

Innovation for Sustainable Agricultural Growth in Ghana



COORDINATION

This report was coordinated by Dr. Oliver K. Kirui (ZEF) and Dr. Fatunbi Oluwole Abiodun (FARA).

CONTRIBUTORS TO THE COUNTRY DOSSIER GHANA

CSIR: Sylvester Dery, Rose Omari, Richard Ameyaw Ampadu

FARA: Yemi Akinbamijo, Fatunbi Oluwole Abiodun

ZEF: Heike Baumüller, Joachim von Braun, Annapia Debarry, Tigabu Degu Getahun, Christine Husmann, Oliver K. Kirui, Ehsan Eyshi Rezaei, Leonie Routil, Sougrynoma Zainatou Sore, Justice Akpene Tambo, Detlef Virchow, Doris Wiesmann
Layout & Editing: Evelyn Baraké, Sebastian Eckert, Katharina Gallant, Hannah Jaenicke, Yesim Pacal, Katharina Zinn

This report is work in progress and continuously being updated. Any feedback and suggestions for further improvement are welcome and can be sent to pari@uni-bonn.de.

SUGGESTED CITATION

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

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.

Table of Contents

1	General background information on the agricultural and food sectors.....	6
1.1	Pan-African policies and strategies	7
1.2	National (and regional) policies and strategies.....	7
1.3	Data on food and nutrition security in Ghana	8
1.3.1	Socio-economic and agricultural data	8
1.3.2	Data on diet quantity, diet quality and nutrition status.....	9
1.4	Data on most relevant crops and value chains	15
1.4.1	Production	16
1.4.2	Trade.....	17
1.5	National (and regional) innovation system.....	18
1.5.1	Research system and organizations	18
1.5.2	Innovation platforms	19
1.5.3	Extension system and organizations	21
1.5.4	Private research and development activities	23
1.6	Key challenges, emerging needs and potential in the agricultural sector	23
1.7	Potential areas for investment in Ghana	24
2	Most relevant value chains in Ghana	26
2.1	GIC-value chains.....	26
2.1.1	Maize	26
2.1.2	Rice	27
2.2	Other relevant value chains	27
2.2.1	Cocoa	27
2.2.2	Cassava	27
2.2.3	Yam	28
2.2.4	Plantain.....	29
2.2.5	Palm oil	29
2.2.6	Groundnut	30
2.2.7	Cowpea	30
2.2.8	Soybeans.....	30
2.2.9	Vegetables	31
2.2.10	Fruits	31
2.3	Promising agricultural products and value chains	31
2.4	Summary on selection of agricultural products and value chains	34
3	Innovations in value chains in the past 20 years	35
3.1	Main limiting factors	35
3.2	Important value-chain related and cross-cutting innovations.....	35
3.2.1	GIC value chains.....	35
3.2.2	Other value chains and cross-cutting innovations	37
4	Suggestions for Collaboration	39
	References	42
	Annex A: Background Information on Nutrition.....	47

List of Tables

Table 1: Selected national economic and health-related data	8
Table 2: Overall Agricultural Growth.....	9
Table 3: Food and nutrition security indicators	10
Table 4: Child feeding practices by region, 2014.....	13
Table 5: Child nutrition status by region, 2014	14
Table 6: Women's nutrition status by region, 2014.....	14
Table 7: Top 10 crops produced by area, volume and value	16
Table 8: Production and Yield Growth for Maize and Rice in Ghana	16
Table 9: Area (ha) planted to some selected food crops of significance to the economy.....	17
Table 10: Ghana's imports.....	17
Table 11: Ghana's exports	18
Table 12: Ghana Performance Indicators.....	25
Table 13: Selection of the most promising agricultural product /value chain	34
Table 14: Summary of all value chains	34

List of Figures

Figure 1: Prevalence of undernourishment and food over-acquisition (1990-92 to 2014-16).....	9
Figure 2: Supply of non-staple foods (1990-2011)	11
Figure 3: Percentage of infants and young children consuming foods from selected food groups (2014)	12
Figure 4: Underweight, overweight and obesity among women of reproductive age (1993-2014)	13
Figure 5: Distance to markets.....	26

Acronyms/Abbreviations

AEA	Agricultural Extension Agent
ARI	Animal Research Institute
AU	African Union
BLT	Bulletin of Tropical Legumes
CAADP	Comprehensive Africa Agriculture Development Programme
CCAFS	Climate Change, Agriculture and Food Security (Science Policy Platform)
CIMMYT	International Maize and Wheat Improvement Center
COCOBOD	Ghana Cocoa Board
CoS-SIS	Convergence of Sciences-Strengthening Innovation Systems
CRI	Crops Research Institute
CSIR	Council for Scientific and Industrial Research
DHS	Demographic and Health Surveys
DONATA	Dissemination of New Agricultural Technologies in Africa
EDIF	Export Development and Investment Fund
FAO	Food and Agriculture Organization
FARA	Forum for Agricultural Research in Africa
FASDEP	Food and Agriculture Sector Development Policy
FBO	Farmer-Based Organization
FCDP	Food Crops Development Project
FRI	Food Research Institute
GASIP	Ghana Agricultural Sector Investment Programme
GCX	Ghana Commodity Exchange Project
GDP	Gross Domestic Product
GGDP	Ghana Grains Development Project
GIC	Green Innovation Center
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit/ German Agency for International Cooperation
GHI	Global Hunger Index
GNI	Gross National Income
GSGDA	Ghana Shared Growth and Development Agenda
IAR4D	Integrated Agricultural Research for Development
ICT	Information and Communication Technologies
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IICD	International Institute for Communication and Development
IITA	International Institute of Tropical Agriculture
IP	Innovation Platform
LBC	Local Buying Company
MoFA	Ministry of Food and Agriculture
NRDS	National Rice Development Strategy
NEPAD	New Partnership for Africa's Development
NGO	Non-Governmental Organization
PARI	Program of Accompanying Research for Agricultural Innovation
PPP	Purchasing Power Parity
R&D	Research and Development
RCA	Revealed Comparative Advantage
RUTF	Ready-to-Use Therapeutic Food
SADA	Savannah Accelerated Development Authority
SARI	Savanna Agricultural Research Institute
SEWOH	"One World, No Hunger" initiative

SNV	The Netherlands Development Organization
SRI	Soil Research Institute
SRID	Statistics, Research and Information Directorate (Ministry of Food and Agriculture)
STEPRI	Science and Technology Policy Research Institute
TFP	Total Factor Productivity
USAID	United States Agency for International Development
WHO	World Health Organization
ZEF	Zentrum für Entwicklungsforschung/ Center for Development Research

1 General background information on the agricultural and food sectors

The Republic of Ghana is situated in West Africa, bordering the Gulf of Guinea (Atlantic Ocean) in the South with a coast line of about 550 km. Ghana borders the Republic of Togo in the East, Côte d'Ivoire in the West, and Burkina Faso in the North. It has a land area of 238,539 km², which contains diverse ecological areas. Ghana has a population of over 26 million and is divided into ten administrative regions. While agriculture is the main occupation of the majority of the population, only 44% of the total cultivable land, which represents an estimated 69% of the total land size of Ghana, is used for crop production.

Ghana's Gross Domestic Product (GDP) has been growing at an annual rate of 4-8% over the past decade, and continued robust performance is expected over the coming years, especially as offshore oil production has begun. The average contribution of agriculture to GDP is close to 30%. It is the largest source of employment for Ghanaians, employing more than half of the total labor force; roughly 49% of which are men and 51%, women. 80% percent of agriculture is conducted by smallholder farmers who produce food and cash crops on 1.2 ha, on average.

Ghana's traditional export crop is cocoa. Because of the significant amount of exchange earnings from cocoa, it has featured importantly in discussions on the country's socio-economic development, reforms and poverty alleviation strategies. The cocoa sub-sector alone offers a source of livelihood for over 700,000 farmers. All cocoa grown for export must be sold to the Ghana Cocoa Board (COCOBOD), which aggregates the crop for sale in the international market. Besides cocoa, Ghana is becoming prominent in the cultivation of fruits, including pineapple and mango, which are exported to Europe.

Additionally, Ghana produces maize, yams, cassava, sorghum, millet and rice as main food crops. As noted earlier, agriculture provides the main source of livelihood, generating income and employment for the vast majority of people in the country. Thus, growing the agricultural sector may provide opportunities to broaden the economic impacts to vast majority. However, there remain some challenges that need to be addressed if the country is to reach its full agricultural potential and for growth rates to be translated into greater food security. These include lack of technological change, poor basic infrastructure, changing rainfall patterns, socio-economic inequalities between the North and South of the country, inadequate productive credit, low organic matter and declining soil fertility, as well as inadequate private sector involvement. Other cross-cutting constraints in the agriculture sector include inequality of access and discrimination by gender, age, social class and ethnicity, among others. The ecological zones of the country also differ significantly with respect to infrastructure development and other investments.

Currently, the government of Ghana is making every attempt to correct some of these constraints and inadequacies. These attempts are in line with the effort to achieve the Comprehensive Africa Agriculture Development Programme (CAADP) targets and to improve the welfare of the local people. Plans to reach these targets are outlined in the recently published development blue-print of Ghana, the Ghana Shared Growth and Development Agenda (GSGDA II).

In twelve African countries, including Ghana, 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 Ghana are rice, and maize. The selection criteria considered the value chains that have high potential to improve productivity, generate income and jobs, and to involve a high proportion of women and young adults.

1.1 Pan-African policies and strategies

In 2003, the African Union (AU) heads of state met in Maputo, Mozambique, and made the first declaration designating the CAADP as an integral part of the New Partnership for Africa's Development (NEPAD). This established the CAADP as Africa's primary policy framework or strategy for agricultural transformation, wealth creation, food security and nutrition, and economic growth and prosperity for all. This new strategy, spearheaded by African leaders, addresses critical challenges facing the continent.

Ghana is among the first African countries that committed to CAADP. In its adoption of CAADP, Ghana agreed to achieve an annual agricultural growth rate of at least 6% and allocate at least 10% of the national budget to agriculture. From 2003 to 2013, Ghana has only surpassed the 6% growth target for agriculture in 4 years out of 10. The country has, however, reached its commitment to allocate 10% of the budget to agriculture consistently since 2009 (see Table 2).

Ghana is among 10 African countries that have signed a cooperative agreement with the G8 donors under the **New Alliance for Food Security and Nutrition** committing to achieve sustained inclusive, agriculture-led growth in the country. The New Alliance is a partnership that brings together capacities and interests of diverse stakeholders to facilitate inclusive, agriculture-led growth in Africa and to address key constraints to private investment, increased smallholder productivity and market access. These include African governments and institutions, the private sector, civil societies, donors, and other development partners, such as research institutions. The New Alliance comprises country-specific commitments codified in Cooperation Frameworks, as well as Enabling Actions that address broad constraints and support country-level actions. As a shared commitment (for member states) to achieve inclusive, agriculture-led growth and raise 50 million people out of poverty over the next 10 years, the New Alliance¹ contributes to and catalyzes the implementation of major components of CAADP. Strong commitment and implementation at the country level are key to its success.

Ghana is also part of the **Grow Africa Partnership**, which works to increase private sector investment in agriculture and to accelerate the execution and impact of investment commitments. The Grow Africa partnership was co-founded in 2011 by the AU Commission, the NEPAD Agency and the World Economic Forum to spur private-sector investment and financing for African agriculture, in support of CAADP. It is an African-owned, country-led, multi-stakeholder platform, which seeks to mobilize private-sector investment. Grow Africa works to advance sustainable agricultural growth by facilitating alignment and partnership among all relevant stakeholders, including African governments, the local and global private sector, international organizations and development partners, civil society and farmers.

1.2 National (and regional) policies and strategies

Ghana Shared Growth and Development Agenda II (GSGDA II) (2014-2017)

GSGDA II (2014-2017) is Ghana's latest blueprint for national growth and development. It builds on previous development policy agendas and focuses on agriculture, fisheries, small and medium-scale enterprises, and sanitation – with special attention to the dry savannah region in the north of the country. GSGDA II also recognizes the importance for the country to invest in:

- Enhancing the competitiveness of Ghana's private sector;
- Accelerating agricultural development and natural resource management;
- Improving infrastructure, human resource development and job creation;
- Consolidating transparent, accountable and efficient governance.

¹ new-alliance.org

Additionally, this policy agenda underscores the central role of the country's *Food and Agriculture Sector Development Policy* for 2009-2015, known as FASDEP II. This policy recognizes the importance of supporting agriculture through value chain development. It was the departure point for the CAADP process in Ghana and comprises the following programs:

- Food security and emergency preparedness;
- Improved growth in incomes;
- Increased economic competitiveness and enhanced integration into domestic and international markets;
- Sustainable management of land and the environment.

To bridge Ghana's North-South economic and social divide, the government has established the **Savannah Accelerated Development Initiative** as part of its overall northern development strategy. At the heart of this long-term (2010-2030) initiative is the Savannah Accelerated Development Authority (SADA), which aims to attract investments to growth corridors in the north. SADA's responsibilities include the three Northern regions (Upper East, Upper West and the Northern Region) and some parts of Volta and Brong Ahafo regions. SADA is an independent agency set up to coordinate a comprehensive development agenda for the northern savannah ecological zone in Ghana. SADA also aims at responding to effects of climate change associated with floods and drought. The agency's main thrust is to promote sustainable development using the notion of a forested and green north to catalyze climate change reversal and improve livelihoods of the most vulnerable citizens in the area.

