Mosaic Disease
CSIP	Cow Peas Storage Innovation Platform
DFID	United Kingdom Department for International Development
DHS	Demographic and Health Surveys
DTMA	Drought-Tolerant Maize for Africa
DTMV	Drought-Tolerant Maize Varieties
ECOWAS	Economic Community of West African States
E-ATP	USAID's Expanded Agribusiness and Trade Promotion
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
FCT	Federal Capital Territory
GDP	Gross Domestic Product
GIC	Green Innovation Center
GESS	Growth Enhancement Support Scheme
GHI	Global Hunger Index
GIZ	"Deutsche Gesellschaft für Internationale Zusammenarbeit" German Agency for International Cooperation
GNI	Gross National Income
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
IP	Innovation Platform
LCU	Local Currency Unit
LGA	Local Government Area
NARP	National Agricultural Research Project
NC	North central
NE	North East
NFDP	National Fadama Development Projects
NGO	Non-Governmental Organization
NGS	Next Generation Sequencing
NIRSAL	Nigeria Incentive-Based Risk Sharing System for Agricultural Lending
NRCRI	National Root Crops Research Institute
NW	North West
PAE	Public Agriculture Expenditure
PARI	Program of Accompanying Research for Agricultural Innovation
PICS	Purdue Improved Cowpea Storage
PPP	Purchasing Power Parity
R&D	Research and Development
RBDA	River Basin Development Authority
RCA	Revealed Comparative Advantage
REFILS	Research-Extension-Farmer-Input Linkage System
ReSAKSS	Regional Strategic Analysis and Knowledge Support System
RIU	Research Into Use
SE	South East

SEWOH	"One World, No Hunger" Initiative
SRI	System of Rice Intensification
S-S	Short-Season
SS	South South
SSA-CP	Sub Saharan Africa Challenge Program
SW	South West
T&V	Training and Visit
TFP	Total Factor Productivity
UNICEF	United Nations International Children's Fund
USAID	United States Agency for International Development
WAAPP	West Africa Agricultural Productivity Program
WHO	World Health Organization
ZEF	Zentrum für Entwicklungsforschung / Center for Development Research

1 General background information on the agricultural and food sectors

Nigeria, a country in the West African sub-region of Africa, is bordered in the west by Benin, by Chad and Cameroon in the East, and by Nigeria the North. On the South, in the Atlantic Ocean, lies the Gulf of Guinea. Nigeria covers 923,768 km^2 with a population of 182.2 million people (estimate 2015) and a population density of 189.9 per km^2. With an estimated nominal Gross Domestic Product (GDP) of US$ 522 billion (est. 2015), Nigeria presently has the largest economy in Africa. Nigeria's external earning is driven mainly by its oil sector, with the country ranking as the sixth largest exporting country globally.

Agriculture employs about two-thirds of the total labor force, contributes about 22% of the GDP and provides 88% of non-oil earnings. More than 90% of the agricultural output is accounted for by small-scale farmers with less than 2 ha under cropping. It is estimated that about 81% of the total land area has potential for agricultural activities, with about 33 million ha under cultivation. Similarly, of the estimated 2 million ha irrigable land area, only about 220,000 ha (11%) is utilized.

In recent years, several attempts have been made by the Federal Government of Nigeria to reform Nigeria's agricultural sector. The most recent is the Agricultural Transformation Agenda (ATA) Program from 2011. The vision in the transformation strategy is to achieve a hunger-free Nigeria through an agricultural sector that drives income growth, accelerates achievement of food and nutritional security, generates employment and transforms the country into a leading player in global food markets to grow wealth for millions of farmers. The strategy was to change the approach to fertilizer, seed and other inputs distribution, with greater emphasis on value chain development, national processing, capacity development and private sector involvement. Consequently, some modest achievements have been made in the last four years with major increases in food production and a reduction in the country's annual food import bills on rice, wheat and other major agricultural crops.

Collaboration with Germany has the potential to contribute to agricultural growth and development in the following ways: by developing improved research capacity in technology generation and improved seeds production; by collaborating in developing and expanding innovation platforms (IPs); and by developing commodity value chains and extension services.

In twelve African countries, including Nigeria, Green Innovation Centers (GICs) have been established in selected regions under the ''One World, No Hunger'' Initiative (SEWOH) of the German government and other investors. The aim of the GICs is to promote agricultural innovation, improve food and nutrition security and build sustainable value chains in the agri-food sector. The selected value chains in Nigeria are maize, rice, Irish potato and cassava (manioc).

1.1 Pan-African policies and strategies

Nigeria was the 12th African country to sign the Comprehensive Africa Agriculture Development Program (CAADP) compact in 2009, but implementation of the compact only started after the reconstitution of the Federal cabinet in 2011. CAADP represents the commitment of Presidents of African countries to commit at least 10% of their budget to agriculture and to grow the agricultural sector at an annual rate of 6%. Nigeria did not meet the CAADP target of 10% national budget allocation to agriculture between 2003 and 2013, but has passed the annual 6% target in recent years.

Nigeria joined the New Alliance for Food Security and Nutrition in 2013 with the commitment to achieve sustained inclusive, agriculture-led growth in the country.

Nigeria is also part of the Grow Africa Partnership, with the goal of increasing private sector investment in agriculture and accelerating the execution and impact of investment commitments. The Grow Africa Partnership comprises over 200 companies and governments in 12 countries. These companies have made formal commitments to the government in the respective country to invest in agriculture. In 2013-2014, US$ 611 million investments were made and 22,672 jobs were created in Nigeria by

international and national companies within the Grow Africa Partnership and New Alliance for Food Security and Nutrition (New Alliance, 2014).

1.2 National (and regional) policies and strategies

Several policies, programs and projects have been formulated and implemented during the last four decades in attempts to ensure that the Nigerian agricultural sector lives up to its traditional roles of providing food, export earnings, industrial raw materials and employment for the country. A brief review of some of the current agricultural policies, programmes and projects is presented below.

Agricultural Development Projects (ADPs) (1974 to date*):* The ADPs were initially funded by the World Bank, starting with pilot establishments at Gombe, Funtua and Gusau. ADPs were set up to provide extension services, technical input support and rural infrastructure services. The ADP concept was a response to the fall in agricultural production and the resulting concern of sustaining domestic food supplies. The ADPs are presently implemented in all 36 States and the Federal Capital Territory (FCT).

The project changed the extension methods from the training and demonstration system to the training and visit (T&V) system. The T&V system was slow, resulting in a top-down rather than responsive recommendations to farmers and continued technical emphasis without paying attention to socioeconomics. Under the project, programmes for multiplication of improved seeds generally fell short of goals. However, the decline in oil prices that started in 1982 and the lack of will on the part of state governments to sustain the ADPs at the initial levels of funding gradually led to declines in agricultural extension delivery nationwide. Supplies of fertilizers were erratic, largely due to centralized government control of international procurement and a very heavy subsidy programme. At project closure, most of the ADPs had a weak and uncertain funding structure and were providing poorer services than expected of the scheme. Efforts are being doubled in recent times to make the ADPs more effective through increased commitment to funding, as well as through capacity and infrastructural development.

River Basin Development Authority (RBDA) (1977 to date): The major instrument of the Water Resources and Irrigation Policy was the establishment of 11 RBDAs in 1977 to develop available water bodies in the country for agriculture, fishing and other purposes. RBDAs were the main instruments for the government's intervention in direct agricultural production through large scale mechanized farming. RBDAs had the mandates of land preparation, development of irrigation facilities and construction of dams, boreholes and roads. RBDAs were also involved in distribution of farming and fishing inputs. Some of the challenges that were faced by the RBDAs include political interference and managerial problems resulting from socioeconomic differences that permeated the nation's sociopolitical, economic and cultural institutions. Moreover, the RBDAs were highly capital intensive, with very little to showcase in terms of the total area irrigated nationally. The failure of the RBDAs to deliver large areas of irrigated lands led eventually to the conception and implementation of the World Bank funded National Fadama Development Projects (NFDPs).

National Fadama Development Projects (NFDPs): The NFPDs have been implemented in Phases I, II and III from 1992 to 2013. Nigeria has large areas of "Fadama" land which has only partially been developed. The Fadama I and II projects successfully refined approaches for improved utilization of these lands. Fadama II implemented an innovative local development planning tool and built on the success of the community-driven development mechanisms. Fadama III supported the financing and implementation of five main components designed to transfer financial and technical resources to the beneficiary.

Agricultural Transformation Agenda (ATA) (2011-date): In 2011, the Federal Government of Nigeria launched an ambitious agricultural reform for the development of its agriculture sector. The agricultural policy in Nigeria was aligned with the ATA, which evolved from the National Economic Transformation Agenda. The ATA strives to increase agricultural productivity and value addition in agriculture in order to reduce food prices and Nigeria's reliance on food imports. The vision of the ATA

is a food secure and prosperous Nigeria. The main aspects of ATA include value chain development, a growth enhancement scheme for the provision of subsidized inputs, special crop processing zones, an incentive-based risk-sharing system for agricultural lending, and private sector involvement.

Some of the strategies adopted to achieve the ambitious agricultural transformational goals in the country include:

- Import substitution of agricultural development initiatives to attain self-sufficiency in food production, reduce the cost of food, etc.;
- Export-oriented agricultural sector development to broaden the resource base of the economy and foreign direct investments in areas where Nigeria has a comparative economic advantage in the production of various agricultural value chains;
- Growth in the value-added agro-processing sector to leverage direct foreign investment, and economies of scale derived from an export-oriented agricultural sector to provide affordable raw materials and stimulate investment;
- Promotion of intra- and inter-sectoral linkages to integrate agriculture into a higher value-added manufacturing scheme, with emphasis on agro and agro-allied industry through the provision of industrial machinery and materials, and to build a solid financial base in the country.

The Nigeria Incentive-Based Risk-Sharing System for Agricultural Lending (NIRSAL): This is a new innovative mechanism targeted at reducing lending risk in the agricultural sector. The goal of NIRSAL, which was developed by the Alliance for Green Revolution in Africa by request of the Central Bank of Nigeria (CBN), is to trigger an agricultural industrialization process through increased production and processing of the greater part of what is produced in order to boost economic earnings across the value chain. NIRSAL is an approach that tackles both the agricultural value chains and the agricultural financing value chain.

Growth Enhancement Support Scheme (GESS): This scheme represents a policy and pragmatic shift within the existing Fertilizer Market Stabilization Program, and it puts the resource-constrained farmer at its center through the provision of series of incentives to encourage the critical actors in the fertilizer value chain to work together to improve productivity, household food security and income of the farmer. GESS targets five million farmers each year for four years that will directly receive GESS on their mobile phone, which totals 20 million farmers at the end of four years. GESS provides support directly to farmers to enable them to procure agricultural inputs at affordable prices at the right time and place. GESS increases productivity of farmers across the length and breadth of the country through increased use of fertilizer, i.e., 50 kg/ha from 13 kg/ha. There is also a change in the role of Government from direct procurement and distribution of fertilizer to a facilitator of procurement, regulator of fertilizer quality and catalyst of active private sector participation in the fertilizer value chain. State Governments are also collaborating with the Federal Government under the GESS.

Staple Crops Processing Zones are about improving investment frameworks for agriculture in Nigeria. This idea focuses on attracting private sector agribusinesses to set up processing plants in zones of high food production and to process commodities into food products. The government intends to put in place appropriate fiscal, investment and infrastructure policies for the staple crop processing zones. These include:

- Tax breaks on imports of agricultural processing equipment;
- Tax holidays for food processors that are located in these zones;
- Supportive infrastructure, especially complementary investment by the government in roads, logistics, storage facilities and power;
- Infrastructure focus on power, irrigation, flood control, roads, rail, air etc.;
- Linking farmers in clusters to food manufacturing plants;
- Developing an Agricultural Investment Code, in partnership with Ministry of Finance and Ministry of Trade and Investment and CBN.

Marketing Corporations: Under the ATA, the government plans to strengthen the markets for agricultural commodities through the establishment of commodity marketing corporations around each of the commodities. The Federal Government intends to support the development of private sector-driven marketing organizations to grow the agricultural sector. These marketing institutions would be driven by agricultural value chains and run as though led by the private sector but government enabled-institutions will empower farmers and value chain actors to generate value. These new institutions, which would be called marketing corporations, will coordinate production and export of target commodities. They will also attract research and development (R&D) investment into the sector for infrastructure and processing. They will also stimulate the development of tailored financial services to grow the sector.

1.3 Data on food and nutrition security in Nigeria and GIC-Region

The following section includes information about important socio-economic and agricultural indicators and data on diet quantity, diet quality and nutrition status.

1.3.1 Socio-economic and agricultural data

Table 1: Selected national economic and health-related data for Nigeria

Indicator	Value	Year
Population, total	178,516,904	2014
Population growth (annual %)	2.8	2014
Rural population (% of total population)	53	2014
GDP per capita, PPP (constant 2011 international $)	5,607	2014
GNI per capita, PPP (constant 2011 international $)	5,166	2013
Poverty headcount ratio at $2 a day (PPP) (% of population)	82	2010
Poverty headcount ratio at $1.25 a day (PPP) (% of population)	62	2010
Poverty headcount ratio at national poverty lines (% of population)	46	2010
Rural poverty headcount ratio at national poverty lines (% of rural pop.)	53	2010
Agricultural land (% of land area)	79	2012
Agricultural irrigated land (% of total agricultural land)	no data	
Agriculture value added per worker (constant 2005 US$)	4,760	2014
Agriculture, value added (% of GDP)	20	2014
Access to electricity, rural (% of rural population)	34	2014
Employees, agriculture, female (% of female employment)	39	2004
Employees, agriculture, male (% of male employment)	49	2004
Employment in agriculture (% of total employment)	45	2004
Literacy rate, adult total (% of people ages 15 and above)	51	2008
Ratio of female to male secondary enrollment (%)	89	2010
Mortality rate, under-5 (per 1,000 live births)	117	2013
Maternal mortality ratio (modeled estimate, per 100,000 live births)	560	2013

Source: World Bank, data.worldbank.org/country

Note: GDP refers to Gross Domestic Product; GNI refers to Gross National Income; PPP refers to Purchasing Power Parity

Table 2: Gross Domestic Product at 1990 Constant Basic Prices (million Naira)