1.3 Data on food and nutrition security in Ghana

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

Indicator	Value	Year
Population, total	26,442,178	2014
Population growth (annual %)	2.1	2014
Rural population (% of total population)	47	2014
GDP per capita, PPP (constant 2011 international \$)	3,953	2014
GNI per capita, PPP (constant 2011 international \$)	3,774	2013
Poverty headcount ratio at \$2 a day (PPP) (% of population)	52	2005
Poverty headcount ratio at \$1.25 a day (PPP) (% of population)	29	2005
Poverty headcount ratio at national poverty lines (% of population)	32	2005
Rural poverty headcount ratio at national poverty lines (% of rural pop.)	44	2005
Agricultural land (% of land area)	69	2012
Agricultural irrigated land (% of total agricultural land)	0.2	2010
Agriculture value added per worker (constant 2005 US\$)	752	2005
Agriculture, value added (% of GDP)	21	2014
Access to electricity, rural (% of rural population)	41	2012
Employees, agriculture, female (% of female employment)	38	2010
Employees, agriculture, male (% of male employment)	46	2010
Employment in agriculture (% of total employment)	42	2010
Literacy rate, adult total (% of people ages 15 and above)	71	2010
Ratio of female to male secondary enrolment (%)	94	2014
Mortality rate, under-5 (per 1,000 live births)	78	2013
Maternal mortality ratio (modelled estimate, per 100,000 live births)	380	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: Overall Agricultural Growth

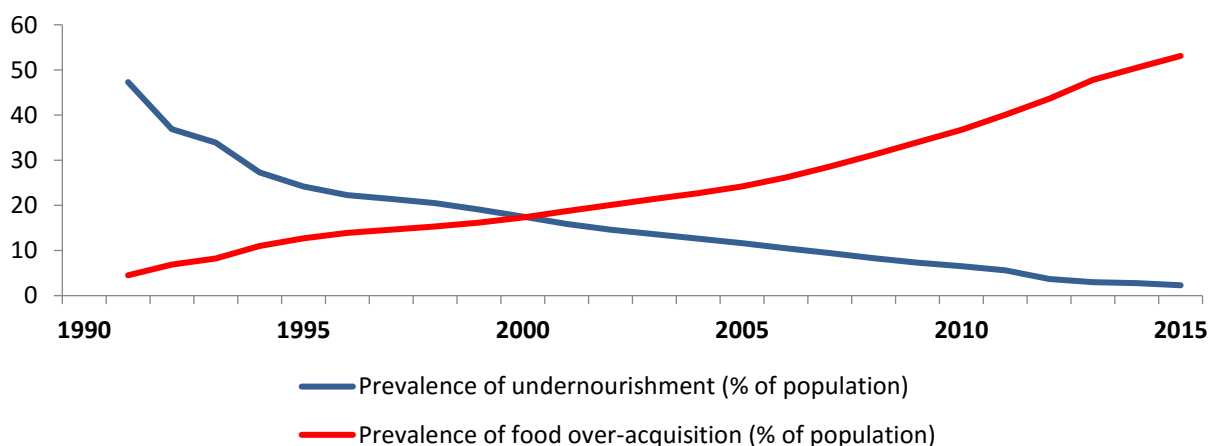
Years	Contribution of Agriculture to GDP (%)	Annual growth rate of Agriculture (%)	Budget allocation to Agriculture (%)
1994	40.8	1.0	
1995	40.6	3.7	
1996	40.8	5.2	
1997	40.4	4.3	
1998	40.6	5.1	
1999	40.5	3.9	
2000	39.6	2.1	
2001	39.6	4.0	6.6
2002	39.5	4.4	6.1
2003	39.8	6.1	6.5
2004	40.3	7.5	8.9
2005	39.5	4.1	9.6
2006	39.3	4.5	8.4
2007	38.0	4.3	9.1
2008	33.9	6.0	9.9
2009	31.8	6.1	10.3
2010	29.8	5.3	16.0
2011	25.3	0.8	11.2
2012	22.9	2.3	13.26
2013	22.4	5.7	
2014	21.5	4.6	
2015	20.3	2.4	

Source: Agriculture in Ghana Facts and Figures 2013, Ministry of Food and Agriculture Statistics, Research and Information Directorate (SRID); the State of the Ghanaian Economy in 1998, 2005, 2009 Ghana Statistical Service, April 2014

1.3.2 Data on diet quantity, diet quality and nutrition status

Data on diet quantity, diet quality and nutrition status are relevant for assessing food and nutrition security. Dietary energy supply per capita – a measure of diet quantity – is more than adequate in Ghana; it exceeds the average dietary energy requirement of the population by 50% (Table 3). The prevalence of food over-acquisition is high; the Food and Agriculture Organization of the United Nations (FAO) estimates that more than half of the population tends to regularly acquire food in excess of their dietary energy needs. The prevalence of undernourishment has been reduced considerably since the early 1990s, while the prevalence of food over acquisition has increased sharply (Figure 1).

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



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

Table 3: Food and nutrition security indicators

Indicator	Value	Year
<i>Diet quantity</i>		
Dietary energy supply (kcal/caput/day)	3367	2014-16
Average dietary energy supply adequacy (% of average requirement)	150	2014-16
Prevalence of undernourishment (% of population)	2	2014-16
Prevalence of food over-acquisition (% of population)	53	2014-16
<i>Diet quality</i>		
Dietary energy supply from cereals, roots and tubers (% of total dietary energy supply)	66	2009-11
Dietary energy supply from carbohydrate (% of total dietary energy supply)	78	2009-11
Dietary energy supply from protein (% of total dietary energy supply)	8	2009-11
Dietary energy supply from fat (% of total dietary energy supply)	14	2009-11
Average protein supply (g/caput/day)	60	2009-11
Average fat supply (g/caput/day)	47	2009-11
<i>Child feeding practices</i>		
Minimum dietary diversity: consumption of 4+ food groups (% of children 6-23 months)	28	2014
Consumption of foods rich in vitamin A (% of children 6-23 months)	67	2014
Consumption of foods rich in iron (% of children 6-23 months)	59	2014
<i>Nutrition status</i>		
Child wasting (% of children under five)	5	2014
Child stunting (% of children under five)	19	2014
Child overweight (% of children under five)	3	2014
Adult overweight and obesity (% of adults 18+ years)	34	2014
Adult obesity (% of adults 18+ years)	12	2014
Vitamin A deficiency (% of children 6-59 months)	50	2013
Anemia in children (% of children 6-59 months)	66	2014
Anemia in women (% of women 15-49 years)	42	2014

Source: FAO (2016), and authors' calculations based on FAO (2016); Ghana Statistical Service, Ghana Health Service, and ICF International (2015); Stevens et al. (2015), quoted in International Food Policy Research Institute (IFPRI) (2015); von Grebmer et al. (2016); World Health Organization (WHO) (2015a)

Note: See Annex A for definitions of the indicators.

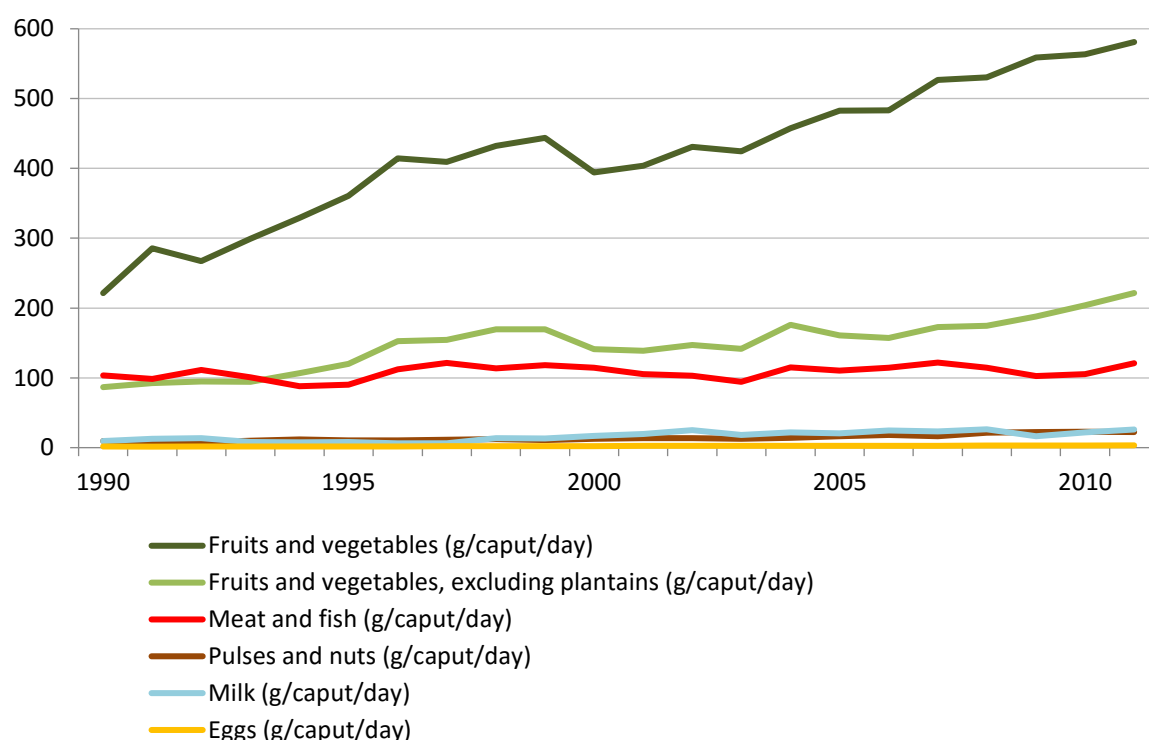
The diet in Ghana is predominantly based on starchy staples (mainly cassava, yams, rice, and maize), which provide about two thirds of dietary energy supply (Table 3). The share of dietary energy supply from carbohydrates exceeds the maximum of 75% recommended by the WHO, whereas the shares of dietary energy supply from protein and fat are slightly below the recommended minimum values of 10% and 15%, respectively (WHO 2003). The imbalance in the composition of the diet arises from an excessive supply of carbohydrate and dietary energy; average protein supply is sufficient to meet protein requirements, and average fat supply would be adequate for a diet that does not greatly surpass the average dietary energy requirement of the population (Table 3; 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 balanced, nutritious diet. Since 1990, meat and fish supply have hovered around 100 g/caput/day in Ghana, and the supply of milk and eggs remains at very low levels (Figure 2). Pulses and nuts are only supplied in small amounts in Ghana. The supply of fruits and vegetables approached an impressive 600 g/caput/day by 2011, which is considerably above the recommended intake of 400 g of fruits and vegetables per day (WHO 2003). Yet, a closer analysis shows that this group of foods is not very diversified: Plantains make up more than 60% of total fruit and vegetable supply

and account for close to two thirds of the strong increase in supply since 1990 (Figure 2). Plantains are a major source of carbohydrates in the Ghanaian diet.²

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 Ghana, infants' and young children's diets fall short of these goals: less than 30% achieved minimum dietary diversity, roughly 60% consumed iron-rich foods, and only about two thirds consumed foods rich in vitamin A the previous day (Table 3). Both breastfed and non-breastfed children aged 6-23 months were most frequently fed foods made from grains (Figure 3). Fortified baby foods, which can compensate for a lack of micronutrients in the diet, were consumed by less than one fifth of breastfed and non-breastfed children.

Figure 2: Supply of non-staple foods (1990-2011)



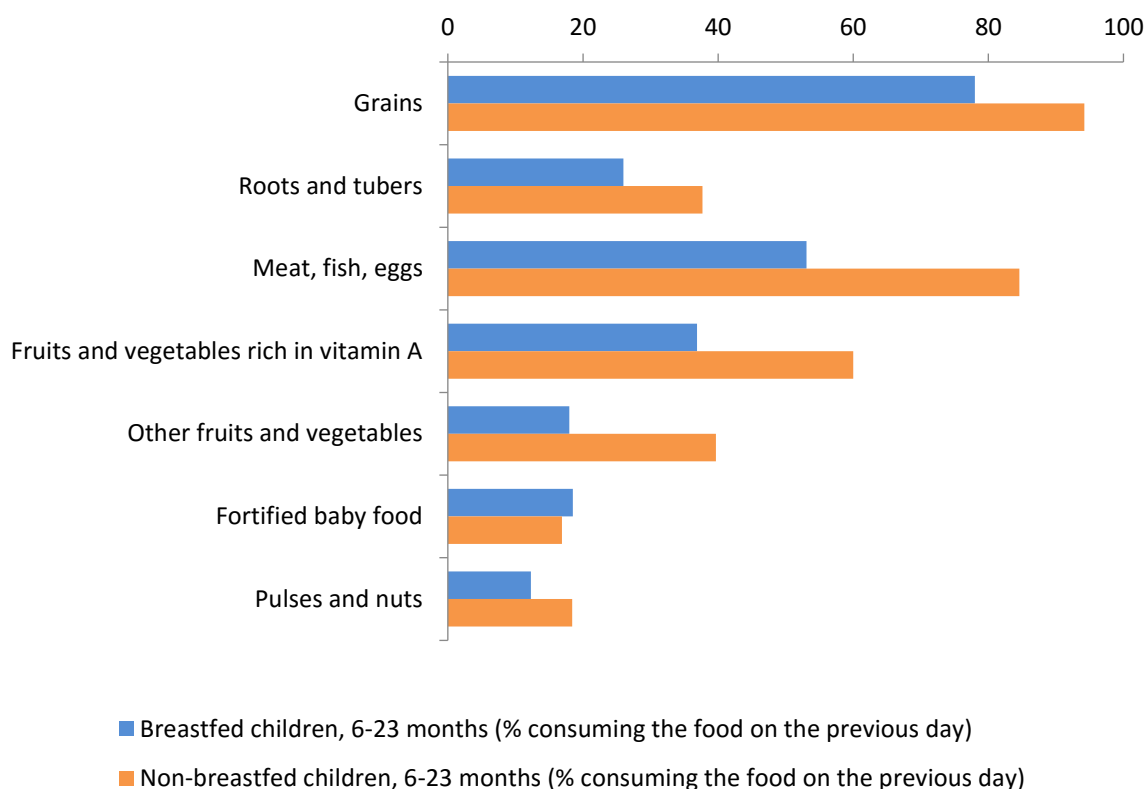
Source: Authors' presentation based on data from FAOSTAT, accessed 07 Oct 2016

Note: Based on their nutrient profiles, pulses and nuts include groundnuts and soybeans, although these foods are classified by FAO as oil crops. Coconuts are not included among pulses and nuts because they have low protein content.

Stunting and wasting are indicators of chronic and acute child undernutrition, respectively. The prevalence of stunting and wasting has decreased in Ghana in the past decades, reaching the threshold for mild public health significance of 5% for wasting and falling below the threshold for mild public health significance of 20% for stunting (Table 3). Meanwhile, overweight in children has risen, but has not reached an alarming level.

² Plantains can be used in place of starchy roots and tubers and are eaten cooked or fried; they are rich in carbohydrate and good sources of vitamin A, vitamin C, and various B-vitamins, but have lower concentrations of micronutrients than dark green leafy vegetables, for example, while having higher energy content (USDA 2016).

Figure 3: Percentage of infants and young children consuming foods from selected food groups (2014)

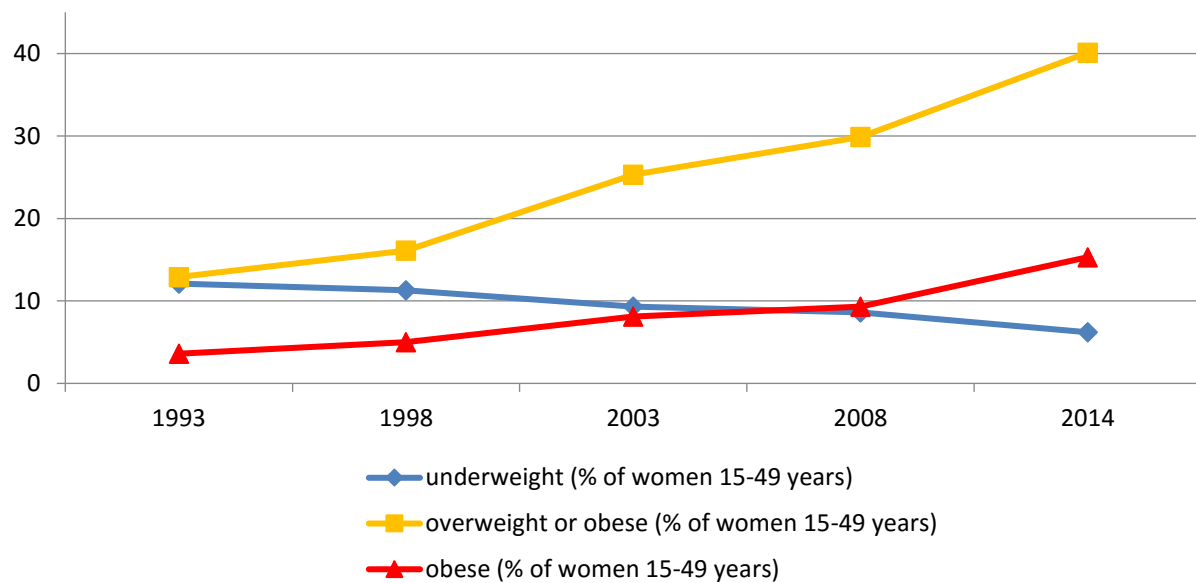


Source: Authors' presentation based on data from Ghana Statistical Service, Ghana Health Service, and ICF International (2015)

Overweight and obesity are risk factors of chronic diseases such as diabetes (Must and McKeown 2012). They affect about one third of adults in Ghana (Table 3). Since the early 1990s, the combined prevalence of overweight and obesity has more than tripled among women of reproductive age, while the prevalence of obesity in this group has more than quadrupled (Figure 4). Concurrently, the prevalence of underweight in women has fallen slowly, but steadily, reaching a rate of 6% in 2014 (see Annex A for definitions of overweight, obesity, and underweight).