	Agriculture	Crop Production	Livestock	Forestry	Fishery	Total GDP	Agri. as % total GDP
1995	96,220.6	80,702.8	10,051.3	2,421.9	3,044.6	281,407.4	34.2
1996	100216.2	83,761.5	10,342.8	2,434	3,677.9	293,755.4	34.1
1997	104514	87,363.2	10,601.4	2,455.9	4,093.5	302,022.5	34.6
1998	108814.1	90,770.4	10,887.6	2,485.4	4,670.7	310,890.1	35.0
1999	114570.8	95,526.8	11,192.5	2,517.7	5,333.8	312,183.5	36.7
2000	117,945.1	98,392.56	11,449.9	2,555.5	5,547.2	329,178.7	35.8
2001	122,522.3	102,131.5	11,793.4	2,606.6	5,990.8	356,994.3	34.3
2002	190,133.4	168,777.9	12,360.6	2,624.8	6,370.1	433,203.5	43.9
2003	203,409.9	181,238.1	12,879	2,664.3	6,628.6	477,533	42.6
2004	216,208.5	192,452.2	13,716.1	2,837.4	7,202.7	527,576	41.0
2005	231,463.6	206,178.4	14,643.9	3,005.4	7,636	561,931.4	41.2
2006	248,599	221,622.3	15,654.7	3,186.2	8,135.8	595,821.6	41.7
2007	266,477.2	237,685.7	16,739.4	3,381.3	8,670.9	634,251.1	42.0
2008	283,175.4	252,469.7	17,877.6	3,587.6	9,240.5	672,202.6	42.1
2009	299,996.9	267,362.8	19,039.1	3,797.5	9,797.5	716,949.7	41.8
2010	317,282	282,605	20,264.4	4,016.8	10,395.4	776,332.2	40.9
2011	335,180	298,414	21,506.9	4,244.6	11,014.2	834,000.8	40.2
2012	348,491	309,644	22,699.3	44,86.7	11,661.1	888,893	39.2
2013	365,277	324,256	23,983.4	4,729.9	12,308.6		

Source: World Bank, data.worldbank.org/country

Table 3: Agricultural Total Factor Production (TFP) index Nigeria, 1995-2011

Index (1992=100)			Index (1961=100)		
Year	**Est1**	**Est2**	**Year**	**Est1**	**Est2**
1995	113	111	**1995**	118	96
1996	116	113	**1996**	122	98
1997	121	116	**1997**	127	100
1998	120	114	**1998**	126	98
1999	124	115	**1999**	130	99
2000	125	115	**2000**	131	99
2001	129	117	**2001**	135	101
2002	134	118	**2002**	140	102
2003	137	118	**2003**	144	101
2004	140	117	**2004**	147	101
2005	141	116	**2005**	148	100
2006	142	115	**2006**	148	99
2007	141	113	**2007**	148	98
2008	135	108	**2008**	142	93
2009	144	114	**2009**	151	98
2010	139	107	**2010**	146	92
2011	136	101	**2011**	142	87

Source: United States Department of Agriculture,
www.ers.usda.gov/dataFiles/Internationalproductivity/AgTFPindividualcountries.xlsx
Note: For each base year (1961 and 1992), two annual estimates of the Agricultural TFP were published on Nigeria by the data source.

Table 4: Annual growth rate of Agricultural Total Factor Production (Nigeria) 1995-2011

Year	Est1%	Est2%
1995	0.038527	0.028587
1996	0.031232	0.01941
1997	0.039133	0.025637
1998	-0.00544	-0.02085
1999	0.028249	0.013903
2000	0.01282	-0.00176
2001	0.03061	0.012189
2002	0.036175	0.012713
2003	0.022765	-0.0048
2004	0.023742	-0.00176
2005	0.007576	-0.01256
2006	0.001308	-0.01128
2007	-0.00424	-0.01112
2008	-0.04145	-0.04583
2009	0.065504	0.052782
2010	-0.03857	-0.06338
2011	-0.02289	-0.05436

Source: United States Department of Agriculture
www.ers.usda.gov/dataFiles/Internationalproductivity/AgTFPindividualcountries.xlsx
Note: Two annual estimates of the Agricultural TFP growth rates were published on Nigeria by the data source.

Table 5: Public agricultural expenditure and Public Expenditure, Nigeria 1995 – 2010

Year	Public Agriculture Expenditure (PAE) Billion LCU	Total Expenditure Billion LCU	Share of Public Agriculture Expenditure (PAE) in Total Expenditure, %
1995	6.2	172.2	3.6
1996	5.5	172.5	3.2
1997	8.3	776.3	1.1
1998	11.8	363.5	3.2
1999	66.2	586.7	11.3
2000	12.1	765.6	1.6
2001	64.9	1,018.0	6.4
2002	47.1	1,018.2	4.6
2003	42.1	1,226.0	3.4
2004	80.9	1,426.3	5.7
2005	117.8	1,930.6	6.1
2006	127.6	1,847.2	6.9
2007	129.2	2,473.1	5.2
2008	130.8	2,880.2	4.5
2009	166.5	3,117.0	5.3
2010	220.8	3,845.8	5.7

Regional Strategic Analysis and Knowledge Support System (ReSAKSS). 2013. CAADP Monitoring &Evaluation Indicators: Agriculture expenditure share in total expenditure. ReSAKSS, International Food Policy Research Institute (FPRI), Washington, DC. LCU refers to local currency unit
(www.resakss.org); data accessed from ReSAKSS Africa-wide Node on September 8, 2015.

1.3.2 Consumption and nutrition status

Data on diet quantity, diet quality and nutrition status are relevant for assessing food and nutrition security. Overall, dietary energy supply per capita – a measure of diet quantity – is sufficient in Nigeria, exceeding the average dietary energy requirement of the population by more than 20% (Table 6). Only 7% of the population is unable to meet the minimum dietary energy requirements and suffers from chronic undernourishment. The prevalence of undernourishment was at a moderate level in 1990-92 and has since then been substantially reduced, by two thirds altogether, although recent years have seen minor rises (Figure 1). The prevalence of food over-acquisition has increased markedly in the past 25 years: the Food and Agriculture Organization of the United Nations (FAO) estimates that about 30% of the Nigerian population regularly acquire food in excess of their dietary energy needs (Table 6).

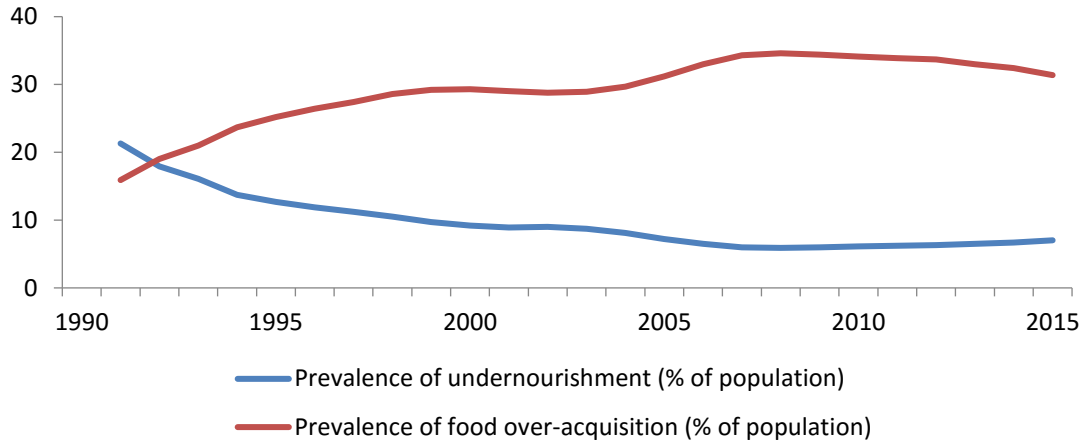
Table 6: Food and nutrition security indicators

Indicator	Value	Year
Diet quantity		
Dietary energy supply (kcal/caput/day)	2639	2014-16
Average dietary energy supply adequacy (% of average requirement)	123	2014-16
Prevalence of undernourishment (% of population)	7	2014-16
Prevalence of food over-acquisition (% of population)	31	2014-16
Diet quality		
Dietary energy supply from cereals, roots and tubers (% of total dietary energy supply)	66	2009-11
Dietary energy supply from carbohydrates (% of total dietary energy supply)	71	2009-11
Dietary energy supply from protein (% of total dietary energy supply)	9	2009-11
Dietary energy supply from fat (% of total dietary energy supply)	19	2009-11
Average protein supply (g/caput/day)	64	2009-11
Average fat supply (g/caput/day)	58	2009-11
Child feeding practices		
Minimum dietary diversity: consumption of 4+ food groups (% of children 6-23 months)	19	2013
Consumption of foods rich in vitamin A (% of children 6-23 months)	52	2013
Consumption of foods rich in iron (% of children 6-23 months)	35	2013
Nutrition status		
Child wasting (% of children under five)	8	2014
Child stunting (% of children under five)	33	2014
Child overweight (% of children under five)	2	2014
Adult overweight and obesity (% of adults 18+ years)	33	2014
Adult obesity (% of adults 18+ years)	11	2014
Vitamin A deficiency (% of children 6-59 months)	42	2013
Anemia in children (% of children 6-59 months)	68	2015
Anemia in women (% of women 15-49 years)	49	2011

Source: FAO (2016), and authors' calculations based on FAO (2016); National Malaria Elimination Programme, National Population Commission, National Bureau of Statistics, and ICF International (2016); National Population Commission and ICF International (2014); Stevens et al. (2015), quoted in International Food Policy Research Institute (FPRI) (2015); United Nations International Children's Emergency Fund/World Health Organization/World Bank (UNICEF/WHO/World Bank) (2016); WHO (2015a); WHO (2015b)

Note: See Annex A for definitions of the indicators.

Figure 1: Prevalence of undernourishment and food over-acquisition (1990-92 to 2014-16)



Source: Authors' presentation based on data from FAO (2016)

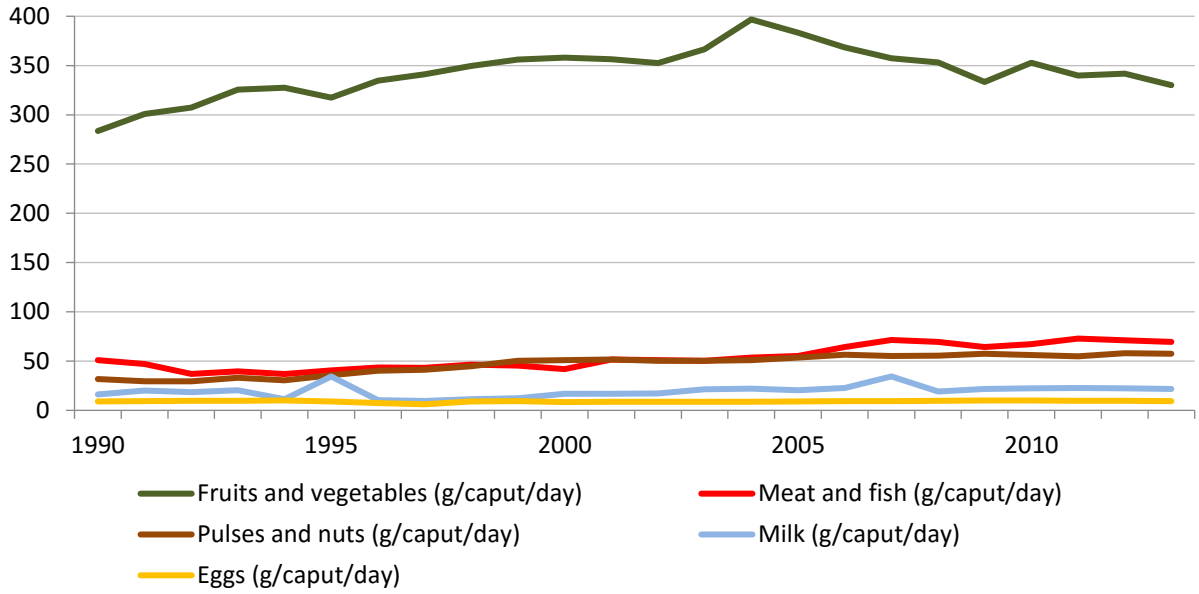
The diet in Nigeria is predominantly based on starchy staples that provide two thirds of dietary energy supply (Table 6). While the shares of dietary energy supply from carbohydrates and fat are within the recommended ranges of 55-75% and 15-30%, respectively, the share of dietary energy supply from protein is below the recommended minimum of 10% (WHO, 2003). The imbalance in the composition of the diet is linked to relatively large supplies of carbohydrates and dietary energy; the average protein supply is sufficient to meet protein requirements and would be adequate for a diet that matches the average dietary energy requirement of the population (Table 6; see Annex A for further explanation).

The consumption of sufficient quantities of non-staple foods such as fruits and vegetables and animal-source foods is essential for a diet that provides adequate micronutrients. Meat and fish supply has grown since the early 1990s, but still amounts to only about 70 g/caput/day (Figure 2). Milk supply has also increased. Nevertheless, it remains at a very low level of roughly 20 g/caput/day. The supply of eggs in Nigeria stands at about 10 g/caput/day and is higher than in other West African countries, but it is low in absolute terms and has hardly grown in more than 20 years. The supply of pulses and nuts has risen steadily, and these foods now account for close to one fifth of the protein supply in Nigeria.[1] The supply of fruits and vegetables peaked in 2004 and declined again afterwards; The total supply of 330 g/caput/day is below the recommended intake of 400 g of fruits and vegetables per day (WHO, 2003).

Infant and young child feeding practices are crucial for children's nutrition and health status and long-term development. Children aged 6-23 months should consume at least 4 out of 7 food groups (minimum dietary diversity) and receive iron-rich foods and foods rich in vitamin A daily. In Nigeria, infants' and young children's diets are lacking with regard to these recommendations; less than one fifth achieved minimum dietary diversity, about half consumed foods rich in Vitamin A, and roughly one third had foods rich in iron on the previous day (Table 6). Both breastfed and non-breastfed children aged 6-23 months were most frequently fed foods made from grains; other, more micronutrient-rich foods such as meat, fish and eggs, fruits and vegetables, and pulses and nuts, were more rarely given (Figure 3). Fortified baby foods, which can compensate for a lack of micronutrients in the diet, were consumed by less than 10% of breastfed and non-breastfed children.

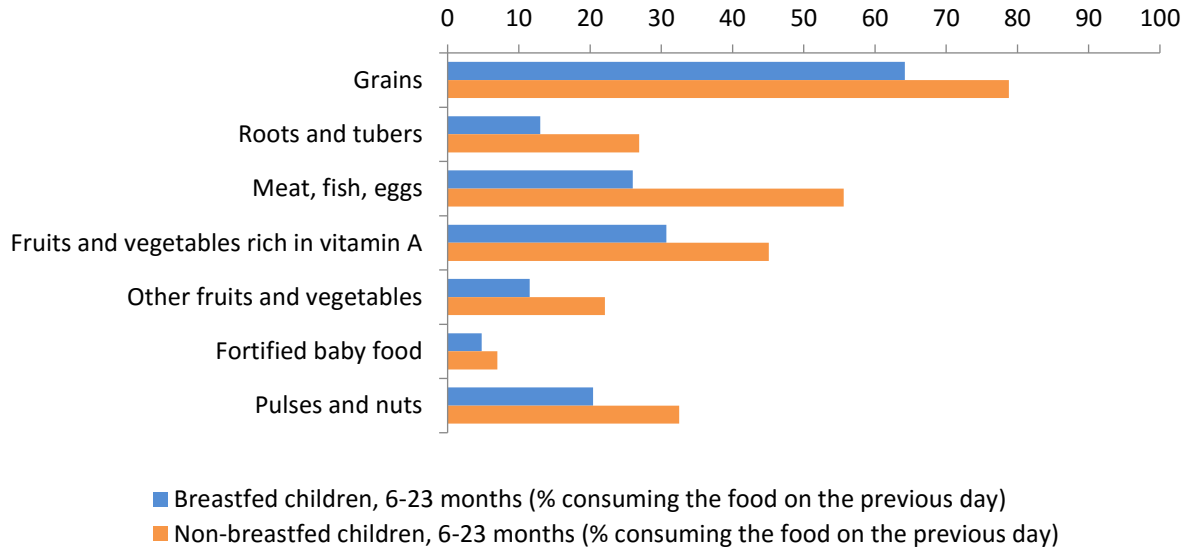
[1] Source: Food balance sheet for Nigeria, 2013, from FAOSTAT, accessed 19 Nov, 2016.