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 Ghana, half of all children in this age group are estimated to be vitamin A deficient (Table 3). More than two fifths of all women of reproductive age and more than two thirds of children aged 6-59 months suffer from anemia (Table 3). About half of the global burden of anemia can be attributed to iron deficiency; malaria, which is endemic in Ghana, is another major cause of anemia.

Regionally disaggregated data are available for indicators of nutrition status and child feeding. The diversity of infants' and young children's diets is particularly low in the Ashanti and Eastern regions (Table 4). The Central and Greater Accra regions are better off in this respect and with regard to the proportion of children consuming foods rich in iron and vitamin A. Children in the Northern, Upper East, and Upper West regions have the highest rates of anemia (Table 5). The Northern region has the highest proportion of stunted children, which is more than three times higher than in the Greater Accra region. This pattern is reversed, however, when looking at the prevalence of overweight in children. Regarding overweight and obesity in women, prevalence is highest in the Ashanti and Greater Accra regions, and lowest in the Northern, Upper East, and Upper West regions (Table 6). Anemia prevalence among women is above average in the Central, Northern, and Volta regions.

Figure 4: Underweight, overweight and obesity among women of reproductive age (1993-2014)

Source: Authors' presentation based on ICF International (2015), the Demographic and Health Surveys (DHS) Program STATcompiler, funded by the United States Agency for International Development (USAID), accessed 12 Sept 2016

Table 4: Child feeding practices by region, 2014

Share of children 6-23 months consuming:					
4+ food groups		Foods rich in vitamin A		Foods rich in iron	
Region	(%)	Region	(%)	Region	(%)
Greater Accra	57	Central	82	Central	78
Central	44	Greater Accra	78	Greater Accra	73
Western	34	Upper West	73	Brong-Ahafo	64
Brong-Ahafo	28	Brong-Ahafo	72	Volta	63
Upper West	20	Volta	67	Eastern	58
Northern	18	Upper East	64	Western	50
Volta	18	Eastern	63	Upper West	50
Upper East	17	Western	63	Ashanti	48
Eastern	17	Ashanti	57	Northern	48
Ashanti	12	Northern	56	Upper East	36

Source: Ghana Statistical Service, Ghana Health Service, and ICF International (2015)

Notes: GIC regions are marked in red. See Annex A for definitions of the indicators.

Table 5: Child nutrition status by region, 2014

Prevalence among children under five:						Prevalence among children 6-59 months:	
Stunting		Wasting		Overweight		Anemia	
Region	(%)	Region	(%)	Region	(%)	Region	(%)
Greater Accra	10	Volta	2.5	Northern	1.3	Ashanti	54
Upper East	14	Eastern	3.2	Brong-Ahafo	1.4	Greater Accra	60
Ashanti	16	Ashanti	3.5	Upper East	1.4	Brong-Ahafo	63
Eastern	17	Greater Accra	3.7	Western	1.5	Western	65
Brong-Ahafo	17	Western	3.9	Ashanti	1.5	Eastern	66
Western	18	Upper West	4.4	Eastern	1.6	Volta	70
Volta	19	Brong-Ahafo	4.5	Upper West	2.8	Central	70
Central	22	Northern	6.3	Volta	4.2	Upper West	74
Upper West	22	Central	7.7	Central	4.6	Upper East	74
Northern	33	Upper East	9.4	Greater Accra	5.2	Northern	82

Source: Ghana Statistical Service, Ghana Health Service, and ICF International (2015)

Notes: GIC regions are marked in red. See Annex A for definitions of the indicators.

Table 6: Women's nutrition status by region, 2014

Prevalence among women of reproductive age (15-49 years):							
Underweight		Overweight + obesity		Obesity		Anemia	
Region	(%)	Region	(%)	Region	(%)	Region	(%)
Central	3.5	Northern	12	Northern	4	Upper West	36
Greater Accra	4.5	Upper East	19	Upper East	4	Brong-Ahafo	36
Western	5.1	Upper West	21	Upper West	5	Eastern	39
Ashanti	6.1	Volta	31	Brong-Ahafo	6	Upper East	40
Brong-Ahafo	6.4	Brong-Ahafo	35	Volta	9	Ashanti	41
Upper West	7.0	Eastern	39	Western	13	Greater Accra	42
Eastern	7.1	Central	41	Central	16	Western	43
Volta	7.2	Western	43	Eastern	17	Central	47
Upper East	9.3	Ashanti	45	Ashanti	17	Northern	48
Northern	11.2	Greater Accra	57	Greater Accra	29	Volta	49

Source: Ghana Statistical Service, Ghana Health Service, and ICF International (2015)

Notes: GIC regions are marked in red. See Annex A for definitions of the indicators.

Among indicators of children's nutrition status, anemia is the most important in terms of prevalence rates, followed by stunting (Table 5). This holds for all regions and the national average. Under the assumption that half of all anemia is due to iron deficiency, iron deficiency anemia among children is of severe public health significance in the Northern region, and of moderate public health significance in the other regions.³ Stunting and wasting have moderate public health significance in the Northern region, and mild significance in the Central and Upper West regions. Overweight in children is a

³ About half of the global burden of anemia is attributable to iron deficiency (WHO 2015b). Since the prevalence of anemia among children in all regions except for the Northern region is in the range of 54-70%, the prevalence of iron deficiency anemia can be estimated to be 27-35%, falling within the range of 20-39% that has been classified as a moderate public health problem (see Annex A). However, it is possible that less than half of all anemia in Ghana is caused by iron deficiency because malaria is endemic in the country.

moderate public health concern in the Greater Accra region, and has mild public health significance in the Volta and Central regions.

Considering indicators of women's nutrition status, anemia as well as overweight and obesity combined have the highest prevalence rates in all regions (Table 6) and consequently also at the national level. In the Greater Accra region, almost 30% of women of reproductive age are obese, and more than half are overweight or obese. The rates of underweight are relatively low in all regions and at the national level.

In summary, the current oversupply of dietary energy and carbohydrate in Ghana as well as recent increases in overweight and obesity suggest that the supply of starchy staples for domestic consumption should not be boosted further.⁴ The supply of micronutrient-rich foods needs to be increased to combat widespread micronutrient deficiencies. In order to diversify the diet, priority should be given 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 the orange-fleshed sweet potato and a yellow cassava variety rich in Vitamin A developed by HarvestPlus, would be another option.⁵

In addition, reducing aflatoxin contamination of foods is necessary to improve food safety in Ghana. 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). Decreasing aflatoxin contamination in maize and groundnuts in Ghana is especially important because these foods are used to produce micronutrient-rich foods for the domestic market, such as groundnut products and fortified baby foods (Anim-Somuah et al., 2013a; Anim-Somuah et al., 2013b).

With regard to the regions, the nutritional deficiencies in the Northern region suggest that it should be a priority area for interventions and agricultural innovations. By contrast, indicators of child feeding, child undernutrition, and underweight in women already indicate quite a favorable situation in the Greater Accra region, whereas overweight and obesity are more prevalent there than in other regions.

Ghana is a member of the Scaling Up Nutrition⁶ 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 produced in Ghana include tubers (yams, cassava, and taro), maize and rice, groundnuts and other pulses, and plantains. Cocoa, oil palm and fruits (oranges, pineapple) are important export crops.

⁴ It may be worthwhile to pursue agricultural productivity increases for starchy staples in order to keep pace with population growth on the long run, alleviate poverty in disadvantaged regions (for example through improvements in rice value chains in Northern Ghana), reduce import dependency, and raise incomes through expanding exports or increasing the production of animal feed and raw materials for industrial use (such as starch from cassava).

⁵ See www.harvestplus.org/what-we-do/crops.

⁶ See scalingupnutrition.org/ for more information.

1.4.1 Production

Table 7: 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 (%)
Cocoa, beans	24.1	Cassava	41.6	Yams	20.6
Maize	15.2	Yams	18.4	Cassava	19.0
Cassava	13.0	Plantains	9.7	Plantains	11.7
Yams	6.3	Oil, palm fruit	6.2	Cocoa, beans	8.9
Oil, palm fruit	5.2	Maize	4.8	Maize	5.7
Plantains	5.1	Taro (cocoyam)	3.4	Taro (cocoyam)	3.5
Groundnuts	5.0	Cocoa, beans	2.3	Groundnuts	3.5
Pulses, nes	3.9	Oranges	1.7	Rice, paddy	3.1
Sorghum	3.4	Pineapples	1.7	Meat, game	2.5
Rice, paddy	3.1	Rice, paddy	1.5	Oil, palm fruit	2.4

Data: average 2012-2014, FAOSTAT, accessed 17 January, 2017

* Gross Production Value (constant 2004-2006 million US\$), data: average 2011-2013, FAOSTAT, accessed 17 January, 2017

Note: GIC value chains marked in red; nes refers to Not elsewhere specified

Table 8: Production and Yield Growth for Maize and Rice in Ghana

Years	Commodities			
	Maize		Rice (paddy)	
	Production (‘000 metric tons)	Yield Growth (%)	Production (‘000 metric tons)	Yield Growth (%)
1994	939.90	1.49	162.30	2.00
1995	1,034.20	1.50	221.30	2.22
1996	1,007.60	1.52	215.70	2.05
1997	996.00	1.53	197.10	1.67
1998	1,015.00	1.46	281.10	2.16
1999	1,014.50	1.46	209.80	1.99
2000	1,012.70	1.46	214.60	2.29
2001	938.00	1.32	253.20	2.88
2002	1,400.00	1.50	280.00	2.28
2003	1,289.00	1.63	239.00	2.03
2004	1,157.60	1.60	241.80	2.03
2005	1,171.40	1.58	236.50	1.97
2006	1,188.80	1.50	250.00	2.00
2007	1,219.60	1.54	185.30	1.70
2008	1,470.10	1.74	301.90	2.27
2009	1,619.60	1.70	391.40	2.41
2010	1,871.70	1.89	491.60	3.03
2011	1,684.00	1.65	464.00	2.35
2012	1,949.00	1.87	481.10	2.54
2013	1,764.50	1.72	569.50	2.64
2014	1,768.54	1.73	604.04	2.69

Source: Agriculture in Ghana Facts and Figures 2013, Ministry of Food and Agriculture Statistics, Research and Information Directorate (SRID).

Table 9: Area (ha) planted to some selected food crops of significance to the economy

Year	Maize	Millet	Rice	Sorghum	Cassava	Cocoyam	Plantain	Yam	Total
1999	697	186	105	312	640	372	253	243	2,808
2000	695	208	115	289	660	247	244	261	2,719
2001	713	193	135	329	726	262	265	287	2,910
2002	940	198	123	337	794	282	277	300	3,251
2003	792	207	118	346	807	277	286	321	3,154
2004	733	182	119	298	784	270	281	311	2,978
2005	740	185	120	305	750	255	290	300	2,945
2006	793	200	125	320	790	260	299	325	3,112
2007	790	163	109	208	801	258	305	324	2,958
2008	846	182	133	276	840	252	312	348	3,189
2009	954	187	162	267	886	225	325	379	3,385
2010	992	177	181	253	875	205	328	385	3,396
2011	1,023	180	197	244	904	206	339	404	3,497
2012	1,442	172	190	231	86	196	337	426	3,080
2013	1,024	161	216	226	875	194	340	422	3,458
2014	1,022	162	225	227	889	200	356	428	3,509
2015	881	162	233	228	917	200	363	430	3,414

Source: Statistics, Research and Information Directorate (SRID), Ministry of Food and Agriculture, Ghana.

GIC value chains marked in red

1.4.2 Trade

Rice accounts for more than 24% of Ghana's total import volume and just over 21% of the total import value. Sugar, wheat and chicken also represent an important share of imports. In export trade, cocoa, sugar and cashew nuts are the most important goods. Pineapple accounts for about 1.6% of the export volume.

Table 10: Ghana's imports

Import volume (tons)		Import value (US\$)	
Top 10	Share of Total (%)	Top 10	Share of Total (%)
Rice – total (Rice milled equivalent)	24.3	Rice – total (Rice milled equivalent)	21.2
Sugar refined	14.8	Sugar refined	11.3
Wheat	11.9	Meat, chicken	10.9
Meat, chicken	7.3	Wheat	6.9
Oil, palm	4.7	Oil, palm	6.4
Tomatoes, paste	4.4	Tomatoes, paste	5.4
Beverages, non-alcoholic	3.1	Beverages, non-alcoholic	3.6
Onions, dry	3.1	Milk, skimmed dried	2.9
Flour, wheat	2.6	Food prep nes	2.4
Pastry	2.0	Food prep, flour, malt extract	2.0
Rank 11: Maize	2.0	Rank 19: Maize	0.9

Data: average 2011-2013, FAOSTAT, accessed 17 January, 2017

Note: GIC value chains marked in red; nes refers to Not elsewhere specified

Table 11: Ghana's exports

Export volume (tons)		Export value (US\$)	
Top 10	Share of Total (%)	Top 10	Share of Total (%)
Cocoa, beans	47.4	Cocoa, beans	71.4
Cashew nuts, with shell	10.0	Cashew nuts, with shell	7.8
Oil, palm kernel	7.7	Cocoa, butter	3.8
Sugar refined	5.9	Oil, palm kernel	2.7
Oilseeds nes	4.4	Sugar refined	1.5
Oil, palm	3.5	Oil, palm	1.5
Sesame seed	2.6	Rubber natural dry	1.5
Cocoa, butter	2.0	Beverages, distilled alcoholic	0.8
Pineapples	1.6	Cotton lint	0.8
Beverages, distilled alcoholic	1.2	Pineapples	0.8
Rank 33: Maize	0.1	Rank 65: Maize	0.0
Rank 111: Rice – total (Rice milled equivalent)	0.0	Rank 126: Rice – total (Rice milled equivalent)	0.0

Data: average 2011-2013, FAOSTAT, accessed 17 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

The role of science, technology and innovation is now greater than ever before. This is due to the significance of agricultural research and investment, which will continue to be the prerequisite for any agriculture development program. The sector will continue to be key to improving food security, reducing poverty and sustaining broad-based economic development, despite the discovery of oil and gas in the country. Without sufficient and continued investment in agricultural research, there may be little reduction of food insecurity and poverty. It is therefore important that the agricultural research agenda responds to the needs and challenges of society.

1.5.1.1 International

Some international (agricultural) research institutions that are carrying out research activities or have research centers in Ghana include:

- International Food Policy Research Institute (IFPRI);
- International Institute of Tropical Agriculture (IITA);
- International Water Management Institute;
- Brazilian Agricultural Research Corporation;
- Africa Rice Center;
- International Fertilizer Development Center;
- FARA;
- Alliance for a Green Revolution in Africa

1.5.1.2 National

Innovation capacities in the agricultural and food sectors exist in the universities and the Council for Scientific and Industrial Research (CSIR). There are 13 research institutes under the CSIR, and the following play key roles in the agricultural and food sectors of Ghana:

- Animal Research Institute (ARI);
- Crops Research Institute (CRI);

- Forestry Research Institute of Ghana;
- Food Research Institute (FRI);
- Oil Palm Research Institute;
- Plant Genetic Resources Research Institute;
- Savanna Agricultural Research Institute (SARI);
- Soil Research Institute (SRI).

Other important national research institutes include:

- Cocoa Research Institute of Ghana;
- Biotechnology and Nuclear Agriculture Research Institute.

There are a number of research centers under the various public universities in Ghana. For instance, the University of Ghana has a Livestock and Poultry Research Centre, a Soil and Irrigation Research Centre and a Forest and Horticultural Crops Research Centre.