Figure 2: Supply of non-staple foods (1990-2013)



Source: Authors' presentation based on data from FAOSTAT, accessed 07 Oct 2016
Note: Based on their nutrient profiles, pulses and nuts include groundnuts and soybeans, although these foods are classified by FAO as oilcrops. Coconuts are not included among pulses and nuts because they have low protein content.

Figure 3: Percentage of infants and young children consuming foods from selected food groups (2013)



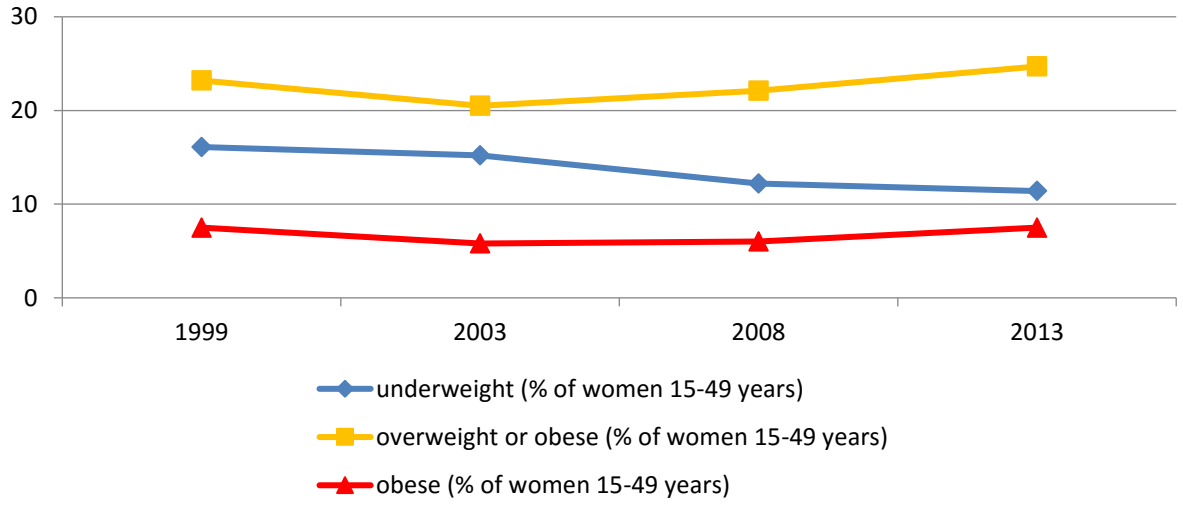
Source: Authors' presentation based on data from National Population Commission and ICF International (2014)

Stunting and wasting are indicators of chronic and acute child undernutrition, respectively. In Nigeria, one third of children are stunted, which means that chronic child undernutrition is a moderate public health problem in the country (Table 6). The prevalence of stunting has been reduced by one fourth since the early 1990s, indicating modest progress (UNICEF/WHO/World Bank, 2016). Wasting has shown strong fluctuations in the same period. According to the latest data, it was cut by more than half overall, and the current prevalence of 8% indicates that wasting has mild public health significance. Yet, as recently as 2013, wasting affected 18% of children and was a severe problem. Overweight in children is low according to the latest data and currently presents no public health concern (Table 6).

Overweight and obesity are risk factors for chronic diseases such as diabetes (Must and McKeown 2012). One third of adults in Nigeria are overweight or obese (Table 6). According to data from the Demographic and Health Surveys (DHS), the combined prevalence of overweight and obesity among women of reproductive age fell around the turn of the millennium and increased again afterwards (Figure 4). It is now only slightly higher than in 1999, while the prevalence of obesity has returned to its initial level. Underweight has fallen since the late 1990s but still affects more than 10% of women.[2]

Vitamin A deficiency is a risk factor for blindness and for mortality from measles and diarrhea in children aged 6–59 months (Imdad et al. 2010; Imdad et al. 2011). In Nigeria, roughly two fifths of all children in this age group are estimated to be vitamin A deficient (Table 6). Close to 70% of children aged 6-59 months and almost half of all women of reproductive age suffer from anemia (Table 6). About half of the global burden of anemia can be attributed to iron deficiency (WHO, 2015b). Anemia is also caused by malaria, and in malaria endemic countries such as Nigeria, the disease accounts for a significant proportion of anemia in children (National Malaria Elimination Programme, National Population Commission, National Bureau of Statistics, and ICF International, 2016).

Figure 4: Underweight, overweight and obesity among women of reproductive age (1999-2013)



Source: Authors' presentation based on data from ICF International (2015), The DHS Program STATcompiler, funded by the United States Agency International Development (USAID), accessed 12 Sept 2016

Regionally disaggregated data are available for indicators of nutrition status and child feeding. The diversity of infants' and young children's diets is extremely variable across Nigeria: Only 4% of children in the state of Zamfara in the North West achieved minimum dietary diversity (4+ food groups on the previous day), but this rate was more than 15 times higher (63%) in the Rivers state in the South South (Table 7). Regarding the proportions of children consuming foods rich in iron and vitamin A, Rivers also ranks best, while Zamfara ranks worst, and the disparities between these two states are once again very large. The share of children who consumed foods rich in iron is also very low in the states of Kano and Katsina in the North West. Anemia among children was least prevalent in the state of Borno (where only urban areas were surveyed, however), followed by the state of Lagos and several states in the South East (Table 8). In Zamfara and three other states in the North West, anemia prevalence surpassed 80% and was therefore extremely high. Stunting ranged from low prevalence rates of under 20% in the South East and some states in the South, to staggeringly high rates of above 50% in six out of seven states in the North West. Notably, the state of Kebbi had the highest rates of both stunting

[2] See Annex A for definitions of overweight, obesity, and underweight.

and overweight in children. Wasting also differed enormously across states, with alarmingly high rates observed in the state of Kano and Kaduna in the North West.

Overweight and obesity in women are most prevalent in the FCT of Abuja and in the state of Lagos – which hosts Lagos, the country's largest city – and least prevalent in some poor north-western states, including Katsina and Zamfara (Table 9). Underweight prevalence is lowest in the state of Anambra, the FCT of Abuja and two states in the North Central zone and is highest in the state of Bauchi and Gombe in the North East and Jigawa in the North West.

Table 7: Child feeding practices by region, 2013

Share of children 6-23 months consuming:								
4+ food groups			Foods rich in vitamin A			Foods rich in iron		
Region		(%)	Region		(%)	Region		(%)
SS	Rivers	63	SS	Rivers	84	SS	Rivers	79
SE	Anambra	52	NC	Benue	76	SS	Bayelsa	71
SE	Enugu	51	SS	Bayelsa	75	NC	Benue	64
NC	FCT-Abuja	42	SE	Enugu	74	SE	Anambra	64
NE	Gombe	41	NE	Gombe	73	SW	Osun	64
SW	Osun	40	SE	Anambra	73	NC	FCT-Abuja	63
SE	Abia	36	NC	FCT-Abuja	73	SE	Enugu	62
SS	Cross River	35	NE	Taraba	68	SS	Cross River	56
SE	Imo	32	SS	Cross River	66	NC	Kwara	55
SE	Ebonyi	30	SE	Abia	65	SW	Ondo	54
NC	Kwara	29	SW	Osun	65	NC	Kogi	52
NC	Kogi	28	NC	Kwara	63	SE	Abia	52
SW	Ondo	27	SE	Ebonyi	62	SS	Delta	51
SS	Bayelsa	25	NE	Bauchi	62	SE	Ebonyi	50
NC	Benue	25	NC	Kogi	60	SW	Lagos	50
SS	Akwa Ibom	24	SW	Ondo	58	NW	Kaduna	47
SW	Ekiti	21	NW	Kaduna	57	SW	Oyo	47
NW	Kebbi	21	SE	Imo	56	NE	Gombe	47
NE	Borno	21	NE	Adamawa	56	SS	Edo	47
NW	Kaduna	18	SW	Lagos	54	SE	Imo	46
SS	Edo	18	SW	Oyo	54	SS	Akwa Ibom	40
NC	Nasarawa	18	SS	Delta	53	NW	Kebbi	38
NE	Adamawa	16	NC	Nasarawa	52	NE	Taraba	37
NW	Jigawa	15	SS	Edo	52	NE	Adamawa	36
SS	Delta	15	NE	Borno	51	SW	Ekiti	36
SW	Lagos	15	NW	Kebbi	51	NE	Borno	36
NC	Plateau	14	SS	Akwa Ibom	49	NC	Nasarawa	35
NE	Taraba	14	NW	Sokoto	48	NW	Sokoto	27
NE	Bauchi	13	NW	Kano	44	NW	Jigawa	23
NE	Yobe	13	NW	Katsina	44	SW	Ogun	22
NW	Kano	12	NW	Jigawa	39	NC	Plateau	21
SW	Oyo	12	NC	Niger	38	NE	Bauchi	19
NW	Sokoto	9	SW	Ekiti	37	NC	Niger	17
SW	Ogun	8	NE	Yobe	32	NE	Yobe	17
NW	Katsina	8	NC	Plateau	30	NW	Kano	11
NC	Niger	5	SW	Ogun	27	NW	Katsina	10
NW	Zamfara	4	NW	Zamfara	24	NW	Zamfara	5

Source: National Population Commission and ICF International (2014)
Notes: GIC regions are highlighted in red. FCT = Federal Capital Territory. Zones: NC = North Central; NE = North East; NW = North West; SE = South East; SS = South South; SW = South West. See Annex A for definitions of the indicators.

Table 8: Child nutrition status by region, 2013/2015

Prevalence among children under five:									Prevalence among children 6-59 months:		
Stunting			Wasting			Overweight			Anemia		
Region		(%)	Region		(%)	Region		(%)	Region		(%)
SE	Enugu	12	SS	Bayelsa	5	SW	Oyo	1	NE	Borno*	38
SS	Delta	15	NC	Kwara	7	SS	Cross River	1	SW	Lagos	48
SS	Edo	16	SW	Ondo	7	NE	Bauchi	1	SE	Anambra	49
SS	Rivers	16	NC	Benue	8	SE	Abia	1	SE	Abia	51
SE	Ebonyi	16	NE	Taraba	8	SE	Ebonyi	1	SE	Imo	52
SE	Imo	17	SW	Ekiti	8	SE	Imo	1	NE	Gombe	53
SW	Lagos	17	SE	Enugu	9	SW	Ekiti	1	SE	Enugu	54
SE	Abia	17	NC	Kogi	10	SW	Ogun	1	SW	Ekiti	58
SE	Anambra	18	NC	Nasarawa	10	NC	Kogi	2	NC	Kwara	58
SW	Ekiti	19	SS	Cross River	10	SE	Enugu	2	SW	Ogun	58
SS	Bayelsa	21	SW	Ogun	10	SW	Lagos	2	SW	Osun	59
SW	Osun	21	SW	Oyo	10	NE	Adamawa	2	SS	Delta	59
NC	FCT-Abuja	21	NC	Plateau	11	SW	Ondo	2	SW	Oyo	60
SS	Cross River	22	SE	Ebonyi	11	NW	Kano	3	NC	Kogi	61
SS	Akwa Ibom	22	SS	Akwa Ibom	11	NC	Benue	3	NE	Bauchi	62
NC	Benue	23	SS	Edo	11	SS	Akwa Ibom	3	NC	Nasarawa	63
NC	Kogi	23	SS	Rivers	11	NC	Niger	3	NC	Plateau	63
SW	Ogun	24	SE	Abia	11	SW	Osun	3	NE	Yobe	64
SW	Ondo	24	SW	Osun	11	NE	Taraba	3	SS	Edo	64
NE	Borno	27	SW	Lagos	11	SS	Bayelsa	3	NC	Benue	67
NC	Kwara	27	SE	Imo	12	NE	Gombe	3	SS	Rivers	67
SW	Oyo	27	NC	FCT-Abuja	14	NC	FCT-Abuja	4	NE	Adamawa	68
NC	Niger	34	NE	Gombe	14	SS	Delta	4	NC	FCT-Abuja	68
NE	Adamawa	34	NE	Adamawa	15	NC	Kwara	4	NC	Niger	69
NC	Nasarawa	35	NW	Zamfara	16	NW	Zamfara	5	NE	Taraba	71
NC	Plateau	36	NW	Jigawa	17	NW	Jigawa	5	SW	Ondo	72
NE	Taraba	43	SS	Delta	17	NE	Borno	5	SS	Akwa Ibom	73
NE	Gombe	48	SE	Anambra	17	NW	Katsina	6	SE	Ebonyi	74
NW	Kano	48	NC	Niger	18	NW	Kaduna	6	NW	Katsina	74
NE	Yobe	49	NW	Kebbi	18	NC	Plateau	6	SS	Bayelsa	76
NE	Bauchi	51	NW	Sokoto	19	NC	Nasarawa	7	NW	Kaduna	79
NW	Sokoto	52	NE	Bauchi	23	NW	Sokoto	7	SS	Cross River	79
NW	Zamfara	56	NE	Yobe	24	SS	Rivers	7	NW	Sokoto	79
NW	Kaduna	57	NW	Katsina	24	SE	Anambra	7	NW	Kano	83
NW	Katsina	59	NE	Borno	28	SS	Edo	9	NW	Kebbi	84
NW	Jigawa	59	NW	Kano	40	NE	Yobe	11	NW	Jigawa	85
NW	Kebbi	61	NW	Kaduna	42	NW	Kebbi	12	NW	Zamfara	87

Source: National Malaria Elimination Programme, National Population Commission, National Bureau of Statistics, and ICF International (2016); National Population Commission and ICF International (2014)

Notes: GIC regions are highlighted in red. * In Borno state, fieldwork was completed in urban areas only because of security concerns. Data on wasting, stunting and overweight were collected in 2013, and data on anemia in 2015. FCT = Federal Capital Territory. Zones: NC = North Central; NE = North East; NW = North West; SE = South East; SS = South South; SW = South West. See Annex A for definitions of the indicators.