1.5.2 Innovation platforms

In Ghana, some efforts have been made to establish a number of innovation platforms (IPs) in the agricultural sector to promote innovative activities and ideas to help improve agricultural productivity and trade. These include IPs developed by the Forum for Agricultural Research in Africa's (FARA) Integrated Agricultural Research for Development (IAR4D). The IAR4D concept encourages all actors, organizations and institutions that are involved in the agricultural sector to interact and to jointly foster the development of the sector. Both the system and the commodity approach are used, and all actors along the commodity value chain are engaged. The IP is thus a forum for groups of relevant actors (including farmers, researchers, extension agents, traders, processors, financial institutions, policy makers, regulators, output market operators, consumers and others), selected along the value chain of a specific commodity or production system, to interact and learn from one another. This was specifically established to help improve the productivity of cereal/legumes, sheep and goats farming systems.

Two IPs, a Soybean IP and a Maize IP, were established under the IAR4D concept. The Soybean Cluster IP was established in 2006 as part of the International Centre for Soil Fertility and Agricultural Development's "From thousands to millions" project (2006-2011). It operates in the Wenchi-Techiman area in the Brong Ahafo region of Ghana to date. In its nine years of activity, the IP has achieved the following: Value chain linkages and peer learning were strengthened; access to credit was improved; production and yields have increased through the introduction of new varieties and better practices; quality has improved; and the economic situation of many farmers improved. There have been problems with establishing trust along the value chain because of "side selling" activities. This hinders scaling up activities.

Another IP is the Dissemination of New Agricultural Technologies in Africa (DONATA). This IP was led by the CSIR's CRI and has been active on the ground for three years. An IP was set up for the **cassava** value chains in each of the five communities in the Wenchi municipal assembly of the Brong Ahafo Region: Wenchi, Amponsakrom, Nkonsia, Wurompo and Ayigbe. This was done in collaboration with the CSIR, Ministry of Food and Agriculture (MoFA), African Agricultural Women in Development and CSIR-INSTI RAILS Project. Stakeholders who participated included the farmer groups, agribusinesses, public and private extension service providers, researchers, policy makers and the media. The IPs successfully facilitated farmers' access to new cassava varieties. Improved husbandry practices were introduced and will be promoted by the established "Good Practice Centre". Overall, the cassava yields increased significantly in the region, and farmer interaction and peer learning increased.

In 2011 the Volta Basin Two Project IP (focusing on innovations on rainwater management) was set up in Digu and in Golinga, both of which are in the Tolon-Kumbungu district of the Northern region, and

Program of Accompanying Research for Agricultural Innovation (PARI)

Naburinye and Orbilli, which are in the Lawra district of the Upper West Region. It was funded by the Netherlands Development Organization (SNV) and set up by CSIR-ARI along with the Agricultural and Environmental Research Institute and the University of Wageningen - Plant Production Systems. A multitude of stakeholders were involved and discussed how to improve the Value Chains in the Volta Basin. To date, the achievements of the IP include enhanced productivity, increased interaction and knowledge sharing, improved access to information and increased use of best practices.

In the Atebubu/Amantin district the Nyame Na Aye crop and small ruminants IP started activities in 2011. It was established by CSIR-CRI and funded by the Australian department of foreign affairs. Farmers (crops and livestock), extension officers, researchers and local authorities jointly addressed the challenges in fodder production and the limiting factors along the value chain. Another IP related to this area was founded in 2011 in Wulugu in the West Mamprusi district in the Northern Region, with the goal of registering it as a seed producing company.

Eight National Agricultural Research and Extension IPs were set up across Ghana and Benin (in the sub-humid agro-ecology) and in The Gambia and Mali (in the semi-arid agro-ecology) of West Africa. The IPs covered innovations on crops (cereal/legume) and small ruminants (sheep/goats) farming systems. From 2011 to 2015, the IPs addressed various limiting factors. A legume seed system was established, the capacity of animal health management systems was improved, and a policy intervention improved the marketing of the sector.

The Convergence of Sciences-Strengthening Innovation Systems (CoS-SIS, 2008-2013) program also established two IPs, an Oil palm IP, which was active from 2008-2013, and a **Cocoa** IP. These were initiated as part of a larger research programme, which was implemented by the University of Ghana along with other universities in Mali and Benin. Technical backstopping was provided by Wageningen University in the Netherlands. The oil palm IP was set up to support improvement in the quality of palm oil. An exploratory study showed that one of the main challenges faced by producers was a lack of or inadequate access to remunerative markets, due to the low quality of their palm oil. Included among the platform actors were the Ghana Standards Board and the Environmental Protection Agency. The platform was organized at the local level, where experimentation takes place with small-scale processors. It aimed to improve smallholder processors' oil processing practices as well as to gather evidence and information to feed into the higher-level platform. Success was achieved in gathering knowledge and increasing the understanding of the causes for poor oil quality, but the IP failed at forming a higher level platform with people from different organizations to further promote these principles.

Three rice innovation platforms were recently established by the Africa Rice Center in collaboration with CSIR-SARI.

The West Africa Agricultural Productivity Project IPs focuses on the development of technologies for dissemination. For example, good agronomic practices, soil fertility and weed management techniques, and improved varieties have been developed for roots and tubers such as yam, cocoyam and cassava. One major outcome of the technology dissemination was that women have especially been encouraged to commercialize the production of yam planting materials. The platforms have also enhanced farmer-to-farmer learning, which is building the confidence levels of actors along the commodity value chain.

Another IP is the *Climate Change, Agriculture and Food Security (CCAFS) Science Policy Platform*, active since 2012 in several participating villages nationwide. This IP was established by the CSIR-ARI to address the effects of climate change and climate variability on growing food insecurity and environmental degradation. It aimed at strengthening climate change adaptive capacity and fostering dialogue among farmers, researchers, local governments, Non-Governmental Organizations (NGOs) and policy makers. The outcomes would then be used to inform decision making at both the local and national levels on specific climate change issues. This should reduce overall vulnerability and enhance food security and the resilience of agricultural development. This platform employs a diversity of actors

for dialoguing. These include institutions, farmers, NGOs, policy, research, the media and donor partners. Key outcomes from the platform include:

- (i) baseline on climate change adaptation conducted in two districts in the CCAFS sites,
- (ii) six partners identified and engaged with for community-based adaptation,
- (iii) a climate change adaptation committee established at the Lawra-Jirapa district site,
- (iv) policy level outputs/outcomes,
- (v) validation of the Ghana climate change vulnerability document for the Cancun conference,
- (vi) research policy consultation (better insight of local gaps and strengths) and launch of the CCAFS Platform with support from 3 ministers, and 2 ministries, departments and agencies' general directors,
- (vii) information shared on CCAFS at the national level, informing policy, Research and Development (R&D) and good practices (climate-smart practices) at the community level.

Challenges encountered included:

- (i) using an integrated systems approach,
- (ii) identifying market opportunities,
- (iii) balancing endogenous versus exogenous development,
- (iv) community CCAFS scenarios development,
- (v) creating institutional incentives for policy learning and capacity strengthening,
- (vi) access to Information and Communication Technology (ICT) (weather forecasting, pricing tracking, etc), and
- (vii) mainstreaming Gender issues.

Awareness of the health effects of aflatoxin contamination is low in Ghana (Florkowski and Kolavalli, 2014). The Ghana Aflatoxin Management IP was established in 2015 by FARA to raise awareness about the aflatoxin problem and to find solutions, especially in the groundnut and maize value chain. Participating villages are Techiman and Nkoranza (Brong Ahafo region), Ejura (Ashanti Region) and Gomaa Aabaasa (Central Region). The initial focus of the IP is to raise awareness, find mitigation measures and train trainers. Demand and supply for aflatoxin-safe products also needs to be stimulated and monitoring and evaluation systems developed and implemented.

Aflatoxin-free foods could be supplied to caterers for Ghana's School Feeding Program and to producers of baby foods and Ready-to-Use Therapeutic Foods (RUTFs)⁷. The Global Alliance for Improved Nutrition (GAIN) aims to partner with a multinational company to produce RUTF and supplementary food products in Ghana, thereby stimulating demand for aflatoxin-free groundnuts (Anim-Somuah et al., 2013a). Hilina, an Ethiopian food-processing company, worked with local farmers and enabled them to produce aflatoxin-free groundnuts that could be used as ingredients for RUTFs. Farmer incomes from groundnuts quadrupled, and the company was able to avoid expensive imports by procuring locally produced groundnuts at a reduced cost (Jones, 2011). Such an integrated, whole value chain approach is considered best practice to address the problem of aflatoxin contamination (Anim-Somuah et al., 2013b).

1.5.3 Extension system and organizations

Agricultural extension in Ghana has gone through a number of political shifts, from a focus on export commodity development prior to independence in 1957, to the promotion of food crop production. These shifts have been motivated by the intention to modernize traditional farming practices, transfer resources and technology, and train personnel to address extension needs of peasant farmers.

⁷ RUTFs are energy-dense, fortified processed foods that were developed for treating severe acute undernutrition.

Program of Accompanying Research for Agricultural Innovation (PARI)

The agricultural extension approaches in Ghana include top-down commodity-based approaches; Training and Visit, participatory approaches, such as farmer field schools; the innovative Information and Communication Technologies based approaches, which provide online advice to farmers; and the promotion of mobile phones and community radio stations. These approaches have been promoted over the years by the various extension service providers, including government (MoFA, the main actors in extension), NGOs, and farmer organizations.

For many years, MoFA has used its staff from the national level down to the field level to implement extension programs. As decentralization has led to the transfer of power to the district level offices, MoFA transferred resources, including staff, to district offices. This transfer lowered the level of involvement of the ministry and the number of technical staff required for coordination activities.

Research-extensions linkages were strong and innovations were widely adopted in the projects supported by the Ghanaian government and its agencies, with the help of development partners, donor agencies and NGOs. On the other hand, extension services were inadequately delivered for unsupported innovations (e.g. in livestock farming). In many areas, the number of extension officers is limited, and female farmers, in particular, receive fewer extension services than male farmers. Therefore, there is need to integrate methods and resources for technology adoption and dissemination into the designing of development projects (Ampadu-Ameyaw et al., 2016). Below are some of the institutions offering agricultural extension in the country:

1.1.1.1 Public Extension Institutions:

- MoFA
 - Directorate of Agricultural Extension Services;
- Ministry of Environment Science and Technology
 - CSIR;
- Ministry of Local Government and Rural Development
 - Regional Coordinating Council
 - Metropolitan and Municipal District Assemblies.

1.1.1.2 Public Research and Education Institutions:

- Agricultural Science and Technology Indicators Agricultural R&D
 - CSIR;
- Sasakawa Africa Fund for Extension
 - University of Cape Coast
 - Kwadaso Agricultural College;
- Cocoa Research Institute of Ghana;
- CSIR
 - Water Research Institute
 - Soil Research Institute
 - Savanna Agricultural Research Institute
 - Plant Genetic Resources Research Institute
 - Oil Palm Research Institute;
 - Forestry Research Institute of Ghana
 - Food Research Institute
 - Crops Research Institute
 - Animal Research Institute;
- Kwame Nkrumah University of Science and Technology;
- University of Development Studies;
- University of Ghana
 - Institute of Statistical, Social and Economic Research and Faculty of Agriculture.

1.5.4 Private research and development activities

Ghana is part of the *Grow Africa Partnership*, which works to increase private sector investment in agriculture. The private sector in Ghana has always joined forces with state institutions in order to establish an effective system of information delivery to farmers. In most cases, private sector performance has been above average, especially in the case of input supply to farmers. As a result, a number of PPPs in commercial agriculture have been developed, e.g. SADA. Some private agencies offering extension to farmers include Africa Atlantic Holdings, Agriaccess Ghana Ltd., Amantin Agro Processing Co. Ltd., Okata Farms and Food Processing and several agro-chemical dealers (e.g. Dizengoff, Agrimat, Chemico, Aglow, Kurama Co. Ltd.).

In addition to the state organizations and institutions providing extension services to farmers, some NGOs have established great reputation for assisting both governments and farmers in the production, processing and marketing of agricultural commodities through extension and other agricultural advisory services. Examples of NGOs and programs working directly in the agricultural sector and local extension services include Africare, CARE International, Christian Relief Service, HarvestPlus, Presbyterian Agricultural Services, Finatrade, and ActionAid.

Aside from the organizations listed above, farmer-based organizations (FBOs) have also been involved in agricultural extension in the country. In Ghana, farmers have the tradition of organizing themselves at local level into membership-based entities (associations, unions, cooperatives or networks), which are mainly organized around a common interest, such as the production and marketing of a given agricultural commodity. These types of organizations assist farmers in various ways, including facilitating the pooling of their resources and facilitating access to credit and farm inputs. Although group formation has the potential to strengthen farmers bargaining power in the market place, most FBOs in Ghana are weak in terms of financing and organization. Some major groups of farmers' organizations in the country include traditional associations/groups, multipurpose associations/groups, informal contact groups, co-operatives and national farmers' organizations⁸.

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

The key challenges faced by the agriculture sector in Ghana include:

- Reliance on rainfed agriculture, little and relatively inefficient irrigated agriculture;
- Low level of mechanization in production and processing;
- High post-harvest losses as a result of poor post-harvest management;
- Low level and ineffective agricultural financing;
- Poor extension services as a result of several institutional and structural inefficiencies;
- Lack of ready markets and processing channels;
- Low performing breeds of livestock; poor livestock feeding practices; high cost of feed for poultry;
- Poor livestock housing and husbandry management; competition from imports and poor post-production product management;
- Over-fishing of natural waters; undeveloped fish value chain (e.g. inadequate supply systems for fingerlings and feed) and lack of skills in aquaculture;
- Limited exploitation of potential income-generating production systems;
- Low levels of income from cash crop production for men and women smallholder farmers;
- Low integration of commodity markets (disjointed value chains with in most agricultural commodities);
- Customary system of land tenure (MoFA, 2010).

⁸ www.g-fras.org

Emerging needs include:

- Ensuring sustainable land management and environmental sustainability to mitigate the impacts of climate change. Otherwise agricultural production will be affected.
- Emphasis on integrated soil fertility management to increase soil productivity.
- Encouraging youth participation in agriculture to create job opportunities for young people and help address the widening unemployment challenges in the country.

1.7 Potential areas for investment in Ghana

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 Ghana⁹:

Expected agricultural growth performance:

- Ghana has increased its agricultural growth by more than the annual 6% agricultural growth target defined by CAADP in only two of the years between 2005 and 2014¹⁰.
- However, Total Factor Productivity (TFP) in Ghana had improved by 16% between 2001 and 2008 (Fuglie and Rada, 2011), indicating that Ghana's innovation performance is above the sub-Saharan African average.

Government commitment:

- Ghana has a track record of political commitment to foster sustainable agricultural growth by being active in the CAADP process and having completed seven of the eight steps in the CAADP process¹¹.
- Ghana only spends 0.6% of its agricultural GDP on agricultural R&D, which is lower than the Sub-Saharan Africa average¹² and the AU's 1% target. This indicates that Ghana's investment on agricultural innovation is not yet sufficient.

Food and nutrition security progress and need:

- Ghana is modestly prioritizing actions for hunger and undernutrition reduction and shows a 10 percentage point improvement in undernourishment between 2001 and 2011 (FAO, 2014).
- Ghana has a Global Hunger Index (GHI) score of 13.9 reflecting a moderate level of hunger (von Grebmer *et al.*, 2014)¹³. This makes investment into the agricultural and food sector in

⁹ Details on the data sources and methodology used in the assessment can be found in Husmann et al. (2015)

¹⁰ www.resakss.org

¹¹ www.resakss.org

¹² www.asti.cgiar.org

¹³ GHI scores less than 10.0 reflect low hunger, scores from 10.0 to 19.9 reflect "moderate" hunger, scores from 20.0 to 34.9 indicate a "serious" level of hunger, scores from 35.0 to 49.9 are "alarming," and scores of 50.0 or greater are "extremely alarming" (von Grebmer *et al.*, 2016).