Table 9: Women's nutrition status by region, 2013

Prevalence among women of reproductive age (15-49 years):								
Underweight			Overweight + obesity			Obesity		
Region		(%)	Region		(%)	Region		(%)
SE	Anambra	3	NW	Katsina	10	NW	Sokoto	2
NC	Plateau	5	NW	Zamfara	11	NW	Zamfara	2
NC	FCT-Abuja	5	NW	Jigawa	13	NW	Katsina	3
NC	Nasarawa	5	NW	Sokoto	13	NW	Kebbi	3
SE	Enugu	5	NE	Bauchi	13	NW	Kano	3
SS	Bayelsa	6	NE	Gombe	16	NE	Bauchi	4
SE	Imo	6	NE	Borno	16	NC	Benue	4
SS	Rivers	6	NW	Kano	17	SE	Ebonyi	4
NC	Niger	7	NW	Kebbi	17	NE	Yobe	4
SE	Abia	7	SE	Ebonyi	17	NE	Gombe	5
SW	Ekiti	7	NC	Benue	18	NE	Borno	5
SS	Delta	7	NE	Yobe	21	NW	Jigawa	6
SW	Lagos	8	NC	Nasarawa	23	NC	Niger	6
NC	Benue	8	NE	Adamawa	23	NC	Nasarawa	6
SS	Edo	8	NW	Kaduna	23	NE	Taraba	6
SS	Akwa Ibom	8	NC	Niger	24	NW	Kaduna	7
SW	Ondo	8	NE	Taraba	24	SS	Delta	7
SS	Cross River	9	NC	Plateau	27	NE	Adamawa	8
NE	Taraba	9	SS	Delta	27	SS	Cross River	8
SW	Osun	9	NC	Kogi	27	NC	Plateau	8
NC	Kogi	9	SW	Oyo	28	SW	Osun	9
NW	Kaduna	10	SW	Osun	28	SW	Oyo	9
NC	Kwara	11	SS	Cross River	29	SE	Abia	9
NW	Kebbi	11	SW	Ekiti	29	SS	Akwa Ibom	9
NE	Yobe	12	SE	Abia	30	SE	Anambra	10
SW	Ogun	12	SW	Ondo	31	SS	Bayelsa	10
SE	Ebonyi	13	NC	Kwara	31	SW	Ondo	10
SW	Oyo	14	SS	Bayelsa	32	SW	Ekiti	11
NE	Adamawa	15	SS	Akwa Ibom	32	NC	Kogi	11
NW	Katsina	15	SE	Enugu	33	SS	Edo	11
NE	Borno	15	SS	Edo	33	SE	Enugu	11
NW	Zamfara	16	SW	Ogun	35	SW	Ogun	11
NW	Kano	19	SE	Anambra	36	NC	Kwara	12
NW	Sokoto	19	SE	Imo	37	SS	Rivers	15
NW	Jigawa	21	SS	Rivers	40	SE	Imo	15
NE	Bauchi	23	NC	FCT-Abuja	43	NC	FCT-Abuja	17
NE	Gombe	23	SW	Lagos	44	SW	Lagos	18

Source: National Population Commission and ICF International (2014)

Notes: GIC regions are highlighted in red. Data on anemia among women are not available at the regional level. FCT = Federal Capital Territory. Zones: NC = North Central; NE = North East; NW = North West; SE = South East; SS = South South; SW = South West. See Annex A for definitions of the indicators.

Among indicators of children's nutrition status that are available at the regional level, anemia is the most important in terms of prevalence rates in all states, followed by stunting (Table 8). Under the assumption that half of all anemia is due to iron deficiency, iron deficiency anemia among children has mild public health significance in urban areas of Borno in the North East, severe public health significance in Zamfara, Jigawa, Kebbi, and Kano in the North West, and moderate significance in all other states.[3]

According to the 2013 DHS, national wasting prevalence was unusually high in Nigeria in the survey year, amounting to 18%.[4] It was a severe public health concern in all seven states in the North West, but also in Borno, Yobe, and Bauchi in the North East, in the state of Niger in the North Central zone, and in Delta and Anambra in the southern part of the country. Wasting was moderate in Ogun and Adamawa and in the states ranked between them (Table 8), while it was mild in all other states. Stunting was a severe public health problem in all states in the North West, as well as in Bauchi, Yobe, Gombe and Taraba in the North East, and it was moderate in Plateau, Nasarawa, and Niger in the North Central zone, and in Adamawa in the North East. In Bayelsa and Oyo and the states ranked between them, stunting was only a mild public health problem. Overweight in children had severe public health significance in Kebbi and Yobe, moderate significance in the Jigawa and Edo and the states ranked between them, and mild significance in all states ranked from Osun to Zamfara.

Of all the indicators of women's nutrition status, anemia has the highest prevalence at the national level (Table 6 and Figure 4), but regionally disaggregated data are not available for anemia among women. In 30 out of 37 regions, the combined prevalence of overweight and obesity surpassed the prevalence of underweight among women, with particularly large discrepancies observed in most states in the three southern zones (South East, South South, and South West), and in the FCT of Abuja and the Kwara and Plateau states in the North Central zone (Table 9). In the Bauchi and Gombe states in the North East and in 5 out of 7 states in the North West (Jigawa, Kano, Katsina, Sokoto and Zamfara), however, the prevalence of underweight was higher than the combined prevalence of overweight and obesity.

In summary, over- and undernutrition coexist in Nigeria and vary greatly across this very diverse, large and populous country. Undernutrition among women and children is a great concern in some states and zones, whereas overweight and obesity prevail in other areas, especially in the large urban centers. Dietary energy deficits in disadvantaged regions need to be addressed, ideally without spurring increases in overweight and obesity in better-off regions. At the national level, the supply of dietary energy and carbohydrates is already quite high, while micronutrient deficiencies persist. This suggests that non-staple foods should be favored over starchy staples in future agricultural development.[5] The supply of micronutrient-rich foods needs to be increased to combat widespread micronutrient deficiencies, giving priority to developing value chains for vegetables, fruits, animal-source foods, pulses and nuts, and possibly also to the value chain for red palm oil (rich in vitamin A). The fortification of staple foods and the production of fortified baby foods could be addressed at the processing stage of the value chain. Promoting biofortified staple foods, such as vitamin A-rich orange-fleshed sweet

[3] About half of the global burden of anemia is attributable to iron deficiency (WHO, 2015b). Since the prevalence of anemia among children in Nigeria is in the range of 48.4-79.3% in 32 out of 37 states, the prevalence of iron deficiency anemia can be estimated to be 24.2-39.7% in these states. An iron deficiency anemia prevalence of 20-39% indicates a moderate public health problem (see Annex A). However, it is possible that less than half of all anemia in Nigeria is caused by iron deficiency because malaria is endemic in the country.

[4] The 2014 national health and nutrition survey in Nigeria indicates a much lower national wasting prevalence of only 8% (UNICEF/WHO/World Bank, 2016).

[5] Raising agricultural productivity for cereals, roots and tubers may still be important to keep pace with population growth, produce animal feed, raise incomes and alleviate poverty, and to reduce the currently high dependence on rice imports. If value chains for cassava are developed, the leaves should be given due attention, since they are a healthy, micronutrient-rich vegetable.

potatoes, yellow cassava and orange maize developed by HarvestPlus, is another option to improve micronutrient intakes.[6]

In addition, reducing the aflatoxin contamination of foods is necessary to improve food safety in Nigeria. Aflatoxins are highly toxic substances that are produced by certain types of fungi and can cause acute poisoning, liver cancer, and stunted growth in children (Bhat and Vasanthi, 2003; Gong et al., 2004). Aflatoxins were found in two thirds of stored maize grain samples from five agro-ecological zones of Nigeria where maize is predominantly produced, and contamination with fumonisins (another type of mycotoxins) was even more common (Adetunji et al., 2014). Another study detected aflatoxins in 90% of raw and roasted groundnut samples that were sold in markets in south-western Nigeria, with one fourth of the samples exceeding regulatory limits (Afolabi et al., 2015). Unsafe concentrations of aflatoxins were present in all groundnut cake samples from major markets in five states of Nigeria, while the large majority of groundnut cake consumers were unaware of the aflatoxin contamination of the food and the associated health risks (Ezekiel et al., 2013). Fumonisins, aflatoxins and multiple other mycotoxins were found in groundnut- and maize-based snacks, and aflatoxin levels in commercial weaning foods were unacceptably high (Kayode et al. 2013; Oluwafemi and Ibeh 2011). Samples of human milk and cow's milk from Ogun state also contained high aflatoxin concentrations (Atanda et al. 2007). An analysis of commercial poultry feed from 17 states of Nigeria showed that 62% of the samples had unsafe levels of aflatoxins (Ezekiel et al., 2012).

A look at the regions reveals that nutritional deficiencies are particularly severe in the North West of the country and also in parts of the North East. This suggests prioritizing states in these areas for interventions and agricultural innovations, although agricultural potential may be limited. In the states in the South and parts of the North Central zone – especially in the FCT of Abuja – children and women have lower rates of undernutrition than in the North West and the North East. The flip side of the coin is that overweight and obesity is much more prevalent among women in the southern and some North Central states; in the urban agglomerations of Abuja and Lagos, more than 40% of the women are overweight or obese.

Nigeria is a member of the Scaling Up Nutrition[7] network, a global movement led by 57 countries that aims to end malnutrition in all its forms.

1.4 Data on most relevant crops and value chains

The most relevant crops in Nigeria include maize, rice, sorghum and millet, tubers (mainly cassava, yams and taro), legumes (including cow peas and peanuts), bananas and plantains, cocoa and oil palm. Production and consumption data are provided below.

[6] See www.harvestplus.org/what-we-do/crops.
[7] See scalingupnutrition.org/ for more information

1.4.1 Production

Table 10: Top 10 crops produced by area, volume and value

Area harvested (ha)		Production volume (tons)		Production value*	
Top 10	**Share of Total**	**Top 10**	**Share of Total**	**Top 10**	**Share of Total**
Cassava	13.6	Cassava	30.8	Yams	27.2
Maize	11.7	Yams	22.7	Cassava	12.5
Sorghum	10.7	Maize	5.6	Vegetables, fresh nes	6.8
Yams	10.1	Oil, palm fruit	4.8	Maize	5.8
Cow peas, dry	7.2	Vegetables, fresh	3.9	Sorghum	3.5
Oil, palm fruit	6.2	Sorghum	3.6	Rice, paddy	3.4
Rice, paddy	6.0	Rice, paddy	3.4	Cow peas, dry	3.1
Groundnuts	5.5	Cow peas, dry	2.4	Fruit, citrus nes	3.1
Millet	2.9	Fruit, citrus	2.3	Pineapples	2.6
Sweet potatoes	2.9	Sweet potatoes	2.2	Groundnuts, with shell	2.2
Rank 25: Potatoes	0.7	Rank 19: Potatoes	0.7	Rank 31: Potatoes	0.6

Data: average 2012-2014, FAOSTAT, accessed 18 January, 2017
* Gross Production Value (constant 2004-2006 million US$), data: average 2011-2013, FAOSTAT, accessed 18 January, 2017
Note: GIC value chains marked in red; nes refers to Not elsewhere specified

Table 11: Average national yields of maize, sorghum, rice and cassava, Nigeria, Kg/ha

National data					FAO data				
Year	**maize**	**sorghum**	**cassava**	**rice**	**Year**	**maize**	**sorghum**	**cassava**	**rice**
1994	1,545	1,056	11,126	1,313	1994	1,272	1,080	10,592.7	1,416
1995	1,588	1,101	11,319	2,102	1995	1,266.6	1,148	10,667.1	1,625.8
1996	1,491	1,146	11,730	1,948	1996	1,326.1	1,144.2	10,664.6	1,749.8
1997	1,649	1,161	11,984	1,924	1997	1,251	1,107.5	11,881.8	1,595.7
1998	1,701	1,250	11,736	1,919	1998	1,320	1,132.8	10,746	1,602.3
1999	5,025	1,185	11,874	1,787	1999	1,599.8	1,126.1	9,599.8	1,495.7
2000	4,445	1,147	11,689	1,864	2000	1,300.1	1,120	9,700	1,499.8
2001	4,357	1,146	11,932	1,855	2001	1,399.9	1,100	9,601.198	1,300
2002	4,424.3	1,156	12,091	1,854	2002	1,489.9	1,100	9,901.335	1,340
2003	4,483.4	1,144	12,213	1,872	2003	1,499.9	1,155.9	10,402.29	1,410
2004	5,000.7	1,141	12,061	1,879	2004	1,600.2	1,220	11,001.13	1,419.9
2005	6,203.1	1,149	12,317	1,948	2005	1,659.8	1,260	10,990.22	1,430.2
2006	6,767.3	1,182	12,571	1,975	2006	1,818.2	1,350	12,000.26	1,483.3
2007	7,073.4	1,143	12,772	1,975	2007	1,704.9	1,159.5	11,202.58	1,299.9
2008	7,970.3	1,154	13,121	2,039	2008	1,957.1	1,223.3	11,800.42	1,754.4
2009	8,645.5	1,268	13,640	2,179	2009	2,196.1	1,114.5	11,767.94	1,930.6
2010					2010	1,850.2	1,439.7	12,215.51	1,838.6
2011					2011	1,527.9	1,410.1	14,022.53	1,770.6
2012					2012	1,809.6	1,254.5	14,025.97	1,800
2013					2013	2,000	1,218.2		1,807.7

Authors' compilation based on data from FAOSTAT

1.4.2 Trade

Wheat and rice are the most important import goods in Nigeria (see Table 12). Cocoa, sesame seed and rubber are the most important export goods. The export of cocoa accounts for 36% of the total export value, but only for about 25% of the export volume. Maize, cassava and potato are negligible.

Table 12: Nigeria's imports

Import volume (tons)		Import value (US$)	
Top 10	**Share of Total**	**Top 10**	**Share of Total**
Wheat	41.0	Wheat	20.7
Rice – total (Rice milled equiv.)	22.5	Rice – total (Rice milled equiv.)	19.1
Sugar (raw, centrifugal	11.7	Oil, palm	16.6
Oil, palm	9.7	Sugar Raw Centrifugal	7.0
Sugar (refined)	3.4	Milk, whole dried	4.8
Tomatoes, paste	1.4	Food preparations, flour, malt extract	4.0
Malt	1.2	Food prep nes	3.7
Food preparations, flour, malt extract	0.8	Sugar refined	2.7
Food prep nes	0.7	Tomatoes, paste	2.6
Milk, whole dried	0.7	Milk, skimmed dried	1.8
Rank 30: Flour, maize	0.1	Rank 51: Flour, maize	0.1
Rank 49: Potatoes, frozen	0.0	Rank 61: Potatoes, frozen	0.0
Rank 61: Starch, cassava	0.0	Rank 82: Maize	0.0
		Rank 99: Starch, cassava	0.0

Data: average 2011-2013, FAOSTAT, accessed 18 January, 2017
Note: GIC value chains marked in red; nes refers to Not elsewhere specified

Table 13: Nigeria's exports

Export volume (tons)		Export value (US$)	
Top 10	**Share of Total**	**Top 10**	**Share of Total**
Cocoa, beans	25.2	Cocoa, beans	36.1
Sesame seed	17.4	Rubber natural dry	13.0
Bran, wheat	12.3	Cashew nuts, with shell	12.4
Cake, palm kernel	9.2	Sesame seed	11.7
Cashew nuts, with shell	8.7	Cocoa, butter	4.7
Rubber natural dry	7.0	Cigarettes	3.8
Cotton lint	3.6	Cotton lint	3.7
Oil, palm	2.2	Cocoa, powder & cake	2.9
Cocoa, butter	2.2	Rubber, natural	1.7
Cocoa, powder & cake	1.5	Crude materials	1.5
Rank 22: Maize	0.3	Rank 44: Maize	0.0
Rank 24: Potatoes	0.2	Rank 47: Potatoes	0.0
Rank 51: Rice – total (Rice milled equivalent)	0.0	Rank 58: Rice – total (Rice milled equivalent)	0.0

Data: average 2011-2013, FAOSTAT, accessed 18 January, 2017
Note: GIC value chains marked in red; nes refers to Not elsewhere specified

1.5 National (and regional) innovation system

1.5.1 Research system and organizations

Nigeria has the highest agricultural research capacity and spending levels in sub-Saharan Africa, but its investment in agricultural research as a share of agricultural GDP has always been quite low (e.g. 0.33% in 2011). The focus of agricultural research is heavily concentrated in the crops and livestock subsectors. Private-sector activity in agricultural research is negligible.

About 144 national agencies conduct agricultural research in Nigeria, including 22 government agencies and 122 higher education agencies (specialized universities, colleges, faculties, and departments). There are 15 national agricultural research institutes, and these are coordinated by the Agricultural Research Council of Nigeria (ARCN). The research institutes within the ARCN are primarily involved in research for technology development, while the universities of agriculture and the faculties of agriculture are involved in training the manpower required by the sector and, to a lesser degree, technology generation and dissemination.

Nigeria also has 13 Federal colleges of agriculture which focus their attention on the training of intermediate level manpower in agriculture and rural development.

1.5.1.1 International

A number of international agricultural research centers have offices or programs in Nigeria. The International Institute of Tropical Agriculture (IITA), a member of the Consultative Group International Agricultural Research (CGIAR), with the mission of increasing agricultural production, food security, and income in the tropics, especially in Africa, is headquartered in Ibadan, Nigeria. It conducts research on key tropical crops, such as banana/plantain, cassava, cocoa, coffee, cowpea, maize, soybean, and yam, under the following thematic areas: biotechnology and genetic improvement, natural resource management, plant production and plant health, and social science and agribusiness. Other CGIAR centers conducting research activities in Nigeria include Africa Rice Center, International Livestock Research Institute, International Crops Research Institute for the Semi-Arid Tropics, World Agroforestry Centre, and International Food Policy Research Institute.

1.5.1.2 National

The 15 national agricultural research institutes are commodity based. They are:

- National Root Crops Research Institute (NRCRI);
- National Horticultural Research Institute;
- Cocoa Research Institute of Nigeria;
- Nigerian Institute for Oil-Palm Research;
- Rubber Research Institute of Nigeria;
- Nigerian Institute for Oceanography & Marine Research;
- Lake Chad Research Institute;
- National Veterinary Research Institute;
- National Institute for Fresh-Water Fisheries Research;
- Nigerian Stored Products Research Institute;
- National Cereal Research Institute;
- Institute for Agricultural Research & Training;
- National Animal Production Research Institute;
- National Agricultural Extension & Research Liaison Services;
- Institute for Agricultural Research.

1.5.2 Innovation platforms (IPs)

IPs are very common in Nigeria. Many projects are currently using the platforms to promote agricultural innovations. Examples are provided below:

- Since 2013, The West Africa Agricultural Productivity Programme (WAAPP) has sponsored the formation of Value Chain IPs in Nigeria in 7 priority commodity subsectors, namely, Aquaculture, Cassava, Maize, Mango, Rice, Sorghum, and Yam. WAAPP is using IPs to disseminate improved technologies in Nigeria. The number of beneficiaries in 2014 was 588,585. The goal of the IPs is to assist farmers' groups and other stakeholders to attain increased productivity, income, and economic opportunities of farming systems. Some of the impacts of platforms include, for instance, the cassava and yam platforms, which have trained about 38,639 of its members on various aspect of cassava/yam cultivation, processing and food standards. It has also facilitated interactions and collaborations among different platform actors and research agencies.
- The Research Into Use (RIU) programme funded by the United Kingdom Department for International Development (DFID) implemented three IPs in Nigeria between 2006 to 2011. These are cowpea and soybean IP, cassava flour value chain IP and aquaculture IP. The platforms enabled farmers to get access to improved seeds and related inputs, improved post-harvest storage methods and skills, and face-to-face meetings with policy makers. An evaluation conducted by the ARCN, found a strong sense of ownership amongst the platform members, good evidence of partnership working with mainstream development and research agencies, and progress in terms of wide adoption of improved farm inputs (planting materials) and skills and knowledge transfer. Currently, two of these IPs (cassava flour value chain and aquaculture) are either being strongly supported by or incorporated into national or state-level processes and priorities.
- The IITA is increasingly using IPs as a scaling-out mechanisms for newly developed and existing agricultural technologies and to strengthen multi-stakeholder collaboration in its research programs and projects, including the Humid tropics program, The Africa Research in Sustainable Intensification for the Next Generation program, and Support to Agricultural Research for Development of Strategic Crops in Africa program.
- The Sub Saharan Africa Challenge Programme (SSA-CP), which was coordinated by FARA, used IPs as its operational frame to engage stakeholders in a network configuration to undertake multidisciplinary and participatory research. Eight IPs were established in northern Nigeria in the Kano–Katsina–Maradi project learning site (see Table 14). These are: maize-legume, rice, vegetable, livestock, two maize-legume-livestock platforms, and two sorghum-legume-livestock platforms. A number of robust studies have been conducted to assess the impact of the SSA-CP innovation platforms. These studies have shown that IPs have positive impact on marketed crop outcomes. They also robustly promote the adoption of crop management innovations, and have positive impacts on the lives of the beneficiaries, valued at about US$1822 per annum or US$4.99 per day per participant (Adekunle *et al.*, 2014; Pamuk *et al.*, 2014).

Table 14: FARA Innovation Platforms

Name of Platform	Location of Platform	Commodities of the platform
NGS Rice IP	Dandume Local Government, Kaduna state	Rice
NGS Maize- Legume IP	Ikara Local Government Area (Villages:Kargo, Bakula, Barangwaje, Jafallan and Rafin Tabo)	Maize, soy bean, cowpea
NGS Vegetable IP	Kudan Local Government Area, Kaduna state	Tomato, sweet pepper, onion etc.
NGS Livestock IP	Kubau Local Government Area	Ruminant fattening
S-S Maize-legume-Livestock IP	Bunkure LGA, 10 communities, Kano	Improved maize, sorghum and legume production systems, improved seed systems, soil fertility and parasitic weed management, improved livestock nutrition, improved market and improved support from government
Sorghum-legume-Livestock	Shanono LGA, 10 communities	Improved sorghum, maize and legume production systems, improved seed systems, soil fertility and parasitic weed management, improved livestock nutrition, improved market and improved support from government
S-S Maize-Legume-Livestock	Musawa LGA, 11 communities, Katsina state	Improved maize, sorghum and legume production systems, improved seed systems, soil fertility and parasitic weed management, improved livestock nutrition, improved market and improved support from government
S-S Sorghum-Legume-livestock	Safana LGA, 10 communities, Katsina state	Improved maize and legume production systems, improved seed systems, soil fertility and parasitic weed management, improved livestock nutrition, improved market and improved support from government

Source: Authors' compilation.
Note: NGS refers to next generation sequencing; S-S refers to short season. LGA = Local Government Area

More information on IPs can be found in the FARA country studies on existing innovation platforms in Nigeria by Phillips et. al. (2016).

1.5.3 Extension System and Organizations

The ADP, initiated with funding from the World Bank in the 1980s, remains the main source of extension and advisory services in Nigeria. Extension activities implemented by the ADPs include establishing demonstration farms, identifying lead farmers, providing lead farmers with information about improved farming practices, facilitating access to improved technology and inputs and helping lead farmers teach other farmers. The quantity and quality of the extension workers are low. It is estimated that there is one extension agent to approximately 2,500 - 10,000 farm families, depending on the state (Obiora and Emodi, 2013). Several extension systems and programmes have been introduced in the country. These include: Unified Agricultural Extension System, Nationally Coordinated Research Programme, Farming System Research and Extension, T&V, Research-Extension-

Farmer-Input Linkage System (REFILS), Commodity-Based Extension, Farmer Field Schools, etc. In addition there are numerous non-governmental organizations and private sector players, notably, the British-American Tobacco, the Evangelical Church Winning All Rural Development Project in the North, the Shell and the Mobil outreach programs in the Niger Delta areas, the Leventis Foundation, the Sasakawa Global 2000 and the USAID-Markets.

REFILS is a research and extension management tool and a platform to bring together all the stakeholders (researchers, extension workers, farmers, the private sector and government) in technology development, adaptation, dissemination, adoption and utilization processes. The development and operation of REFILS reached its peak during the World Bank-assisted National Agricultural Research Project (NARP) support to the National Agricultural Research and Extension System in Nigeria (1995-2000). Similar to the ADPs experience, the termination of the NARP support marked the downward turn of REFILS and its virtual collapse today. Consequently, the REFILS has remained weak, uncoordinated, poorly funded and ineffective.

1.5.4 Private Research and Development activities

In the ATA, the government of Nigeria recognizes the essential role of the private sector in achieving agricultural growth and prosperity through investment in production, marketing and processing. Private companies, dealers, and civil society organizations are involved in the implementation of ATA. There is increased private sector participation in the fertilizer and seed value chains in Nigeria. Through the Grow Africa Partnership, a number of private companies are investing in the agricultural sector of Nigeria. Among the companies are: Free Range Farms Ltd., Okomu Oil Palm Company Plc, Syngenta International AG, The Coca-Cola Company, Global Shea Alliance, Maslaha Seeds Limited, etc.

1.6 Key challenges, emerging needs and potentials in the agricultural sector

Major challenges hindering the development of agriculture in Nigeria include:

- Underfunding of research;
- Lack of access to credit;
- Poor extension services;
- Low adoption of best practices and improved technologies;
- Threats from diseases, pests and climate;
- Poor post-harvest management;
- Lack of local storage and processing;
- Lack of market linkages and poor road network;
- Civil unrest, i.e., *Boko Haram.*

1.7 Potential areas for investment in Nigeria

Based on the general approach presented in chapter 4 of Husmann et al (2015) and in pursuit of efficiency and effectiveness, investment by Germany into the agricultural and food sector are suggested in African countries that:

- Show actual progress in sustainable agricultural productivity driven by related innovations, as indicated by comprehensive productivity measurement and innovation actions on the ground;
- Have a track record of political commitment to foster sustainable agricultural growth, as indicated by performance under CAADP; and
- Prioritize actions for hunger and malnutrition reduction and show progress, but where agricultural and rural development and nutrition interventions are likely to make a significant difference, as indicated by public policy and civil society actions.

Results of the assessment for Nigeria[8]:

Expected agricultural growth performance:

- Nigeria has increased its agricultural growth to more than the annual 6% agricultural growth targeted by CAADP in only four of the years between 2005 and 2014 (www.resakss.org).
- Total factor productivity in Nigeria has improved by 11% between 2001 and 2008 (Fuglie and Rada, 2011).

Government commitment:

- Nigeria has a track record of political commitment to foster sustainable agricultural growth by being active in the CAADP process and has completed five of the eight steps in the CAADP process (www.resakss.org).
- The Nigerian government has not shown much commitment to invest in the agricultural sector. In no single year has the government has invested more than 10% of the total government expenditures (CAADP target) in agriculture between 2005 and 2014 (www.resakss.org).
- Nigeria only spends 0.3% of its agricultural GDP on agricultural research and development, which is much lower than the Sub-Saharan Africa average (www.asti.cgiar.org) and the African Union target value of 1% spent on R&D. This indicates that Nigeria´s investment on agricultural innovation is not yet sufficient.

Food and nutrition security progress and need:

- Nigeria is hardly prioritizing actions for hunger and malnutrition reduction and shows a reduction of less than 3% in undernourishment between 2001 and 2011 (FAO, 2014).
- In addition, Nigeria has a Global Hunger Index (GHI) score value of 14.7 reflecting a serious level of hunger (von Grebmer *et al.,* 2014)[9]. This makes the investment into the agricultural and food sector in Nigeria very urgent to fight the high rates of food insecurity.

Table 15: Nigeria performance indicators

Indicator	Indicator score	Overall score
1. Number of years with more than 6% agricultural growth (2005 to 2014)	4	40
2. Percentage point change in TFP index between 2001 and 2008	11	60
3. Number of years with more than 10% government expenditure (2005 to 2014)	0	0
4. Average share of agricultural GDP spent on R&D (2005 to 2011) in %	0.3	33
5. Steps in CAADP completed	5	63
6. Percentage point improvement in undernourishment between 2001 and 2011	2.7	30
7. Global hunger index (2014)	14.7	30
Total score (weighted)		37

Data source: Husmann et al (2015)
Note: TFP refers to Total Factor Productivity

[8] Details on the data sources and methodology used in the assessment can be found in Humann et al. (2015)

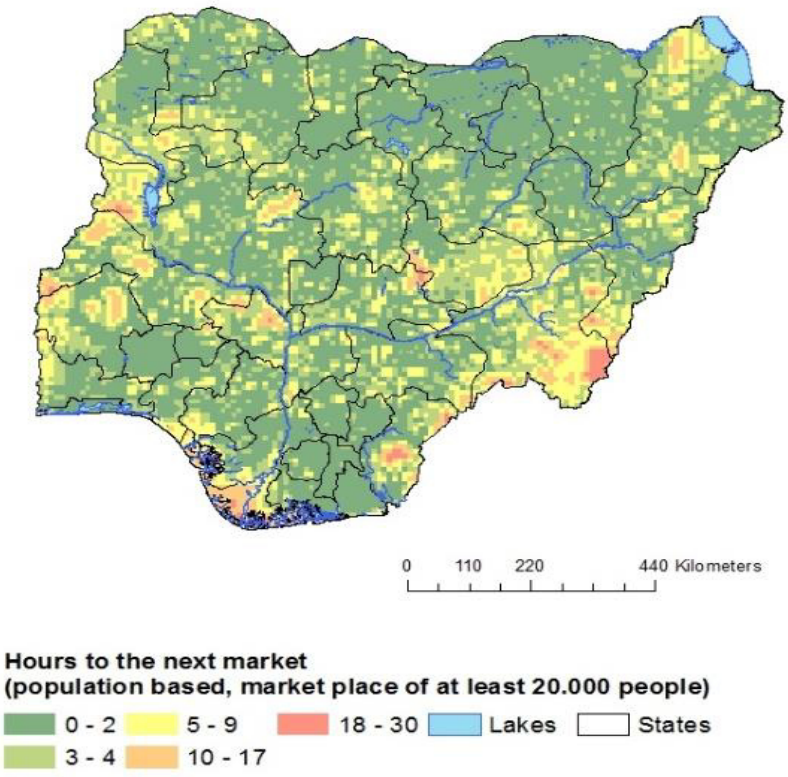
[9] GHI score Values less than 5.0 reflect low hunger, values from 5.0 to 9.9 reflect "moderate" hunger, values from 10.0 to 19.9 indicate a "serious" level of hunger, values from 20.0 to 29.9 are "alarming," and values of 30.0 or greater are "extremely alarming"(von Grebmer *et al.,*2014).