Ghana less urgent to reduce child mortality, the proportion of undernourished people, and wasting and stunting in children.

Table 12: Ghana Performance Indicators

Indicators	Indicator score	Overall score
1. Number of years with more than 6% agricultural growth (2005 to 2014)	2	20
2. Percentage point change in Total Factor Productivity (TFP) index between 2001 and 2008	16	100
3. Number of years with more than 10% government expenditure in agriculture (2005 to 2014)	0	0
4. Average share of agricultural GDP spent on R&D (2005 to 2011) in %	0.6	62
5. Steps in CAADP completed	7	88
6. Percentage point improvement in undernourishment between 2001 and 2011	10	60
7. Global Hunger Index score (2016)	13.9	0
Total score (weighted)		47

Data source: Husmann et al (2015)

Note: TFP refers to Total factor Productivity

In summary, the economic, political, and social/nutrition framework in Ghana does not seem to suggest a need for accelerating investment into the agricultural and food sector of the country. Nonetheless, the potential of food-based approaches to combat widespread micronutrient deficiencies, such as vitamin A deficiency and iron deficiency anemia, and rising levels of overweight and obesity in Ghana should be further explored (see Table 3 and Figure 4). Regional disparities that lead to micronutrient-poor diets and higher levels of undernutrition and anemia in the Northern region should also be taken into account when targeting investments (see Tables 4-6 for nutrition data by region).

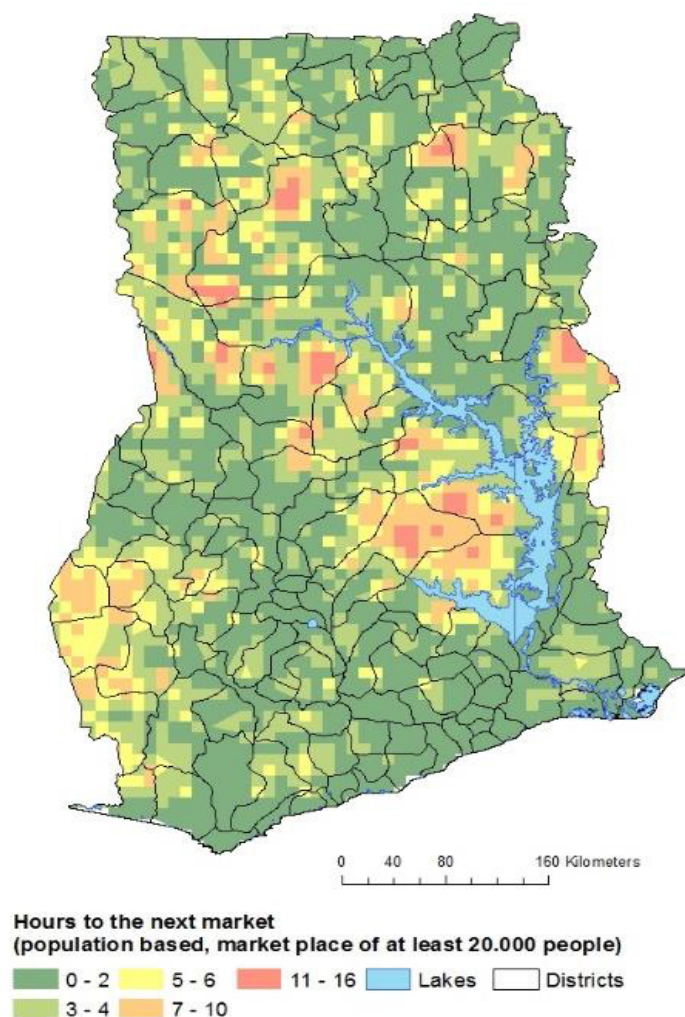
The areas of potential in Ghana's agricultural sector include:

- Production and export of non-traditional agricultural commodities, such as pineapple, yam, banana, fish, cashew, mango and papaya;
- Growing demand for guinea fowl meat nation-wide and the high potential for increased production;
- Urban and peri-urban agriculture;
- Aquaculture;
- Irrigation;
- Agro-processing;
- Opportunities to increase incomes from cassava, with growing interest in the use of cassava in different industries, e.g. exporting starch to the international market;
- Private sector participation (MoFA, 2010).

Based on this approach, investments into the agricultural and food sector of Ghana can be expected to have only modest effects on food and nutrition improvement in the country. However, indicators of micronutrient deficiencies and over-nutrition are not included among the country-level performance indicators, and the present approach neglects the potential of the agriculture and food sector to help solve these nutrition problems by providing micronutrient-rich and low-energy foods.

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 Ghana.

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 Ghana

2.1 GIC-value chains

2.1.1 Maize

Maize is Ghana's most important cereal crop and is grown by the vast majority of rural households. It is widely consumed throughout the country, and it is the second most important staple food in Ghana, next to cassava. It accounts for 55% of total grain production (Angelucci, 2012). It is grown in all regions of Ghana. In 2011, production was highest in the Brong Ahafo region, which accounted for 27% of national production, followed by the Eastern (20%), Central (12%), Ashanti (12%), and Northern (11%) regions (Ragasa *et al.*, 2013a). Average yield is 1.9 tons/ha and potential yield is 6 tons/ha. About 57% of total production is consumed directly by farm households, about 30% is traded either formally or informally, and about 13% is used for animal feed in the poultry industry (Ragasa *et al.*, 2013a). More than 20% (1 million) of smallholder households gain their primary income from the production of maize (WABS consulting 2008).

2.1.2 Rice

Rice is the second most important cereal crop, after maize. Paddy rice accounts for 23% of total grain output. Production of rice is highly prioritized by the Ghanaian government in order to reduce imports, and the agricultural development plans and strategies have featured rice as one of the targeted food security crops. In order to increase productivity, the National Rice Development Strategy (NRDS) was established in 2009. The majority of local rice production comes from the Northern (37%), Upper East (27%), and Volta regions (15%) (Ragasa *et al.*, 2013b). Average rice yield in the country is estimated at 2.5 tons/ha, whereas the achievable yield is 6.5 tons/ha (Ragasa *et al.*, 2013b). Due to the continuous increase in rice consumption, the NRDS aims to double rice production by 2018 with 10% annual increase. Imported rice has a better quality, better taste and appearance, and is long-grain perfumed; it is priced 15-40% higher than local rice. To support the rice value chain in northern Ghana, MoFA is currently implementing the Rice Sector Support Project in collaboration with the French development agency, l'Agence Française de Développement.

2.2 Other relevant value chains

The other relevant value chains besides those selected for the GICs are discussed in this subsection. The 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 share of area cultivated (harvested), production volume, and trade importance (import and export).

2.2.1 Cocoa

Cocoa makes up the biggest share of total area harvested in Ghana with 24.1% of total cultivated area (see Table 7). It has high trade potential, with a Revealed Comparative Advantage (RCA) index as high as 61 (see Table 13). The cocoa value chain consists of few actors, whose activity spans from the local to the international level. The key actors at the local level include farmers, the National cocoa board, COCOBOD, produce buying companies, haulers, warehousing and logistic service providers, domestic chocolate manufacturers, domestic grinders, distributors, retailers and local consumers. At the international level, some of the key actors along the chain are multinational brokers/traders, shipping companies, international warehouses, international grinders and manufacturers, and international. Similarly to most of the food crops in Ghana, cocoa is mainly farmed by smallholders. The COCOBOD fixes the price of the beans locally, and this price uniformity allows farmers all over the country to benefit equally (that is, if transportation costs are not taken into account). However, in Ghana, farmers have the advantage that there are a large number of local buying companies (LBCs) to choose from, and as such, farmers tend to choose LBCs that offer cash and credit facilities. Ghana's strategy is to encourage secondary and tertiary processing in the country since local processing will add more value to the product along the chain (Kolavalli and Vigneri, 2011). First stage processing into butter and liquor is only 5% of the final value added. Further processing to liquid chocolates is about 10%, and the final manufacturing and retailing constitutes 74% of the processing. Ghana has a considerable grinding capacity of about a third of local production. Recently, the capacity was enhanced with an aggregate investments of US\$ 300 million, equivalent of 400,000 metric tons. Capacity utilization is close to 60%. The industry states that it has created an estimated value of US\$ 56.31 million in 2011 from the US\$ 18 million it received in incentives, through utility revenues, job creation, capacity building, business opportunities and tax revenues.

2.2.2 Cassava

Cassava is a starchy root crop. Cassava leaves do not have a market value in Ghana since they are not consumed as a vegetable (Angelucci, 2013). Cassava can be considered a primary crop for food security in Africa due to its resistance to drought and plant disease and its flexible planting and harvesting

cycles. Cassava constitutes about 22% of Ghana's agricultural GDP and is one of Ghana's main staple crops. It is the largest food supply crop with over 6 million tons and provides on average 700 kcal per head per day (FAOSTAT, 2016). In terms of area harvested, cassava is now the third largest food crop after cocoa beans and maize, occupying 13% of harvest land. It is also the crop with the highest production value, representing 41.6% of total production value (see Table 7). According to the World Bank, Ghana's cassava value chain is still in its infancy (World Bank, 2009). Emerging growth opportunities, however, can be identified with reference to different cassava-derived products (Angelucci, 2013). The three most common products from cassava are (i) *gari* (ii) starch and (iii) dried chips for export, and (iv) cassava flour for the preparation of a local food, *Konkonte* or bread.

a. *Gari*

Ever since mechanical graters were introduced to prepare *gari* in the late 1990s, cassava has increasingly been produced and processed as a cash crop for urban consumption (Angelucci, 2013). The largest food processing enterprises, whose products include *gari* and cassava flour, employ about 20 to 50 workers. These enterprises have modernized the traditional processing technologies through the adoption of better manufacturing processes in production (Angelucci, 2013). The upgrade of processing technologies in Ghana was possible due to the public-private partnerships between private sector institutions engaged in business promotion and agro-industrial research.

b. Starch

The production of cassava for industrial starch was implemented in Ghana under the Presidential Special Initiative on Cassava Starch. Through this initiative, the concept of Corporate Village Enterprise, functioning as a limited liability company with farmers and strategic investors as shareholders, was established. Furthermore, farmers were organized in associations to ensure the sustainable production of cassava for the Ayensu starch company, created in 2004. However, cassava is a major food crop in the country and it has alternative market outlets other than the industrial starch market. Therefore, farmers could choose to sell to the Ayensu Starch Company or not, depending on price relativities on the different outlets. This situation led to problems both for the supply and demand sides (Angelucci, 2013). The starch company was shut down in January 2008 due to the inability to operate at its full capacity as the supply of fresh cassava by farmers declined. Furthermore, the variety produced for the starch industry had higher starch content. Hence, it was not very suitable for traditional processing. Consequently, buyers for traditional processing paid lower prices for the produce (Angelucci, 2013).

c. Chips

Ghana has several cassava processing plants, particularly in the Brong Ahafo, Ashanti and Eastern Regions of the country, and this makes mechanized cassava processing a common activity in the country. Due to high transport costs for raw fresh roots, a majority of farmers manually produce chips or through on-farm processing using chipping machines. In Ghana, the export companies are the sole buyers of cassava chips, and they establish the chipping/buying centers in the producing districts. Hence, in the case of cassava chips for the export market, there is no wholesale market, since the exporter deals directly with the many smallholder farmers and small scale processors to obtain adequate volumes of chips for exports. Obtaining adequate volume of chips for export is also essential in order to make internal transport costs affordable for the exporters (Angelucci, 2013).

2.2.3 Yam

Yam is the second most important among the root and tuber crops and contributes about 16% to agricultural GDP (Anaadumba, 2013). It is currently the fourth leading staple crop in terms of area harvested (6.3%) after cocoa, maize and cassava, but it is the most important crop in terms of production value (20.6%) (see Table 7). Yam production thrives in the deciduous forest, transitional and northern savannah agro-ecological zones. Most prominent producing areas include the Brong Ahafo (39% of total production), Northern (25%) and Eastern Regions (12%) (Anaadumba, 2013). The share of total food supply in tons of yams amounts to 15%, which makes it the second most supplied crop. Yam consumption is estimated at 148.5 kg per capita and year (FAOSTAT, 2016), and it is

undoubtedly an important energy source in the Ghanaian diet. Yields per hectare are slightly higher than for cassava and significantly higher than for taro. The contribution of yams to farmer and trader income as well as food security could be further increased given the right support and improvements in the production and marketing process (Kenyon et al., 2000).

On the international market, there is high demand for the Ghanaian yam. As a result Ghana is the largest exporter of yam, although the volume of exports represents an insignificant amount of total national yam output. About 90 percent of the country's yam exports go to the United Kingdom, the United States and the Netherlands because of high demand from the large Ghanaian and West African population in these countries (Anaadumba, 2013).

Yam can also be processed into secondary products such as flour. According to Anaadumba (2013) the yam value chain is less developed compared to rice and maize value chains. Although the opportunity to increase production exists, the unavailability of improved yam seeds significantly hinders yam production. The use of local planting materials results in lower productivity. Additionally, the yam value chain is affected by post-harvest losses (Anaadumba, 2013).

2.2.4 Plantain

Plantain is the third most consumed food crop in Ghana, measured in kg, after cassava and yam. It constitutes over 3.2 million tons of food supply and provides over 300 kcal per capita per day (FAOSTAT, 2016). The total demand is met fully by local/domestic production. In fact, Ghana has been exporting plantains since the early 2000s (Robinson and Saúco, 2010). There has been a decline in plantain production in less fertile regions and struggles with yield declines and reduction in plantation life prior to 2000 (Schill et al., 2000). Data from the MoFA shows that the cultivation area for plantains has been steadily increasing since then (see Table 9). Plantain production is confined to the forest areas of the country due to their favorable agronomic conditions. Ghana ranks first in terms of plantain production in West Africa and third in Africa, after Uganda and Rwanda (Dzomeku et al., 2011). The average plantain yield is 10.5 tons/ha, about half of its achievable yield. Schill et al. (2000) showed that farmers identified decreasing soil fertility, the high cost of labor for weeding, pests and diseases, lack of good quality planting material and marketing-related issues as the major production constraints. Further nematodes and the foliar disease, black sigatoka, can cause extensive damage to plantain plantations, though underestimated by the farmers. Fertile soils has a decreasing effect on pest damage. The study recommends integrated pest management, practiced within the context of cropping systems management, as an effective solution (Schill et al., 2000; Robinson and Saúco, 2010).

Plantain accounts for about 13.1% of agricultural GDP (Dzomeku et al., 2011). It is one of the commodities that Ghana exports mainly to the United States and the European Union. Products derived from plantain include plantain chips and plantain flour for the preparation of local food called plantain fufu. The production of plantain chips presents opportunities for stakeholders in this sub-sector, as it has value on the domestic as well as export market. Plantain chips are already consumed on the domestic market, offering income generating activities for producers and vendors.

2.2.5 Palm oil

Oil palm ranks among the top ten crops produced in Ghana occupying 5.2% of the total harvested area and representing 6.2% of the total production volume (see Table 7). It is native to West Africa and mainly cultivated in Côte d'Ivoire, Ghana, Nigeria and Sierra Leone, the latter being a major producer of both palm oil and palm kernel oil. Yet, the reliability of the supply of palm oil is hampered by internal marketing and supply-side constraints, as well as by subsidies for commercial production and food aid imports of competing vegetable oils, which have dramatically reduced the domestic availability of Ghanaian palm oil. However, consumption of palm oil and other palm products is projected to increase with the increase in population of consuming countries. Statistics show that production of palm oil now

accounts for 37% of the total global output of oilseeds, overtaking soybean oil as the leading vegetable oil. Ghana imported about 112,000 metric tons of vegetable oil in 2010, of which almost 45% was palm oil (crude and refined). Thus, there is the opportunity for Ghana to develop the oil palm industry to meet the increasing market interest in oil palm products.