The economic, political, and social/nutrition framework in Nigeria does not seem to suggest accelerated investment into the agricultural and food sector of the country. It is therefore questionable whether Germany´s envisaged investment in Nigeria is worthwhile.

Nonetheless, there are a number of areas of potential in Nigeria's agricultural sector. The large area of uncultivated land, coupled with the natural fertility of its soil, is one of the key sources of potential. Nigeria has about 84 million hectares of arable land, but less than 40% of this land is cultivated. The country also has a large potential for the expansion of both small- and large-scale irrigation investments in Africa (You *et al.,* 2011). In addition, there is abundant labour; the population of about 170 million people provides a large domestic market; and many improved technologies are available.

The selection of value chains on which to focus is also determined by market access, i.e. transport intensive products should be promoted in areas that are well connected to markets, whereas the remote areas should focus on low volume and livestock value chain segments. Figure 5 presents the average time (number of hours) it takes to reach the nearest market place of at least 20,000 people in Nigeria.

Figure 5: Distance to markets



Data sources: Hours to next market - HarvestChoice, 2015;
Administrative areas: www.gadm.org, accessed 20.9.2015
Inland water bodies: www.diva-gis.org/gData (water bodies), accessed 20.9.2015

2 Most relevant value chains in Nigeria

Cassava, cotton, fisheries, maize, fruits, palm oil, poultry, rice, cowpea, soybean, and tomato are among the most promising agricultural value chains in Nigeria. Through the ATA, commodity value chains are playing an essential role in the economy of Nigeria. Table 16 (below) presents a summary of the achievements of the major value chains in the country (Federal Ministry of Agriculture and Rural Development, 2015).

Table 16: Selected value chains and achievements 2011-2014

Value chain	Key achievement
Rice	1,744,922 jobs created; 7 million metric tons of paddy production and a consequent 45 % reduction in national supply gap; Net value of over 400 billion Naira
Poultry	1,696 jobs created; 305,000 metric tons of broiler meat produced and a consequent 84 % increase in production; 49% increase in the production of eggs; Net value of over 106 million Naira
Oil palm	1,080,000 jobs created; 2,760,000 metric tons of increased output; Over 38.9 billion annual revenue
Cocoa	Establishment of a cocoa factory in Ondo state; 21,000 jobs created; 45.5 million seed output; 7.5 billion Naira annual net revenue
Cassava	55,934 jobs created; 5% increase in output, over 2.6 million of additional production; Net value of over 7 billion
Fishery and aquaculture	36,723 jobs created; 21% increase in aquaculture and 39% increase in artisanal fisheries; Net value of over 1.5 billion Naira
Cotton	129,000 jobs created; 293,000 metric tons of total lint production;
Maize	26,000 jobs created; About 8% increase in acreage and 50% increase in yield ; 793,000 metric tons of seed output; 78 million of annual revenue
Wheat	300,000 jobs created; About 50% increase in acreage and 160% increase in yield; 18% reduction in supply gap
Soybean	23% increase in acreage and 61% increase in production; 22,000 jobs created; Over 5.6 billion Naira net revenue
Sorghum	Over 210,000 jobs created; About 2% increase in acreage and 5% increase in production. 18% reduction in supply gap. 430,000 metric tons added output; Over 55 billion Naira in net revenue

Source: Federal Ministry of Agriculture and Rural Development, 2015

2.1 GIC-value chains

The value chains that were chosen for the GICs include rice, maize, cassava, and Irish potato.

2.1.1 Maize

Nigeria is the largest maize producer in Africa. It is grown in all 36 States and the FCT of Nigeria, but the main producing area is the north-central zone of the country (Cadoni and Angelucci, 2013). Maize occupies the second largest area of cultivated land in the Nigeria (11.7%, see Table 10). It is one of the most frequently consumed staples in Nigeria. A significant amount of maize produced in the country is used by the industrial sector for production of flour, beer, malt drink, corn flakes, starch, animal feeds, etc. Average production of maize in the last 20 years is estimated at over 6,597,000 tons, and per capita consumption of maize and maize products stands at 33 kg per year (FAOSTAT, 2016).

2.1.2 Rice

Nigeria is the largest rice producer in West Africa. Rice is both a food and a cash crop for farmers, contributing to smallholders revenues in the main producing areas. Rice is mainly produced in the middle belt and in the northern states of Benue, Kaduna, Niger and Taraba, as well as in the south eastern states of Enugu, Cross River and Ebonyi. Production of rice has more than doubled from roughly 3 million tons in 1993 to 6.734 million tons in 2014 (FAOSTAT, 2016). Per capita consumption of rice (milled equivalent) is estimated at 28 kg (Ibid). Nigeria is the second largest importer of rice in the world. To reduce dependence from imports, the government of Nigeria has set the ambitious target of achieving self-sufficiency in rice production by 2015 through the ATA and rice sector policies. The main actors in the Nigerian rice value chain are farmers, paddy traders, millers, rice traders and retailers. The rice sector provides employment to over 1.7 million people in the country.

2.1.3 Cassava

Cassava is the most widely cultivated crop in Nigeria and it is predominantly grown by smallholder farmers with average land-holdings of less than 2 ha. Nigeria is the world's largest producer of cassava. Cassava is produced across the country, but the main producing states are located in the south-western and south-eastern parts of the country. There are only limited quantities produced in the northern part of the country. Production has been steadily increasing over the last 20 years, and average production stood at over 38 million tons (FAOSTAT, 2016). This significant growth has been primarily due to rapid population growth, leading to a large internal demand. The per capita consumption of cassava is the highest amongst crops, at 119 kg per year (FAOSTAT, 2017). Moreover, the availability of high-yielding improved varieties of cassava, a relatively well developed and organized market structure and access infrastructure, and the existence of improved processing technology further spurred the growth of the sector (FAO and International Fund for Agricultural development (IFAD), 2005). The cost of cassava production is also low; hence, it is generally more affordable when compared to other staples. Most of the cassava consumed in Nigeria is processed into gari, flour, etc. using traditional methods. It has numerous alternative uses in feed, food and agro-industry. The six main actors in the cassava value chain in Nigeria are producers, processors, industrial processors, wholesale traders/transporters, retailers, and consumers.

2.1.4 (Irish) Potato

The potato only has marginal relevance for food security in Nigeria. Irish potato represents hardly 1% of the total annual output of all staple crops in Nigeria (Ayuba and Kitsche, 2014). Nigeria has one of the world's lowest potato yields per hectare (Ugonna *et al.,* 2013). Efficiency of production is very low. Potato production is constrained by a lack of suitable varieties, late blight disease, inappropriate storage facilities, etc. (Ayuba and Kitsche, 2014). Potatoes are cultivated by rural farmers in marginal

areas of the country. More than 90% of all harvested potatoes in Nigeria come from the Jos Plateau in Plateau state. Potato consumption in Nigeria is very low. In recent years, however, consumption of potatoes has been on the rise, notably in rapidly growing urban areas. This has opened new market opportunities for potato farmers. Potato production has increased from 80,000 tons in 1993 to about 1.248 million tons by 2014 (FAOSTAT, 2016).

2.2 Other relevant value chains

The other relevant value chains aside from those selected for the GICs are discussed in this subsection. Their relevance in this case is based on, among other things, the extensive review of available literature on the crop, the importance of the crop in relation to the share of the cultivated area, production volume, and trade importance (import and export).

2.2.1 Sorghum

Nigeria is the largest sorghum producer in West Africa and the third largest in the world. The country accounts for about 71% of the total regional output. Sorghum is also the 6th most important crop in terms of quantity produced in the country (see Table 10). The crop plays an important role in food security, as the majority of production is consumed domestically. Only a small portion is traded, mainly on local markets. Sorghum grows well on deep, fertile and well-drained loamy soils. The main growing regions in Nigeria include the North West and the North East. The most extensively grown sorghum varieties are Vulgare and S. bicolor, which can be white or yellow. White sorghum can be processed into malt, while the red and yellow varieties are used for human consumption and animal feed. Sorghum is eaten in the form of flour or paste, and has an important nutritional value. Average production for the past 20 years stood at over 7.3 million tons, and per capita consumption is estimated at 31 kg per year (FAOSTAT, 2016; Gourichon, 2013).

2.2.2 Yam

Nigeria is the world's biggest yam producer and accounts for two-thirds of global production each year (National Bureau of Statistics, n.d.). Yam is a highly regarded food crop in the humid tropical West African countries, as it plays an important role in the social, cultural, economic and religious aspects of life. In Nigeria, yam is considered a "man's property," and traditional ceremonies are organized for the production of the crop. The major yam producing regions are the Centre and South in states, including Adamawa, Benue, Cross River, Delta, Kaduna, Plateau, etc. The Benue state is the largest producer. Since 1993, average yam production has reached more than 29.8 million tons and is the second most consumed tuber after cassava. Per capita consumption is estimated at 105 kg per year (FAOSTAT, 2016; Diop, 1998).

2.2.3 Oil palm

Oil palm (Elaeis guineensis) is one of the most important commercial crops in Nigeria. It is the fourth most-produced crop in terms of quantity (see Table 10), with an average production of more than 8.112 million tons of palm fruit between 1993 and 2014 (FAOSTAT, 2016). Oil palm is believed to be indigenous to the Nigerian coastal plain before being grown inland. The components of the tree can be used to derive products such as palm oil, palm kernel oil, palm wine, broom, and palm kernel cake. The Nigerian oil palm belt extends over 24 states, which are mainly located in the south. The states of Cross River, Delta, Ondo and Edo export the highest quantities. 80% of production from that belt comes from several million smallholders, dispersed over an area of 1.65 million to 3 million ha. The total area of oil palm plantations is estimated to be between 169,000 ha (72,000 ha of estate plantations and 97,000 ha of smallholder plantations) and 360,000 ha (Foundation for Partnership Initiatives in the Niger Delta, 2011).

2.2.4 Cowpeas

Nigeria is the largest producer and consumer of cowpeas. 61% of African production and 58% of world production comes from Nigeria. The crop is a protein-rich grain and fares better in the dryer Northern regions of the country. It also provides fodder for livestock, improves the soil by fixing nitrogen nutrients and constitutes a source of income for many smallholder farmers (CGIAR, n.d.). National production peaked at almost 5.15 million tons in 2012 before falling to 2.14 million tons in 2014 (FAOSTAT, 2016). The major growing areas are Borno, Zamfara, Sokoto, Kano, Gombe and Yobe.

2.2.5 Cocoa beans

Nigeria is the 4th leading cocoa exporter in the world, behind the Ivory Coast, Indonesia and Ghana. Cocoa is the main agricultural export of Nigeria. The export of cocoa accounts for 36% of the value of total exports and 25% of the total volume of exports (see Table 13). Nevertheless, its production represents only 0.3% of the agricultural GDP. After the investments in the oil sector, the cocoa sector witnessed a decline in the 1970s and 1980s. The 2000s, however, saw an overall increasing trend, punctuated with a fall in 2007 and a slight improvement since then. Alomnado cocoa is the main variety grown in Nigeria, and its high quality commands a price premium on the international market. Nigeria lost this premium after the dismantling of its national Cocoa Board in the 1990s and the subsequent relaxation of quality control. Production stood at 367,000 tons in 2013 (FAOSTAT, 2016). The main production areas include the south east and south west states of Cross River, Edo, Ekiti, Ogun, Ondo, Osun, Oyo (Cadoni, 2013).

2.3 Promising agricultural products and value chains

In addition to assessing the returns on investments into institutional innovations in Nigeria, analyses are also undertaken in order to choose the most promising value chains in the country. This analysis is important because it provides an objective indicator for priority value chains that would have the highest returns on investments into technological and institutional innovations. The trio objectives of PARI (to promote and support the scaling of proven innovations in the agri-food sector; to support and enhance investments in the GICs through research; and to contribute to the development of the agri-food sector in Africa and India through the identification, assessment and up-scaling of innovations) guide the selection of indicators. The indicators should thus focus on improving the food and nutrition security, reducing poverty and improving the market participation of the small holder farmers. Taking into account the availability of data and the purpose of the study, four indicators that focus on poverty and market potential are used to select the five most promising agricultural products from the long list of agricultural products that the country produces and sells. These indicators are:

1. Trade potential (Revealed Comparative Advantage (RCA) index): computed to identify value chains over which the country has revealed, albeit may not necessarily potential, comparative advantage in the export market. The revealed comparative advantage is an index used in international economics for calculating the relative advantage or disadvantage of a certain country in the production and export of a certain class of goods or services as evidenced by trade flows. It is based on the Ricardian comparative advantage concept. We use Balassa's measure of RCA to determine the competitiveness of selected agricultural products in overseas export markets. In the present case, the RCA index compares the share of a given agricultural product in the country's export basket with that of the same product in total world exports.
2. Yield gap: used to assess the expected return of the envisaged investment on the given country value chains. The yield gap of a crop grown in a certain location and cropping system is defined as the difference between the yield under optimum management and the average yield achieved by farmers. A standard protocol for assessing yield potential and yield gaps is applied for some crops

based on best available data, robust crop simulation models. It is a powerful method to reveal and understand the biophysical opportunities to meet the projected increase in demand for agricultural products.

3. Average yield growth: used to examine the potential of the product for poverty reduction. The most widely used indicator of crop productivity is production per unit of land (also referred to as crop yield). Average yield growth may reduce poverty in the following ways: (1) higher yield implies higher surplus product that could be sold in the market and thereby increase farmers income, (2) higher surplus product mean large quantity of food supplied to urban and rural market at a relatively lower price which in turn reduces urban and rural food poverty, (3) higher agricultural productivity will stimulate growth in the non-agricultural sector through its strong backward and forward linkage. For example, it boosts growth in the industry sector by freeing agricultural labor and reducing urban wage pressure (Lewis, 1962), and (4) agriculture's fundamental role in stimulating and sustaining economic transition, as countries (and poor people's livelihoods) shift away from being primarily agricultural towards a broader base of manufacturing and services (DFID, 2004).
4. Total production of the crop as a share of total supply (production + imports) is also used to assess the relevance of investing on that crop .Because it signals whether the agro-ecological system is suitable for the production of that crop in meeting the global demand for that particular crop. The ratio of production to total supply also illuminates the degree of integration of the producers that particular crop, small holder farmers in most African countries cases, into markets. The extent to which small holder farmers are able to participate in both input and output markets, and the functionality of those markets, are key determinants of their willingness and ability to increase marketable surpluses (Arias, 2013). Across the developing world, smallholders farm in diverse agro-climatic systems which together with their assets and skills, shape their economic lives. Markets and the extent to which they are functioning well, also play a determining role.

Note: The share of production of that particular crop over the total crop production is another key indicator considered in this study while assessing the relevance of investing on a particular crop in a country. This indicator is used as an eliminating criteria. If the share of a given crop out of total crop production is less than 0.5 %, we consider it as less relevant and exclude from the list of most promising value chains.

The summary of the most five promising value chains based on RCA index, average yield growth, relative yield gap, and relevance of crop is reported in Table 17. The production share, RCA index, actual yield growth and relative yield gap for the GIC GIZ-selected value chain(s) is also reported at the bottom of the table, when they are not included in the list of the first five most promising value chains.

Table 17: Selection of promising agricultural products /value chain

	Rank by RCA		Rank by Yield progress		Rank by yield gap		Rank by relevance of crop	
Rank	Name of agricultural product	**RCA index (2011)**	Name of the crop	**Average annual yield growth (2005 to 2012)**	Name of staple crop (rain fed)	**Relative yield gap (%)****	Name of agricultural product	**Production share of supply (2011)***
1	Cashew nuts, with shell	122	Sesame seed	45	Rainfed maize	85	Millet and products	100
2	Sesame seed	39	Cow peas, dry	26	Rainfed sorghum	83	Cereals, Other	100
3	Cocoa, beans	24	Potatoes	8	Rainfed rice	66	Sweet potatoes	100
4	Ginger	14	Sugar cane	8	Irrigated rice		Yams	100
5	Vegetables, nes	7	Okra	7			Roots, Other	100
	Maize	0.00	Rice	5			Cassava	100
	Potatoes	0.01	Maize	-1			Rice	62
			Cassava	-8				

Source: * Own computation based on FAO 2015 data, ** from Van Bussel et al. (2015).
Note: *** a minimum of 0.5% production (volume) share threshold is used as a screening (crop relevance) criteria.

Results of assessment (Table 17):

- The trade potential (RCA index) is high for cashew nuts, sesame, cocoa beans, ginger and vegetables. This indicates that Nigeria has comparative advantage (in the export) of these commodities. The RCA value for the other GIC selected crops, maize and potatoes, is less than 1, indicating that Nigeria has a comparative disadvantage on the export of these products;
- The yield performance, indicating progress, suggests that over the CAADP period (2005 to 2012) sesame seed, cow peas, potatoes (the GIZ selected value chain), sugarcane and okra are the five most promising value chains. The yield level of rice, one of the GIZ selected value chain, also shows a continuous and modest growth (5%) on average, while the yield level of the other two GIZ selected value chains (maize and cassava) declined over the same period, on average;
- Yield gaps indicate the yield potential from another perspective, and are observed to be high for rain-fed millet, rain-fed rice, and rain-fed maize and irrigated rice, indicating the high potential returns from investing into these value chains;
- Millet, other cereals, sweet potatoes, yams, roots and the GIZ selected Cassava are the most relevant (in terms of production share of supply). The total production of these products exceeds the total supply. More than three fifth of the total supply of rice, the other GIZ selected crop, is also domestically produced.

2.4 Summary on selection of agricultural products and value chains

This chapter has presented different relevant and important value chains in Nigeria based on different criteria, which has resulted in different value chains. In summary, the top three value chains – GIC selected value chains, other relevant value chains, and those identified by analysis of promising agricultural products and value chains – are presented in Table 18. The summary table shows overlaps in all the value chains suggested by all three methods, i.e. GIC selection, Literature review and analysis of promising agricultural products and value chains, with the exception of oil palm.

Table 18: Summary of all values chains

GIC value chains	Other value chains	Promising agricultural products and value chains (top 3)			
		RCA	Yield progress	Yield gap	Relevance of crop
Maize	Sorghum	Cashew nuts, with shell	Sesame seed	Rainfed maize	Millet & products, Cereals other
Rice	Yam	Sesame seed	Cow peas, dry	Rainfed sorghum	Sweet potatoes, Yams
Cassava	Oil palm	Cocoa, beans	Potatoes, Sugar cane	Rainfed rice	Cassava, Roots other
Irish potato	Cow peas				
	Cocoa beans				

Source: Authors' compilation

3 Innovations in value chains in the past 20 years

3.1 Main limiting factors

The limiting factors include:

- Limited human resource capacity;
- Slow increase in number of researchers with PhD degrees, and many senior researchers are approaching retirement age;
- Agricultural research agencies remain underequipped and lacking in research-related infrastructure and facilities;
- Inadequate funding for research.

3.2 The most important / beneficial innovations in the relevant value chains

In this section, we describe some of the key innovations that have been initiated in selected value chains in Nigeria in the last 20 years. These are considered significant or beneficial because of their widespread adoption or proven positive impact on increasing productivity, and their potential for increasing incomes, adapting to the environmental challenges (such as drought), creating employment etc.

3.2.1 GIC value chains

These include:

- **Drought tolerant maize varieties**

The Drought Tolerant Maize for Africa (DTMA) was a project initiated and implemented by the International Maize and Wheat Improvement Center, the IITA and the national research and extension systems of 13 African countries. Launched in 2006, the DTMA had the aim of developing drought-tolerant maize varieties (DTMVs) with potential yields of 1 t/ha under moderate drought conditions, thereby increasing productivity under typical conditions faced by farmers by 20-30%. The project was funded by the Bill & Melinda Gates Foundation.

Results of the use of DTMVs among farmers in Nigeria showed a 23% (268 kg/ha) increase in maize productivity as a result of the adoption of the improved varieties. Furthermore, per capita food consumption increased by N10,683 (about $35) male-headed households increased their per-capita food consumption by N11,303, while female-headed households' consumption increased by N5,919. The adoption of DTMV by farmers also had a direct impact on 370,000 households, lifting an equivalent of 2.68 million individuals out of poverty. This gain translates into an average poverty reduction of 4.9% in 2014/2015 (IITA, 2016).

- **Improved cassava varieties**

Cassava productivity at the farm level has been 10-12 mt/ha on average for nearly two decades; however, on-station and on-farm experimental trials have shown that improved cassava varieties are capable of yielding 25-30 mt/ha. Farmers are confronted with problems of access to improved cassava varieties (that are high-yielding and resistant to Cassava Mosaic Disease, CMD), post-harvest value adding technologies and ready markets for their harvests. Thus, the entry point for the assistance provided in 2009 by RIU-Nigeria was to organize a platform to bring together partners that will address farmers' endemic cassava production problems. Specifically, stakeholders were organized to grant farmers access to CMD varieties of cassava and to post-harvest value addition through linkage to private agro-processors, who by extension, provided sure access to markets for farmers' cassava tubers (Phillips et. al., 2016).

The IITA and the NRCRI developed two other cassava varieties in addition to CMD varieties, which are UMUCASS 42 and UMUCASS 43 and have the following characteristics:

- Well-suited for High Quality Cassava Flour—a sought-after trait in cassava transformation,
- High dry matter, which is positively related to starch and crucial for cassava value chain development
- High leaf retention, which is positively related to drought tolerance and is crucial for cassava production in the drier regions and for mitigating the impact of climate change,
- Moderate levels of betacarotene for enhancing nutrition,
- The roots are yellow and contain moderate levels of pro-vitamin A (Archive news, 2013).

- **System of Rice Intensification (SRI)**

Trials of SRI took place in the Sabon Gari station of Ahmadu Bello University in 2006-07, and farmer trainings and trials were done in Ondo State in 2007, but did not generate any well-documented results. In 2010, however, the Nigerian NGO Green Sahel-RDI undertook SRI in Jigawa State, and in 2011, Green Sahel Agricultural and Rural Development Institute held a training program on SRI and organic methods with support from E-ATP, USAID's Expanded Agribusiness and Trade Promotion project in the same state. Nigeria is part of the Improving and Scaling up the System of Rice Intensification in West Africa (SRI-WAAPP) project, which is funded by the World Bank, and covers 13 countries of the Economic Community of West Africa (ECOWAS) region. The project was formally launched in January 2014. Adoption of SRI has proven to improve rice yields from 2.7 to 3.6 metric tons in the state of Kano for participant farmers, and farmers trained by the E-ATP SRI events in Nigeria reported yields up to 10 tons/ha) (SRI-RICE, 2015).

3.2.2 Other value chains and cross-cutting innovations

- **Aflasafe for biological control of aflatoxins**

Aflatoxin is a poison produced by a fungus called Aspergillus flavus, which is present in soil and dead and decaying matter in the field. It affects less than 25% of maize and groundnut crops produced in Nigeria and attacks other crops, such as cassava, yam, and rice. Aflatoxin is known to cause liver cancer, to suppress the immune system, and to hinder growth and development in children. Furthermore, contaminated feed and food decrease human and animal productivity, and can even cause death. As a result, contaminated crop are either sold cheaply or destroyed, presenting a health risk and income losses to farmer households.

Aflasafe was tested and developed by the IITA in partnership with the United States Department of Agriculture, the University of Bonn and the University of Ibadan. Aflasafe is a biocontrol product developed from native atoxigenic strains of Aspergillus flavus to eliminate their toxin-producing cousins, thus reducing aflatoxin contamination. The natural, non-toxic technology was used and tested in farms in Kaduna and Oyo states. The use of the product reduced aflatoxin contamination of maize and groundnut by 80-90%. This success translates into an important positive impact on food and nutrition security, health and into better trade opportunities for farmers by reducing their crop losses or the rejection of their commodities on the market (www.iita.org).

- **Purdue Improved Cowpea Storage (PICS)**

Cowpea is the leading legume crop in the northern states of Nigeria. The storage of cowpea after harvest has posed perennial problems at the smallholder level in Nigeria. The insects called Bruchids causes considerable storage losses for cowpea farmers. The best option for protecting cowpea grains in storage has been the application of agro-chemicals. These chemicals are known to cause health hazards to consumers.

The entry point for the cowpea storage IP was the introduction of the triple layer PICS hermetic cowpea storage to farmers, which avoids the use of chemicals. PICS was developed by a Purdue university scientist, with active participation of some African scientists. The PICS project, initiated by Purdue University, was funded by Bill and Melinda Gates Foundation.

RIU Nigeria initiated and funded the Cow Peas Storage IPs (CSIP) through the IITA in 2009. Extension services were provided within the IP by state ADPs and local government agencies. The private sector, led by Lela Agro Enterprises, manufactured the PICS bags locally, while marketers association sold the bags. Local community and religious leaders assisted to spread the health advantages of the PICS bags over agro-chemical options.

The CSIP using the PICS bags empowered both the farmers and marketers in the sense that both groups were given the freedom to publicly evaluate the bags and freely decide whether or not to adopt. The PICS bags were sold through the state and local government extension agents. One unresolved issue is the optimal size of the PICS bags. Women preferred small-size bags that would allow them keep their beans in small units for domestic consumption and seed saving (to avoid frequent opening of the bags). Wholesalers, on the other hand, prefer big bags because they deal in the assembly of large grain volumes (Phillips et. al., 2016).

- **Electronic Wallet (e-wallet) system for fertilizer distribution**

The e-wallet system was developed by the government to remedy the previous ill-functioning system of procurement and distribution of fertilizer. For decades, the Nigerian government supported farmers in the country by relying on fertilizer distributors who acted as middlemen between farmers and the government. Significant discrepancies between the government subsidized prices to these distributors and the higher retail prices to farmers led the Ministry of agriculture to adopt the e-wallet system to

get rid of the middlemen. The new system, which allocates subsidized vouchers to be used like cash to purchase inputs directly from agro-dealers, allows farmers to get a 50% subsidy on a maximum of two bags of fertilizer.

The e-wallet system gained rapid adoption across the value chain, and 10 million farmers have access to the system. Furthermore, the number of fertilizer and seed companies has increased ten-fold and now represents a one billion dollar industry. Considering the success of the scheme, the Ministry of Agriculture partnered with the Federal Ministry of Communication Technology to distribute 10m mobile phones to farmers. Furthermore, the country inspired other nations such as Uganda and Kenya, which are collaborating with Nigeria, to introduce the e-wallet system in their respective agricultural sectors (Okunseinde, 2014; Oxford Business Group, 2013).

- **Innovation platforms**

IPs are good avenues for farmer innovations in Nigeria. The existing IPs that can be explored include; cassava IPs, cowpea storage IP, cowpea crop/livestock IP, and improved fish meal IP, cocoa IP and plantain IP. The recurrent lessons that came out of the IP reviews include the need for broad-based consultation and interactions among the value chain stakeholders for their mutual benefits. For example, the various reviewed IPs showed that through multi-stakeholder cooperation, farmers increase their income and secure market for their products; processors secure raw materials for their processing activities; intermediation guarantees credit availability to needy IP members; stakeholders have access to improved technologies and can make feedback available to the researchers; and extension agents are on the same platform as the farmers, researchers and other technology dissemination stakeholders. On the IP, everyone appears to benefit.

4 Suggestions for collaboration

Priorities for areas of collaboration include:

- Investment in rural infrastructure development to promote private investments in all agricultural areas and to facilitate linkages between these areas and markets and processing industries.
- Improvement of downstream agricultural commodity activities: storage, processing, marketing and distribution channels need to be strengthened, innovated upon and supported through adequate infrastructure (physical, economic, and social), efficient financial institutions, adequate human capital, quality control services, etc.
- Improvement of agricultural production, processing and trade through increased access to resources, such as land, technology (improved inputs, equipment, processes), credit, training.
- Government should strive for a stable macroeconomic environment i.e. ensure price stability, safety and security for life, property and investments.
- Increased support for agricultural research and extension.
- Employment and income generation enhancement through the promotion of a diversified rural economy,
- Capacity building of actors in value chains.
- Encouragement of better environmental management by promoting and adopting techniques, strategies and practices to preserve soils and the environment (Olukunle, 2013).

To pursue these objectives, the entry point for effective partnership lies within the existing structure for agricultural research and innovation within Nigeria, i.e. the 15 national agricultural research institutes that are coordinated by the ARCN. The partnership should consider the ARCN and its research agenda. Consideration should also be given to government departments such as the Federal Ministry of Agriculture and Rural Development and to higher education agencies, particularly to the 13 federal

colleges of agriculture. The network with the governmental institutions would provide both technical and political support to attain good results from collaboration and an effective synergy of actions.

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Annex A: Background Information on Nutrition

This annex provides background information on diet quantity and quality, child feeding practices and nutrition status (including micronutrient deficiencies) and definitions of the food and nutrition security indicators presented in Chapter 1.4.2.