2.2.6 Groundnut

Groundnut is the most important legume crop in Ghana, contributing to food and nutritional security. It is the main source for vegetable protein in Ghanaian diets (Angelucci and Bezzucchi, 2013). Like tree nuts, groundnuts are a good source of many micronutrients (B-vitamins, vitamin E, iron, zinc, etc.) and healthy fatty acids. Aside from being consumed by households, the crop represents a source of income for farm households. It is also used in preparing animal feed in the livestock industry. The three regions of the North (Northern, Upper East and Upper West) account for 94% of the groundnut produced in Ghana. Groundnut is therefore considered a strategic crop because growth in this subsector significantly reduces poverty in the Northern part of Ghana (Angelucci and Bezzucchi, 2013). According to the Science and Technology Policy Research Institute (STEPRI) (2008), groundnut yields in Africa are far below the world average due to several constraints limiting productivity of the crop. In Ghana, the average yield is 1.4 tons/ha, compared to achievable yields of 2.5 tons/ha. Opportunities exist to close this gap through good crop management practices and through the use of improved varieties with desirable traits such as higher yields, early maturity and resistance to leaf spot diseases. Ghana is self-sufficient in the production of groundnut. According to MoFA's food balances, the supply of groundnut far outperformed domestic demand in 2012/2013, resulting in a surplus of about 116,580 tons (MoFA, 2013). Because supply exceeds the country's demand, groundnut is also exported to the international community, mainly to African countries such as Niger and Burkina Faso.

2.2.7 Cowpea

According to the Bulletin of Tropical Legumes (BLT), cowpea is the second most important leguminous crop after groundnut in Ghana (BLT, 2012). Ghana is ranked fifth largest producer of cowpea, and it records the fastest cowpea growth rates on the continent (BLT, 2012). Cowpea is mainly cultivated in the savannah agro-ecological zones of Northern Ghana. The average yield is 1.3 tons/ha, which is half of the achievable yield (MoFA, 2013). It is an important source of protein in the diet of Ghanaians. Protein content is about 23-25%. The average person in Ghana consumes about 9kg of cowpea per year (BLT, 2012). Cowpeas can also serve as fodder for farm animals. Demand for cowpea is increasing due to rapid growth in population, especially urban population. This demand is met by increases in domestic production. Ghana's 2012/2013 food balance indicates that domestic supply exceeded the estimated total needs, leaving a surplus of 60,215 Mt (MoFA, 2013). The production of cowpea comes with the additional advantage of improving soil fertility. This is because, as a legume, it fixes nitrogen in the soil, leading to increased soil productivity, and thus reducing fertilizer usage.

2.2.8 Soybeans

Soya is also produced by smallholder farmers under rainfed conditions. Under these subsistence methods, soya yields average only 0.8 metric tons per hectare. This is despite the fact that demonstrated soya yields are as high as 4.5 metric tons per hectare under the best commercial agricultural practices in Ghana. Crop rotation of soya with maize on commercial farms in Ghana will improve fertility on fields that rotate between multiple crops per year. Although current production and consumption data for soya are not readily available, the FAO estimates that Ghana imported between 2,700 and 7,826 metric tons of soybean oil alone annually between 2001 and 2007. Increasing soy production will substitute soybean oil imports. The soybean meal that remains after oil extraction can be used as animal feed.

According to Hammond (2014) the expansion of soy production is facing challenges due to a partly negative perception of soy products within the population. Processed soy products are in higher demand than raw soy beans, as they are seen as convenient, tasty and relatively cheap, compared to alternative products. They are mainly demanded by health conscious households, older consumers and those with higher education and high income. Target group-tailored marketing campaigns will have to go hand-in-hand with the expansion of soy production (Hammond, 2014).

2.2.9 Vegetables

GhanaVeg believes that vegetable exporters, processors, wholesalers and retailers can become key drivers of change for improving the productivity of vegetable production and the quality of vegetables in Ghana. Closer arrangements between the chain actors in terms of contracting, service provision and certification can boost the reliability and quality of the vegetable supply to the high-end domestic and export markets. Target vegetable crops include: tomatoes, onions, capsicum, okra, eggplant, other Asian vegetables and members of the Cucurbitaceae family (cucumbers, squash, butternut and melons). GhanaVeg is continuously issuing calls for proposals to strengthen the vegetable value chain in Ghana (ghanaveg.org/).

Besides the high-value market potential, improving the vegetable supply is especially important for poor consumers, considering that they have lower-than-average dietary diversity and that micronutrient deficiencies are more prevalent among them. About 46% of children aged 6-23 months in the highest wealth quintile achieved minimum dietary diversity on the previous day, while this number was only 17% in the lowest quintile (Ghana DHS, 2014). Anemia prevalence among children is almost 80% in the lowest wealth quintile and lower than 50% in the highest quintile.

2.2.10 Fruits

The domestic market for fresh fruits and fresh juice in Accra was estimated at US\$ 402 million in 2011, representing 17% of total non-traditional exports. Out of all the fresh fruits, oranges are preferred in the metropolitan area, followed by pineapple, mango, watermelon and pawpaw, and demand is growing at a rate of 100% per annum. The African Development Bank's Export Marketing and Quality Awareness Project was set up to address the marketing challenges of horticultural produce and to introduce new fruits and vegetables for both the local and external markets. One critical factor that could reduce the performance of the sub-sector is a lack of basic infrastructure, such as sheds, cold rooms and packing areas. It has also been noted that about 90% of market women consider post-harvest and food safety education in the markets a major challenge, and they called on all stakeholders to step up their efforts in that direction.

2.3 Promising agricultural products and value chains

In addition to assessing the returns on investments into institutional innovations in Ghana, 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 five most promising value chains based on the RCA index, average yield growth and relevance of crop is reported in Table 13 below. The production share, RCA index, actual yield growth and relative yield gap for the GIC 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.

Results of assessment (Table 13):

- The trade potential (RCA index) is above 1 for cocoa beans, cashew nuts, coffee, Pineapples and vegetable oil. This indicates that Ghana has a comparative advantage (in the export) of these commodities. The RCA value for the other GIC-selected crop, maize, is less than 1, indicating that Ghana has a comparative disadvantage on the export of this commodity. The other GIC value chain products are not exportable;
- The yield performance indicating progress suggests that over the CAADP period (2005 to 2012) pineapples, coconuts, oranges, dry beans and ground nuts were the five most promising crops¹⁴. The yield level of the other two GIC selected value chains, maize and rice, increased at a low rate only over the period under consideration;
- The yield gap is observed to be high for rainfed millet, rainfed rice, rainfed maize and irrigated rice, which indicates a high potential return on investing in these value chains;
- The leading crops in terms of relevance (production share of supply) are plantains, millet, sorghum, sweet potatoes, roots, and maize. The total supply of these products is domestically met.

In the future, the nutritional value of foods and their potential to close the main micronutrient gaps in Ghana should also be considered for value chain selection. Vitamin A deficiency and anemia are widespread among preschool children (see Table 3).¹⁵ Emphasis should therefore be placed on animal-source foods that are rich in iron and vitamin A (meat, especially organ meat, fish, poultry, and eggs) and on plant foods that are rich in vitamin A (dark green leafy vegetables, red palm oil, and yellow or red fruits; vegetables, roots and tubers, such as mango, papaya, carrots, pumpkin, red or yellow yams or squash, vitamin A-rich cassava and orange-fleshed sweet potatoes). Consuming fruits and vegetables rich in vitamin C (e.g. plantains, oranges, pineapples, peppers, cabbage, tomatoes, and most leafy vegetables) has the additional benefit of increasing iron absorption from other foods.

Partly replacing starchy staples in the diet with pulses (e.g. cowpeas and soybeans), groundnuts or tree nuts (cashew nuts) would contribute to a more nutritious and diversified diet. Moreover, promoting the consumption of micronutrient-rich, low dietary energy foods, such as most fruits and vegetables, lean meat and fish, could also help balance energy intakes and thereby counteract further increases in overweight and obesity.

¹⁴ However, it should be noted that the extremely high average pineapple yield growth rate is due to a massive increase in yield between 2010 and 2011 (from 52,632 Hg/ha to 561,224 Hg/ha) with only a small area expansion (from 9,500 ha in 2010 to 9,800 ha in 2011). The pineapple yield has steadily increased at a modest rate of 6% since 2011.

¹⁵ Since dietary diversity is low, it is likely that vitamin A deficiency and iron deficiency anemia coexist with other micronutrient deficiencies for which no data exist. Iodine deficiency is also a public health problem in Ghana, but it is not discussed in the context of agricultural value chains, because it is best addressed by promoting salt iodization.

Table 13: Selection of the most promising agricultural product /value chain

Rank by RCA			Rank by Yield progress***		Rank by yield gap		Rank by relevance of crop	
Rank	Agricultural product	RCA index (2011)	Crop	Average annual yield growth (2005 to 2012)	Staple crop (rainfed)	Relative yield gap (%)**	Agricultural Product	Production share of supply (2011) in %*
1	Cocoa, beans	61	Pineapples	136	Rainfed millet	86	Plantains	100
2	Cashew nuts, with shell	41	Coconuts	21	Rainfed rice	82	Millet & products	100
3	Coffee, husks and skins	14	Oranges	15	Rainfed maize	80	Sorghum & products	100
4	Pineapples	8	Beans, dry	10	Irrigated rice	79	Sweet potatoes	100
5	Vegetable oil	5	Groundnuts, with shell	8			Roots, Other	100
GIC selected	Flour, maize	0.22	Maize	3			Maize	99

Source: * Own computation based on FAOSTAT 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 GIC value chains are marked in red

2.4 Summary on selection of agricultural products and value chains

This chapter (chapter 2) has presented different relevant and important value chains in Ghana based on different criteria – resulting in the selection of different value chains. In summary, the top three value chains in each set – GIC selected value chains, other relevant value chains, and those identified by analysis of promising agricultural products and value chains – are presented in Table 14. The summary table shows that there are many overlaps between the GIC-selected value chains, those suggested through the literature review, and the analysis of promising agricultural products and value chains. These products/value chains are maize, rice, fruits (pineapple), cocoa, and plantain.

Table 14: Summary of all value chains

GIC value chains	Other value chains	Promising agricultural products and value chains (top 3)			
		RCA	Yield progress	Yield gap	Relevance of crop
Maize	Cocoa	Cocoa, beans	Pineapples	Rainfed millet	Plantains
Rice	Cassava	Chew nuts, with shell	Coconuts	Rainfed rice	Millet/ Sorghum & products
	Yam	Coffee, husks and skins	Oranges	Rainfed maize	Sweet potatoes, Roots other
	Plantain, palm oil				
	Vegetables, fruits				
	Groundnut, cowpea, soybeans				

Source: Authors' compilation

3 Innovations in value chains in the past 20 years

3.1 Main limiting factors

The limiting factors include:

- Lack of access to production inputs;
- Lack of access to efficient produce markets;
- Poor infrastructure;
- Prohibitively high cost of new technologies for most smallholders;
- Very limited access to credit from the formal sector;
- Inadequate security in land tenure;
- Low response to demand for new varieties of products (as in the case of pineapple);
- Low innovation adoption by farmers;
- Poor agricultural extension;
- Poor coordination among actors in value chain;
- Competition with cheap imports;

3.2 Important value-chain related and cross-cutting innovations

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

An inventory compiling the innovations of roughly the last three decades, carried out by FARA, identified 270 new technologies. The differentiated areas of innovation were crop variety improvement, improved agronomic and cultural practices, crop pest and disease management, weed control, soil fertility management, water management and irrigation technologies, poultry-related technologies, fisheries technologies, ruminants and other livestock-related technologies, agro/food processing technologies and food engineering-related technologies. The crop variety improvements comprised the biggest share of innovations, making up 44% of all technologies. Agro- and food processing and engineering technologies accounted for 17.8% of the technologies. Technologies for improved agronomic and cultural practices together with pest and disease, soil fertility, weed and water managements accounted for 22.6% of all the technologies identified. Most of the crop variety improvements were focused on maize, cowpea, groundnut, rice, cassava and sweet potato, ranked in descending order based on the number of technologies (Ampadu-Ameyaw et. al., 2016).

Some local crop technological innovations refer to crop improvements for maize, rice, cowpea, soybean and groundnut. There are additional innovations for cassava, yam, cocoyam, sweet potato, vegetables and fruit crops, plantain and bananas, as well as for some legumes of local importance. These have mainly been developed by the universities and some key institutions of the CSIR. The institutes plan to enter into some diverse PPP arrangements in the areas of production, processing and marketing activities for improved crop varieties of rice, cassava, maize, pepper, groundnuts and any other exportable and local products.

3.2.1 GIC value chains

3.2.1.1 Maize

Maize technologies include the development and release of 26 improved varieties since 1983 (Ragasa et al., 2013a). The development and dissemination of these varieties was made possible through collaborative research efforts between the International Maize and Wheat Improvement Center

(CIMMYT), the IITA, Crop Research Institute (CRI) and SARI. The improved varieties have been developed to incorporate distinct characteristics such as high yield, quality protein, disease and pest resistance, Striga tolerance, streak resistance, drought tolerance, lodging resistance. Crop management practices were recommended so as to maximize the potential of the innovations.

The innovations are considered successful because they are high yielding, and some contain quality protein essential for nutritional security. A big driver of the success of these innovations is the collaboration between stakeholders – researchers, extension agents and farmers. CIMMYT and IITA provide the germplasm, CRI and SARI breeders develop and promote the varieties by incorporating desirable traits, and farmers were willing to offer farm plots as demonstration sites. Government policies should focus on facilitating market integration to ensure farmers have access to local and regional markets for their maize produce.

The Ghana Grains Development Project (GGDP, 1979-1997) showed that the adaptation of new varieties by farmers worked fairly well, and depends on farmer characteristics and the farming environment; about half of Ghanaian maize farmers adopted innovations (Morris et al., 1999). However, a newer study found that the adoption of modern varieties has not increased, which is a disproportionate effect, considering the very active research sector and high number of new varieties released. A likely reason for the unpopularity of new varieties is their failure to produce higher yields than popular older varieties. New hybrid varieties that have been shown to produce twice the yields of widely used older varieties should also be more widely promoted. Extension services have to be strengthened in order to increase awareness about the existence of potentially beneficial technologies. Fertilizer use improved significantly in regions with low soil fertility. Herbicide use also grew very popular, with the application of herbicide on 73% of maize fields. However, herbicides are used above the recommended rate, which again indicates the need for better training and further research analyzing the impacts of herbicide overuse on soil quality, health and food safety. (Morris et al., 1999; Ragasa et al., 2013a)

In maize production, suitable crop rotations have shown to result in returns on investment of up to 235% (cassava-maize, on fertile soil). The use of fertilizer has shown to decrease return on investment, meaning that the increase in yield did not compensate for the high input and labor costs of applying fertilizer. (Adjei-Nsiah et al., 2007)

The provision of microfinance to Ghanaian maize farmers was shown to have a marginal effect on their social and economic wellbeing (Adams et al., 2010). Future investment, therefore, should rather concentrate on cooperation along the value chain, post-harvest technologies and marketing to eradicate the most relevant limiting factors.