Background on food and nutrition security

Diet quantity: Dietary energy supply per capita is an indicator of diet quantity that can be gauged against a population's average dietary energy requirement. The data are based on FAO's food balance sheets that estimate the quantity of each food item available for human consumption at the national level. It has to be emphasized that supply does not equal intake: Supply includes food that households feed to domestic animals or pets and food that they waste. Also, a sufficient average supply of dietary energy (or a nutrient such as protein) may leave those parts of the population deprived that have greater-than-average requirements or lower-than-average intakes. Indicators of undernourishment and food over-acquisition seek to consider the distribution of dietary energy consumption in the population and the minimum/maximum requirements of the average individual in a country (Cafiero, 2014).

Diet quality: Assessing diet quality requires a look at the composition of the diet. In the absence of national food consumption surveys for most countries, data from FAO's food balance sheets are used. The percentage of dietary energy supply from starchy staples (cereals, roots and tubers) is a rough indicator of diet quality: generally, the higher this percentage, the lower the micronutrient density of the diet; starchy staples are rich in carbohydrate and good sources of dietary energy, but they are usually not very micronutrient-rich. Non-staple foods are important for micronutrient and protein supply: Foods of animal origin are good sources of high-quality protein and vitamin A as well as highly bioavailable iron and zinc (meat, fish) and calcium (milk, small fish eaten whole with bones). Pulses and nuts are also good sources of protein and micronutrients. Fruits and vegetables provide a range of micronutrients while generally contributing little dietary energy (USDA, 2016).

The shares of dietary energy supply from carbohydrate, protein, and fat roughly indicate whether the diet is balanced in terms of its macronutrient composition. The recommended shares of dietary energy are 55-75% for carbohydrate, 10-15% for protein, and 15-30% for fat (WHO, 2003). It should be noted that these shares do not reveal whether dietary energy supply per capita and average protein supply are insufficient, sufficient, or excessive in absolute terms. A diet that meets the average dietary energy requirement for Africa as a whole (2200 kcal/day according to FAO, 2016) and provides 55-82.5 g protein per day and 36-73 g fat per day contains the recommended shares of 10-15% of dietary energy from protein and 15-30% of dietary energy from fat. For an adult weighing 60 kg, a protein intake of 50 g/day is considered sufficient, and 60 g/day for an adult weighing 75 kg. No safe upper limit of protein intake has been established, but it is unlikely that intakes of twice the recommended level pose any risk (WHO/FAO/UNU, 2007).

Child feeding practices: Feeding practices are determined by local food availability and household access to food, but also by maternal knowledge and care. Breastfed and non-breastfed children aged 6-23 months should eat foods rich in iron (meat, fish, or eggs) and fruits and vegetables rich in vitamin A daily, and consume at least 4 out of 7 food groups every day (PAHO/WHO, 2003; WHO, 2005; WHO, 2010).

Nutrition status: Household food security, the health environment, and mothers' caring capacity influence children's dietary intakes and the risk of infection, and thereby their nutrition and health status (UNICEF, 2013). Wasting, or acute undernutrition, is the result of recent rapid weight loss or the failure to gain weight that is caused by inadequate diets or infection. Stunting is the failure to grow adequately and results from chronic or recurrent undernutrition or infection (UNICEF/WHO/World Bank, 2016). Stunting in early childhood can have irreversible consequences, such as impaired motor and cognitive development, shorter adult height, lower attained schooling, and reduced adult income, whereas wasting carries a higher mortality risk (Victora et al. 2008; Black et al. 2013; Olofin et al. 2013). Overweight in children and overweight and obesity in adults occur when dietary energy intakes exceed

dietary energy requirements. Overweight and obesity increase the risk of noncommunicable diseases (UNICEF/WHO/World Bank, 2016).

Micronutrient deficiencies arise from insufficient intakes or absorption of essential vitamins and minerals. Major causes are poor diets, diseases, and increased requirements during life stages such as early childhood, pregnancy, and lactation. Micronutrient deficiencies are not limited to poor populations with inadequate dietary energy intakes, but may coexist with overweight and obesity in individuals and communities. Measuring micronutrient deficiencies poses challenges: There is often a need to resort to proxy indicators and large data gaps persist. Anemia, for example, is used as a proxy indicator for iron deficiency, although only about half of the global burden of anemia can be attributed to iron deficiency. Iron deficiency anemia impairs cognitive and motor development, causes fatigue and low productivity, and may result in low birth weight and increased maternal and perinatal mortality if pregnant women are affected (WHO 2015b). Whenever survey data on anemia prevalence are not available, modeled estimates from WHO (2015b) are used. Vitamin A deficiency increases the risk of vision problems, infectious diseases, and death among children (Imdad et al., 2010). Without exception, the data on vitamin A deficiency that are presented in this dossier are modeled estimates (Stevens et al., 2015, quoted in IFPRI, 2015).[10]

Table A1: Cutoffs to identify nutrition problems of public health significance in children

Category of public health significance	Stunting	Wasting	Overweight	Iron deficiency anemia
Severe	≥40	≥15	≥10	≥40
Moderate	30-39	10-14	5-9	20-39
Mild	20-29	5-9	3-4	5-19

Source: Adapted from World Bank (2006) and based on data from WHO (1995) and WHO (2000)

Notes: The cutoffs for public health significance were applied to prevalence rates of stunting, wasting, overweight and iron deficiency anemia (estimated from anemia prevalence) that were rounded to the first decimal. In the tables in Chapter 1.4.2, the data have been rounded to integers, which may lead to seeming contradictions: In a region where 29.8% of children under five were stunted (30% if rounded), stunting would be considered a mild public health problem, and in a region where 30.3% of children under five were stunted (also 30% if rounded), stunting would be considered a moderate public health problem.

Indicator definitions

Dietary energy supply: National average energy supply, expressed in kcal/caput/day (FAO, 2016).

Average dietary energy supply adequacy: Dietary energy supply expressed as a percentage of the average dietary energy requirement. Each country's average supply of calories for food consumption is divided by the average dietary energy requirement estimated for its population to provide an index of adequacy of the food supply in terms of calories (FAO, 2016).

Prevalence of undernourishment: Probability that a randomly selected individual from the population consumes an amount of calories that is insufficient to cover her/his energy requirement for an active and healthy life (FAO, 2016). This indicator seeks to estimate of the percentage of individuals in the population who are chronically undernourished because they fail to meet their minimum dietary energy requirements on a consistent basis.

Prevalence of food over-acquisition: Percentage of individuals in a population who tend, on a regular basis, to acquire food in excess of their maximum dietary energy requirements (FAO, 2016).

Dietary energy supply from cereals, roots and tubers: Percentage of dietary energy supply provided by cereals, roots and tubers (FAO, 2016). A higher share of dietary energy supply from cereals, roots and tubers is generally associated with a lower micronutrient density of the diet.

[10] Iodine deficiency disorders are an important public health problem in many countries. They are not discussed here because salt iodization, the main prevention and control strategy, is not related to agricultural value chains.

Dietary energy supply from carbohydrate: Percentage of dietary energy supply provided by carbohydrates, calculated by subtracting dietary energy supply from protein and dietary energy supply from fat from 100%.

Dietary energy supply from protein: Percentage of dietary energy supply provided by protein, calculated as average protein supply times 4 kcal/g divided by total dietary energy supply.

Dietary energy supply from fat: Percentage of dietary energy supply provided by fat, calculated as average fat supply times 9 kcal/g divided by total dietary energy supply.

Average protein/fat supply: National average protein/fat supply, expressed in g/caput/day (FAO, 2016).

Minimum dietary diversity: consumption of 4+ food groups: Percentage of children aged 6-23 months fed four or more food groups in the 24 hours preceding the survey. The food groups are 1) infant formula, milk other than breast milk, cheese or yogurt or other milk products; 2) foods made from grains, roots, and tubers, including porridge and fortified baby food from grains; 3) vitamin A-rich fruits and vegetables (and red palm oil); 4) other fruits and vegetables; 5) eggs; 6) meat, poultry, fish, and shellfish (and organ meats); 7) legumes and nuts (ICF International, 2015, The DHS Program STATcompiler).

Consumption of foods rich in vitamin A: Percentage of children aged 6-23 months who consumed foods rich in vitamin A in the 24 hours preceding the survey. Foods rich in vitamin A include meat (and organ meat), fish, poultry, eggs, pumpkin, red or yellow yams or squash, carrots, red sweet potatoes, dark green leafy vegetables (for example, cassava leaves, pumpkin leaves, kale or spinach), mango, papaya, and other locally grown fruits and vegetables that are rich in vitamin A (ICF International, 2015, The DHS Program STATcompiler).

Consumption of foods rich in iron: Percentage of children aged 6-23 months who consumed foods rich in iron in the 24 hours preceding the survey. Foods rich in iron include meat (and organ meat), fish, poultry, and eggs (ICF International, 2015, The DHS Program STATcompiler).

Child wasting: Percentage of children under five who are wasted, that is, have weight-for-height below minus 2 standard deviations of the median of the WHO Child Growth Standards. This means that they are too thin for their height (UNICEF/WHO/World Bank, 2016).

Child stunting: Percentage of children under five who are stunted, that is, have height-for-age below minus 2 standard deviations of the median of the WHO Child Growth Standards. This means that they are too short for their age (UNICEF/WHO/World Bank, 2016).

Child overweight: Percentage of children under five who are overweight, that is, have weight-for-height above 2 standard deviations of the median of the WHO Child Growth Standards. This means that they are too heavy for their height (UNICEF/WHO/World Bank, 2016).

Adult overweight and obesity/overweight and obesity among women of reproductive age: Percentage of adults aged 18 years or older/percentage of women of reproductive aged 15-49 years whose body mass index (BMI) is equal to or greater than 25 kg/m2 (WHO, 2015a; ICF International, 2015, The DHS Program STATcompiler). BMI is calculated by dividing body weight in kg by squared height in m.

Adult obesity/obesity among women of reproductive age: Percentage of adults aged 18 years or older/percentage of women aged 15-49 years whose body mass index (BMI) is equal to or greater than 30 kg/m^2 (WHO, 2015a; ICF International, 2015, The DHS Program STATcompiler).

Adult underweight/underweight among women of reproductive age: Percentage of adults aged 18 years or older/percentage of women aged 15-49 years whose body mass index (BMI) is below 18.5 kg/m^2 (ICF International, 2015, The DHS Program STATcompiler).

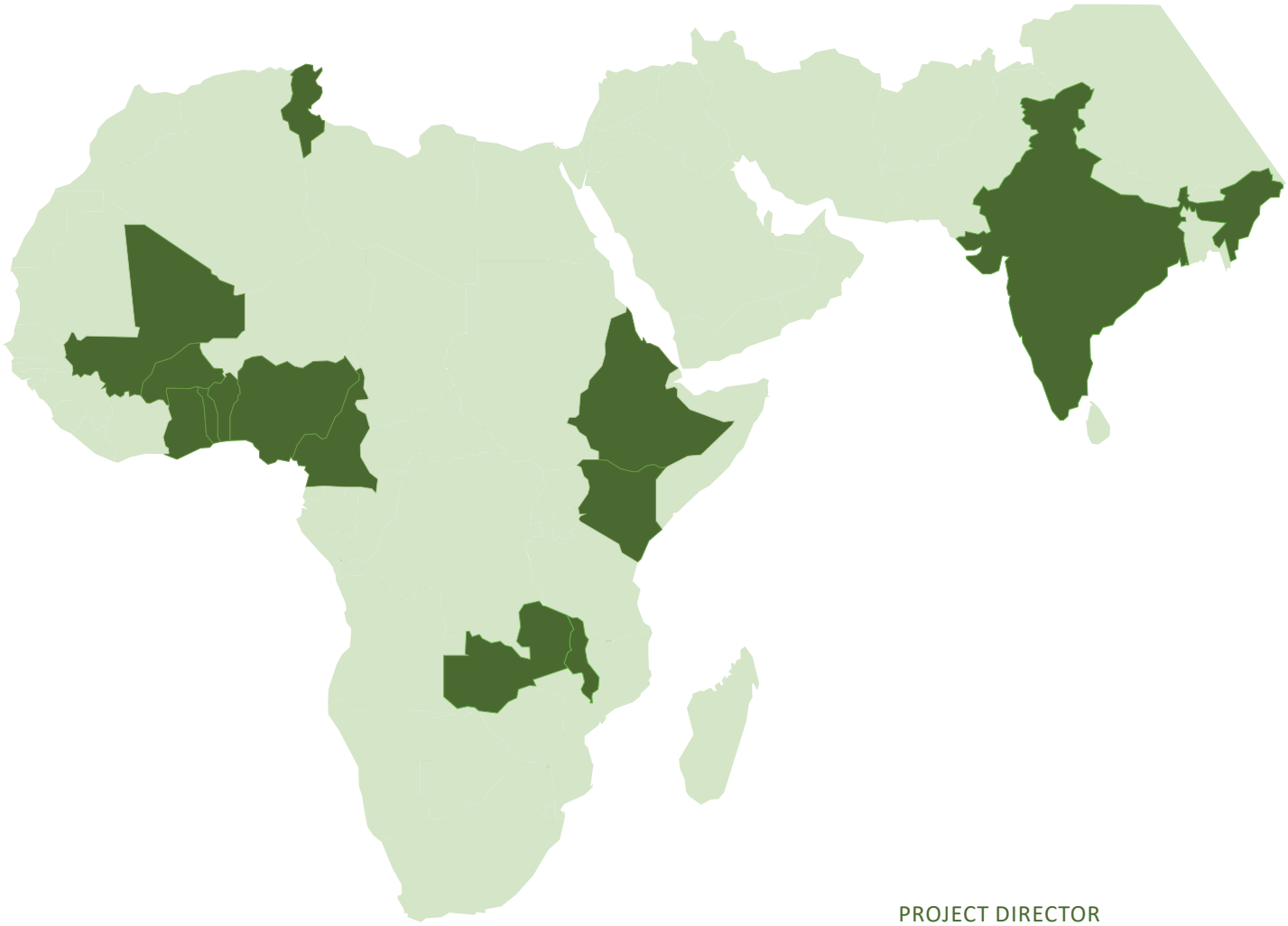
Vitamin A deficiency: Percentage of children aged 6-59 months with a serum retinol concentration below 0.7 µmol/l.

Anemia in children: Percentage of children aged 6-59 months with anemia, namely, a blood hemoglobin concentration below 11.0 g/dl.

Anemia in women: Percentage of women aged 15-49 years with anemia, namely, a blood hemoglobin concentration below 12.0 g/dl for non-pregnant women and below 11.0 g/dl for pregnant women.

ABOUT PARI

The Program of Accompanying Research for Agricultural Innovation (PARI) brings together partners from Africa, India and Germany to contribute to sustainable agricultural growth and food and nutrition security in Africa and India as part of the “One World, No Hunger” Initiative supported by the German government.



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