3.2.1.2 Marketable Rice Technologies

Seven improved varieties of rice were released in Ghana between 1997 and 2010. Each of these improved varieties has its own unique attributes, including the growing ecology, number of days to mature, potential yield, milling yield, cooking quality, grain shape, color and aroma. Among the innovations are varieties with high yielding potential, which could increase rice output, leading to a reduction in rice imports and improving food and nutritional security. The International Rice Research Institute and the Africa Rice Center provided the germplasm for the innovation process, while CRI and SARI breeders developed and promoted the varieties by adapting them to various rice ecologies and incorporating desirable traits. Farmers willingly offered farm plots as demonstration sites. Government policies should now focus on improving the post-harvest handling of rice to ensure that standards are observed along the value chain in order to improve rice quality and to facilitate the marketing of rice. The policies should also promote the consumption of locally produced rice.

Technical inefficiencies lead to a 27% loss relative to potential maximum profits in rice production in the northern regions of Ghana, with a mean technical efficiency of rice farms of about 50%. 70% of rice farmers in Northern Ghana are illiterate, which affects their ability to adopt innovations and increase their productivity. High input costs for fertilizer, pesticides and machine power further weaken

advancement. Institutional innovations, therefore, have great potential to improve productivity. Since 14% of variations in output can be explained by natural hazards such as erratic rainfall, crop diseases, worms, bushfires, birds and grasshoppers, innovations strengthening the resilience against these risks are needed. (Al-hassan, 2008)

Encouraging farmer learning and innovation has proven to be an effective method for increased productivity in rice husbandry in Ghana. Consequently, good documentation and reporting channels for successful farmer innovations should be set up (Bentley et al., 2010).

3.2.2 Other value chains and cross-cutting innovations

3.2.2.1 High Yielding Early Maturing Soybean Varieties

Soybean yields in Ghana were known to be very low, compared to achievable yields. This, along with unreliable rainfall patterns, informed farmers' decision to demand high yielding, early maturing varieties for the minor season in the South and late planting in the North of Ghana (STEPRI, 2008). To address the concerns of farmers, two varieties that incorporate high yields and early maturity (90-97 days) traits, Ahoto and Nangbaar, were released in 2005. These traits suitably enabled planting during the minor season in the Southern part of Ghana and late planting in the Northern part of Ghana. Aside from having comparable protein and oil contents, these varieties have higher calcium (more than 260mg/100g) and iron contents (more than 11.5mg/100g) than the old local variety (STEPRI, 2008). The new varieties also fix more nitrogen in the soil than old varieties.

The release of the varieties was made possible through a collaborative project. Breeders at the CRI Legume Breeding program developed the varieties in collaboration with IITA Soybean Breeder, MoFA District Staff in the Food Crops Development Project (FCDP), CSIR-FRI, extension agents, and additional actors. Demonstration farms were provided by communities to promote the adoption of the innovations. IITA Soybean Breeder provided the germplasm. On-farm trials and demonstrations were carried out to showcase the potential of the improved varieties, with participation by key stakeholders. This gave farmers the opportunity to observe the performance of the new variety. Funding for the project came from the Government of Ghana, MoFA, FCDP and Agricultural services Sub-Sector Investment. Foundational seeds were developed by the Grains and Legumes Development Board following successful deployment of the breeder seed to make increase availability of seeds to farmers'. Dissemination of the seed innovations would contribute to improving food and nutrition security, stabilizing farm incomes and reducing poverty (STEPRI, 2008).

3.2.2.2 Improved cassava varieties

Ten improved cassava varieties have been released and disseminated by CSIR-CRI since 1993. The key attributes of these varieties are their resistance and tolerance to the Cassava Mosaic Disease. Most suitable ecologies for these varieties are the Forest, Forest Savannah and Coastal Savannah zones.

In addition to the improved cassava varieties, good production practices were established, which included procedures for site selection, land preparation, planting materials selection, when and how to plant, soil fertility, and pest and diseases management. These were developed as a package for increased cassava production. In collaboration with the IITA, CSIR-CRI has developed protocols for the biological control of cassava mealy bugs.

Universities and research institutes in Ghana and Nigeria have designed tractor-pulled cassava harvesters to facilitate a reduction in farmer labor input (Arndt et al., 2015).

3.2.2.3 Groundnut

Groundnut yields were identified to have fallen below potential yield in Ghana. This situation was attributed to biotic, abiotic and socio-economic factors (STEPRI, 2008). To address the declining groundnut productivity, improved groundnut varieties have been developed and released through a collaborative groundnut seed project between the Export Development and Investment Fund (EDIF) and the Savannah Agricultural Research Institute of CSIR. The EDIF provided funding, under the

auspices of the Government of Ghana, while SARI provided the technical expertise for the execution of the project. Other actors who contributed to the dissemination of the innovations are MoFA, farmers, extension officers, and NGOs. The varieties include *Kpanielli*, *Edorpo-Munikpa*, *Nkatiesari*, *Mani Pinta* and *Jusie-Balin*. They have an early to medium maturation period, and are resistant to leaf spot diseases. They have higher yield potential than traditional varieties that ranges between 2.0-2.4 tons/ha. Moreover, the oil content of the kernel of these varieties is higher than that of the Chinese varieties; for example, *Kpanielli* has 51.8% oil and *Edorpo-Munikpa* has 48% oil in comparison to 46.6% oil for the Chinese variety common to farmers (STEPRI, 2008). Good management practices to accompany these innovations were also recommended for higher yields. They include but are not limited to field rotation between cereals and groundnut, adequate land preparation and weed control, and high-density planting at (STEPRI, 2008).

3.2.2.4 Cowpea

Prior to the 1980s, the cowpea crop was neglected by the research community. During this time, constraints to cowpea production that could cause yield loss in the range of 15-100% became widespread (BLT, 2012). In light of this situation, the need for research into improved varieties became clear. In the initial stages of planning, CSIR-SARI's researchers along with MoFA, farmers and other relevant stakeholders identified and listed the major constraints associated with cowpea production, including late maturity, low yields and *Striga* infestation. Through active collaboration six improved varieties of cowpea have been developed and released since 2004. Initial breeding programs centered on developing high yielding and early maturing cowpea varieties such as *Apagbala* and *Marfo-Tuya*. Today, researchers incorporate other important characteristics, such as seed coat color, cooking ability, drought and *Striga* tolerance, and resistance to field and storage pest (BLT, 2012). The other varieties include *Padi-Tuya*, *Songotra*, *Zaayura* and *Baawutawuta*. Funding for the project that led to the release of *Apagbala* and *Marfo-Tuya* was largely provided by IITA. CSIR-SARI conducted the research, while the other actors helped in the dissemination of the innovations. The adoption of these varieties would lead to increased cowpea production and farm incomes and contribute to poverty reduction and food and nutritional security.

3.2.2.5 Others

Further innovations include the release of several pepper varieties and fertilizer recommendations for citrus and plantain.

The minisett yam technique was developed in order to address the problem of insufficient planting material for yams by producing good quality planting material. However, as is often the case when improved procedures or new technologies are brought forward, there was poor adoption of the measure by Ghanaian farmers. This is attributable to multiple reasons, which indicates the high necessity of well-designed and strongly promoted innovations tailored to the end-users and combined with a strong feedback mechanism. (Kenyon et al., 2000)

Other cross-cutting innovations include an innovation contest in which awards serve as incentives to overcome innovation secrecy. This has been found to be a good instrument in scouting innovations developed by farmers in the Upper East region of northern Ghana (Tambo and Wünscher, 2014).

Local Innovation Support Funds that support innovative farmers to further develop and disseminate their innovations have also been used to accelerate farmer innovations in northern Ghana (Avornyo et al., 2011).

Improved production methods such as plastic mulching, trellising and drip irrigation have increased yields of vegetable crops in Ghana. High-yielding, disease-resistant vegetable varieties adapted to African smallholder farming conditions are being developed by East West Seed International. Rhizobium inoculants have increased soybean yields by up to 40%. Easy-to-use 'inoculation' has

improved nitrogen fixation and yields in soybeans. A one-dollar investment in inoculum can give returns of up to USD20 in extra grain (2Scale, 2014).

Other promising innovations include advances in ICT, such as the laying of fibre optic cables, which provides uninterrupted data transmission to and from remote areas of the country. The International Institute for Communication and Development (IICD) set up ICT projects supporting Ghanaian farmers and connecting them to other actors along the value chain through telecommunication, such as multimedia centers and online knowledge-sharing platforms, enabling farmers to access health insurance. Esoko Ghana has been providing the agricultural markets in Ghana with price information, weather forecasts and growing tips via SMS since 2011. These ICT innovations can help farms of all sizes increase yields and profits by facilitating medium and long-term planning, strengthening their negotiation position and thereby ensuring a fair income. (National Food and Agric Show, 2011; IICD, 2006)

The first modern national commodity exchange set up by the Ghana Commodity Exchange Project (GCX) promises to be a fruitful institutional innovation. Feedback from actors positioned all along the agricultural value chains shape the design of the project. There is much support for the view that the GCX will transform the agricultural sector and help alleviate poverty (Larbi, 2016; Ghana News Agency, 2016).

4 Suggestions for Collaboration

The Ghana Agricultural Sector Investment Programme (GASIP) aims to facilitate scaling up investments for private sector-led, pro-poor agricultural value chain development by providing a framework and institutional basis for long-term engagement and supplementary financing. GASIP will contribute to the realization of Ghana's Medium Term Agriculture Sector Investment Programme, which provides the road map for the CAADP compact in Ghana. MoFA will implement GASIP, with the aim to promote a "standard setting approach." This approach will steer its policy, serve as a core investment for value chain development in Ghana, and align complementary parallel financing, following the modalities that each of the Development Partners prefer.

GASIP is built along the following four strategic axes, which are in line with the agreed Strategic Framework for the International Fund for Agricultural Development (IFAD) in Ghana (2012 Country Strategic Opportunities Program):

- a. Linking smallholder farmers to agribusinesses in order to enhance pro-poor growth;
- b. Nationwide scaling up of a successful value chain investment approach;
- c. Promoting and mainstreaming climate change resilience approaches in Ghana, particularly in the northern regions, financed through the Adaptation for Smallholder Agriculture Programme;
- d. Knowledge management, harmonization of intervention approaches and policy support.

The Ghanaian government's agricultural development plans, along with the strategic priorities of the National Agricultural Research System, have identified a number of prime commodities (such as chilies, pineapples and maize) and their value chains for research. In order to promote these value chains, focus has been placed on locating market opportunities. Collaboration in research on these selected commodities on technology generation, production, development and dissemination has been critical to all these activities, and it may have served as the hub for all of these relationships and partnerships.

Some of the key initiatives supported in Ghana include:

- Value chain approach and out-grower schemes;
- Policy advice and capacity building at different levels;
- Improvement in quality standards;
- Cooperation with the private sector;
- Agricultural finance.

Program of Accompanying Research for Agricultural Innovation (PARI)

The German Development Cooperation's approach has been based on value chain development. This has aimed at linking stakeholders in the value chains and distributing value added equally. This approach has ensured that quality along the value chain is not compromised.

Through the Ghana-Germany relations, nine value chains have been supported. They include value chains for rubber, mango, pineapple, citrus, chili pepper, maize, guinea fowl, grass cutter and fish in five regions (Western, Central, Brong Ahafo, Volta and Northern) of the country. In total, about 5,800 farmers as well as other processing companies have been directly supported.

Dating back to Ghana's independence in 1957, Ghana and Germany have had long-standing diplomatic relations in several areas, specifically in the areas of socio-cultural and human development. The collaboration between the two countries has aimed at promoting development in agriculture, the private sector and good governance. More recently, Germany has continued to support Ghana in the development of sectors including road infrastructure, health, and education, water and reforestation and forestry management. This collaboration continues to be strong, and the two countries are seeking further and greater collaboration for nation building.

Partnership in the agriculture sector has been enormous; the role of R&D has been critical to the relationship as a way of helping Ghana with the many challenges it faces in alleviating poverty, through agriculture-led economic development. This relationship has supported the development of some innovation systems and platforms in the country. Their goal is to complement these research efforts and to translate research output into development outcomes, over and above the demand-driven research process and other benefits.

The institutions that are part of the German Development Cooperation that already work in Ghana are Kreditanstalt für Wiederaufbau for Financial Cooperation, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the German Institute of Metrology.

A call for a good partnership framework is crucial in order to continue the strong Germany-Ghana collaboration. The main prospective partners for Germany in Ghana are the following national and international institutions:

- MoFA;
- CSIR, particularly, SARI, CRI, FRI, STEPRI;
- USAID-Ghana (maize and rice value chain);
- IFPRI;
- IITA, Tamale, Ghana;
- NGO ACDI/VOCA (maize and rice value chain).

Summary of Recommendations for Consideration

- Improvement in system performance, especially through better Agricultural Extension Agent (AEA) motivation and incentives, particularly in the context of governmental decentralization;
- Farmers groups and organizations should receive capacity-building training to advocate for increased access to agricultural extension services;
- Local government (District Assembly) capacity to utilize extension to improve small-holder incomes and food security should be strengthened so that decentralization does not further damage the small-holder farmers' access to these services;
- Capacity building at the national level is necessary to improve the coordination of extension activities and programs across a wide variety of extension providers;
- Support and strengthen MoFA ICT-based extension efforts;
- Ensure that training materials and supporting supplies are widely available for all the major crops in northern Ghana, particularly rice, maize, and soya;

- Increase the media development capacity of the MoFA Extension Directorate through training, coaching and learning by doing;
- Develop a properly catalogued and shared (via the internet and via a resource library) set of all extension training materials for Ghana;
- Ensure that AEAs and other front-line extension workers are able to access in-service training programs through a variety of delivery platforms;
- Ensure that Ghanaian universities and other extension training programs offer the strongest possible degree and certificate training programs through faculty-strengthening and exchanges;
- Establish a pilot program and empower farmers' organizations to directly hire, finance, and utilize AEAs;
- Build upon existing and previously developed and implemented programs of community extension volunteers (lead farmers, etc.) through strengthening, training, and support so that farmers' groups and their extension needs are met;
- Develop and promote small-scale independent farm advisory programs to provide services to farmers on a fee-for-service basis;
- Implement an extension program targeted at mechanization service providers (tractors, combines, threshers, etc.) in northern Ghana to strengthen business skills and technical capacity, as well as their business lines and offerings.

With the help of the FARA and GASIP, as along with a good partnership with Germany, agricultural R&D will be improved in the country.

The PARI initiative, which is one of the newest in the country and aims at ensuring that research activities result in development, has taken this approach in Ghana and has advanced plans to align research actions with the German-led GICs in the country.

References

- 2Scale. 2014. Business as unusual - The 2Scale Project, Highlights 2014. Retrieved April 11, 2016 from ifdcorg.files.wordpress.com/2015/07/2scale_highlights20141.pdf
- Adams, S. and Bartholomew, T. A. 2010. The impact of microfinance on maize farmers in Nkoranza (Brong Ahafo Region of Ghana). *Journal of Management Research*, 2(2), 1
- Adjei-Nsiah, S., Kuyper, T. W., Leeuwis, C., Abekoe, M. K. and Giller, K. E. 2007. Evaluating sustainable and profitable cropping sequences with cassava and four legume crops: Effects on soil fertility and maize yields in the forest/savannah transitional agro-ecological zone of Ghana. *Field Crops Research*, 103(2), 87-97
- Akudugu, M. A., Guo, E. and Dadzie, S. K. 2012. Adoption of modern agricultural production technologies by farm households in Ghana: What factors influence their decisions. *Journal of Biology, Agriculture and Healthcare*, 2(3)
- Al-hassan, S. 2008. Technical Efficiency of Rice Farmers in Northern Ghana (No. RP_178). African Economic Research Consortium
- Ampadu-Ameyaw R., Omari R., Owusu Essegbey G. and Dery S. (2016). Status of Agricultural Innovations, Innovation Platforms, and Innovations Investment. 2015 PARI project country report: Republic of Ghana. Accra and Bonn: Forum for Agricultural Research in Africa (FARA) and Center for Development Research (ZEF), University of Bonn.
- Anaadumba, P. 2013. Analysis of incentives and disincentives for yam in Ghana. Technical notes series, MAFAP, FAO, Rome.
- Angelucci, F. 2012. Analysis of incentives and disincentives for maize in Ghana. Technical notes series, MAFAP, FAO, Rome
- Angelucci, F. 2013. Analysis of incentives and disincentives for cassava in Ghana. Technical notes series, MAFAP, FAO, Rome
- Angelucci, F. and Bazzocchi, A. 2013. Analysis of incentives and disincentives for groundnuts in Ghana. Technical notes series, MAFAP, FAO, Rome.
- Anim-Somuah, H., Henson, S., Humphrey, J. and Robinson, E. 2013a. Strengthening Agri-Food Value Chains for Nutrition: Mapping Value Chains for Nutrient-Dense Foods in Ghana. Institute of Development Studies (IDS) Evidence Report 2. IDS, Brighton, UK
- Anim-Somuah, H., Henson, S., Humphrey, J. and Robinson, E. 2013b. Undernutrition Policy Guidelines: Enhancing Markets for Nutrient-Dense Foods in Ghana. Institute of Development Studies (IDS) Evidence Report 28. IDS, Brighton, UK
- Arias, P., Hallam, D., Krivonos, E., & Morrison, J. 2013. Smallholder integration in changing food markets. Food and Agriculture Organization of the United Nations, Rome.
- Arndt, C., Evans, N. and Weiss, T. 2015. Innovations benefitting Smallholders. Technology transfer recommendations for the Malawi Green Innovation Centre. AFC Consultants International GmbH on behalf of Gesellschaft für Internationale Zusammenarbeit (GIZ)
- ASTI. 2017. Homepage. Accessed from: www.asti.cgiar.org/
- Avornto F.K., Lambon J., Nchor J. and Alenyorege B. 2011. Action Research on Farmer Access to Innovation Resources (FAIR): The Ghana Experience. Prolinnova-Ghana, ACDEP Tamale, Ghana
- Bentley, J. W., Van Mele, P. and Acheampong, G. K. 2010. Experimental by Nature: Rice Farmers in Ghana. *Human Organization*, 69(2)

- Bhat, R. V. and Vasanthi, S. 2003. Mycotoxin food safety risk in developing countries. In: Unnevehr, L. J. (ed.). 2020 Focus 10: Food safety in food security and food trade. IFPRI, Washington DC
- Bulletin of Tropical Legumes (BLT). 2012. Cowpea Farming in Ghana. A Monthly Bulletin of the Tropical Legumes II Project, International Center for Tropical Agriculture (CIAT), ICRISAT and IITA.
- Cafiero, C. 2014. The excessive (and wasteful) consumption of food. Technical note 3. In: IFPRI. Global Nutrition Report 2014: Actions and Accountability to Accelerate the World's Progress on Nutrition. IFPRI, Washington, DC
- DFID. 2004. "Agriculture, Growth and Poverty Reduction", Accessed from: www.dfid.gov.uk/Documents/publications/agri-poverty-reduction.pdf
- Dzomeku, B. M., Dankyi, A. A. and Darkey S. K. (2011), "Socioeconomic Importance of Plantain Cultivation in Ghana," *Journal of Animal & Plant Sciences*, 21(2), pp 269-273.
- FAO. 2014. The State of Food Insecurity in the World 2014. Rome: FAO, WFP, IFAD
- FAO. 2016. Food security indicators. Retrieved June 17, 2016, from www.fao.org/economic/ess/ess-fs/ess-fadata/en/
- FAOSTAT. 2017. Food and agriculture data. Last accessed on January 17, 2017 from: www.fao.org/faostat/en/#home
- Florkowski, W. J. and Kolavalli, S. 2014. Strategies to control aflatoxin in groundnut value chains. IFPRI Discussion Paper 01369. IFPRI, Washington DC
- Fuglie K. and Rada N. 2011, „Policies and productivity growth in African agriculture“, in Agricultural R&D: Investing in Africa's Future. Analyzing Trends, Challenges and Opportunities, Bd. 19 (ASTI/IFPRI-FARA Conference, Accra, Ghana: Citeseer, 2011), citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.371.9698&rep=rep1&type=pdf.
- Gatune J., Chapman-Kodam M., Korboe K., Mulangu F. and Rakotoarisoa M.A. 2013. Analysis of trade impacts of the fresh pineapple sector in Ghana. FAO Commodity and Trade Policy Research Working Paper No. 41. FAO, Rome, Italy
- Ghana Statistical Service (GSS), Ghana Health Service (GHS), and ICF International. 2015. Ghana Demographic and Health Survey 2014. GSS, GHS, and ICF International, Rockville, Maryland.
- Ghana News Agency. 2016, April 1. Ghana Commodity Exchange Market must have strong legal backing. Modern Ghana. Retrieved April 11, 2016, from www.modernghana.com/news/683620/ghana-commodity-exchange-market-must-have-strong-legal-backi.html
- Global Forum for Rural Advisory Services. 2017. Homepage. Accessed from: www.g-fras.org/en/
- Gong, Y., Hounsa, A., Egal, S., Turner, P. C., Sutcliffe, A. E., Hall, A. J., Cardwell, K., Wild, C. P. 2004. Postweaning exposure to aflatoxin results in impaired child growth: a longitudinal study in Benin, West Africa. *Environmental Health Perspectives*, 112(13), 1334-1338
- Hammond, D. E. 2014. Consumers' Perception of Attributes and Related Benefits of Soy and its Consumption in Ghana. Doctoral dissertation, Kwame Nkrumah University of Science and Technology
- HarvestChoice. 2015. Travel time to nearest town over 20K (mean, hours, 2000). International Food Policy Research Institute, Washington, DC., and University of Minnesota, St. Paul, MN. Available online at harvestchoice.org/data/tt_20k
- HarvestPlus. 2017. What we do: crops. Accessed online at www.harvestplus.org/what-we-do/crops

Program of Accompanying Research for Agricultural Innovation (PARI)

- ICF International. 2015. The DHS Program STATcompiler. Last accessed on September 12, 2016 from: www.statcompiler.com/en/
- Husmann C., von Braun J., Badiane O., Akinbamijo Y., Fatunbi A.O., Virchow D. 2015. Tapping Potentials of Innovation for Food Security and Sustainable Agricultural Growth – an Africa-wide Perspective. Program of Accompanying Research for Agricultural Innovation (PARI). Bonn: Center for Development Research.
- IFPRI. 2015. Global Nutrition Report 2015: Actions and Accountability to Advance Nutrition and Sustainable Development: Nutrition Country Profiles. IFPRI, Washington DC.
- IICD. 2006. ICTs for agricultural livelihoods - Impact and lessons learned from IICD supported activities. Retrieved April 11, 2016 from www.iicd.org/documents/icts-for-agricultural-livelihoods-impact-and-lessons-learned-from-iicd-suported-activities/
- Imdad, A., Herzer, K., Mayo-Wilson, E., Yakoob, M. Y. and Bhutta, Z. A. 2010. Vitamin A supplementation for preventing morbidity and mortality in children from 6 months to 5 years of age. Cochrane Database of Systematic Reviews, 12, CD008524
- Imdad, A., Yakoob, M. Y., Sudfeld, C., Haider, B. A., Black, R. E., Bhutta, Z. A. 2011. Impact of vitamin A supplementation on infant and childhood mortality. BioMed Central Public Health, 11(Suppl 3), S20
- Jones, C. J. 2011. Shifting functions to create value for producers in the value chain for ready-to-use therapeutic foods in Ethiopia. In: Hawkes, C. and Ruel, M. T. Value Chains for Nutrition, 2020 Conference Paper. IFPRI, Washington DC
- Kenyon, L. and Fowler, M. 2000. Factors affecting the uptake and adoption of output of crop protection research on yams in Ghana. Natural Resource International Limited. UK, 15-25.
- Kolavalli, S. and Vigneri M. 2011. Cocoa in Ghana: shaping the success of an economy.
- M.A. Punam Chuhan-Pole (Ed.), Yes, Africa Can: Success Stories from a Dynamic Continent, World Bank Publication, Washington, DC, pp. 201-217
- Larbi, C. 2016, February 19. Commodity exchange must transform agric sector. Modern Ghana. Retrieved April 11, 2016, from www.modernghana.com/news/676014/commodity-exchange-must-transform-agric-sector.html
- Lewis, W. A. (1962). Education and economic development. Caribbean Quarterly, 7(4), 171-184.
- Ministry of Food and Agriculture (MoFA). 2010. Medium Term Agriculture Sector Investment Plan (METASIP) 2011-2015. Ministry of Food and Agriculture, Accra, Ghana
- Ministry of Food and Agriculture (MoFA). 2013. Agriculture in Ghana: Facts and Figures (2012). Statistics, Research and Information Directorate (SRID), Accra, Ghana.
- Morris, M. L., Tripp, R. B. and Dankyi, A. A. 1999. Adoption and impacts of improved maize production technology: A case study of the Ghana Grains Development Project
- Must, A. and McKeown, N. M. 2012. The disease burden associated with overweight and obesity. In: De Groot, L. J., Beck-Peccoz, P., Chrousos, G., Dungan, K., Grossman, A., Hershman, J. M., Koch, C., McLachlan, R., New, M., Rebar, R., Singer, F., Vinik, A., and Weickert, M. O. (editors). Endotext. MDTText.com, Inc., South Dartmouth (MA). Retrieved October 10, 2016, from www.ncbi.nlm.nih.gov/books/NBK279095/
- National Food and Agric Show. 2011. A vibrant Agricultural Sector - Is ICT the antidote? Retrieved April 11, 2016, from fagroghana.com/index.php?opt=contents
- New Alliance for Food Security and Nutrition. 2017. Homepage. Accessed from: new-alliance.org/

- Ragasa C., Dankyi A., Acheampong P., Wiredu A.N, Chapot, A., Asamoah M. and Tripp R. 2013a. Patterns of adoption of improved maize technologies in Ghana. IFPRI Working Paper 36 of the Ghana Strategy Support Program
- Ragasa C., Dankyi A., Acheampong P., Wiredu A.N, Chapoto A., Asamoah M. and Tripp R. 2013b. Patterns of Adoption of Improved Rice Technologies in Ghana. IFPRI Working Paper 35 of the Ghana Strategy Support Program
- Rapsomanikis, G. 2014. The economic lives of smallholder farmers; An analysis based on household surveys. Rome: Food and Agriculture Organization.
- ReSAKSS. 2017. Homepage. Accessed from: resakss.org/
- Robinson, J. C. and Saúco, V. G. 2010. Bananas and plantains. Cabi. Wallingford, UK
- Scaling Up Nutrition. 2017. Homepage. Accessed from: scalingupnutrition.org/
- Schill, P. F., Afreh-Nuamah, K., Gold, C. S. and Green, K. R. 2000. Farmers' perceptions of constraints to plantain production in Ghana. The International Journal of Sustainable Development & World Ecology, 7(1), 12-24.
- Science, Technology and Policy Research Institute (STEPRI). 2008. Agricultural Innovations: Technological Inputs for Enhancing Agricultural Production in Ghana. CSIR – INSTI Press. Accra, Ghana.
- The Netherlands Development Organization (SNV). 2010. Technology for Improved Income of Smallholder Pineapple Producers, Ghana. Case study 68
- Stevens, G. A., Bennett, J. E., Hennocq, Q. et al. 2015. Trends and Mortality Effects of Vitamin A Deficiency in Children in 138 Low- and Middle-Income Countries: Pooled Analysis of Population-Based Surveys. The Lancet, 3(9), e528–e536
- Tambo J.A. and Wünscher T. 2014. Identification and prioritization of farmers' innovations in northern Ghana. Renewable Agriculture and Food Systems. doi:10.1017/S1742170514000374.
- Van Bussel L.G.J., Grassini P., van Wart J., Wolf J., Claessens L., Yang H., Boogaard H., de Groot H., Saito K., Cassman K.G., van Ittersum M.K. 2015. From field to atlas: Upscaling of location-specific yield gap estimates. Field Crops Research, 117, 98-108.
- Van Huis, A., Jiggins, J., Kossou, D., Leeuwis, C., Röling, N., Sakyi-Dawson, O., ... and Tossou, R. C. 2007. Can convergence of agricultural sciences support innovation by resource-poor farmers in Africa? The cases of Benin and Ghana. International Journal of Agricultural Sustainability, 5(2-3), 91-108
- von Grebmer, K., Bernstein, J., Nabarro, D., Prasai, N., Amin, S., Yohannes, Y., Sonntag, A., Patterson, F., Towey, O. and Thompson, J. 2016. 2016 Global Hunger Index: Getting to Zero Hunger. Welthungerhilfe, IFPRI, and Concern Worldwide, Bonn, Washington DC, and Dublin.
- UNICEF. 2013. Improving child nutrition: The achievable imperative for global progress. UNICEF, New York.
- UNICEF/WHO/World Bank. 2016. Levels and Trends in Child Malnutrition: UNICEF-WHO-The World Bank: Joint Malnutrition Estimates, August 2016. New York, Geneva, and Washington, DC. Retrieved September 26, 2016, from who.int/nutgrowthdb/estimates2015/en/
- USDA (US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory). 2016. USDA National Nutrient Database for Standard Reference, Release 28 (Slightly revised). Retrieved October 5, 2016, from www.ars.usda.gov/ba/bhnrc/ndl
- WABS Consulting Ltd. 2008. Draft report of 'Maize Value Chain Study in Ghana: Enhancing Efficiency and Competitiveness. WABS Consulting Ltd.

Program of Accompanying Research for Agricultural Innovation (PARI)

- WHO. 1995. Physical Status: The Use and Interpretation of Anthropometry. Report of a WHO Expert Committee. Technical Report Series 845, WHO, Geneva.
- WHO. 2000. The Management of Nutrition in Major Emergencies. WHO, Geneva.
- WHO. 2003. Nutrition and the prevention of chronic diseases. Report of a Joint WHO/FAO Expert Consultation. Technical Report Series 916, WHO, Geneva.
- WHO. 2005. Guiding principles for feeding non-breastfed children 6-24 months of age. WHO, Geneva.
- WHO. 2010. Indicators for Assessing Infant and Young Child Feeding Practices, Part 1: Definitions. WHO, Geneva.
- WHO. 2015a. Global Health Observatory Data Repository: Adult overweight and adult obesity. Retrieved September 15, 2016, from apps.who.int/gho/data/node.main.A897A?lang=en and apps.who.int/gho/data/node.main.A900A?lang=en
- WHO. 2015b. The Global Prevalence of Anemia in 2011. WHO, Geneva.
- WHO/FAO/UNU. 2007. Protein and amino acid requirements in human nutrition. Report of a joint FAO/WHO/UNU expert consultation. Technical Report Series 935, WHO, Geneva.
- World Bank. 2006. Repositioning Nutrition as Central to Development: A Strategy for Large-Scale Action. World Bank, Washington DC.
- World Bank. 2017. Country data. Retrieved from data.worldbank.org/country

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).¹⁶

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.

¹⁶ 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/m² (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/m² (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.



PROJECT DIRECTOR

Prof. Dr. Joachim von Braun

Center for Development Research (ZEF)
Genscherallee 3
53113 Bonn, Germany
E-Mail: pari@uni-bonn.de
Phone: +49 - (0)228-73 6740

www.research4agrinnovation.org

Follow us on Facebook and Twitter
www.facebook.com/pari.zef
Twitter: @PARI_ZEF